



**PLAN4COLD**

**DEFINING SUSTAINABLE LOCAL  
HEATING AND COOLING PLANS:  
A PRACTICAL HANDBOOK**

## Authors

Chiara Lazzari | Ambiente Italia  
Joana Fernandes and Rita Pestana | ADENE  
Davide Quaggiotto | R2M Solutions Srl

## Contributors

Tiago Marques and Sílvia Remédios | ADENE  
Afroditi Kakagia and Vassiliki Drosou | CRES  
Nadège Seguel | FEDARENE  
Marco Calderoni | R2M Solutions Srl  
Alicia Göpner and Felix Platz | Climate Alliance  
João Fonseca and Mónica Alves | INOVA+  
Chiara Tringali and Matteo Mazzolini | APE FVG  
Barbara Sarnari and Vito Azzara | SVIMED  
Filipe Oliveira, Fabio Pereira and Ruben Figueira | AREAM  
Isabel Rodriguez and Orlando Paraíba | ENA  
Emmanouil Varouchakis and Georgia Poligotsi | TUC  
Foteini Papamichailidou and Kyriaki Kissa | RDFCM  
Andrea Diaz-Barredo and Indalecio Gonzalez | FAEN  
Vedran Krušvar | REA KVARNER

Date: 04/03/2026

Grant agreement No: 101167534 — LIFE23-CET-Plan4COLD

Project start date: 1st October 2024

Duration: 36 months



Co-financed by  
the European Union

Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

## ABBREVIATION AND ACRONYMS

**Plan4COLD:** Supporting South Europe municipalities in the definition of Sustainable Local Heating and Cooling Plans

**EE:** Energy Efficiency

**EED:** Energy Efficiency Directive

**EPBD:** Energy Performance of Buildings Directive

**DHC:** District Heating and Cooling

**DHW:** Domestic Hot Water

**GHG:** Greenhouse Gases

**H&C:** Heating and Cooling

**KPI:** Key Performance Indicator

**RED:** Renewable Energy Directive

**RES:** Renewable Energy Sources

**RH&C:** Renewable Heating and Cooling

**SLHCP:** Sustainable Local Heating and Cooling Plan

**CHP:** Combined heat and power

**EPC:** Energy Performance Contract

**EU:** European Union

**LPG:** Liquefied Petroleum Gas

**NECP:** National Energy and Climate Plan

**SECAP:** Sustainable Energy and Climate Action Plan

**SEAP:** Sustainable Energy Action Plan

**SME:** Small and Medium-Sized Enterprise

# EXECUTIVE SUMMARY

Sustainable local heating and cooling plans (SLHCPs) are quite a new topic in the energy sector and, therefore, Municipalities, or other actors in charge of developing them on their behalf, should be duly guided in this complex process.

This document presents a wide-valuable methodology for the development of local heating and cooling energy plans on a step-by-step basis, and it was produced starting from the initial context analysis carried out in the pilot Municipalities of the Plan4COLD European project, co-financed by the European Commission under the LIFE-CET-LOCAL call.

The methodology provides operational and procedural guidance on how a local heating and cooling strategy should be defined, planned, implemented and monitored.

Structure and contents will be consistent with Art. 25 of the Energy Efficiency Directive but duly tailored on the territorial peculiarities detected during previous activities, to make the task easier for the local authorities involved. More in detail, the methodology describes all the main phases to be tackled, detailing the main sources of data and information needed and proposing possible and more suitable methodological and procedural approaches and simulation tools for their implementation, according to different starting situations.

**The introduction** of the guidelines stresses the role of Heating & Cooling (H&C) as a key enabler of the energy transition, also giving some snapshot on the current legislative framework on this topic at the European. A deep dive into the EU legislation is then provided in **ANNEX 1**.

**Part 1** presents the SLHCP in a nutshell, describing its scope, time horizon and structure and highlighting its five key phases: Prepare the ground, H&C baseline assessment ("Where do we stand now?"), the SLHCP strategy development ("Where do we want to go and how do we get there?"), Roadmap and SLHCP implementation, and, finally, the Monitoring of the plan ("How are we doing?"). This 1st part closes with the 1st Phase, Prepare the ground, presenting a section on practical tips that Municipalities should keep in mind before starting: ensure political commitment and create a governance structure, engage citizens and key stakeholders in the SLHCP process, deepen the knowledge on reference policy and strategic context, consider good examples and follow an integrated approach, the "Energy efficiency first" principle.

In **Part 2** of the document, the 2nd Phase of the methodology is analysed in detail, H&C baseline assessment, starting from the H&C energy inventory (on both the demand and supply sides), the emission inventory, as well as the weather and

climate trends, risks and vulnerabilities. Further topics are presented, focusing on the assessment of energy poverty and on H&C mapping. Regarding the energy inventory preparation, the guidelines deepen the topic of data analysis showing how to address and manage municipal buildings, equipment and facilities, data from national and regional sources, data from energy market operators and, finally, data collected from surveys among stakeholders.

**Part 3** explores the 3rd Phase, SLHCP strategy and development underlining three steps: the business-as-usual scenario, the intervention scenarios and target scenario. Finally, the 4th Phase is presented, Roadmap and SLHCP implementation. Furthermore, this section presents a general overview of possible actions and interventions, both on the H&C demand and supply side, provided with the aim of guiding municipalities towards potential application areas and sectors, also connecting to the hot topic of urban planning and regeneration. It also tackles the necessary additional measures a Municipality can promote and activate for the development of actions and interventions on territory and the concrete implementation of the SLHCP strategy, focusing on management, control and regulation, financial and incentive, enhancing and empowering. A more detailed presentation of the actions and measures for the different sectors is provided in **ANNEX 2** and **ANNEX 3**.

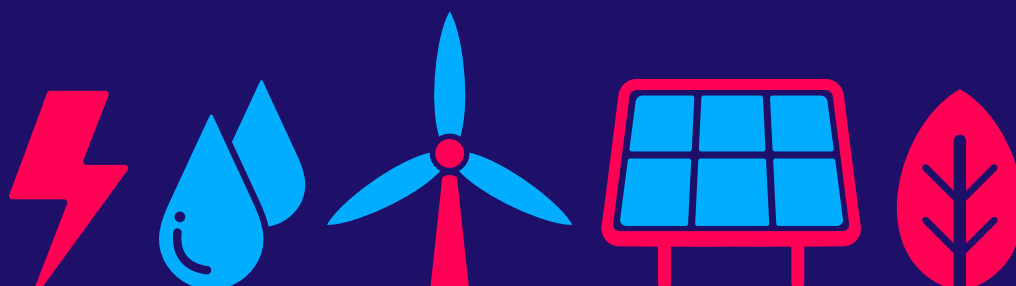
Part 3 closes with the 5th Phase, Monitoring of the SLHCP, on how to set up an adequate monitoring of the implementation and of the degree of success of their plan, suggesting concrete goals, steps and timelines for the monitoring process, as well as the key performance indicators needed for an appropriate assessment.

This section asks Municipalities to reflect first on where the SLHCP has arrived so far, thus meaning analysing which actions have been implemented and how and which actions are still ongoing and how. Then, the Municipalities should also assess what has already been achieved, which are the effects of each implemented and ongoing action and how far they are from reaching the SLHCP targets initially set. In the end, also a critical analysis of what went wrong and why is needed.

**Part 4** focuses on approaches, methods and tools for preparing the SLHCP, from the H&C baseline and processing the intervention scenarios, analysing different application sectors (residential, tertiary, manufacturing and public buildings) with a focus also on the local H&C energy supply.

Then, a selection of simulation and software tools are presented and described, highlighting their main characteristics, such as developer, resource type, phase of the SLHCP development, availability, required input, output, main advantages, and disadvantages and including the assessment of related performances and strengths. These simulation and software tools can help Municipalities in performing some of the steps in the development of the SLHCP. An additional resource is provided in **ANNEX 4** that presents a simplified table of contents as a suggestion to structure and present a SLHCP following the Plan4COLD methodology.

Finally, the guidelines also provide, in **ANNEX 5**, some insights on how to further learn and get inspired about SLHCPs, providing best practices and successful applications, materials, publications, reports, manuals, thematic online portals and platforms that can contribute to the capacity building process.



# TABLE OF CONTENT

## INTRODUCTION

|                                                              |   |
|--------------------------------------------------------------|---|
| 1. Heating & Cooling: A key enabler of the energy transition | 8 |
|--------------------------------------------------------------|---|

## PART A - THE SLHCP IN A NUTSHELL

|                                                                          |    |
|--------------------------------------------------------------------------|----|
| 1. About the Sustainable Local Heating and Cooling Plan                  | 9  |
| 2. How to prepare a SLHCP – A 5 stages approach                          | 11 |
| 2.1 Prepare the ground - Tips and key issues before starting             | 11 |
| 2.2 The H&C baseline assessment - Where do we stand now?                 | 13 |
| 2.3 The SLHCP strategy - Where do we want to go and how do we get there? | 14 |
| 2.4 Roadmap and SLCHP implementation                                     | 15 |
| 2.5 The H&C Plan monitoring - How are we doing?                          | 15 |

## PART B - THE H&C SYSTEM BASELINE - *Where do we stand now?*

|                                                                            |    |
|----------------------------------------------------------------------------|----|
| 1. How to approach the H&C baseline assessment                             | 16 |
| 1.1 The H&C energy inventory – The demand side                             | 16 |
| 1.2 The H&C energy inventory – The supply side                             | 20 |
| 1.3 The H&C emissions inventory                                            | 21 |
| 1.4 The weather and climate trends, risks and vulnerabilities              | 21 |
| 1.5 A further step – H&C energy poverty assessment                         | 22 |
| 1.6 A further step – H&C mapping                                           | 22 |
| 2. Data collection and sources for the H&C system baseline preparation     | 23 |
| 2.1 Data from local sources: Municipal buildings, equipment and facilities | 24 |
| 2.2 Data from national and regional sources                                | 25 |
| 2.3 Data from energy market operators                                      | 25 |
| 2.4 Data and information from stakeholders                                 | 26 |

## **PART C - THE SLHCP STRATEGY - *Where do we want to go and how do we get there?***

|                                                                                                         |    |
|---------------------------------------------------------------------------------------------------------|----|
| 1. How to approach the SLHCP strategy development and launch                                            | 28 |
| 1.1 The business-as-usual scenario - Where the local H&C system is going                                | 29 |
| 1.2 The intervention scenario - Where the local H&C system can go                                       | 30 |
| 1.3 The target scenario- Where the local H&C system shall go and how shall get there                    | 31 |
| 1.4 The Roadmap – Preparing and launching the SLHCP implementation                                      | 34 |
| 2. Actions and enabling technologies                                                                    | 36 |
| 2.1 Urban regeneration                                                                                  | 36 |
| 2.2 The building sector - Residential and Tertiary                                                      | 37 |
| 2.3 The manufacturing sector - Industry and Agriculture                                                 | 38 |
| 2.4 The local H&C energy supply – Renewable Energy Sources enabling technologies and integrated systems | 39 |
| 3. Supporting measures                                                                                  | 42 |
| 3.1 Management, control and regulation measures                                                         | 43 |
| 3.2 Financial and incentive measures                                                                    | 43 |
| 3.3 Enhancing and empowering measures                                                                   | 44 |
| 4. The SLHCP monitoring – How are we doing?                                                             | 45 |
| 4.1 Goals, steps and timelines of the monitoring                                                        | 45 |
| 4.2 The key performance indicators                                                                      | 46 |

## **PART D – APPROACHES, METHODS AND TOOLS**

|                                                                                                            |    |
|------------------------------------------------------------------------------------------------------------|----|
| 1. Methods and procedures for preparing the H&C energy inventory and processing the intervention scenarios | 54 |
| 1.1 The residential sector                                                                                 | 54 |
| 1.2 The tertiary sector                                                                                    | 55 |
| 1.3 The manufacturing sector - Industry and agriculture                                                    | 56 |
| 1.4 The public building stock                                                                              | 57 |
| 1.5 The local H&C energy supply                                                                            | 58 |
| 2. Simulation tools and software                                                                           | 62 |

## **ANNEXES**

### **Annex 1 - The policy and strategic framework**

The EU level

### **Annex 2 – Action and enabling technologies**

Urban regeneration

The building sector - Residential and tertiary

The manufacturing sector - Industry and agriculture

The local H&C energy supply – Renewable energy sources

The local H&C energy supply – Enabling technologies and integrated systems

### **Annex 3 – Supporting measures and tools**

Management, control and regulation measures

Financial and incentive measures

### **Annex 4 – Proposed table of contents for a Sustainable Local Heating and Cooling Plan**

### **Annex 5 -The SLHCP toolbox - Learn and get inspired**

Inspiring best practices of H&C planning

International and EU thematic platforms & portals

Sector associations

# INTRODUCTION

## 1. Heating & Cooling:

A key enabler of the energy transition

In Europe, heating and cooling are responsible for more than 50% of energy consumption and greenhouse gas emissions. Although the decarbonization of heating and cooling is underway, progress has been slow, and about 75% of the energy consumption is still reliant on fossil fuels, mainly gas, while the share of renewables is growing very slowly, and most of it comes from solid biomass which is used across all sectors in different systems and efficiency levels.

Heating and cooling are directly tangible to citizens; it represents more than 60% of the energy used by households affecting both people's comfort and their health. The cost of heat and cold also directly affects competitiveness: process heat represents 60% of all the energy used by the EU industry and the cost of fossil fuels for heating is expected to rise.

With increasing temperatures on European Union's (EU) territory (twice the global average) and frequent heatwaves, cooling is becoming a major energy security issue for citizens and the energy system as a whole and creating cooling infrastructure also in cities will be essential for health issues and for limiting the economic impact of heat waves.

The decarbonization of the heating and cooling sector is therefore essential in the energy transition to reach Europe's ambitious 2050 targets (carbon neutrality), and there is a huge potential for action to increase energy efficiency and sustainability, both through measures to reduce end-use consumption and through the deployment of RES installations.

The EU's strategy for decarbonization envisions transformative changes in H&C production, distribution and consumption, focusing on the in-

tegration of a high share of RES and waste heat into district H&C systems and on the renovation of the building stock, the single largest energy consumer in Europe, responsible for around 40% of the total energy consumption.

This strategy is driven, among others, by:

- The revised **Energy Efficiency Directive II** (EED II, EU Directive 2023/1791- [Directive \(EU\) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation \(EU\) 2023/955 \(recast\)](#))
- The **Renewable Energy Directive III** (RED III, Directive 2023/2413 - [Renewable Energy Directive](#))
- The **Energy Performance of Buildings Directive IV** (EPBD IV, entered into force on May 28, 2024 - [Energy Performance of Buildings Directive](#))

The recently agreed EU legislation can provide solutions to many of the challenges of decarbonization of heating and cooling. However, given the complexity of the issues, to maximize the potential of this measures an effective and timely implementation will require considerable support at the national level and Member States need to put in place robust legal and extensive support frameworks, which ensure that local governments have the knowledge, resources and capacity needed to effectively prepare and implement their plans.

The current state of play for local heating and cooling plans for each EU country is shown in the [Energy Cities Tracker](#) that is regularly updated to follow Member States' progress on transposing the obligation into their national context in the coming two years.

# PART A

## THE SLHCP IN A NUTSHELL

### 1. About the Sustainable Local Heating and Cooling Plan

Article 25.6 of the Energy Efficiency Directive (EED) mandates that municipalities in EU Member States with over 45,000 inhabitants must prepare local heating and cooling plans.

These plans aim to decarbonize the heating and cooling sector, improve energy efficiency, reduce fossil fuel reliance and enhance citizens' well-being and local economies, aligning local actions with national objectives.

Article 25.6 provides detailed requirements which must be included in the local heating and cooling plans. The plans should at least:

- Be based on assessment of the current local heating and cooling demand and energy consumption, identifying existing infrastructure and supply systems, including district heating, individual technologies and renewables and evaluating related greenhouse gas emissions,
- Provide an estimate and mapping of the potential for increasing energy efficiency, including via low-temperature district heating readiness, high efficiency cogeneration, waste heat recovery, and renewable energy in heating and cooling in that particular area,
- Be compliant with the energy efficiency first principle and include a strategy for the use of the identified potentials,
- Include an analysis of heating and cooling appliances and systems in local building stocks, considering the area-specific potentials for energy efficiency measures and addressing the worst performing buildings and the needs of vulnerable households,
- Be prepared with the involvement of all relevant regional or local stakeholders and ensure the participation of public, including operators of local energy infrastructure,
- Consider the common needs of local communities and multiple local or regional administrative units or regions,
- Assess the role of energy communities and other consumer-led initiatives that can actively contribute to the implementation of local heating and cooling projects,
- Assess how to finance the implementation of policies and measures and identify financial mechanisms allowing consumers to shift to renewable heating and cooling,
- Include a trajectory to achieve the goals of the plans in line with climate neutrality and the monitoring of the progress of the implementation of policies and measures identified.



In line with the requirements of article 25.6, a Sustainable Local heating and Cooling Plan (SLHCP) can be defined as an integrated, strategic and operational plan that outlines commitments and actions to address heating and cooling decarbonization targets and the transition to sustainable energy on a territory.

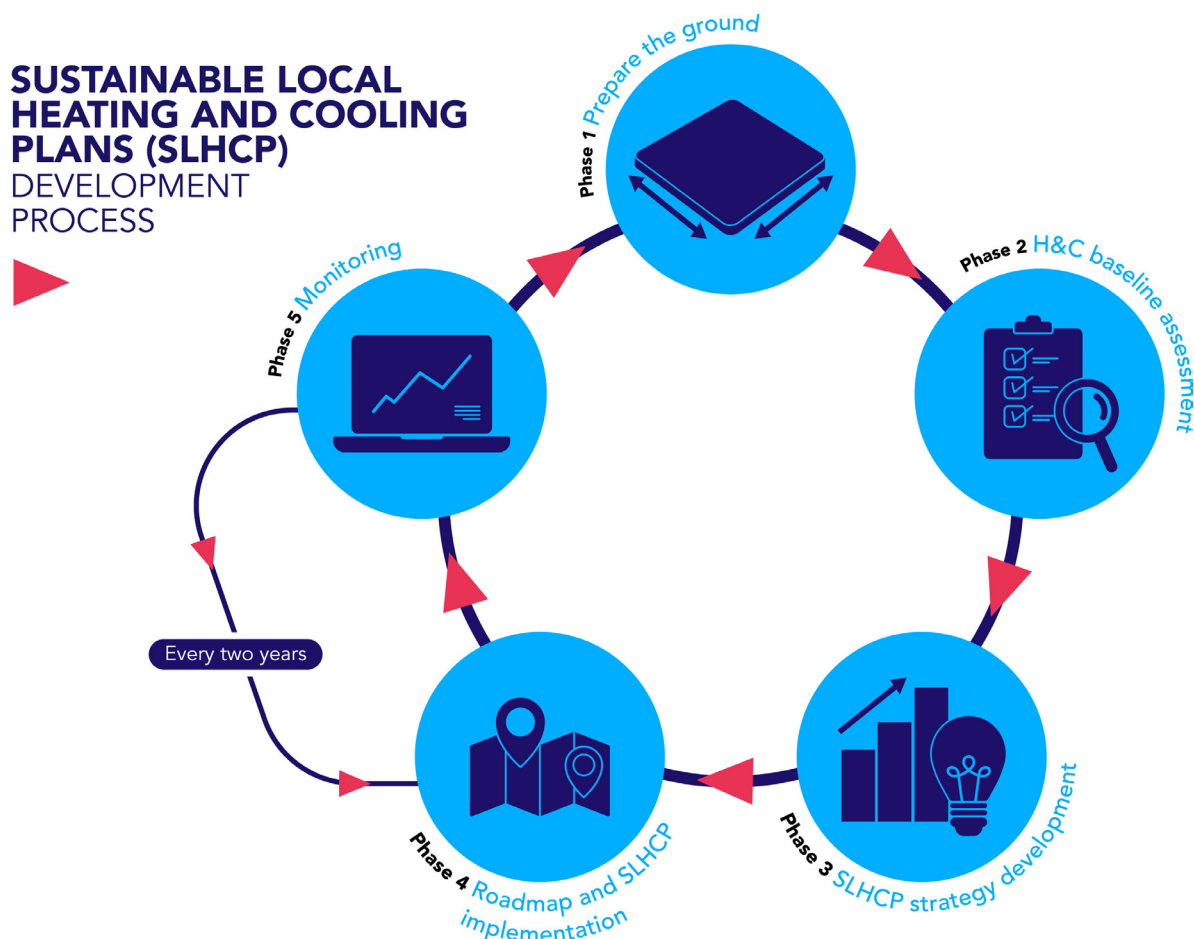
**A SLHCP should be developed by the Municipality, which sets, and shares with citizens and local stakeholders:**

- **A strategic vision and objectives to be achieved**
- **A set of actions and supporting measures across different sectors to reach objectives and**
- **A roadmap on implementation aligned with, or going beyond, national and international commitments and objectives.**

Even if article 25.6 doesn't define a time horizon for the SLHCP, 2040 can be assumed as the reference target year, in compliance with the EU's strategy for decarbonization timeframe and the intermediate deadlines foreseen therein.

## 2. How to prepare a SLHCP – A 5 Phases approach

The SLHCP processing can be broken down into the following 5 main Phases.



### 2.1 Prepare the ground - Tips and key issues before starting

The **1<sup>st</sup> Phase, Prepare the ground**, starts with a contextual alignment to guarantee political commitment of the Municipality, the engagement of the relevant stakeholders and coherence with the national, regional and local strategies in place.

#### Secure political commitment

**Ensure buy-in at all political levels and establish a clear governance structure from the start.**

To ensure the success of the SLHCP preparation it is crucial that key decision-makers of the Municipality are fully involved in the process, provide guidance and support, and give a clear mandate to their respective technical offices/units.

Designing and implementing a SLHCP is a complex and time-consuming process that requires thorough planning and ongoing management. It requires collaboration and coordination between various departments in the administration of the Municipality. It is thus essential for these departments to view the SLHCP as an integrated part of their daily operations, aligned with current and planned local projects and programs, rather than as an external or imposed task.

A successful SLHCP relies on a cross-sector and holistic approach, supported by a clear organisational structure with assigned responsibilities. Lack of coordination between the various policy levels and municipal departments could be a major obstacle. Therefore, the conditions to foster interdepartmental collaboration should be ensured.

## Engage early and often

**Reach, involve and engage the local community and relevant stakeholders in the SLHCP preparation from the beginning,** to ensure the

- commitment of key actors and the transparency of the process, as well as the credibility of the SLHCP and acceptance of actions.

Stakeholders' involvement is the starting point for stimulating the behavioural changes that are needed to complement the technical actions embodied in the SLHCP. This is the key to a concerted and coordinated way to implement it.

Citizens and stakeholders are likely to be influenced by the solutions devised but they can also help reach the targets. The views of citizens and stakeholders should be known before a detailed plan is developed.

Therefore, citizens and other stakeholders should be involved in all the key stages the SLHCP elaboration process. Plan4COLD suggests the creation of Local Communities of Practice (LCoP) has the preferred methodology to successfully engage with the key stakeholders.

The main objective of LoCPs involvement and engagement should be at least:

- *Collect information on the level of awareness and knowledge on the issues of the climate crisis and the energy transition*
- *Share data and information on the main qualitative and quantitative aspects of current trends in the H&C energy system*
- *Collect hints and suggestions on main critical issues, main obstacles as well as main opportunities related to the implementation of interventions in the H&C field*
- *Make available data and information on any programs, actions and interventions already undertaken or planned*

- *Analyse and discuss possible or necessary energy upgrading and/or efficiency measures/actions*
- *Analyse and discuss necessary supporting measures and policies to ensure actions concrete implementation and diffusion*

Identifying and mapping of stakeholders is the first step for the development of a co-created, shared and inclusive SLHCP. Creating a comprehensive list of stakeholders is a prerequisite for municipalities to launch and development an effective engagement process. To this end an excel mapping tool is available to support the identification and prioritize of the stakeholders to invite.

ANNEX 3 provides a brief concept note on how to assemble a LCoP.

As identified stakeholders may differ in terms of characteristics, impact and interests at stake, it is important to map them according to their attributes, level of impact/interest and role in relation to key issues to be tackled.

To design a shared and inclusive SLHCP, the highest participation of stakeholders and citizens should be sought. Participation can be obtained through a variety of methods and approaches, and different levels of involvement may be considered:

- *Information and communication (brochures, newsletters, social networks, site visits, etc.)*
- *Information and feedback (website, public meetings, surveys and questionnaires, etc.)*
- *Involvement and consultation (workshops, focus groups, forums, etc.)*
- *Extended involvement (community advisory committees, planning for real, etc.)*

## Deepen your knowledge on reference policy and strategic context

**Map the existing framework of main national, regional or local policies and regulations** and keep track of its possible evolutions, to ensure the SLHCP is embedded and coordinated at all levels of governance and across all energy-related policy areas and targets.

## You do not have necessarily to start from scratch

**Build on existing work.** Signatory cities of the Covenant of Mayors potentially will have had already developed Sustainable Energy Action Plans (SEAP) or Sustainable Energy and Climate Action Plans (SECAP) that can be a good starting point for the definition of the SLHCP. Furthermore, any other already existing local energy strategy or plan should be considered and can provide good initial inputs and a useful reference for the SLHCP preparation by providing:

- A preliminary set of possible data sources
- A large amount of basic data and information for the H&C baseline assessment
- Reliable methods of calculation and estimate procedures applicable or easily adaptable
- Useful information on trends or critical aspects within the local H&C system through their monitoring
- A basic set of actions and measures that can already be included in the SLHCP target scenario appropriately revised, enhanced, integrated | necessary.

## Learn from peers

**You do not have necessarily to reinvent the wheel.** The legislation about H&C planning is clearly lagging the real life, since examples of at least heating plans exist for many years in several EU countries, such as Germany, Denmark and the Netherlands.

- Investigate pioneer experiences, get inspired and adapt approaches, methodologies and

models already developed.

- Learn from projects, measures and best practices already implemented in or by other municipalities all over Europe in the H&C field
- Enhance and widen your technical know-how on H&C topics by getting in touch and interact with EU networks and ongoing projects or benefitting from the results of already closed ones, related to local energy planning, renewable energies, energy efficiency measures, enabling technologies, etc.

## Adopt and follow a whole-system and integrated approach

**When preparing the SLHCP intervention strategy stick to the “Energy Efficiency first principle”** and follow a whole-system and integrated approach based on the following core requirements:

- *Reduce H&C needs by minimizing the heat island effect at the urban scale and enhancing buildings thermal performances through passive measures*
- *Serve reduced H&C needs with the least amount of energy by applying more efficient and best-fit technologies, plants and operations*
- *Reduce H&C energy demand by changing behaviours*
- *Decarbonize the energy produced to meet H&C needs by increasing the share of local RES*
- *Remember that electrification of H&C final uses doesn't necessarily imply decarbonization.*

## 2.2 The H&C baseline assessment - Where do we stand now?

The **2<sup>nd</sup> Phase, H&C baseline assessment**, foresees an in-depth analysis and a sound assessment of the current situation of the local H&C system, as for energy demand and supply and of the technological, socio-economic, environmental factors that determine or influence them.

An analysis of the main climatic key factors and risks at urban level will be also included as an important step towards charting a whole-system approach to SLHCPs.

An energy inventory will be the output of this analysis, providing updated data on final energy consumption related to H&C uses by sources and sector or activity (demand) and on H&C production from renewable and non-renewable sources (supply). Based on the results of a H&C energy inventory, a H&C energy baseline emission inventory can be prepared, determining the relative share of GHG emissions of each sector.

By understanding relative contributions, sources and drivers behind the current H&C system, the inventory can provide crucial insight to identify “hotspot” and improvement opportunities and thus it is the fundamental starting point for the SLHCP intervention strategy towards decarbonization.

### The key concepts driving the H&C baseline assessment

- *Where H&C is needed, why and by whom*
- *How the needed H&C is provided and distributed*
- *What and how much energy is necessary to meet the H&C needs and how it is produced*
- *Which exogenous factors are influencing the H&C needs*

## 2.3 The SLHCP strategy - Where do we want to go and how do we get there?

Starting from the H&C baseline assessment, the **3<sup>rd</sup> Phase, SLHCP strategy and development**, foresees the design and development of a robust operational strategy for the decarbonization of the local H&C system, based on feasibility, sustainability and coherence. To do so, three steps will be foreseen so that, based on the local specific context, unique needs and goals can be duly addressed.

### Step 1 – The business-as-usual scenarios

A framework will be provided of the ongoing and expected trends within the local H&C system as for energy demand and supply and the factors that will determine or influence them in the absence of the SLHCP.

### Step 2 - The intervention scenario

Once the business-as-usual scenario is defined, the scope for action at the local level will be investigated, to identify a potential portfolio of actions and interventions for reducing GHG emissions in each sector within the H&C system. The intervention scenarios processing will foresee

the assessment of the potential for energy efficiency solutions, according to different final uses and services, along with the assessment of RES availability on the territory.

### Step 3 - The target scenario

Inputs and outcomes from the intervention scenarios will be integrated into a strategic action plan for the decarbonization of the local H&C system. The plan will identify priority sectors in which to act, rank and prioritize interventions to be launched, define related specific quantitative targets as for energy saving, RES share increase and GHG reduction, and propose a set

of measures and policies to support and ensure the concrete implementation of intervention. The selection of priority actions will be based on high-impact feasible solutions, possibly integrating, besides techno-economic feasibility,

also other key factors such as security of energy supply, reduction of energy costs, energy poverty prevention, local air quality improvement, health care and support to local economies.

### The key concepts driving the SLHCP strategy definition

- *Where the local H&C system is going*
- *Where the local H&C system can go*
- *Where the local H&C system shall go and what it needs to get there*

## 2.4 Roadmap and SLHCP implementation

The **4<sup>th</sup> Phase, Roadmap and SLHCP implementation**, foresees an implementation pathway, so called **Roadmap**, that will be established, providing all the necessary technical and non-technical instructions, including a reference time plan, to concretely launch and operationalize each selected action.

## 2.5 The H&C Plan monitoring - How are we doing?

The **5<sup>th</sup> Phase, Monitoring of the SLHCP**, is the monitoring procedure, that will be set-up to follow the SLHCP implementation and periodically assess the actual evolution of the local H&C system, the advancement status of actions and the progress towards targets. For the monitoring procedure processing, a set of auditable, reportable, and verifiable key performance indicators (both quantitative and/or qualitative) will be set-up and regularly updated according to a well-defined frequency, in order to ensure its effectiveness, and based on the same approach and methodologies used for the set-up of the H&C baseline and the intervention scenarios.

The monitoring process makes it possible to understand whether the Municipality is on track to reach the defined target, to identify factors that affect results and understand where some revisions to the strategy are necessary.

### The key concepts driving the monitoring process

- *Where the H&C system has arrived so far*
- *Where the SLHCP has arrived so far and what has already been achieved*
- *What went wrong and why*
- *Where and how the SLHCP strategy must be revised and empowered*

# PART B

## THE H&C SYSTEM BASELINE: WHERE DO WE STAND NOW?

### 1. How to approach the H&C baseline assessment

This section of the guidelines focuses on the 2nd Phase of the SLHCP definition process, concerning an in-depth analysis and a sound assessment of the current situation of the local H&C system, as for energy demand and supply and of the technological, socio-economic, environmental factors that determine or influence them. Based on the results of the analysis, a H&C energy baseline emission inventory can thus be prepared, determining the relative share of GHG emissions of each sector.

#### KEY CONCEPTS

**Where H&C is needed, why and by whom**

*sector, activities, final uses*

**How the needed H&C is provided and distributed**

*technologies, devices and equipment*

**What and how much energy is necessary to meet the H&C needs**

*H&C energy demand*

**How and where the energy necessary to meet the H&C needs is produced**

*H&C energy supply*

**Which exogenous factors influence the H&C needs**

*The local climate trends*

### 1.1 The H&C energy inventory – The demand side

This analysis of the local H&C system shall result in the set-up of an **energy inventory** providing updated data on final energy consumption related to H&C needs and uses by sources and sector or activity (demand) and on H&C production from renewable and non-renewable sources (supply). More in detail, a database, that can be traced back to a **vector/sector matrix**, shall be prepared linking different energy/fuel sources with the socio-economic areas in which they are used and consumed. Based on the results of a H&C energy inventory, it will be possi-

ble to determine the relative share of emissions of each sector. Understanding relative contributions, sources and drivers behind current H&C energy inventory can provide crucial insight to identify “hotspot” and improvement opportunities. The level of detail that shall be achieved has to cover at least all the main energy carriers statistically detectable and the main sectors of use, as described in the Table 1.

**Table 1 H&C energy demand - Sectors, activities and final uses**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Public buildings, equipment and facilities</b></p> <p>Final energy consumption occurring in buildings and facilities owned/operated by the Municipality, as well as by other regional or national authorities, and related to space heating and/or cooling and hot water production (e.g., offices, schools, police stations, hospitals).</p>                                                                                                                                                                                                                                                                                                             |
| <p><b>Tertiary buildings, equipment and facilities</b></p> <p>Final energy consumption occurring in buildings and facilities of the tertiary sector (e.g., offices of private companies, banks, commercial and retail buildings, private schools, hospitals, institutional buildings not owned/operated by the Municipality) and related to space heating and/or cooling and hot water production.</p>                                                                                                                                                                                                                                                          |
| <p><b>Residential buildings</b></p> <p>Final energy consumption associated with buildings that are primarily used for residential purposes and related to space heating and/or cooling and hot water production. Social housing buildings, both owned by the Municipality or other public entities, at the regional and national level, shall be considered, as well as privately owned buildings.</p>                                                                                                                                                                                                                                                          |
| <p><b>Industry</b></p> <p>Final energy consumption associated with manufacturing and construction industries not covered by the EU ETS or similar schemes (typically with below or equal to 20 MW as thermal energy input) and related to space heating and/or cooling, hot water production, refrigeration, cold chain, production processes. Considering industries covered by the EU ETS or similar (over 20 MW as thermal energy input) is not recommended. Exceptionally, these may be included if they were accounted for in previous energy or climate change mitigation action plans, or in previous emission inventories, to maintain consistency.</p> |
| <p><b>Agriculture, forestry and fishing</b></p> <p>Final energy consumption associated with buildings, facilities and machinery of the primary sector (agriculture, forestry and fisheries), such as livestock facilities and farm machinery and related to space heating and/or cooling, hot water production, refrigeration, cold chain, production processes.</p>                                                                                                                                                                                                                                                                                            |



For each of the above sectors, data on final H&C energy consumption within the local territory should be disaggregated by **energy source/carrier**. Essentially, the annual amount of energy used in each of the activity sectors should be quantified for all relevant energy sources/carriers.

All final consumption should be provided in the same unit, usually MWh, and thus unit conversion is often needed, considering that fuel

data are often available on a mass or volume basis. An adequate conversion is essential to ensure accurate GHG emission estimates. Typically, fuel use data shall be converted using net calorific values (NCV), which express the energy content of fuels per unit of mass or volume (e.g., in MWh/t, MJ/l). Default NCV values for different types of fuels are provided by the IPCC (2006), and country-specific values may also be available.

**Table 2 H&C energy demand - Energy sources**

### Electricity

This includes the electricity supplied to and used within the Municipality for H&C, regardless of its origin (e.g., national grid or local generation sources).

### Heat/cold

This includes heat/cold that is supplied and used at end-use points (final consumers, end-use buildings, facilities) within the Municipality (e.g., from district heating/cooling, CHP generation or waste heat recovery). This may include heat/cold from local generation, which should also be considered in the 'Local energy generation and supply' section of the inventory. Building heating that is not supplied as a commodity but generated in buildings through small-scale systems shall not be included here (e.g., natural gas boilers in buildings).

### Fossil fuels

This includes all fossil fuels supplied to and used in the territory for H&C. For example, in buildings, fossil fuels may be used for cooking, or space and/or sanitary water heating. Fossil fuels are also often used as input in combustion processes in the industrial and primary sectors. Fossil fuel data are typically provided for the following types: Natural gas, Liquid gas, Heating oil and other fossil fuels.

### Renewable energy sources

This includes all energy from renewable sources/carriers that are supplied to and used at end-use points (final consumers, end-use buildings, facilities) in the local territory. They include any biofuels (liquid, gaseous or solid fuel produced from biomass) and solar thermal and geothermal energy. Biofuels include (and should be disaggregated by) several sources/carriers: liquid and gaseous biofuels, such as bio-gasoline, biodiesel and biogas; and solid biomass, such as organic municipal solid waste, wood and wood waste.

**Note:** The energy sources/carriers and categories described here are commonly used in the EU context. However, it is important to ensure that the SLHCP and its inventories adequately reflect the local context/situation, so that the resulting GHG emissions are accurate and consistent.

Besides the detection of the socio-economic components requiring the use of energy sources for H&C (sectors, activities and final uses), the analysis of how the needed H&C is provided and distributed should also be foreseen. This means the analysis of the technological components (plants, devices, equipment, building structures and materials, etc.) that are

the means of this need, considering their type, their efficiency, the rate of diffusion within sectors and activities. This will ensure a sounder assessment and a more accurate modelling and understanding of the current situation of the local H&C demand, thus concretely contributing to a better calibration of the SLHCP intervention scenarios.

**Table 3 H&C energy services - Technologies, devices and equipment**

|                             |                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Building sector</b>      | <b>Municipal buildings</b>    | <ul style="list-style-type: none"> <li>• Buildings structure and performances (age, n° of floor, n° of dwellings, heated surface or volume, type of envelope, roof, windows, etc.)</li> <li>• Heating plants (type, age, power, efficiency, etc.)</li> <li>• Cooling devices (type, age, power, efficiency, etc.)</li> </ul>                                                                                                                                                                     |
|                             | <b>Tertiary buildings</b>     | <ul style="list-style-type: none"> <li>• Buildings structure and performances (age, n° of floor, n° of dwellings, heated surface or volume, type of envelope, roof, windows, etc.)</li> <li>• Heating plants (type, age, power, efficiency, etc.)</li> <li>• Cooling devices (type, age, power, efficiency, etc.)</li> <li>• Refrigeration and cold chains (type, age, power, efficiency, etc.)</li> </ul>                                                                                       |
|                             | <b>Residential buildings</b>  | <ul style="list-style-type: none"> <li>• Buildings structure and performances (age, n° of floor, n° of dwellings, heated surface or volume, type of envelope, roof, windows, etc.)</li> <li>• Heating plants (type, age, power, efficiency, etc.)</li> <li>• Cooling devices (type, age, power, efficiency, etc.)</li> </ul>                                                                                                                                                                     |
| <b>Manufacturing sector</b> | <b>Industry   Agriculture</b> | <ul style="list-style-type: none"> <li>• Buildings structure and performances (age, n° of floor, n° of dwellings, heated surface or volume, type of envelope, roof, windows, etc.)</li> <li>• Heating plants (type, age, power, efficiency, etc.)</li> <li>• Cooling devices (type, age, power, efficiency, etc.)</li> <li>• Refrigeration and cold chains (type, age, power, efficiency, etc.)</li> <li>• Productive chain plants and machinery (type, age, power, efficiency, etc.)</li> </ul> |

## 1.2 The H&C energy inventory – The supply side

Information shall also be acquired and processed, concerning the energy production and processing plants on the territory, considering the technologies, the installed power, the type and quantity of primary sources used, the amount of thermal energy and/or electricity produced.

All local generation units directly providing energy to be used for H&C within the Municipality, shall be detected and detailed data collected separately and for each unit/supplier.

**Table 4 H&C energy supply. Local energy production**

|                                                   |                                    |                                                                                                                                                                                                          |
|---------------------------------------------------|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Local generation and supply of electricity</b> | <b>Renewable energy sources</b>    | Local electricity generation from renewable energy sources (including wind power, hydropower, photovoltaics, geothermal, biofuels), regardless of the technology and capacity of generation units.       |
|                                                   | <b>Combined heat and power</b>     | Local electricity generation from combined heat and power (CHP) units, regardless of the capacity of generation units.                                                                                   |
|                                                   | <b>Electricity-only units</b>      | Local electricity generation from electricity-only power plants that are not covered by the EU ETS (with a capacity limit of 20 MW).                                                                     |
| <b>Local generation and supply of heat/cold</b>   | <b>Combined heat and power</b>     | Local heat/cold generation from distributed CHP units and supplied through district networks for use within the local territory, regardless of the capacity or location of generation units.             |
|                                                   | <b>Waste heat</b>                  | Local heat generated from industries or tertiary services, such as data centres, wastewater treatment plants that can potentially be integrated into a district heating and cooling distribution system. |
|                                                   | <b>District plants and network</b> | Any other local heat/cold generation distributed and supplied through district networks for use within the local territory, regardless of the capacity or location of generation units.                  |

### 1.3 The H&C emissions inventory

Starting from data on H&C final energy consumption by sources and sector and from H&C production from renewable and non-renewable sources, applying appropriate emission factors, the Municipality can estimate the emissions associated with the local H&C system and prepare a **GHG Emission Inventory**.

GHG emission accounting strongly depends on the methodological approach and data selected in relation to GHG emission factors (EFs). Municipalities can choose between the activity-based approach, in line with the IPCC guidelines for accounting GHG emissions associated with energy and waste ([IPCC, 2006, Volumes 2 and 5](#)), focusing on direct GHG emissions associated with energy conversion, such as fuel combustion), and the life-cycle (LC)-based approach (adding GHG emissions associated with the energy supply chain). If the activity-based approach is selected and if the sectors and actions in the SLHCP are limited to energy-related activities, they may choose to account for CO<sub>2</sub> only. After selecting the GHG accounting approach, the Municipality can select or calculate its EFs accordingly. They may use default EFs (e.g., provided by the JRC or other reference organizations), or define GHG EFs that may better reflect their specific local context.

For a sound preparation of the H&C Emission Inventory, the Covenant of Mayors Guidebook [“How to prepare a greenhouse gas emission inventory”](#) can be adopted.

### 1.4 The weather and climate trends, risks and vulnerabilities

To achieve a clear and exhaustive framework of the factors that can determine or influence the local H&C system, the baseline assessment should also include the analysis of the main climatic key factors and risks at urban level, as an important step towards charting a whole-system approach to SLHCPs:

- Seasonal temperature ranges
- Temperature and humidity characteristics
- Seasonal variations
- Cooling degree days
- Frequency and patterns of extreme heat events
- Heat islands mapping.

The analysis should provide the general framework of main climate-related hazards on the territory, mainly focusing on temperatures and heatwaves, to assess the risks and vulnerabilities profile of the Municipality, as well as high-

light the vulnerable and/or more exposed sectors, areas and population groups.

Beyond SECAPs or local adaptation plans, if existing, national and regional authorities are reliable sources of information as for climate and weather trends and related hazards and risks as well. Thematic portals, departments and agencies can in fact provide a wide range of data at different levels and frequency, thus ensuring to municipalities a reliable context framework.

Furthermore, several official EU tools and por-

tals are available supporting risks assessment at the local level, among which the [Risk Data Hub](#) of the Disaster Risk Management Knowledge Centre (DRMKC), a free-access platform designed to centralize and standardize risk, damage and loss data at a pan-European level and developed with the goal of supporting risk

assessment and risk analysis processes. It offers a variety of datasets, tools, and resources that can be used by policymakers, researchers, and practitioners for understanding and mitigating risks. No data about Urban Heat Islands is included.

## 1.5 A further step – H&C energy poverty assessment

The H&C local system assessment should also provide a comprehensive understanding of energy poverty within the local context, including where possible its extent, underlying causes, and contributing factors.

As energy poverty is a complex and multidimensional phenomenon driven by multiple transversal factors, ranging from local climate conditions to socio-economic circumstances, the assessment is particularly important to understand how these elements interact together and impact the local H&C context. Effective and tested approaches, methodologies and models for a sound energy poverty assessment and monitoring at the local level are provided in the Guidebook “[How to develop an energy poverty assessment](#)” recently published by the Covenant of Mayor and can also be found in the [Energy Poverty Advisory Hub](#) of the European Commission and in the [Energy poverty Indicators Dashboard](#) where EPAH indicators organized by topics for each European country can be found.

Furthermore, useful inputs, suggestions and best practices can be acquired getting in touch and interacting with ongoing [LIFE projects](#) or benefitting from the results of already closed ones.

## 1.6 A further step – H&C mapping

Based on the energy inventory, whenever possible and relevant, a mapping may be carried out, showing spatial distribution of H&C demand and supply (consumption broken down by sector and vector, energy production plants, distribution of renewable sources, etc.), of the H&C services and socio-economic, territorial and climate (e.g. heat islands) factors, so as to locate the main H&C energy phenomena and their underlying causes.

The detail of the mapping will depend on the different sectors/ areas of reference and the data that will be made available. It may be characterized by areal elements and/or point elements. Areal elements may be represented, for example, by municipal boundaries, census islands or other urban clusters (e.g. districts or neighbourhoods), forests cropland areas, while point elements may be represented by specific infrastructures such as municipal or public buildings, energy production plants, business, commercial or industry districts, etc.

With support of free-access map databases (e.g. [OpenStreet-Map](#), QGIS, Google Earth, [Copernicus Land Monitoring Service](#)), existing municipal platforms and portals (e.g. territorial information systems) and GIS appliances, it will thus be possible to:

- Overlap and integrate different local thematics (energy and context) and detect and locate the main parameters characterizing them,
- Identify and locate areas/zones of the territory with homogeneous characteristics and highlight their relative energy impact on the overall territorial context,
- Identify vulnerability areas (e.g. heat island, energy poverty, etc.),
- Fully compare the contributions of the sectors and/or energy sources in the territorial areas identified.

H&C mapping can be a very useful tool for decision makers and a source of information on local energy demand and supply. A H&C map shows spatial distribution of the energy demand (used for heating/cooling buildings or in industrial processes) in each area. It is useful for analysing different scenarios in different sectors and to implement energy efficiency measures for the future. The mapping is a way to visualize the H&C needs and the zoning (or potential

zoning) of H&C sources and influencing factors as well. With this vision, it is then possible to better connect the need and the sources to reduce the energy costs and the greenhouse gases emissions. H&C mapping is also a powerful tool to target the areas that require refurbishment to improve energy efficiency and can also help to investigate socio-economic difficulties such as fuel poverty.

## 2. Data collection and sources for the H&C system baseline preparation

### KEY CONCEPTS

**Data collection is an integral part**  
of the H&C Energy and Emission Inventory preparation

**Reference and reliable data sources shall be identified and activated**  
at the national, regional and local level

**Reference context-specific data sources are preferred**  
over the national and regional ones

**You do not have to start from scratch!**  
SECAP/SEAP can represent a good starting point for the data collection activity

To carry out a SLHCP process, it is necessary to collect and use knowledge and data about the location and amount of H&C that is required, the supply options, and the state of the H&C final uses, services and technologies.

In many countries, regions and cities, H&C have not traditionally been an object of governance. Energy policies are most often found in sectorial policies focusing on electricity and gas on the supply side and buildings' efficiency on the demand side. Therefore, knowledge of the fundamental state of play of the H&C sectors is often lacking. Perhaps, electricity and gas supply are measured, but only as aggregated energy supply figures that mix cooking, lighting, heating and other end-use demands together. Heating and, particularly, cooling demands can thus be

unknown and therefore hard to use for strategic planning purposes.

Quantifying and mapping H&C demand and sources is a difficult task. Before investing in a long-term H&C strategy, access to reliable data is key. The collection and integration of fragmented data can be time-consuming and usually requires involving many stakeholders like municipal services, building owners, facility managers, utility companies, energy companies and distribution system operators, civil groups, industrial companies etc.

This section provides recommendations and tips on where basic data and information can be found and how they can be requested and collected, to ensure a sound and comprehensive H&C system baseline assessment.

## 2.1 Data from local sources: Municipal buildings, equipment and facilities

Implementing a robust and reliable energy monitoring system in municipal buildings is important not only for estimating and reporting H&C energy and emissions inventories, but also for improving the energy management of these buildings. It allows for the identification of buildings and/or processes associated with high energy consumption (hotspots), for example, which may be targeted or prioritized in energy efficiency actions within the plan.

It should thus be necessary that a centralized census system of municipal buildings is organized and regularly updated, storing and managing energy data and information. The system can be set up and implemented, according to the following steps:

- Identify the persons/departments receiving and managing energy data (e.g., billing invoices)
- Identify all buildings, equipment and/or facilities owned/managed by the Municipality
- Identify all energy supply points and types of energy used (e.g., electricity, natural gas, heat from heating district networks, fuel oil tanks)
- Collect data and information from the energy bills concerning consumption of energy sources, with a yearly and, possibly, also monthly frequency, that can support heating

and cooling needs evaluation or simulation.

- Collect data and information on the buildings structure and main characteristics (n° of floors, heated/cooled surface area and volumes, age, envelop materials, efficiency class, etc.)
- Collect data and information on installed plants, devices and equipment (year of installation, fuel used, type of technology, installed power, average efficiency, etc.)
- Collect information on how the buildings are used (opening days and times, number of occupants, etc.)

Through such a system a preliminary modelling of the energy behaviour of each building can be set, critical issues as for plants, equipment or devices performance detected, and the energy quality assessed, mainly through simplified performance indicators (e.g. kWh/m<sup>2</sup>, etc.).

Furthermore, if regularly updated the system can provide a useful monitoring tool, by verifying over time the effectiveness and energy and economic benefits of any implemented measure or intervention.

If data from bills are not available or not easily accessible, energy consumptions, according to

different frequencies, can be directly requested to the electricity/gas providers.

This information should also be assessed for other public buildings, namely managed by regional or national authorities, though the information may be more dispersed.

## 2.2 Data from national and regional sources

Thanks to several EU directives, many Member States and regional governments have developed tools and datasets to support municipalities in energy transition plans preparation, providing statistics or periodically updated information on final consumptions of fuels and energy sources, energy final uses, services and market, energy production systems at different territorial levels.

Energy, GHG and climate observatories or agencies (at the national and/or regional levels) may also provide relevant data for different regions, areas and sectors. These may include regional or local platforms based on collaboration models for data sharing.

As such, it is important to check what is already available from national and regional authorities/bodies, such as census, cadastres, statistical portals, energy, environmental or economic ministries, organizations, territorial and energy agencies and regulatory authorities.

In this context, it is particularly important to observe the plans and analysis performed at higher levels, such as regional or country level, as these are often mandatory and could be a reference source of information.

Particularly National Energy and Climate Plans and regional energy or climate plans as well, can include useful data and information at different levels of granularity, based on which reliable estimates or calculation can be developed.

## 2.3 Data from energy market operators

With the liberalization of gas and electricity markets, the number of stakeholders related to energy supply has increased, and data from energy providers and operators have become increasingly protected and difficult to collect.

Under Directive 2023/1791 on energy efficiency, energy market operators that are designated by the state should provide on request aggregated statistical information on their final customers. Although the directive specifically acknowledges the role of urban areas in achieving energy efficiency objectives, it is not explicitly aimed at energy data sharing between energy suppli-

<sup>1</sup> E.g French law on energy data  
<https://redi4heat.ehpa.org/wp-content/uploads/2024/07/Best-Practice-1.pdf>

ers and local authorities. Nevertheless, there are cases where national laws have specifically introduced provisions that facilitate the access of municipalities to energy data<sup>1</sup>.

Municipalities may thus identify and ask for data from energy suppliers active in their local territory or, as an alternative, collect data from energy grid operators.

Ideally, energy data should be specific to the local territory and disaggregated by residential, tertiary and industry for each energy source/carrier (e.g., electricity, heat, natural gas). A higher level of disaggregation can significantly help design, implement and monitor effective energy-saving actions. For example, energy data further disaggregated by subsectors, industry and neighbourhoods, among others, can inform targeted and effective actions.

Information on local electricity and heat/cold generation is often available or can be provided by local energy providers and/or unit operators. For large plants, data on the (distributed or centralized) local generation can usually be obtained through direct contact with plant managers (e.g., a municipal power agency or private company) or with network operators. Otherwise, data may be obtained through surveys involving local producers/suppliers.

**It may be advisable to formalize agreements between the Municipality and the data providers to facilitate cooperation and ensure regular data availability and consistency across the SLHCP implementation.**

## 2.4 Data and information from stakeholders

When data from statistics, market operators or other organizations/entities are not available with adequate levels of quality, disaggregation and detail, it may be necessary to complement them with information collected through local surveys and the direct involvement and engagement of local stakeholders. This is typically the case for energy sources that can have many local suppliers (such as wood or LPG) and for energy sources and technologies providing cool, or for some complex sectors/activities like the industrial and tertiary one, with many sub-sectors, activities or processes to be considered.

The surveys shall depend on what kind of statistical information is already available at the municipal level that can be combined with local data. Besides the type and quantity of energy used and the local energy generation (e.g., solar photovoltaics, CHP), other indicators and data related to H&C final uses and services, useful for interpretation, comparison or extrapolation purposes,

may be also requested so that reference performance indicators can be processed (e.g. kWh/dwelling, kWh/m<sup>2</sup> of cooled surface, etc.). The surveys can particularly collect data and information on how the needed H&C is provided and distributed, namely looking into the technological components (plants, devices, equipment, building structures and materials, etc.)

that are the source of this need.

Data collected through surveys should enable the Municipality to provide an overall picture of final H&C energy uses in the local territory, by activity sector and energy source/carrier. This will ensure a sounder assessment and a more accurate modelling of the current situation of the local H&C demand, thus concretely contributing to a better calibration of the SLHCP intervention scenarios.

Several approaches and methodologies can be followed to implement the surveys (by phone interviews, in-person meetings, (online) questionnaires, working tables, etc.), tightly depending on the specific data or information needed, the reference sectors or activities and the target groups to be reached:

- For sectors and energy carriers with many small, distributed end users (e.g., the residential sector), the survey can be addressed to a representative sample of the population, spread over all areas, districts or neighbour-

hoods of the Municipality, but it should be ensured that a representative and relevant sample of answers is collected.

- For sectors and energy sources where the number of actors is more limited, it may be worthwhile addressing the survey to all energy consumers mainly through their associations. This may be the case, for example, for the SMEs or the so-called 'small and medium-sized tertiary' (shops, offices, but also B&Bs, hotels, bars and restaurants)
- For sectors and energy sources where there are many stakeholders (suppliers and/or end users) but a few large ones are likely to account for the majority of energy use in the local territory, it is important to include at least all large players (e.g., supermarkets, hospitals, universities, housing companies, large office buildings, large power plants or production facilities). They can be identified through local knowledge, statistical or commercial data, or specific requests to the trade associations.

## Within the Plan4COLD

project a preliminary framework of already available data and information concerning energy needs, energy demand and production in the H&C sector has been set and assessed, from the national to the regional and local levels, addressing the involved municipalities.

For each category of data investigated, several factors have been detected and verified, among which:

- Type of source
- Geographical scale
- Availability
- Accessibility
- Format
- Aggregation level
- Frequency

Data and information investigated has then been assessed, trying to identify main gaps and unevenness, along with obstacles to their collection and organization. Factsheets have been filled in with collected information for each category and type of data sources.

These are to be regularly updated, integrated and complemented across the SLHCPs preparation, to finally set a comprehensive framework of available data and information sources regarding H&C sector to support a sound plan implementation and monitoring.

# PART C

## THE SLHCP STRATEGY: WHERE DO WE WANT TO GO AND HOW DO WE GET THERE?

### 1. How to approach the SLHCP strategy development and launch

This section of the guidelines focuses on the 3rd Phase of the SLHCP definition process, providing a structured approach on how to design and develop a robust action plan, based on feasibility, sustainability and coherence, and on how to prepare an implementation strategy. To do so, three key steps are addressed so that, based on the local specific context, unique needs and goals can be duly addressed:

1<sup>st</sup> step – Business-as-usual scenario

2<sup>nd</sup> step – Intervention scenario

3<sup>rd</sup> step – Target scenario

## KEY CONCEPTS

**Where the local H&C system is going**  
*energy, socio-economic and climate trends*

**Where the local H&C system can go**  
*in which sectors H&C needs can be reduced and how  
in which sectors the efficiency of H&C final uses can be increased and how  
how the production of H&C can be decarbonized and RES share increased*

**Where the local H&C system shall go and how shall get there**  
*which are the priorities and goals to be reached  
how to reach objectives in a feasible and sustainable way  
sectors and key actions  
costs, direct impacts and co-benefits  
resources and supporting measures  
how to plan and start the path*

**You do not have to start from scratch!**  
*SECAP/SEAP monitoring can represent a good starting point and provide useful hints*

## 1.1 1<sup>st</sup> step - The business-as-usual scenario - Where the local H&C system is going

Building on the local context analysis and the H&C baselines outcomes, a **business-as-usual scenario** should be outlined as a first step of the H&C strategy and development process, providing a qualitative and, where possible, quantitative framework of the ongoing or expected trends within the local H&C system as for energy demand and supply and the factors that will determine or influence them in the absence of the SLHCP.

Within a business-as-usual scenario, it is assumed that no specific actions are taken with the aim of changing H&C energy dynamics and that its evolution depends on mechanisms and factors linked to the current climate, socio-economic and market trends, as well as on any urban and territorial planning and regulatory tools and legislative measures, including the ones at a supralocal level.

The business-as-usual scenario will essentially imply a “H&C due-diligence” for the Municipality, assessing the future needs for H&C, the impacts of business-as-usual growth in H&C and identifying the key variables and stakeholders that intersect with it. Such an assessment is the essential starting point towards holistic planning and an informed basis to prioritize actions and measures within the SLHCP.

The business-as-usual scenario development should start from the local context analysis and the H&C baselines outcomes and from the **monitoring** of the SEAP/SECAP, if existing, and of any projects, interventions, measures already implemented, ongoing or on the way on the territory, promoted by the local administration or by private actors. It will thus be possible to:

- Obtain information on results already achieved, deviations from expected targets, any necessary corrective and supplementary measures,
- Assess the replicability of actions, measures and interventions in other areas and contexts, or assess the necessary scope for improvement,
- Refer to trends already in place and assess their effect on the overall territorial context for the purpose of setting the SLHCP targets.

Attention should then be given also to con-

ditions that can bring changes in the coming years on the territory and, consequently, on the local H&C system.

For the outlook of the local H&C, an understanding of the growth drivers influencing the **local climate trends**, the long-term pattern of weather and the trajectory of urban heat will be very important.

The **city's development trends**, particularly as population growth, should also be factored into any forward-looking plans and strategies for sustainably addressing urban H&C. It will be necessary to evaluate what the territorial structure in the coming years will be, what the characteristics of the future demand for H&C energy services (evolution of the population and demographic structure, housing supply in terms of new volume, etc.) and the levels of use/diffusion of plants and equipment.

Ongoing or foreseen trends such as immigration or the increase in populations, are important indicators of the growth in H&C demand and its impacts. In fact, population increase generally brings associated land-use changes and is directly linked to (in most cases the single largest driver of) a city's development plans. Other possible trends or triggers for development could include, for example, technology hubs, business or commerce districts or increase of transport and communication.

Furthermore, it is important to understand the **reference policy framework** as for any supralocal commitments, legislations, strategies and targets that intersect or interact with H&C. This may include national or regional relevant

plans and regulatory documents, such as mandates covering energy transition and climate neutrality, promotion of energy-efficiency in buildings and low-climate-impact solutions (building energy codes, minimum energy performance standards for H&C equipment, etc.), existing or on the way financial instruments and funding opportunities. Understanding the national/regional context and its priorities is an important roadmap for aligning the SLHCP and the Municipality's action.

Finally, also the **existing local plans** and **strategies** should also be considered and assessed. This should include visions, policies, targets

and mandates that are within the control of the local government, such as for examples development plans, master plans, urban plans, spatial/territorial plans, waste management plans and other relevant strategic documents that can affect local energy policy. This review will help identify potential synergies, overlaps and gaps in the current planning framework, as well as between different levels of governance, thus ensuring that the SLHCP is consistent with and builds upon existing planning efforts. The successes and challenges of previous planning efforts should also be considered, as these can provide valuable insights and lessons learned for the development of the new one.

## 1.2 2<sup>nd</sup> step - The intervention scenario - Where the local H&C system can go

Once the business-as-usual scenario is defined, the scope for action at the local level shall be investigated, to identify a potential portfolio of interventions for reducing GHG emissions in each sector within the H&C system. The 2<sup>nd</sup> step, definition of the intervention scenario processing will foresee the assessment of the potential for energy efficiency solutions within each sector, according to different final uses and services, along with the assessment of RES availability on the territory. Actions related impacts and benefits, as for H&C final consumption

and GHG emissions reduction and local H&C production, should then be quantified. The intervention scenario should follow a **whole-system** and **integrated approach** based on a new planning model, that **integrates clean energy** into **urban design**. To this end the **Plan4COLD approach to define SLHCPs considers three core dimensions: urban planning**, considering outdoor and green areas, **buildings and infrastructures**, considering design and renovation and **behaviour change**, considering both stakeholder engagement and citizen awareness.

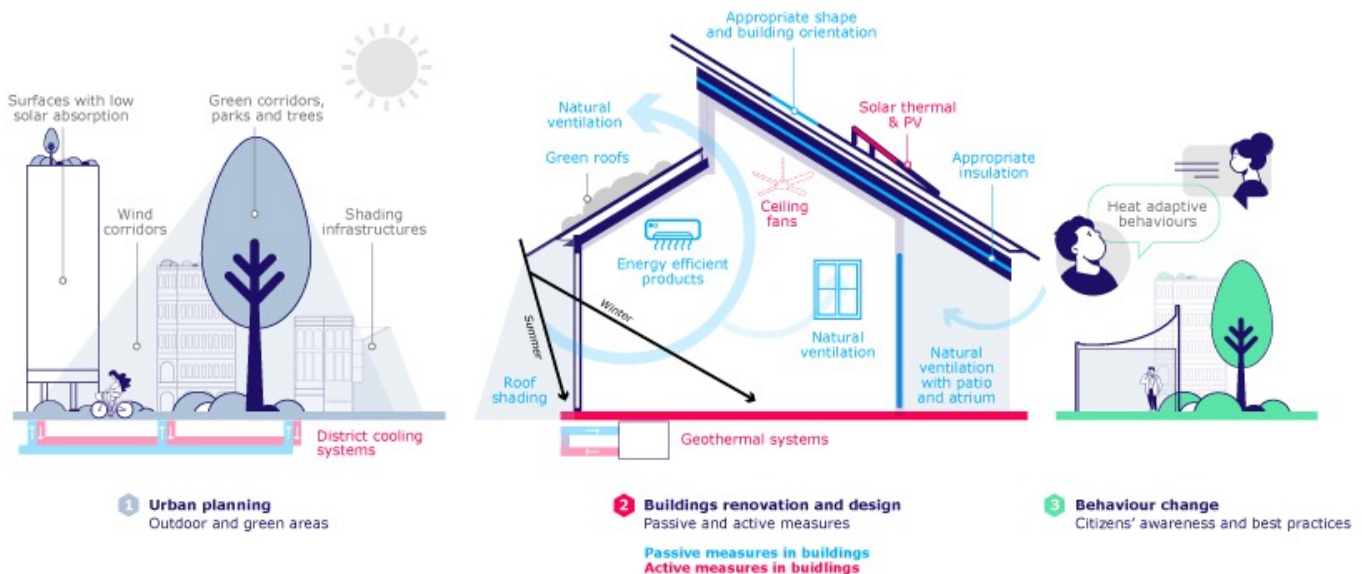


Figure 1 – Plan4COLD integrated approach to SLHCPs

The whole-system and integrated approach primarily refers to the **"Energy Efficiency first principle"** that prioritises energy efficiency as the primary strategy for achieving energy sustainability. The principle driving concept foresees that reducing energy needs and consumption through urban planning, the design of buildings and public spaces, efficient materials, technologies, practices and behaviours is often the most cost-effective and environmentally beneficial way to meet energy demands and also to promote the development of renewable energy sources, ensuring their economic sustainability with respect to fossil fuels and a cleaner and cheaper energy local supply. Furthermore, it fits and complies with several of the United Nations [Sustainable Development Goals](#) such as: Affordable and Clean Energy (SDG 7), Sustainable Cities and Communities (SDG 11), Climate Action (SDG 13), Good Health and Well-being (SDG 3), Decent Work and Economic Growth (SDG 8), Reducing Inequality (SDG 10).

Within this approach, three core guiding principles should be considered when preparing an intervention scenario, following:

1. **Reduce H&C needs**
2. **Serve H&C needs more efficiently**
3. **Decarbonize the energy produced to meet H&C needs by increasing the share of local RES.**

The **first guiding principle** in the whole-system integrated approach concerns both the reduction of heat island effect at the urban scale through heat resilient urban planning and infrastructures (e.g. nature-based practices), the enhancement of buildings structures thermal performances, minimizing the mechanical heat-

ing or cooling loads (passive measures) and a fundamental shift in knowledge, behaviours and practices of final users and consumers.

Several intervention strategies already exist that can contribute significantly to keeping urban areas cooler, while also reducing the mechanical cooling or heating needs. These strategies can be grouped in three main categories: heat-resilient urban form and planning (distribution of urban surfaces and building density), nature-based solutions (green spaces and tree canopy) and cool surfaces (construction practices and commonly used materials).

Key principles of passive measures to reduce mechanical cooling or heating loads may include building orientation, appropriate materials and design features in the building envelope (insulation, windows and shading to minimize heat/cold gain due to thermal transmittance) and natural ventilation where temperature, humidity and air quality allow.

The **second guiding principle** shall foresee the diffusion of efficient and best-fit technologies, plants and operations to deliver the required amount of H&C with the least amount of energy. Together, steps one and two have a powerful compounding effect: lowering urban heat results in less cooling load on buildings, thermally efficient buildings structures lead to reduced requirements for mechanical H&C that can be served with more efficient plants and systems.

The integration of local RES, **third guiding principle**, to meet the reduced energy demand can then strongly contribute to further lowering the greenhouse gas impact of H&C final uses and the energy costs as well.

### 1.3 3<sup>rd</sup> step - The target scenario - Where the local H&C system shall go and how shall get there

The third step in development of the SLHCP strategy and development is the integration of all inputs from intervention scenarios into a cohesive outlook and vision for the city, and, based on that, the set-up of strategic goals and actionable targets. This will point out the direction in which the local authority wants to head, establishing strategic priorities and intervention fields, and will be the guiding principle of the local authority's SLHCP work.

The vision needs to be aligned with the EED art.25 and the wider EU policy framework commitments and foresee a decarbonization path for the local H&C, including the need of GHG emission reduction, energy savings, renewable energy production, socio-economic and environmental sustainability. Furthermore, the vision for the local H&C decarbonisation should be aligned with previous strategies and goals set for the territory guaranteeing coherence and synergies amongst initiatives, as well as with the National Energy and Climate Action Plans.

- The vision can be set considering different objectives: **energy reduction, decarbonization, citizens comfort, increasing RES share, net zero emissions**, etc. The vision should be established considering national alignment, previously defined local strategies that impact H&C and the baseline assessment, that evidences the needs and strengths of the territory, namely in terms of the potential to reinforce the share of renewables in the H&C supply.

Once the vision is well established, it will be necessary to translate it into a balanced, ambitious and reachable strategy identifying **priority sectors** in which to act, **ranking** and **prioritising interventions** to be launched, according to established criteria focused on high-impact feasible solutions, also in terms of financing, and defining related specific objectives and targets to be reached.

Some actions may result from the extension, re-modelling or re-calibration of actions already included in the SEAP/SECAP (or other existing local energy strategies), while some others be defined from scratch, considering the European and national reference framework, as well as recent technological, market and operation developments.

Given the potential portfolio of actions provided within the intervention scenario (step 2), besides the direct impacts (energy saving, GHG emissions reduction, RE production), the selection of priority actions within each key sectors shall primarily foresee the **feasibility** assessment (including relative costs and necessary investments estimation) and the selection

of the necessary additional **supporting tools** and **measures** the Municipality can promote to ensure their development and concrete implementation.

Prioritizing actions is highly context-specific and dependent on political priorities; thus, it should be conceived as a **dynamic and flexible process** that can change over time. Given the complexity of the H&C local systems and the constant changes that might occur in it and in external factors, the list of priority actions should be periodically monitored and refined or revised if and where necessary, to reap further opportunities and learn from previous experiences.

Furthermore, for the SLHCP strategy preparation, **stakeholder engagement, namely via the LCoP and participatory approaches** are crucial to ensure the commitment of key actors and the transparency of the process, as well as the credibility of the plan strategy and acceptance of actions. Citizens and stakeholders are likely to be influenced by the solutions devised but they can also help reach the targets, therefore, they should be involved in all the key stages of the elaboration process.

The technologies/interventions costs for the economic assessment may be based on regional and national public price lists and/or any other average market values taken from scientific literature, sectorial studies and directly from trade associations or technologies national and EU networks.

For specific actions, involving single users or groups of users (e.g. public buildings) the cost-benefits analysis necessary for ranking, should consider a costs comparison for the interventions under analysis, expected savings, and the difference between operating and maintenance costs before and after. The classic financial parameters (NPV, IRR, PBT, etc.) are also to be calculated, considering any applicable incentive mechanisms. For widespread actions, the cost-benefit analysis can be produced using the same methodology, but based

on a sample of standard interventions, and the results can be extended, parametrically, to the number of interventions planned for implementation.

In addition to the direct impacts, the actions ranking and prioritizing process should also detect and analyse, depending on the SLHCP defined vision, priorities and strategic goals, other possible indirect impacts or co-benefits ranging from environmental, social, economic or governance-related issues:

- **Social benefits** related to local well-being, quality of life and health improvement, energy poverty and inequality reduction, increase of social cohesion and sense of community, education and awareness.
- **Economic benefits** for the local economy, such as job creation and small-business op-

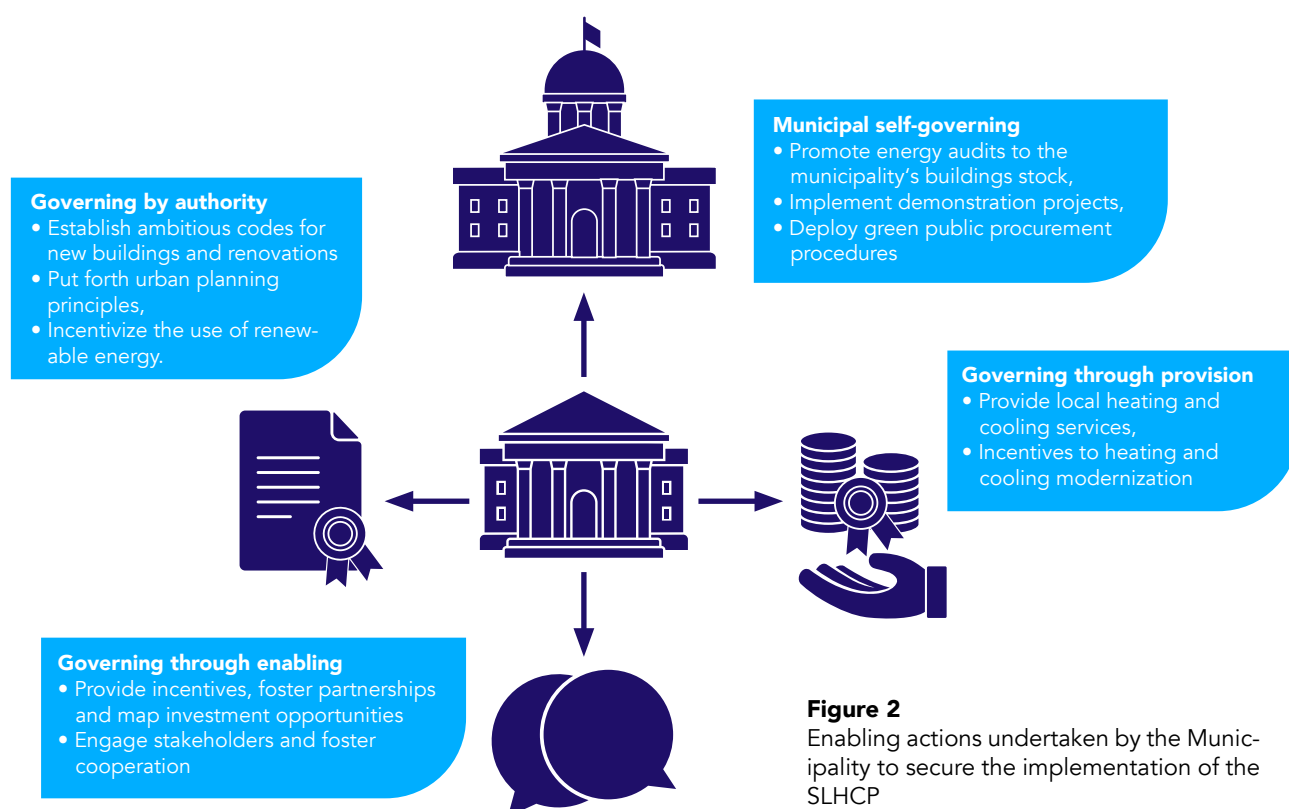
portunities promotion, reduction of infrastructures costs, competitiveness increase.

- **Environmental benefits** related to air quality improvement, water and soil pollution reduction, biodiversity conservation, ecosystems and water protection.

As better detailed in chapter 3 and ANNEX 3, **supporting measures** can be grouped in three main categories

- Management, control and regulation measures
- Financial and incentive measures
- Enhancing and empowering measures

and shall refer to the role that a local authority can play in the energy planning as described below.



**Figure 2**

Enabling actions undertaken by the Municipality to secure the implementation of the SLHCP

## Owner and manager - Municipal self-governing

Municipalities and Local authorities have the capacity and responsibility to control and manage their own activities and to undertake strategic investments in Municipality-owned assets or in areas of action under their direct competence or control. The main measures that can be promoted are energy audits, demonstration projects in public facilities and public procurement, which can be used to better manage the local authority estate. Moreover, this mode of governance can also rely on modifications or reorganization and institutional innovation. Awareness raising among public servants and transversal communication among different departments are key measures to implement SLHCPs and progress towards sustainability.

## Governing through provision

The Local Authority is a provider of urban services and as such, has control or influence over infrastructure development. Direct provision of funding mechanisms or the direct investment on urban infrastructure are some of the main actions that a Municipality could deploy. This may include the establishment of revolving funds, the implementation of public-private partnership models, or the use of green bonds to finance large-scale projects, energy efficiency improvements, or green infrastructure.

## Planner and regulator - Governing by authority

A close interaction and strong alignment is needed between the SLHCP and other urban and spatial policies, strategies and plans for which the administration has a direct responsibility, proposing the integration and adaptation of its objectives and sectorial targets. In addition to capacities as implementer, enabler, and provider, local authorities govern by authority through setting regulations and putting forth urban planning principles. They can revise building codes to promote the improvement of energy efficiency in buildings, as well as incentivise the use of renewable energy in the building stock for distributed generation or promote the deployment of green/blue infrastructure through urban strategic planning. In the context of local energy generation, this mode of governing involves setting requirements on the mandatory use of renewable energy and ruling on strategic energy planning decisions. Based on such tools as ordinances and strategic energy planning, local authorities can assist in addressing certain shortcomings for supporting niche markets and emerging technologies as well as insufficient guidance to inform decision-making for local energy generation.

## Promoter, coordinator and partner - Governing through enabling

As a facilitator, the local authority has an active role in enabling cooperation between among citizens, market players, local companies and key actors in the local H&C chain, able to ensure the availability of economic resources for the concrete implementation of actions and also providing the leverage mechanisms ensuring overall sustainability in the long term. Moreover, the involvement of a range of different partners increases the democracy of the processes. The local authority also has a crucial role in building a bridge between investors and investments through the promotion of cross-cutting information, training and social marketing initiatives to increase public awareness, empower and widen local knowledge and technical expertise on RES, energy efficiency in final uses, costs and financial support mechanisms, permit-granting procedures, behaviour practices for a sound use of technologies and equipment and waste reduction. These measures can be actively used within the capacity of local authorities to overcome any lack of business models to leverage financial resources as well as inadequate knowledge.

### 1.4 The Roadmap – Preparing and launching the SLHCP implementation

While the creation of a city-wide SLHCP is a significant step in the transition to sustainability and decarbonization, the real results and benefits will come only from effective implementation. Thus, the 4th Phase of the SLHCP preparation process is the definition of an implementation pathway, so called **Roadmap and SLHCP implementation**, providing all the necessary technical and non-technical instructions and information to con-

cretely launch and operationalize each selected action, such as:

- Target sector/sub-sector
- Scope and main objectives
- Responsibilities within the Municipality
- Stakeholders/actors involved
- Technical-economic feasibility (including estimated investment costs)
- Funding sources/mechanisms and possible

supporting tools

- Expected impacts and co-benefits
- Timing and phases
- Reference regulatory framework (directives, legislation, etc.)

A reference template is proposed to collect key data and information for the Roadmap setting.

| Action title                                                   |                               |
|----------------------------------------------------------------|-------------------------------|
| Sector                                                         | Sub-sector/activity           |
| Scope and main objectives                                      |                               |
| Description                                                    |                               |
| Promoter(s)                                                    | Responsible body(ies)         |
| Department(s) involved                                         | Stakeholders involved         |
| Reference regulatory framework (directives, legislation, etc.) |                               |
| Estimated investment costs                                     | Phases and Timing             |
| Funding sources, financing mechanisms                          | Supporting tools and measures |

| Impacts     | Energy saving [MWh] | RES production [MWh] | GHG emissions reduction [ton] | Energy costs reduction [€] |
|-------------|---------------------|----------------------|-------------------------------|----------------------------|
|             |                     |                      |                               |                            |
| Co-benefits | Social              |                      |                               |                            |
|             | Economic            |                      |                               |                            |
|             | Environmental       |                      |                               |                            |

## 2. Actions and enabling technologies

A holistic understanding of key interventions and technological options that can be available at the local level is necessary to support municipalities and local authorities in designing the SLHCP strategy and selecting the most suitable tools and measure for its implementation towards the H&C system decarbonization.

For this reason, in this section a general overview of possible action and interventions are described with the aim of providing guidance towards potential application areas and sectors.

A more detailed approach of actions and interventions for the different sectors is provided in **ANNEX 2**.

### 2.1 Urban regeneration

Aside from the geographic location and climate conditions, several variables influence how urban areas experience and accumulate excess heat. These include, among others, the existing land cover (distribution of urban surfaces, green spaces and tree canopy), the building density, construction practices, and commonly used materials.

Proven and demonstrated strategies exist that can contribute significantly to keeping urban areas cooler while reducing the mechanical cooling needs of buildings.

*They include a wide range of physical interventions, ranging from optimizing the shape of the built environment, to changing the composition and colors of streets, sidewalks and other surfaces, to increasing the quantity and quality of green spaces.*

While some of these may require policy, regulatory changes and significant planning, many are “quick wins” in most climate zones.

What remains clear, however, is that all these interventions do mitigate the urban heat island effect, and many of them increase indoor and outdoor thermal comfort. Details on the magnitude of impact will have to be modelled and tested on a case-by-case basis.

Strategies and interventions can be broadly grouped in three inter-related categories:

- **Heat-resilient urban form and planning** - Appropriate changes to land use and design controls that prioritize green space and green infrastructure, and promote water-sensitive urban design, will help change the way that buildings and communities are constructed and designed

- **Cool surfaces** - In an urban environment, the surfaces that contribute to the urban heat island effect (roads, sidewalks, parking lots, building walls and roofs, even car exteriors) can however be replaced with or modified to be surfaces that reflect heat instead of absorbing it.

- **Nature-based solutions (NBS)** - Natural features provide cooling benefits through evapotranspiration and direct shade in the case of trees and other vegetation (forests, wetlands, green belts and parks, natural wastewater plants, ecosystem corridors, etc.) and by acting as heat sinks in the case of bodies of water.

## 2.2 The building sector - Residential and Tertiary

Buildings account for approximately 40% of the EU's energy consumption, while 75% of buildings' heating and cooling is produced from fossil fuels. Nearly 35% of the existing buildings in Europe are more than 50 years old, and almost 75% of the building stock is considered inefficient.<sup>2</sup> The building sector is a critical component of urban infrastructure, accounting for more than half of the share of energy consumption and approximately half of the total GHG emissions in EU municipalities.

Buildings have a long lifespan covering many decades, and therefore efficiency measures embedded into them can have significant benefits that last far into the future.

With most of Europe's building stock already built, achieving climate neutrality depends on prioritising deep, scalable renovation of existing buildings.

At date, the building renovation rate is still rather low and increasing it can thus contribute to the more efficient use of energy and the reduction of GHG emissions while improving indoor comfort.

With a wide range of building types, residential, tertiary, public, the sector can reduce its GHG emissions due to H&C needs through various measures, targeting the **envelope** on the one hand and the **technological components** on the other. The **integration of local RES** to meet the reduced energy demand can then strongly contribute to further lowering the environmental impact of H&C final uses and the energy costs as well.

The building envelope consists of **roofs, walls, floors, windows** and **doors** and acts as the 'skin' of the building, regulating contact and energy exchange with the outside. Interventions to improve its thermal performance and minimize the mechanical heating or cooling loads, so called **passive measures**, must be the first step in the process of energy upgrading of a building and can include:

- Cladding of vertical walls and insulation of floors, roofs and foundations
- Substitution of glazed surfaces and windows and installation of solar shading
- Natural ventilation openings

Passive measures could reduce cooling loads by 24%, with savings in investments, energy costs and GHG emissions.

According to an integrated approach, passive measures must be complemented with the **renovation** of the **installed plants** and **devices** and the installation of new and **more efficient technologies** or **operations systems** to deliver the required H&C needs with the least possible amount of energy and emissions.

Reducing energy loads in the H&C chain is important because the replacement cycle for plants and equipment is typically around 10 to 15 years, which is much shorter than for buildings (50 years).

Mechanical H&C ranges from the use of **natural gas condensing boilers** or **wooden biomass boilers, solar thermal plants, heat pumps, fans, air coolers and air conditioners to complex HVAC or centralized systems**.

H&C technologies may also concern **refrigeration and cold chains**<sup>3</sup> for storing food or specific products in tertiary facilities such as supermarkets and food warehouses, but also public services such as hospitals, health centres, pharmacy, etc., which offer interesting opportunities for efficiency improvements thanks to the availability of widely tested materials, technologies and plant solutions.

Furthermore, H&C can entail measures to ensure efficient operations – including **maintenance** and **demand-side management and control systems** also including building automation.

**Air-conditioning** systems are expected to remain an important choice for space cooling in the building sector soon, because they are easy to use, scalable and reliable in all climate conditions and applications. Unfortunately, a significant gap still exists between the most efficient air-conditioning products available in the market, and those that are most purchased by users, particularly in the residential sector.

Air conditioning and refrigeration are energy intensive, because they depend largely on grid electricity that is mainly fed by fossil fuels in most countries, driving indirect greenhouse gas emissions.

**Electrification vs decarbonization could so be a crucial point for the sustainability of cooling and refrigeration plants and devices.**

Further, they are associated with refrigerants that have high global warming potential, responsible for direct greenhouse gas emissions. Finally, they reject waste heat into the outdoors, contributing to excessive warming in the urban environment.

Thus, while cooling technologies are a necessity to enhance thermal comfort and temperature control, their careful selection is essential to drive the transition towards efficient and best-fit solutions.

With a wide range of technologies available, the choice of the most suitable and efficient solution will depend on several factors, but particularly on the specific final use (heating, cooling, hot water, cooking, refrigeration, etc.) and the type and scale of the built environment being addressed (residential, tertiary, etc.), that is whether H&C is to be provided, for example, for a room, a single dwelling or building, more buildings or at district level.

Planning integrated actions for groups of buildings requires a systems-thinking approach that considers the complex interactions between buildings, neighbourhoods, and communities. One of the key challenges is scaling up actions to achieve widespread impact, while also addressing the unique needs and circumstances of individual buildings. However, this also presents opportunities for economies of scale and collective impact. Moreover, groups of buildings can also be used to test and demonstrate new technologies and approaches, creating opportunities for innovation and learning and to pilot new energy efficiency measures, such as district-scale energy systems.

**3** The cold chain can be best defined as: "The series of actions and equipment applied to maintain a product within a specified low-temperature range from harvest/production to consumption, including farming/fishing, food processing, cold storage, transportation, food services, and domestic uses, as well as specialized products like medicinal products and vaccines" (UNEP OzonAction 2020a).

## 2.3 The manufacturing sector - Industry and Agriculture

The **industry sector** is one of the largest energy consumers in the EU, accounting for 25,1% of final energy consumption. In EU municipalities, industry accounts for 12,5% of energy consumption and 13% of total GHG emissions.

**Process heating** is the most important energy use in the EU industrial sector, corresponding to more than half of accounted energy demand, and mainly dependent on fossil fuels. Also in the agriculture sector, process heating is often the most relevant energy use, generally connected to farm and livestock products processing. In both, other relevant H&C final uses can also include space H&C, refrigeration and cold chains.

Energy is an important component of production costs in many industrial sectors, although

its share can strongly vary. These differences are influenced by the dimension of firms, the type

and complexity of production processes, the technologies, operational practices and management approaches.

For highly energy-intensive industries, managing energy costs can be a question of survival. These heavier industries (such as chemicals, metals, pulp and paper, refining and cement) are characterised by high fixed costs and capital-intensive processes, where efficiency improvements often require substantial upfront investment. For less energy-intensive sectors (such as electronics, machinery, automobiles, textiles, and food and drink processing), energy generally plays a smaller role in overall costs. However, they have significant potential to achieve cost-effective energy savings in the short term, with lower capital costs. Managing costs in lighter industries is also crucial, not only to improve firm competitiveness but also to achieve broader economic objectives.

In general, three main areas of interventions can be considered within a local H&C energy strategy:

- The sector as a final user and an energy consumer, which must therefore be analysed and evaluated considering its potential for efficiency improvements
- The sector as a possible energy supplier through, for example, the recovery of residual process heat or product processing residues
- The sector in terms of its conversion or upgrading, also in relation to brownfield sites of interest in urban and spatial plans.

Several physical and technological measures can be deployed at the local level for reducing H&C energy demand and improving **energy**

**efficiency: The adoption of energy-efficient equipment and motors, process improvement, RES and low-carbon technologies, digital tools**, management procedures to optimize the process control.

**Electrification is an essential part of industrial decarbonization** and electric equipment's (Heat pumps, boilers/furnaces, resistance heating, arc furnaces and induction technologies) could meet-up heat or cool demand at a wide range of temperatures. Electrified processes are more efficient than those based on fossil fuels, however they are not always the ideal or the only possible solution and a crucial point should concern the sustainability of such solutions.

**Industrial symbiosis** approaches are also relevant in this context where industries located in the close vicinity can collaborate to exchange resources, materials or byproducts to minimise waste and maximise resources.

The potential for efficiency increases in the productive sector is certainly very high. However, for a municipality the development of an effective local intervention strategy can be more difficult and complex than for other sectors, depending on the high variety of sub-sectors and areas of activity within it and of stakeholders to interact with, characterised by dynamics and peculiarities that can greatly vary one from the other. Suitable actions and interventions can thus be selected and evaluated only based on a deep knowledge of the local productive context and of the related H&C chain.

## 2.4 The local H&C energy supply – Renewable Energy Sources enabling technologies and integrated systems

As municipalities continue to grow and urbanise, the demand for heat and cold production is increasing, posing significant challenges for energy systems and the environment. Traditional heating and cooling production systems often rely on fossil fuels, contributing to GHGs and air pollution. Non-renewable local production in EU municipalities reached around 98% of total local heat/cold production, representing a share of around 25% on total heat/cold consumption.<sup>4</sup>

Municipalities can play a key role in promoting the development of RES and the diffusion of more efficient, sustainable, and resilient production and distribution systems able to ensure access to a cleaner and cheaper energy, improve energy security and public health and support the local economy. However, the deployment of RES at local level, both electrical and thermal, must necessarily be assessed within realistic assumptions, considering and assessing factors such as land availability, land use changes, potential habitat disruption and local possible environmental and social impacts.

- To address these challenges, municipalities can promote plants and solutions that make use of
  - existing areas and surfaces, helping to reduce
  - the need for new land use or land reconversion
  - while supporting increased energy generation.
- In addition, they can support the development of systems integrating different RES and different enabling technologies such as heat pumps, district networks and energy, optimising the use of generated electricity, or heat or cool.

This section and the following, are intended to provide a collection of key measures to promote the uptake of renewable sources, enabling technologies and integrated urban energy systems for a sustainable local H&C supply chain.

**Solar energy** - Solar energy is the fastest-growing renewable resource, providing clean, inexhaustible power and significantly reducing greenhouse gas emissions. Key technologies include **solar photovoltaic (PV)**, and **solar thermal converting** sunlight directly into electricity and heat available for various applications.

**Photovoltaic (PV)** is one of the most promising approaches to electricity production largely due to a huge drop in costs in the last decades. Most PV systems are used to generate power connected to an electricity grid, while there is also a smaller market for off-grid power, particularly in remote areas and developing countries. They can be installed on rooftops, in solar parks and in areas such as roads and roundabouts, railways, water bodies, brownfields, or other underutilised areas. Integration in buildings is generally the most promising area of interven-

tion and PV modules can also become “architectural elements” (so called Building Integrated photovoltaics -BIPV) replacing parts such as roof tiles or facade glass, walls, semi-transparent façades, skylights and shading systems. Another interesting application is AgroPV allowing for the simultaneous production of food and energy, mitigating concerns about land competition between solar panels and farming activities and able to improve growing conditions, land-use efficiency and crop yield.

The diffusion of PV plants at the local level requires careful consideration of several factors and challenges remain mainly due to solar energy's variable supply, low conversion efficiency, technical hurdles for the building integration, suitable areas availability, impact on agricultural practices, etc.

**Solar thermal systems (ST)** can be employed in various applications and in terms of efficiency, require three times less roof space than PV panels to generate the same amount of energy. Currently, it is mainly used for domestic hot water (DHW) and space heating in single and multi-family homes. Large-scale system can provide heat for industrial applications (like preheating of raw materials, provision of hot water, or generation of steam for various manufacturing processes), can be used in agriculture and farming, (e.g. to dry crops, to warm food/drinks for animals, to warm greenhouses etc), in multi-family homes, hospitals, hotels and retirement homes and can also be integrated into an existing district heating network. Furthermore, solar thermal panels can be effectively combined with other renewables such as biomass, heat pumps, biogas, and PV (PV/T systems), improving overall system efficiency and furthering decarbonization

**Geothermal** - Geothermal energy is a renewable energy source harnessed from the thermal energy stored in rocks and fluids deep within the earth's crust. Drilled wells connect the fluid to the earth's surface, allowing it to be used for a range of purposes such as to generate electricity or provide direct heat for district heating, water heating or industrial processes. A major advantage of geothermal energy, compared to other renewable energy sources, is that it is not

dependent on the weather conditions and can help to offset the risks associated to an energy system based on variable supplies of other energy sources.

**Biomass** - Biomass is defined as biological material which is directly or indirectly produced by photosynthesis. Examples are wood and wood residues, energy crops, crop residues, and organic waste/residues from industry, agriculture, landscape management and households.

Biomass interacts strongly with the agriculture, forestry and waste management sectors, can be converted to solid, liquid or gaseous fuel and is the main source of renewable energy today, contributing to energy used in power generation, heat for industry and buildings, and for transport. Technologies for producing heat and power from biomass are already well developed and competitive in many applications. The energy production by biomass can also be combined in a synergic way with other sources, to reduce the fuel consumption and the related emissions, for example, by coupling with a solar thermal plant.

While biomass is attractive as a renewable fuel, its utilization as an energy resource is not without potential environmental impacts: Competition for arable lands required for food and fiber production, soil disturbance, nutrient depletion and impaired water quality, air pollutants, solid waste and wastewater, etc.

**Waste heat** - Excess heat or waste heat includes all the heat flows resulting from any process that cannot be recovered for the process itself but can be reutilized for other purposes. There are many industrial processes that release heat to the environment and can be utilized among which refineries, cement production and steel mills. Other types of lower-temperature (below 70 °C) waste heat sources are data centres, supermarkets, sewage treatment facilities or metro ventilation. Waste heat recovery can be used in a variety of ways, including feeding it into district heating networks, providing direct heat to buildings, and powering industrial processes. Other potential uses of waste heat include heating greenhouses and aquaculture facilities, powering desalination and water treatment processes. Additionally, it can be used to pro-

duce fuels such as methanol and biodiesel, and to power hydrogen production through electrolysis. Waste heat may also be employed for producing cooling thanks to absorption chillers.

**Heat pumps** - Heat pumps combine high energy conversion with the capability of using athermal, geothermal or hydrothermal heat at useful temperature levels. Heat pumps present a versatile energy technology, that can use electricity or thermal energy as their primary energy source, can provide both heating and cooling in a great variety of building contexts and applications, and can be combined with smart technologies and storage. Furthermore, they can also provide flexibility for the integration of variable renewable-based electricity sources when combined with adequate heat storage. Regardless of the heat source, heat pumps perform at a higher efficiency when they are used to deliver heat at a lower temperature instead of at a higher temperature.

**Energy storage** - The rapid deployment of a hugely increased share of variable renewable energy sources will require more flexibility, allowing the energy system to adapt to the changing needs of the grids and manage the variability and uncertainty of energy supply and demand.

Besides being an important flexibility solution, **electric energy storage** can reduce price fluctuations, lower electricity prices during peak times and empower consumers to adapt their consumption to prices and their needs. It can also facilitate the electrification of different economic sectors, notably buildings and transport.

**Thermal energy storage (TES)** has an important role to play, particularly in cities where the population density is high enough to adopt district systems. It consists of a system able to accumulate thermal energy to remove the seasonal discrepancy between the demand and supply profiles, and the competition between each other in summer. It usually makes use of water as storing fluid, due to its large heat capacity and low price, but the ground can work as well. The size of thermal storage has a wide range (from a few hundreds of cubic meters to hundreds of thousands) and can accommodate

a range of timescales from hourly to seasonal. TES is considerably cheaper than electricity storage such as batteries or pumped hydro.

**District heating and cooling (DHC)** – District Heating and Cooling is a heat and/or cool distributing system, generated in one or several central (or decentralised) location(s) and transported through a network of insulated transmission and distribution pipes and auxiliary equipment. These systems can meet the requirements of space heating or cooling, domestic hot water (DHW), process heat or refrigeration.

A key advantage of district energy networks is that they are a proven solution for the efficient use of multiple renewable energy sources on a large scale, that would be unsuitable for use in stand-alone systems, including biomass, geothermal and solar thermal, waste heat from electricity production, incineration, industrial processes, data centers, wastewater, etc.

The implementation of DHC and the integration of RES or waste heat offers multiple benefits at the local level, including:

- Higher efficiency standards
- Greater flexibility and resilience with respect to possible variations in climatic and market conditions, resource availability, and end-user needs
- Simplified management and consequent reduction in operating and maintenance costs
- Significant reduction in the concentrations of certain pollutants and improvement of air quality

The development of subsequent DHC technologies has resulted in improved efficiency and the use of lower supply temperature, from the first generation district heating systems, characterized by high temperature supply from steam, to third and fourth generation systems operating with lower and lower distribution temperatures, paving the way for better utilisation of renewable and recycled low-temperature heat, till the fifth generation systems, based on ultra-low temperatures (10–30°C) combined with localised heat pumps.

By leveraging biomass, geothermal, solar thermal, and waste heat, DHC networks are expected to become the backbone of urban heating and cooling and the transition to 5th generation will be crucial, because it operates at lower temperatures and maximizes the efficiency of RES in compliance with art. 26 of the Energy Efficiency Directive revision, setting the criteria and steps for reaching “efficient DHC” and the complete decarbonization within 2050.

Implementing DHC at city level requires careful planning, coordination and investment. A thorough feasibility study is necessary to identify potential heat and cooling sources, assess demand, and develop a masterplan outlining infrastructure requirements and stakeholder roles. Significant investment in infrastructure, including pipelines and distribution systems, is also necessary.

### 3. Supporting measures

This section provides a general overview of the necessary additional measures a Municipality can promote and activate for the development of actions and interventions on territory and the concrete implementation of the SLHCP strategy towards the H&C system decarbonization.

A detailed characterization for each measure is then provided in **ANNEX 3**.

Measures can be grouped in three main categories:

### 3.1 Management, control and regulation measures

*Energy management and permitting procedures, green public procurement procedures, revision and update of building, urban and territorial plan and codes, certification schemes, etc.*

Governance and institutional measures are essential for supporting the transition to a low-carbon H&C. Building codes and standards, such as those related to energy efficiency, RES and green building, can be developed and implemented. Certification programs and initiatives, such as energy audit campaigns, can provide a framework for evaluating and recognising low-carbon buildings. Additionally, policies and regulations, such as zoning laws and building permitting requirements, can be used to encourage the development of low-carbon buildings and retrofitting of existing buildings to improve their energy efficiency.

### 3.2 Financial and incentive measures

*Financing and incentive instruments, such as green bonds, tax credits and grants, revolving funds, EPC, Public Private Partnership, participative schemes such as crowdfunding/lending/investing, etc.*

Municipalities are central in bridging the gap between financial planning and implementation, ensuring that the investment strategies are translated into effective and coherent actions. Their responsibilities include identifying funding sources, fostering partnerships, and ensuring efficient allocation of resources to maximise energy, climate and social benefits.

Funding is typically grant-based, provided by governments and NGOs, and focuses on public benefits without requiring financial returns. Financing, however, involves investments with an expected return, and often targets economically viable projects.

In addition, municipalities can design and implement a quite wide range of additional financial instruments including tax-based tools, such as green levies, tax increment financing schemes and green bonds, which can generate additional revenue and influence private investment decisions in line with sustainability goals. Moreover, municipalities are increasingly engaging with private actors through public-private partnerships and third-party investment models. Thanks to their deep understanding of the local context, they can activate these collaborations effectively, ensuring sharing of risks and benefits and fostering trust among citizens,

private investors and technicians.

Nonetheless, despite their strategic position, municipalities usually face institutional, regulatory, and technical challenges hindering the implementation of financial tools, and innovative approaches are so needed like energy cooperatives and crowdfunding platforms empowering citizens to invest directly in local renewable-energy projects, fostering ownership and engagement.

While traditional models provide a solid foundation for more established projects, innovative and alternative instruments are essential for addressing emerging challenges and driving greater energy and climate sustainability.

A strategic mix of these tools, combined with effective risk management and targeted financial planning, can provide the resources needed to successfully implement energy and environmental projects.

### 3.3 Enhancing and empowering measures

Partnership agreements, working tables and communities of practices, communication and information campaigns, training and capacity building initiatives, OSS services, pilot projects promotion, etc.

Public awareness and social engaging play a key role for successful SLHCPs. Measures to promote behaviour change and to provide education and skills significantly contribute to the decrease of energy consumption through social and non-technological approaches that must be included in policies that support energy efficiency and energy savings.

To this end, the SLHCP strategy should also include cross-cutting information, training and social marketing initiatives, with the aim of increasing awareness and building a bridge between investors and investments through the empowering and widening of local knowledge and technical expertise on RES, energy efficiency in final uses, costs and financial support mechanisms, permit-granting procedures, behaviour practices for a sound use of technologies and equipment and reduce waste.

Knowledge and behavioural change measures play a vital role in empowering citizens and communities to take control of their energy consumption, make informed decisions, and access available resources.

Through initiatives such as **one-stop-shops**, **energy advice offices**, community-based **energy cafés**, and targeted energy-saving programmes, municipalities can foster a culture of energy awareness, provide tailored support to vulnerable households, and promote inclusive and sustainable energy solutions.

By engaging with local communities, leveraging existing social networks, and providing accessible information and guidance, these measures can help bridge the gap between energy policy and practice.

**Capacity-building** and **training** program can enhance the level of success of urban H&C initiatives by increasing and empowering the skills and expertise of city authorities and key actors and technicians.

First, capacity-building measures should target and involve city officials in regulatory and policy bodies. Given the cross-cutting nature of H&C, capacity building efforts should cover multiple

departments including sustainability offices, energy, facilities, general services, public works, codes and permitting, planning and transport. Furthermore, Local Authorities can lead workforce development program to develop the technical capacity for workers to implement sustainable urban H&C solutions. These programs can cover a wide range of topics, such as training on how to install green or cool roofs, green façades, district cooling, and other infrastructures; training for efficient operations and maintenance of building systems; and training for health-care professionals to better address the health impacts of heat.

City governments alone or in partnership with each other, businesses and non-profit organizations can use demonstration and **pilot projects** to model and test specific H&C mitigation strategies. Demonstration and pilot projects can be used to test the effectiveness of different approaches, interventions or technologies and provide opportunities for public feedback.

## 4. The SLHCP monitoring – How are we doing?

This section introduces concepts for the set-up of SLHCP monitoring procedure, the 5<sup>th</sup> and last Phase in the LSHCP preparation process.

### KEY CONCEPTS

#### Where has the H&C system arrived so far

*The energy and emissions inventory update*

#### Where has the LSHCP arrived so far

Which actions have been implemented and how

Which actions are ongoing and how

#### What has already been achieved so far

*Which are the effects of each implemented and ongoing action*

*How far we are from the LSHCP targets*

#### What went wrong and why

*Where and how the SLHCP strategy has to be revised and empowered*

### 4.1 Goals, steps and timelines of the monitoring

Through monitoring, the outcomes of the implemented strategy, the advancement status of actions and the progress towards the targets can be periodically assessed. In other words, the monitoring process makes it possible to understand whether the Municipality is on track to reach the target and to identify factors that affect results.

The monitoring exercise should be considered by the Public Administrations as an opportunity to evaluate the strategy and the actions considering the progress achieved, of new available knowledge and expertise, of the latest technological or financial opportunities for sustainable energy projects.

The H&C plan should indeed be considered as a **living document** and not as a static one, as it should be periodically adjusted to improve its effectiveness.

In compliance with the Covenant of Mayors<sup>5</sup>, the H&C plan monitoring procedure can be based on two main steps:

- **H&C energy baseline monitoring**
- **Actions monitoring**

The H&C baseline monitoring foresees the update of the H&C energy and GHG emissions inventory, to follow and assess local trends and ongoing processes, both on the H&C demand side and on the supply one.

The actions monitoring should make it possible to follow the development of the planned strategy, record and evaluate the interventions and initiatives already launched, realized or ongoing, analyse results already achieved, detect delays or deviations from the targets and identify any corrective and supplementary measures. More in detail, this implies the assessment of the following main aspects:

- The state of implementation of the actions included in the H&C plan
- The overall effects of the implemented/ongoing actions in terms of energy consumption and GHG emissions reduction, increase in RES production, socio-economic and health benefits
- The distance to the Plan targets of each implemented action

This assessment will thus also help identify the barriers and challenges encountered and highlight the strengths and weaknesses of the plan itself.

The H&C plan monitoring must be planned and realized with a **well-defined frequency**, to ensure its effectiveness. If not specifically defined in the national legislation, it can be suggested to:

- Annually compile the H&C baseline,
- Every two years, assess the initiatives and

measures implementation, monitoring the plan's effective execution,

- Update the SLHCP every five years, benefiting from the monitoring results to perceive and propose the necessary adjustments to the SLHCP.

The advantages of regular and consistent progress monitoring are:

- A detailed continuous understanding of the various factors that influence the H&C dynamics in the territory
- An annual input to decision-making, allowing prompt reaction and, if needed, the adjustment of the plan
- Transparent communication, promoting credibility, increased engagement and uptake.

Despite the value of the periodical exercise, a longer period may be foreseen for sake of pressure on human or financial resources. In that case, the plan should be monitored at least every 4 years.

Within the SLHCP implementation governance structure, the **responsible** for the monitoring must already be identified within, as well as the monitoring methodology and reporting format.

The local authority is encouraged to draft a **monitoring report** and have it approved by the Municipal Council to ensure transparency and accountability.

## 4.2 The key performance indicators

To guarantee a tangible and actionable monitoring procedure, a **set of auditable, reportable, and verifiable key performance indicators** (both quantitative and/or qualitative) must be set-up and periodically updated, namely during the H&C baseline assessment and the plan's implementation.

The selection of the most suitable indicators must be based on the same approach and methodologies used for the set-up of the H&C baseline and the intervention scenarios but can be

adjusted accordingly to the progress of the actions and to the information and data available as well. Furthermore, for an efficient monitoring process, measuring mechanisms and constant

data collection need to be put in place. As for the action monitoring, the indicators can be organised in the following categories:

- Impact indicators (measure the final direct benefits)
- Implementation indicators
- Co-benefits indicators (indirect effects from the action).

**Impact** indicators focus on the direct effects related to an action and assess the contribution of the proposed action to the targets of the plan related to the reduction of emissions. In that sense, monitoring parameters that track the progress of the emissions due to a specific process should be considered. This means that all related indicators for measuring energy savings, renewable

energy generation or any other fuel-use related emissions are included in this category.

Indicators to track the **implementation** of actions focus on the parameters related to the development of the action. Normally, these types of indicators are easier to monitor compared to impact indicators, as they verify and quantify (when possible) the primary results of an action, or the steps needed to put an action in place.

In the following, some examples of monitoring indicators are presented to illustrate the potential aspects that can be measured at action level. These indicators are non-exhaustive, and the monitoring parameters may vary depending on the local H&C context of each Municipality.



## TABLES

**Table 5 - H&C energy baseline update**

| TYPE                                      | INDICATOR                                                                                                                                                                                                         |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>H&amp;C consumption</b>                | <ul style="list-style-type: none"> <li>- Total by source (MWh/year)</li> <li>- Total by sector (MWh/year)</li> <li>- Total per capita (MWh/year*inhabitant)</li> <li>- By sector and source (MWh/year)</li> </ul> |
| <b>Local renewable H&amp;C production</b> | <ul style="list-style-type: none"> <li>- Production by source (MWh/year)</li> <li>- From district networks (MWh/year)</li> <li>- Share on total (%)</li> </ul>                                                    |

**Table 6 - H&C GHG baseline update**

| TYPE OF INDICATOR                 | INDICATOR                                                                                                                                                                        |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Local H&amp;C emission</b>     | <ul style="list-style-type: none"> <li>- For electricity (ton/year)</li> <li>- For heat/cold (ton/year)</li> </ul>                                                               |
| <b>H&amp;C specific emissions</b> | <ul style="list-style-type: none"> <li>- Total per capita (ton/year*inhabitant)</li> <li>- Total per unit of energy consumed (ton/MWh)</li> <li>- By sector (ton/MWh)</li> </ul> |

**Table 7 - Actions monitoring – impact indicators (to be processed for each action)**

| TYPE OF INDICATOR                  | INDICATOR                                                                                                                                                                                                                                          |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Effectiveness of the action</b> | <b>Achieved objectives</b> <ul style="list-style-type: none"> <li>- Consumption reduction (MWh)</li> <li>- Local energy production (MWh)</li> <li>- Reduction of CO<sub>2</sub> emissions (tonnes)</li> </ul>                                      |
| <b>Advancement of the action</b>   | <b>Status of the action</b><br>C - completed<br>A - started/ongoing<br>P - programmed/to be started<br>S - suspended/postponed                                                                                                                     |
|                                    | <b>Distance to targets and level of implementation</b> <ul style="list-style-type: none"> <li>- Consumption reduction (MWh, %)</li> <li>- Local energy production (MWh, %)</li> <li>- Reduction of CO<sub>2</sub> emissions (tonnes, %)</li> </ul> |

**Table 8 - Actions monitoring – implementation indicators**

| Filed of action                             | Intervention                                                                                                                                                          | Indicator                                                                                                                                                                                                                                                                                |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Building envelope refurbishment</b>      | <ul style="list-style-type: none"> <li>- Wall insulation</li> <li>- Floor/roof insulation</li> <li>- Windows retrofit</li> </ul>                                      | <ul style="list-style-type: none"> <li>- m<sup>2</sup> of refurbishment area</li> <li>- % improvement in comfort</li> <li>- Number of interventions implemented</li> <li>- Average savings per intervention (MWh)</li> </ul>                                                             |
| <b>Thermal plants renovation</b>            | <ul style="list-style-type: none"> <li>- Plants replacement (&gt;15 years)</li> <li>- Fuel shifts</li> </ul>                                                          | <ul style="list-style-type: none"> <li>- Number and type of installations replaced and installations installed</li> <li>- Average annual efficiency per type of installation</li> <li>- Installed power per plant type (kW)</li> <li>- Average savings per intervention (MWh)</li> </ul> |
| <b>Renovation of ACS production devices</b> | <ul style="list-style-type: none"> <li>- Replacement of electric boilers with heat pumps</li> <li>- Replacement of electric gas boilers with solar thermal</li> </ul> | <ul style="list-style-type: none"> <li>- Number of interventions implemented</li> <li>- Average savings per intervention (MWh)</li> </ul>                                                                                                                                                |
| <b>Renovation of cooling devices</b>        | <ul style="list-style-type: none"> <li>- Old plants replacement</li> <li>- Replacement with HPs</li> </ul>                                                            | <ul style="list-style-type: none"> <li>- Number of interventions implemented</li> <li>- Average savings per intervention (MWh)</li> </ul>                                                                                                                                                |

|                                                      |                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PV plants integrated into building structures</b> | <ul style="list-style-type: none"> <li>- On residential buildings</li> <li>- On tertiary or productive structures</li> </ul>                | <ul style="list-style-type: none"> <li>- Number of installations installed</li> <li>- Installed power (kW)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Expansion and upgrade of urban DHC systems</b>    | <ul style="list-style-type: none"> <li>- expansion of the urban DHC network</li> <li>- RES and waste integration in DHC networks</li> </ul> | <ul style="list-style-type: none"> <li>- Network extension (km)</li> <li>- Volume connected to the network (m<sup>3</sup>) per final use</li> <li>- Thermal energy supplied to end-users (kWh)</li> <li>- % of thermal energy from RES and waste heat</li> <li>- Average saving per intervention (MWh)</li> <li>- network extension (km)</li> <li>- Nolume connected to the network (m<sup>3</sup>) per final use</li> <li>- Thermal energy supplied to end-users (kWh)</li> <li>- % of thermal energy from RES and waste heat</li> <li>- Average saving per intervention (MWh)</li> </ul> |
| <b>Heat island reduction</b>                         | <ul style="list-style-type: none"> <li>- urban renovation</li> <li>- urban forestry</li> </ul>                                              | <ul style="list-style-type: none"> <li>- De-impermeabilized surfaces (m<sup>2</sup>)</li> <li>- Surfaces made more reflective (m<sup>2</sup>)</li> <li>- Increase in green spaces</li> <li>- NBS and green areas created (n° of interventions, m<sup>2</sup>)</li> </ul>                                                                                                                                                                                                                                                                                                                   |

The implementation of actions can achieve its intended objectives while also bringing additional positive benefits and outcomes that should be also monitored by assigning them some specific indicators. The type and extent/ effect of co-benefits can vary depending on the local context and the related action and target key environmental and/or socio-economic issues, with specific focus on energy poverty. A non-exhaustive classification of co-benefits and examples is presented below<sup>6</sup>.

<sup>6</sup> European Commission - How to plan mitigation, adaptation and energy poverty actions Covenant of Mayors Guidebook| Complementary document 4

**Table 9** Source: Joint Research Center - Covenant of Mayors Guidebook, Complementary document 4 "How to plan mitigation, adaptation and energy poverty actions"

Table 9 – Co-benefits, classification and description

|               |  | Co-benefits                                      | Description                                                                                                            |
|---------------|--|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Environmental |  | Air quality improvement                          | Reduced particulate matter, nitrogen dioxide and ozone levels                                                          |
|               |  | Reduction of air pollution                       | Decreased volatile organic compounds and other pollutants                                                              |
|               |  | Biodiversity conservation                        | Preservation of natural habitats, protection of endangered species, promotion of urban ecosystems                      |
|               |  | Water conservation                               | Efficient use of water resources, reduced wastewater generation, improved water quality                                |
|               |  | Enhanced micro-climate                           | Reduced urban heat island effect, increased shading                                                                    |
| Social        |  | Public health improvement                        | Reduced morbidity and mortality rates, improved mental health, and increased physical activity                         |
|               |  | Increased social cohesion and sense of community | Stronger social bonds, community engagement, and a sense of belonging among residents                                  |
|               |  | Enhanced quality of life                         | Improved access to amenities, services, and opportunities, leading to increased overall well-being                     |
|               |  | Education and awareness                          | Increased knowledge and awareness about sustainability, energy efficiency, and environmental protection                |
|               |  | Community empowerment                            | Increased participation of residents in decision-making processes, enhanced civic engagement, and a sense of ownership |
|               |  | Reduced poverty and inequality                   | Job creation, improved access to services, and targeted support for vulnerable populations                             |
| Economic      |  | Cultural preservation and promotion              | Protection and celebration of local heritage, traditions, and cultural identity                                        |
|               |  | Job creation                                     | New employment opportunities in sustainable sectors, such as renewable energy, green infrastructure, and eco-tourism   |
|               |  | Stimulate local economies                        | Increased local investment, economic growth, and competitiveness                                                       |
|               |  | Increased property values                        | Enhanced property values, increased tax revenues, and improved urban aesthetics                                        |
|               |  | Reduced infrastructure costs                     | Reduced maintenance and operational costs linked to energy-efficient buildings, smart grids, and green infrastructure  |
|               |  | Attracting businesses and talent                 | Municipalities that invest in sustainability and innovation can attract businesses, entrepreneurs, and skilled workers |
|               |  | Improved resource efficiency                     | Reduced energy and water consumption, minimised waste generation, and optimised resource use                           |
|               |  | Increased competitiveness                        | Municipalities that prioritise sustainability can become more attractive to investors, businesses, and residents       |

# PART D

## APPROACHES, METHODS AND TOOLS

### KEY CONCEPTS

**Bottom-up or top-down approaches may be followed**  
*to calculate or estimate final H&C energy consumption and energy production*

**Bottom-up approaches using context-specific data**  
*should be preferred, whenever relevant and possible*

**Direct calculation procedures or simulation tools/software**  
*can be applied for quantitative evaluation or estimates*

**You do not have to reinvent the wheel!**  
*SECAP/SEAP can provide reliable methods and estimate procedures*  
*Several simulation tools and software are already available and applicable*

This section of the guidelines presents possible approaches, methodologies and simulation tools for the set-up of the H&C energy inventory, for preparing the intervention scenarios in the sectors of activity relevant to the SLHCP and for quantifying the related targets as for H&C final consumption and GHG emissions reduction and H&C RES production increase.

To carry out a SLHCP process and evaluate the feasibility of actions within it, it is necessary to collect and process information and data about the amount of H&C that is required, the potential supply options, the type of final users and uses, the state of the building and facilities stock, etc. It is also important to consider other key aspects to identify wider changes, such as

increasing amounts of RES, increasing energy demands, climate trends, etc. The location of the demand and supply on territory is also of critical importance, because enables connecting them together and assessing their viability. As a general approach for the set up and quantification of a SLHCP target scenario, regardless of the specific sector or activity, the following main steps and key concepts should thus be considered.

For the **2<sup>nd</sup> Phase, Baseline assessment** the following should be considered:

- **Locate, quantify and assess the H&C demand (Heat and Cool mapping)**  
 Evaluate the actual demand for H&C and map

it on territory, considering end uses within key sectors in the urban area. This understanding and quantification should also include data on local electricity consumption for cooling, so as to identify and deal with electricity demand challenges locally instead of only relying on improvements and the development of the national grid.

- **Identify local H&C sources**

Identify and quantify possible RES available locally for H&C such as solar, geothermal, biomass and waste heat. Also identify and locate existing infrastructures (e.g. natural gas or DHC networks).

For the **3<sup>rd</sup> Phase, SLHCP strategy and development**, the following should be considered:

- **Quantify and assess H&C saving potentials vs. sustainable supply**

Consider the energy saving potential within the H&C system before developing new supply solutions. Energy efficiency measures have a supply chain effect and are, however, not a substitute, but complementary. A decrease in energy demand can also translate into less capacity needed in the supply and distribution side and for new district energy systems to be planned or in refurbishment projects, this is a very important concept to include, as new infrastructures can so fit new demand levels. Furthermore, lower energy demand can also foster a higher shares of local RES.

- **Establish scenarios for H&C supply**

The aim of estimating demand, supply and potentials for energy savings is to establish scenarios that fulfil these boundaries and harnesses locally available resources, ensuring more efficient, sustainable, and resilient systems of H&C production, distribution and consumption and the access to a cleaner and cheaper energy as well, possibly fostering the activation of chains integrated with the local economy.

When defining these scenarios, not only market aspects and business perspectives should be considered but also, and above all, socio-economic issues. The socio-economic

assessment should consider connection with other contexts, as electricity or gas supply, because H&C are not separate parts of a local energy system and competition with other energy fields may arise. Moreover, issues such as climate change, air pollution, health, equity and job creation must be considered and evaluated, thus providing guidance on which technical scenario better aligns with the scope and perspective set for the SLHCP.

The H&C system baseline should be the starting point for the evaluation and quantification of outputs in each step and the initial screening within it deepened and enhanced, if and where necessary depending on the level of detail and depth already achieved, by collecting and processing additional data and information.

In many countries, regions and cities, H&C have not traditionally been an object of governance. Energy policies are most often found in sectorial policies focusing on electricity and gas on the supply side, and buildings' efficiency on the demand side. Perhaps, electricity and gas supply are measured, but usually only as aggregated energy supply figures that mix cooking, lighting, heating and other end-use demands together. Knowledge of the state of play of the H&C sectors is so often lacking or partial and therefore hard to use for strategic planning purposes.

In general efforts should be made to follow a **bottom-up approach**, considering the technological components means of the H&C needs (plants, devices, equipment, buildings dimension, structure and materials, etc.) and their expected evolution, possibly building on **context-specific data and input**.

In a bottom-up approach the local H&C demand (needs and final consumption) and supply can be modelled and simulated building on the analysis of the technological components (plants, devices, equipment, buildings dimension, structure and materials, etc.) that are the means of the H&C needs within each sector and activity, considering their type, age, their efficiency or energy performances, the rate of diffusion, etc.

Through this procedure, estimates can be

processed to quantify the useful H&C energy demand per, sector/subsector and final use. Furthermore, performance indicators can be elaborated to assess the average energy quality (kWh/m<sup>2</sup>, kWh/inhabitants, kWh/employee, kWh/kW, etc.).

Therefore, a bottom-up approach requires greater effort and use of resources but can ensure a sounder assessment and a deeper understanding of the current situation within the local H&C system, thus concretely contributing to a better calibration of the SLHCP intervention scenarios later.

The bottom-up approach can be implemented at different levels of detail and following different methodologies, depending on the specific sector/activity, information reachable and available resources within the local administration.

Generally, it can better fit sectors/sub-sectors or activities where a limited number of facilities, users or suppliers is involved (e.g. the municipal or public building stock, industrial and commercial facilities or districts, large office buildings, individual production plants etc.), data sources more easily detectable and related stakeholders engageable and reference quantities directly measurable. In this context, more accurate procedures can be applied and processed, providing a detailed modelling and assessment of the present and future energy performances.

If reference data are unavailable, only partially available, or can't be directly measured (this can be the case of sectors with a large number of distributed users like the residential and the tertiary one), bottom-up modelling of energy performance, applied to a sample of buildings' or facilities' sufficiently representative in the local context, can be a way forward for the estimation, through aggregation, of the expected overall H&C demands.

Modelling or estimating requires data and information that can be provided by a quite wide range of sources at the national, regional or local level, which can greatly vary depending on the country and the Municipality as well. Official sources like Census of Population and

Housing, Territorial Information Systems (SIT), the Cadastre of Thermal Plants, the Energy Performance Certificates database, integrated with information and benchmarks from official sources, studies, researches and scientific literature, can be used with a certain approximation, through scaling, thereby adjusting them based on relevant local-level variables or, better, by complementing them with results of surveys and field work with key stakeholders, so as to establish sufficiently granular information to model the H&C demands.

If data and information from the local level can't be collected or is completely missing, **simplified procedures** can be followed for the estimation of H&C energy needs, consumptions and production. They are mainly based on energy datasets or energy benchmarks available from sector studies and researches, registries or census, plans or strategies at the regional, national and even EU level, that can be used to calculate proxies at the municipal level using statistical information (e.g. population, n° of dwellings, n° of companies and employees, degree days, etc.) or as references to set trends of increase/ decrease and percentage breakdown. This approach gives a less accurate result and cannot duly highlight local peculiarities.

For quantitative evaluations or estimates, both direct calculation procedures, based on specific algorithms, or **simulation tools** and **software** can be applied. Several tools, implemented mainly within EU projects, are already available and applicable for the preparation of the target scenarios, possibly also providing a top-down modelling of the present or expected spatial distribution of H&C demands and local RES sources, so as to identify priority areas of intervention, and economic evaluation, in addition to the possibility of comparing different scenarios.

Within the Plan4COLD project, some of these tools have been scouted and a preliminary selection has been processed as detailed in chapter 4.

## 1. Methods and procedures for preparing the H&C energy inventory and processing the intervention scenarios

Below, for the main sector of intervention, further tips and suggestions are provided on possible estimation methods and calculation procedures that can be used for the H&C modelling in different sectors of intervention.

### 1.1 The residential sector

In the building sector, and particularly in the residential one, the construction of new buildings with high energy standards and an increase in the efficiency of existing buildings are needed to achieve the goal of reducing H&C energy consumption and emissions.

The construction of new low-energy buildings is easier to achieve, partly because it is supported by legislation pushing the entire sector in this direction. Regulation of new buildings is necessary because every building constructed to a lower standard than that available is a missed opportunity that will continue to consume more energy than necessary for decades. However, given that new buildings will account for only a small percentage of the total building stock, the greatest potential for savings lies in existing buildings.

The residential sector can reduce its GHG emissions due to H&C needs through various energy retrofit measures, targeting the building envelope on the one hand and the building's H&C technological components, such as thermal plants and electric devices, on the other hand. More in detail, key interventions should mainly include:

Source The refurbishment of building envelopes (walls, roofs, floors, windows)

- The renewal and efficiency improvement of heating and cooling plants and of hot water production systems, through the gradual replacement of older or less efficient ones
- The removal of the remaining share of plants fed by petroleum products (LPG, heating oil, etc.)

The starting point for the target scenarios set up should necessarily be a as much as possible detailed assessment of the current situation of

the building stock. This implies collecting and processing data and information concerning at least:

- As for buildings: age, dimensions, surfaces, number of floors, etc.
- As for plants and devices: year of installation, fuel used, type of system/boiler (autonomous, centralised, condensing, traditional, renewable, etc.), installed power, volume served, the average efficiency and/or efficiency class, etc.

Official data sources like Census of Population and Housing, Territorial Information Systems (SIT), the Cadastre of Thermal Plants may be used, possibly integrated with information from the Energy Performance Certificates dataset, as well as benchmarks from official national or regional sources, studies and research, or scientific literature.

For a sound definition and quantification of the intervention scenario, it should also be useful

to monitor local trends already in place and collect information on the average yearly rate of renovation of envelopes and of installed plants and the level of efficiency already achieved at local level. For this kind of analysis, possible sources of information, in addition to the SE-CAPs and related monitoring reports if existing, may be national or regional reports concerning tax deductions or subsidies programs statistics and usually providing the total number of interventions per year and the average energy savings achievable for each type of intervention (walls, roofs, windows, condensing boilers, heat pumps, biomass plants, geothermal plants, solar thermal plants, etc.).

By complementing these sources with outputs from surveys and field work with local communities and key stakeholders, a credible even if simplified model (as for H&C needs and de-

mand) of the local building stock, or at least of a sample of buildings sufficiently representative and scalable, can be defined, energy performances preliminary assessed and possible scope of intervention identified.

A possible approach to finalise the set up and quantification of the target scenario, can than foresee an increase in the annual rate of the various interventions, assuming a related average energy saving value according to detected current trends. Assumptions should be aligned with the regional, national and even EU regulation framework and sectoral targets within it. Particularly the Energy Performance of Buildings Directive IV (and possibly the National Renovation Plans transposing it) can be assumed as a key reference for the set-up of strategic lines of intervention and related time plan.



## 1.2 The tertiary sector

Like for the residential sector, an effective intervention strategy in the tertiary sector should be mainly focus existing structures and facilities. That said, one main aspect has to be considered when approaching the set-up and quantification of a target scenario: the usually high complexity of the sector, involving several and quite different sub-sectors and possible activities can make more difficult and complex, compared to other sectors, to define a comprehensive and effective renovation and efficiency strategy.

Most of the interventions considered for the residential building, are undoubtedly also applicable to a large part of the so-called 'small and medium-sized tertiary' (shops, offices, but also B&Bs, hotels, bars and restaurants), especially if included in condos facilities.

Instead, as for or large-scale tertiary structures with particular uses (such as heating, cooling and/or refrigeration in shopping centres, supermarkets, large retailers, logistics and business districts, hospitals, etc.), possible interventions are usually not standard and can therefore be identified and evaluated only by clearly knowing specific activities, services, processes (which can also be very complex) and the type of H&C energy uses related to them.

A preliminary screening should so be foreseen, through work on field and interaction with local stakeholders, to detect main type of structures, processes, services, as well as of H&C plants, devices and technologies installed, the related energy required for their operation, etc.

Based on the screening outputs, some pilot structures and facilities sufficiently representative of the local sector (as for type, dimensions, activities and processes), can be selected and an in-depth analysis developed on them with the aim to evaluate (or even directly measure) H&C energy consumption, allocate them to specific services or activities and assess the related energy quality or efficiency level through specific performance indicators (kWh/m<sup>2</sup>, kWh/

inhabitants, kWh/employee, kWh/kW, etc.). These indicators can be a way forward for the target scenario preparation, assuming an evolution towards better values in line with existing reference benchmarks and, in any case, in compliance with the sector targets within the regulation framework (present and foreseen) and for the estimation, through aggregation, of the expected overall new H&C consumption.

As an alternative, a more advanced approach can be foreseen, depending on available resources and information, focusing on the selection and assessment of specific measures, or a group of measures, and the evaluation of related energy savings, considering by-law reference parameters and/or benchmarks.

At a deeper level an energy audit approach can also be followed on the selected structures, or at least some of them, for a detailed modelling and assessment of the energy performances and an in-depth simulation of necessary or priority interventions. Measures and interventions on both the thermal and electric demand side should be included, along with integration of renewable energy systems (solar thermal, solar photovoltaic, low enthalpy geothermal).

This approach generally implies the application of quite complex calculation procedures, based on specific algorithms, or of simulation software for both of which specific technical skills are required and, in general, also a license must be purchased.

### 1.3 The manufacturing sector - Industry and agriculture

The agricultural and industrial sectors can be quite important for a local economy and their contribution as for H&C energy consumption and emissions reduction and increase of RES production can be relevant and concretely contribute to the development of a more organic and effective SLHCP, centred on the integrated energy systems and circular economy.

A quite critical aspect while defining possible intervention scenarios and renovation strategies, concerns their complexity due to several and very different sectors, sub-sectors, activities and processes and the presence of both small and medium-sized structures and large factories and companies.

The same approach followed for the tertiary sector and described above can so be applied, basing on a strong work on field and survey procedures, interaction with key stakeholders, the set-up of performance indicators and the modelling or simulation of present and future energy performances, considering provisions included in the Clean Industrial Deal and in the national reference regulatory framework.

As better described in the following, for both sectors other possible key fields of intervention should be considered, focused on the concept of integrated energy production systems and circularity and concerning RES production and supply (e.g. the recovery of process heat and/or of production process residues) and urban renovation (application of NBS and SUDs..., recovery of brownfields).

## 1.4 The public building stock

Although, from an energy point of view it has relatively little impact on the overall H&C baseline, efficiency measures on public buildings and facilities, such as schools, hospitals, and government offices, can be extremely effective as they can act as examples for sustainability and energy efficiency, showcasing the benefits and influencing the behaviour of citizens and other stakeholders. For instance, public buildings can be used as demonstration projects for new technologies and approaches, showcasing the benefits of sustainability and energy efficiency to a wider audience. In this context, social housing managed or owned by the municipalities plays an important role. Furthermore, they can improve the energy quality of public assets, also ensuring economic saving.

The starting point for the target scenarios should foresee the set-up of a centralized census system of buildings, to regularly store and manage energy data and information, as detailed in par. 2.1, PART 2. Through such a system a simplified model of the energy behaviour of each building can be set, critical issues as for plants, equipment's or devices' performance identified, and the energy quality assessed, mainly through simplified performance indicators (e.g. kWh/m<sup>2</sup>, etc.).

At a simpler level, if not all data are available for all buildings, the system can be applied only to a group of them (from a same typology, with the higher energy costs, requiring extraordinary maintenance, already included in the three-year public works plan, etc.). The focus could be on school buildings, for example, since they usually are among the most representative and the most energy-intensive and most subject to changes (regulatory compliance in terms of safety, routine maintenance, extraordinary maintenance).

Performance indicators can be a way forward for the target scenario preparation, assuming an evolution towards better values in line with existing reference benchmarks. As an alternative, buildings and/or processes associated with high(est) energy consumption (hotspots) can be identified, possible priority intervention, or group of intervention, assessed and related energy savings evaluated considering by-law reference parameters and/or benchmarks.

As an alternative, the Energy Performance of

Buildings Directive sector targets may be also considered, gradually introducing, for non-residential buildings, minimum energy performance standards, based on nationally determined thresholds. This will trigger the renovation of the 16% worst-performing buildings by 2030 and of the 26% worst-performing buildings by 2033. These objectives can be taken as a reference, assuming the requalification of a part of the lower energy class buildings.

At a deeper level, audit campaigns can be implemented, possibly involving most energy-intensive structures (hotspots). Energy audits, including technical and economic analyses and cost-benefit assessment, can provide a large amount of real data on energy consumption, opportunities to increase energy efficiency and the corresponding economic savings. Through energy audits, possible or necessary interventions can be ranked according to a cost/benefit ratio and a set of integrated measures selected able to ensure greater economic advantage, or lower investment, for the same amount of energy saved.

Measures and interventions on both the thermal and electric demand side should be included along with integration of renewable energy systems (solar

thermal, solar photovoltaic, low enthalpy geothermal).

This approach can require economic resources from the local authority and the involvement of qualified professionals. In fact, it generally fore-

sees the application of quite complex calculation procedures, based on specific algorithms, or of simulation software for both of which specific technical skills are required and, in general, also a licence must be purchased.

## 1.5 The local H&C energy supply

Europe has the ambition to be the world number one in renewable energy. To fulfil this objective, the H&C production from RES must be strongly promoted and enhanced and the energy that is produced from RES must be integrated into the energy system in an efficient, cost-effective and sustainable manner, so as to empower local opportunities in the context of local characteristics and available resources.

The options for the transition to sustainable local energy generation systems range from decentralised RES plants to integrated solutions, such as district heating and/or cooling networks.

Decentralised RES technologies offer the possibility to produce H&C with a much lower impact on the environment, when compared to conventional energy technologies. Furthermore, distributed generation allows to reduce transport and distribution losses, while increasing the diffusion of low-scale RES.

### Solar energy systems

As for solar energy systems (solar thermal, PV, Hybrid ST-PV) key interventions should primarily concern the integration in the buildings stock (mainly on roofs), providing thermal and/or electric energy, to individual structures or groups of structures for residential, tertiary or productive uses (heating, cooling, refrigeration, productive processes). This aligns with the requirements of art. 10 of the Energy Performance of Buildings Directive, and of most of the existing national regulations and incentive schemes (e.g. IN-ECP, NRRP) mandating increased deployment of suitable solar energy installations on new buildings and certain existing non-residential buildings, where technically and economically feasible.

When planning possible interventions, it should be considered that PV and ST may be competing in terms of installation surfaces, and that, in terms of efficiency, ST panels require three times less roof space/surface than PV panels to generate the same amount of energy. On the other hand, PV has a wider potential of diffusion, considering that it is usually connected to

the electric grid, while ST to specific users. PV panels can also be installed on parking and on many other street furniture.

As a rule, the set-up of intervention scenarios as for solar systems must be based on realistic assumptions, considering the available surfaces not already occupied by installations and if only a portion of them can be used for new ones. It should be considered that:

- In some buildings installations are not possible because of architectural constraints or structural issues
- In some buildings roof surfaces are not suitable for installations because of non-optimal slope or azimuth
- In some buildings installations may face problems because of technical, operational or management issues (e.g. composite property facilities and condos).

The starting point for the intervention scenarios set up should so necessarily be the assessment of the current situation of installed plants

and the detection of available rooftops surfaces within the building stock, based on SEAPs/ SECAPs and related monitoring reports if existing, on official datasets or statistics (at national, regional or municipal level), and also foreseeing a hard field work, the involvement of local communities and surveys to key stakeholders, so that a more credible and exhaustive basic overview can be pursued.

As for existing and available rooftop surfaces, useful sources of information may be the municipal zoning plans and geographic information systems, OpenStreetMap or similar geographic datasets, Census of Population and Housing.

**Small-medium scale solar thermal systems** may be mainly applied in the residential and small tertiary sectors for hot water production, replacing electric boilers or integrating natural gas ones.

For the monitoring of local current trends and the assessment of the average yearly rate of installations or substitutions, possible sources of information, in addition to the SECAPs, may be the thermal plant regional cadastres and also the national or regional reports concerning tax deductions or subsidies programs statistics and usually providing the total number of interventions per year and the average energy savings achievable.

A possible approach to finalise the set up and quantification of scenarios, can then foresee an increase of the annual rate of installations/substitutions, assuming a related average energy saving in line with detected current trends or an average percentage of HW needs (per inhabitant or dwelling) covered, in compliance with regulation and/or building codes provisions (60% can be a reference value).

As an alternative, the total number of dwellings can be considered and different percentages of installation assumed, according to the building types. For example, a higher percentage can be realistically assumed in single or double family buildings than in multi-family ones, because of technical issues and operational and management issues. Percentages will have also to consider percentages of non-accessible surfaces/roofs because of architectural constraints,

unsuitable slope or azimuth, or because already occupied by a plant.

As for **large-scale ST integrated systems** feeding industrial and/or farming facilities (so called Solar Heat for Industrial Processes- SHIP), interventions are usually not standard, depending on the type and size of activity and productive processes involved. The scope for intervention, and related energy savings and RES share increase, can therefore be identified and evaluated only thorough a detailed analysis of the specific activities, services, processes and the type of H&C energy use related to them. Involvement and direct engagement of stakeholders from the local productive chains shall so be crucial for the modelling or simulation of possible interventions and the set-up of SLHCP scenarios.

As for **integrated PV systems**, in addition to the SECAPs, several sources, at the national or regional level, are usually available (solar cadastres, RES statistics, regional energy plans etc.) providing data on the installed plants at municipal level and related power, and so a useful information base on the current local situation. For the set-up of intervention scenarios, the main parameter to be considered is the number of new possible installations, directly connected to the number and area of rooftops surfaces. If data on rooftop surfaces are available, assumptions can be made on the percentage effectively exploitable, also considering the type of related buildings or structures. In the residential sector for example, like for solar thermal systems, a higher percentage can be realistically assumed for single or double family buildings than multi-family ones.

For the residential sector an alternative simplified approach can be followed, starting from the total number of dwellings, assuming that a PV plant can cover the electric yearly demand of a single house and that (or at least the yearly electric demand for H&C uses) and higher percentage of dwellings in single or double family buildings than in multi-family ones can be involved. Percentages will have also to consider non accessible surfaces/roofs. For the electric (H&C) yearly demand, an average value can be considered, taken from the baseline assess-

ment or the business-as-usual scenario.

Also, the diffusion of PV systems integrated in tertiary and productive structures should be considered, also including farms and agriculture facilities. These are, in fact, structures with, on average, a high availability of rooftop surfaces and therefore particularly suitable for power installations and more easily detectable on territory-

Large scale ST and PV plants can also be placed on the ground, ensuring high productivity, because optimal slope and azimuth can be ensured. Therefore, a key aspect to be considered is the land use and related possible environmental constraints. Abandoned/non-productive areas or brownfields (contaminated sites, landfills, and areas along the infrastructure system) should so be preferred and, as for PV, also agrivoltaics systems. For the detection and mapping of such areas, main reference sources may be the municipal zoning plans or urban and building renovation plans.

For the implementation of agrivoltaics at the local level, preliminary in-depth analysis of several factors and particularly of possible impacts on agricultural land practices has to be foreseen, because not all practices can be suitable. That said, the potential of diffusion of this type of plants will strongly depend on preliminary agronomic analyses and no ex-ante quantitative evaluation can be processed.

## Biomass

Biomass and bioenergy represent a concrete option, for the H&C sector, in terms of renewable energy potential and technological development. Moreover, they can actively contribute to the relaunch of agricultural, forestry and livestock activities, which represent an important part of local economies in many European countries and a priority element for the protection of territories and ecosystems.

Agro-forestry biomass, can have different origins (wood and wood residues, energy crops, crop residues, and organic waste/residues from industry and agriculture), different possible uses and can be classified depending on the sector of origin, industrial residues an waste or agriculture and forestry residues, and the type of energy products that can be obtained.

To identify and map biomass local availability and quantify related bioenergy potential, a detailed assessment of the situation of the sectors of origin and of the activities related to them must be foreseen. It should be based on a detailed in-depth territorial analysis duly complemented by surveys to and direct engagement of key stakeholders from the local agro-forestry chain, so that a more credible and exhaustive basic overview can be pursued.

A large amount of data and information should be collected and processed, among which for example:

- Type and extension of forest areas, management procedures, quantity of residues produced, destination or reuse
- Number and type of farms, extension of agricultural areas, type and quantity of residues, destination or reuse
- Number and type of industries, production processes, type and quantity of residues produced, destination or reuse.

Possible official data sources for the analysis can include Regional Forestry Information Systems, management plans, agriculture plans, national and regional censuses and statistics, land cover and land use inventory (e.g. Corinne Land Cover), as well as SEPS/SECAPs.

A careful analysis of the existing sectoral regulatory and strategic framework should also be developed to detect possible environmental constraints as well as supporting tools and measure and identify the boundaries for effective actions.

The result of this territorial analysis will provide a preliminary quantification and mapping of locally available biomass that can be used for energy purposes.

If reference data are unavailable or only partially available, the survey can focus just on a sample of companies and facilities sufficiently representative in the local context and results as for their residues potential than scaled up according to the total number of companies.

As an alternative, reliable benchmark values can be taken from official research and scientific literature and applied as reference parameters to the different type of companies detected on the

territory. Finally, also simulation tools assessing the exploitation potential of biomass through a top-down modelling of the spatial distribution can be used.

### **Waste heat**

Besides waste or excess heat from industrial processes, other types of non-conventional lower-temperature (below 70 °C) waste heat sources are data centres, supermarkets, sewage treatment facilities or metro ventilation.

An effective integration of waste heat in the H&C energy system requires a thorough understanding of the local waste heat chain and the development of a comprehensive plan to recover and utilise it as energy source.

That said, for the set-up of possible intervention scenarios, a detailed in-depth territorial analysis should be implemented, duly complemented by surveys to and direct engagement of key stakeholders from the key sectors, so that a clear and exhaustive mapping of sources can be provided and related energy potential assessed.

Excess and waste heat from industries or other service facilities is a type of data that is very process-specific and hence data should be collected on site-level to avoid specific conditions to be neglected.

Relevant companies can be identified, reached and activated mainly through business registers and the local chamber of commerce or sectoral associations as well.

It should be considered that the involvement and engagement of companies could be not such an easy process because they typically have two interests that may conflict with the research: Usually they do focus on their core processes/business and are rather reserved about sharing data that may tell competitors about processes, size etc.

If reference data are unavailable or only partially available, the survey can focus just on a sample of companies and facilities sufficiently representative in the local context and results as for their waste heat potential than scaled up according to number of total number of companies.

As an alternative, reliable benchmark values can be taken from official research and scientific literature and applied as reference parameters

to the different type of companies detected on the territory.

Finally, also simulation tools assessing the exploitation potential of waste heat through a top-down modelling of the spatial distribution can be used.

### **District heating and cooling systems**

By leveraging biomass, geothermal, solar thermal, and waste heat, DHC networks are expected to become the backbone of low-carbon urban heating and cooling systems and the transition to 4th and 5th DHC generation will be crucial, because it operates at lower temperatures and maximizes the efficiency of RES. For the preparation of intervention scenarios, three main situations can be considered: retrofitting an existing district energy system, development of a new district energy system in an existing area, and a new district energy system in a new development area.

Parameters and technical requirements necessary for a preliminary feasibility assessment of a district heating and cooling system must derive from an accurate territorial survey, aimed at modelling and mapping the demand for local heat and cooling.

The H&C system baseline should be the starting point and the initial screening within it eventually deepened and enhanced, collecting and processing additional data, if and where necessary, concerning the current situation of the building stock and its expected evolution:

As for buildings: age, dimensions, surfaces, number of floors, etc.

As for plants and devices: year of installation, fuel used, type of system/boiler (autonomous, centralised, condensing, traditional, renewable, etc.), installed power, volume served, the average efficiency and/or efficiency class, etc.

If reference data are unavailable, only partially available, or can't be direct-



ly measured, estimation procedures can be applied, based on information provided by a quite wide range of sources at the national, regional or local level, which can greatly vary depending on the country and the Municipality as well. Official sources like Census of Population and Housing, Territorial Information Systems (SIT), the Cadastre of Thermal Plants, the Energy Performance Certificates database, integrated with information and benchmarks from official sources, studies, researches and scientific literature, can be used with a certain approximation, through scaling, thereby adjusting them based on relevant local-level variables or, better, by complementing them with results of surveys and field work with key stakeholders, so as to establish sufficiently granular information to model the H&C demands.

The territorial survey should also include the identification and mapping of the main locally available renewable sources suitable to produce thermal energy.

Through the survey it will be possible to select the most suitable urban areas as for RES availability and the presence (current or future) of users with high annual thermal demand and with energy characteristics or requirements particu-

larly suited to connection to a district heating network (e.g., no natural gas supply, inefficient or end-of-life heating system, already centralized heating system, etc.).

Based on the detection of potential users, the plant can be sized, its location identified, the amount of renewable energy needed for its supply quantified, and the network preliminary tracked, considering as reference parameter the “linear heat density”, i.e. the ratio between the annual thermal energy supplied and the extension of the network (kWh/ m).

The limit value of the linear heat density can be assumed to be 1,000 kWh/m and can be used for an initial evaluation of the economic viability of the project. Low linear heat density means high heat losses and therefore low profitability. District heating projects with low linear heat density will be difficult to do both technically and economically.

While planning the project, the use of increasing shares of RES, waste heat, and high-efficiency cogeneration shall be considered, to meet intermediate the EED Art. 26, starting in 2027, and then reaching the final objective in 2050, when DHC networks must be operated using RES only, or waste heat only, or a combination of RES and waste heat.

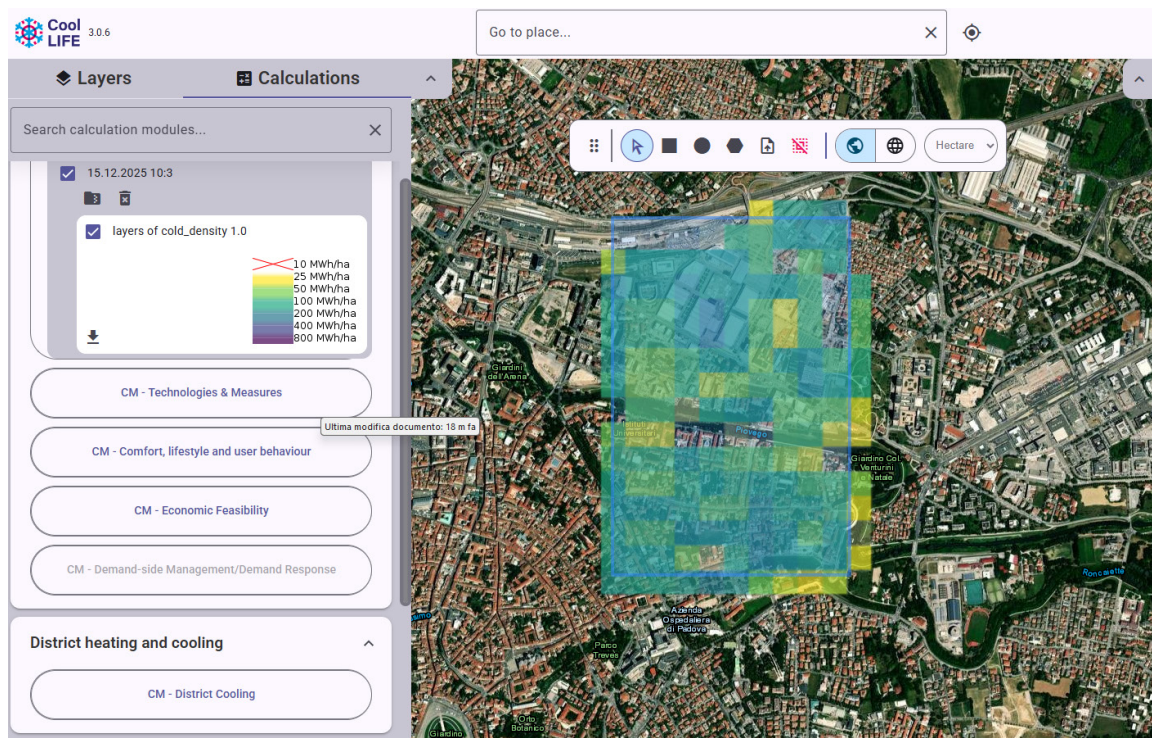
## 2. Simulation tools and software

For quantitative evaluations or estimates, both direct calculation procedures, based on specific algorithms, or simulation tools and **software** can be applied.

Within the Plan4COLD project, several tools and software have been scouted and a selection of tools defined, mainly focusing on open-source, user-friendly and free to use ones.

In this section of the Guidelines, the tools selected to cover the different phases of SLHCPs are shortly described, highlighting their main characteristics, such as developer, resource type, SLHCP Phase, availability (free/license), required input, output, main advantages, and disadvantages and including the assessment of related performances and strengths.

# CoolLIFE



## SOURCE

<https://tool.coollifeproject.eu/map>

## DEVELOPER

CoolLife project EU funded

## TYPE OF RESOURCES

Planning tool

## SHORT DESCRIPTION

It is a planning and analysis tool designed to support public authorities, engineers and other stakeholders in making better low-carbon cooling decisions for buildings and cities by mapping space cooling demand from the local (hectare) scale up to the EU-wide (continental) level, analysing current and future cooling needs including behavioural and comfort factors, offering recommendations on efficient and sustainable cooling options such as the integration of renewable energy sources, and presenting the economic, legal, policy and regulatory considerations that influence cooling-related decisions.

## PHASE OF THE H&C PLAN

- **Baseline assessment:** H&C demand and consumption
- **Intervention and decarbonisation scenarios:** Simulating building retrofits.

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

User-friendly

## TUTORIALS AVAILABLE

<https://www.youtube.com/watch?v=BNxwndkm3zI>

## OUTPUT OF THE TOOL

- Space cooling demand of buildings with efficiency measures (fans and shading) [MWh/yr]
- Cooling power capacity with efficiency measures (fans and shading) [MW]

## REQUIRED INPUT

Selected area

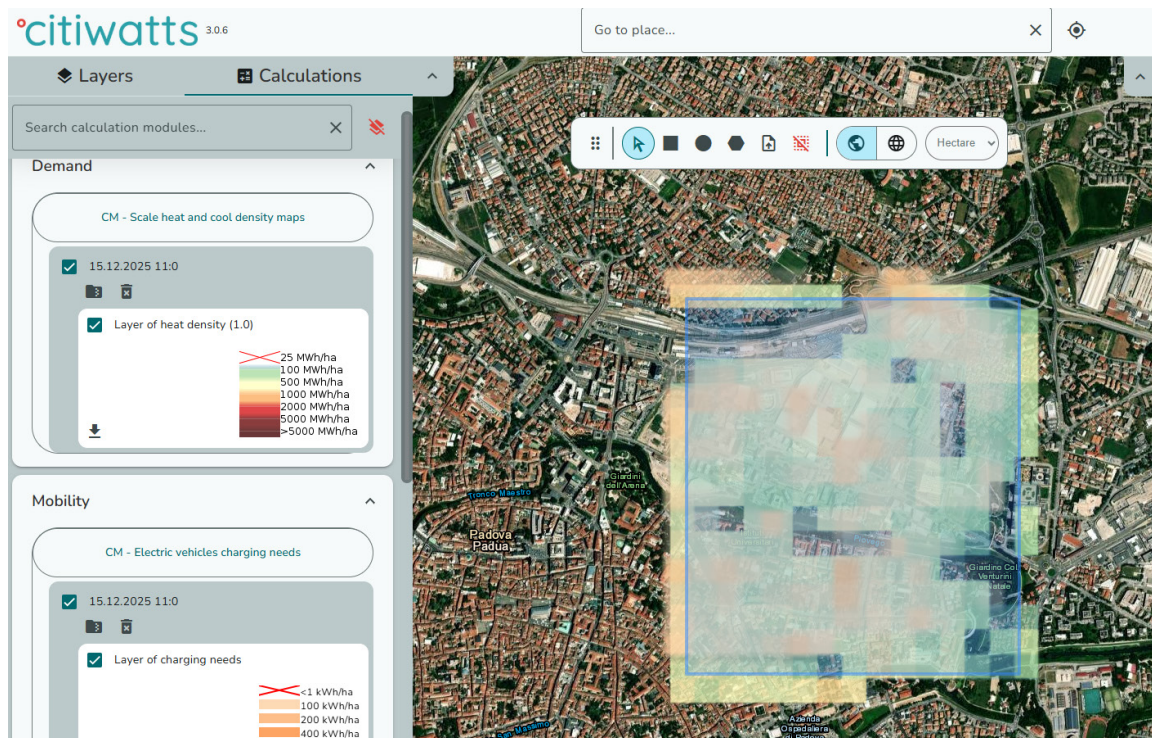
## MAIN ADVANTAGES

- Very userfriendly and free.
- Addresses legal, policy and regulatory considerations.
- Timely and Relevant: as the project ended in August 2025 its findings and materials are up-to-date and relevant to the current challenges.

## MAIN DISADVANTAGES

- Only for cooling (no heating)
- No info about CO2 emissions

# Citiwatts



## SOURCE

<https://tool.coollifeproject.eu/map>

## DEVELOPER

CoolLife project EU funded

## TYPE OF RESOURCES

Planning tool

## SHORT DESCRIPTION

It is an open-source heating/cooling mapping and planning toolbox that intends to allow public authorities to identify, analyses, model and map resources and solutions to supply energy needs within their territory of responsibility in a resource and cost efficient way. Those results will help authorities to develop heating and cooling strategies on local, regional and national scale which are in line with RES and CO<sub>2</sub>-Emission targets on national and EU level.

## PHASE OF THE H&C PLAN

- Baseline assessment: H&C demand and consumption
- Intervention and decarbonisation scenarios: renewable energy sources, enhancement of distribution grids.

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

User-friendly

## TUTORIALS AVAILABLE

<https://www.youtube.com/watch?v=BNxwndkm3zl>

## OUTPUT OF THE TOOL

- Space heating and cooling density needs of buildings [MWh/ha]
- Heating and cooling demand of buildings (total, residential, non-residential) [MWh]
- Industrial Sites Excess Heat (localisation, temperature range) [GWh/yr]
- Excess heat from wastewater treatment plants (localisation) [kW]
- Potential solar thermal collectors (rooftop or open-field) [MWh/yr]
- Potential PV panels [MWh/yr]
- Shallow geothermal energy potential [W/mk]

## REQUIRED INPUT

Selected area

## MAIN ADVANTAGES

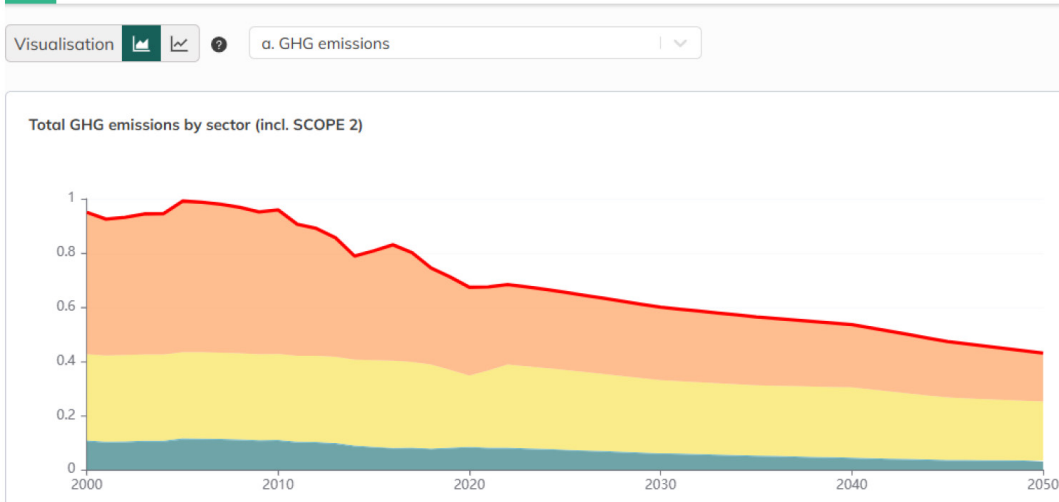
Open-source and free to use

## MAIN DISADVANTAGES

No real-time data

# EU City Calculator

Total Buildings Transport Food and AFOLU Industry Energy production Resources



## SOURCE

<https://eucitycalc.climact.com>

## DEVELOPER

EU Project

## TYPE OF RESOURCES

Planning tool

## SHORT DESCRIPTION

The EU City Calculator aims to deliver an energy modelling tool adapted to the city needs and representative of the major material, energy and emission-related processes happening within the city's administrative areas and beyond. The tool plans to integrate specific mitigation actions formulated at the city level into its modelling framework and provide cities with an easy-to-use web-interface for model exploration. Possibility for the users to manually import all relevant data. While the interface is intuitive once data is uploaded, there is no step-by-step import -wizard, and support materials may be needed.

## PHASE OF THE H&C PLAN

- Baseline assessment: H&C demand and consumption
- Intervention and decarbonisation scenarios: Simulating building retrofits.
- Evaluation and comparison of different scenarios – Roadmap: energy comparison, emission comparison, economic comparison, roadmap development.

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

User-friendly

## TUTORIALS AVAILABLE

<https://www.youtube.com/watch?v=qtnfTPsX-E>

## OUTPUT OF THE TOOL

- Final energy demand at municipal level (baseline and intervention scenarios) [GWh]
- Primary energy demand and production at municipal level (baseline and intervention scenarios) [GWh]
- Primary energy demand and GHG emissions per scenario comparison
- Costs per scenario comparison (capex, opex, fuel) [€]
- Visualisation of different roadmaps (Current local policy, Moderate and Ambitious) related to GHG emissions and to primary energy demand

## REQUIRED INPUT

SECAP

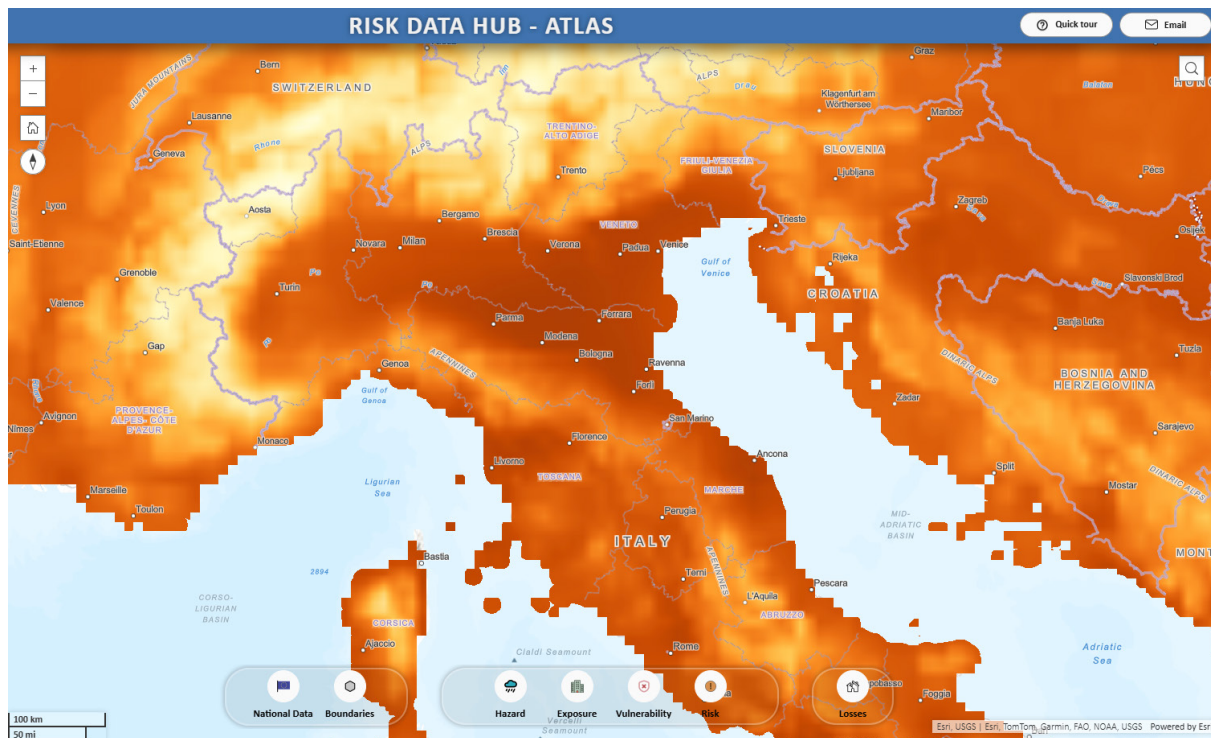
## MAIN ADVANTAGES

The webtool is designed to facilitate the transfer of data from the SECAP template provided by the Covenant of Mayors to the EU City Calculator, and the transfer of outputs from the webtool (measures and their implications) back to the SECAP template.

## MAIN DISADVANTAGES

It is a linear model and does not provide optimised scenarios or forecasts. The tool is more difficult to use when the city is not included in the existing database (and even more difficult without a covenant of mayors account), as it requires significant manual data preparation and input before accessing its full functionality.

# Risk Data Hub - ATLAS



## SOURCE

<https://drmkc.jrc.ec.europa.eu/risk-data-hub#/atlas>

## DEVELOPER

European Commission Disaster Risk Management Knowledge Centre

## TYPE OF RESOURCES

Database

## SHORT DESCRIPTION

The Risk Data Hub (RDH) is a geospatial webplatform that collects and standardises hazard, exposure, vulnerability and risk at the European level. Developed with the goal of supporting risk assessment and risk analysis processes, the RDH facilitates the collection, sharing, and analysis of data that is crucial for understanding and mitigating risks. This repository offers a variety of datasets, tools, and resources that can be utilized by policymakers, researchers in the field of disaster risk reduction.

## PHASE OF THE H&C PLAN

- Baseline assessment: assessment of local vulnerabilities

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

User-friendly

## TUTORIALS AVAILABLE

<https://www.youtube.com/watch?v=IJ821FSQJII>

## OUTPUT OF THE TOOL

Extreme Heat Hazard (Wet Bulb Globe Temperature indicator) [°C]  
River Flood [100-year return period]

## REQUIRED INPUT

Location

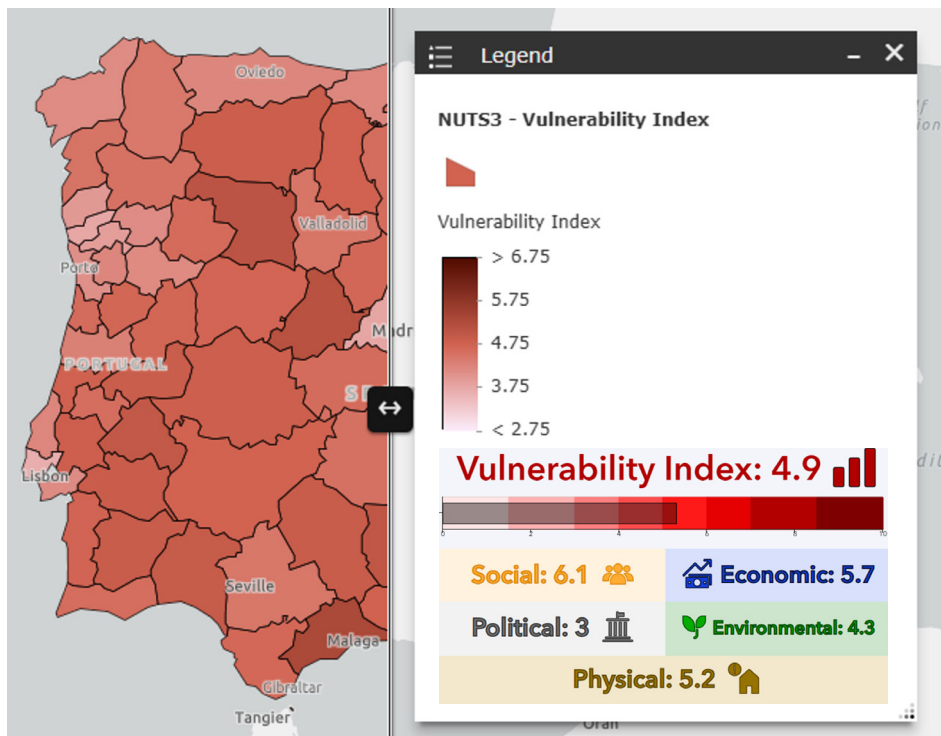
## MAIN ADVANTAGES

- Centralized, curated EU-wide data
- Support for decision-making
- Geospatial visualization and analysis
- Policy and framework Alignment

## MAIN DISADVANTAGES

- Data analysis requests
- Focus on post-event data challenges
- Limited attention to uncertainty

# Vulnerability dashboard DRMKC



## SOURCE

<https://drmkc.jrc.ec.europa.eu/risk-data-hub#/vulnerability/dashboard>

## DEVELOPER

European Commission Disaster Risk Management Knowledge Centre

## TYPE OF RESOURCES

Database

## SHORT DESCRIPTION

It assesses vulnerability at the European level, considering five dimensions: social, economic, political, environmental and physical, without relating to any specific hazard. The index is scored on a scale of 0 to 10. There are time series for the indicators inside each of the five dimensions (EU, country and NUT2 and NUT3 levels).

## PHASE OF THE H&C PLAN

- **Baseline assessment:** Assessment of local vulnerabilities

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

User-friendly

## TUTORIALS AVAILABLE

<https://www.youtube.com/watch?v=KFczUZfGTUY>

## OUTPUT OF THE TOOL

Vulnerability index considering five dimensions: social, economic, political, environmental and physical

## REQUIRED INPUT

Location

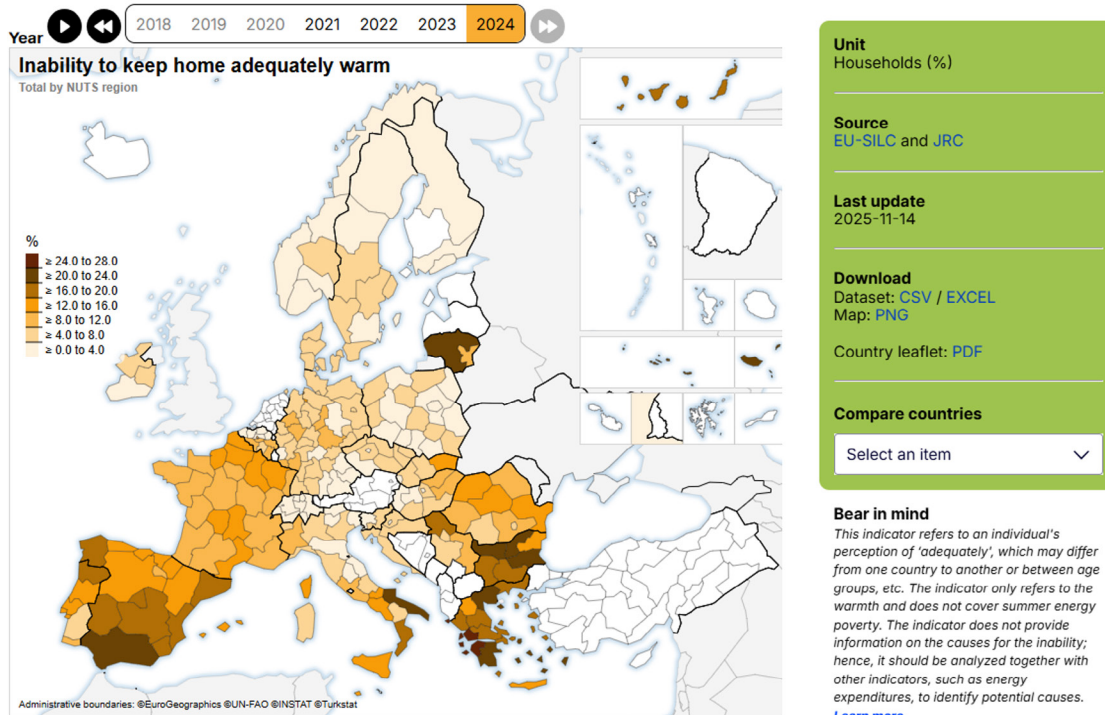
## MAIN ADVANTAGES

- Harmonised and comparable overview of vulnerability indicators across European countries and region
- Multiple datasets into a single, easy-to-use visual platform

## MAIN DISADVANTAGES

- Strong dependence on the availability, quality and update frequency of datasets, which can lead to gaps or uncertainties in some regions or indicators

# Energy poverty indicators dashboard



## SOURCE

<https://energy-poverty.ec.europa.eu/epah-indicators>

## DEVELOPER

The European Commission

## TYPE OF RESOURCES

Database

## SHORT DESCRIPTION

In this database, you can find energy poverty indicators organised by topics for each European country. In this indicators collection, publicly available EU-wide datasets are considered.

## PHASE OF THE H&C PLAN

- Baseline assessment: assessment of local vulnerabilities

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

User-friendly

## OUTPUT OF THE TOOL

- S- Inability to keep home adequately warm [%]
- Population living in dwellings comfortably cool in summer time [%]
- Population living in a dwelling equipped with heating facilities [%]
- Population living in a dwelling equipped with air conditioning [%]

## REQUIRED INPUT

Location

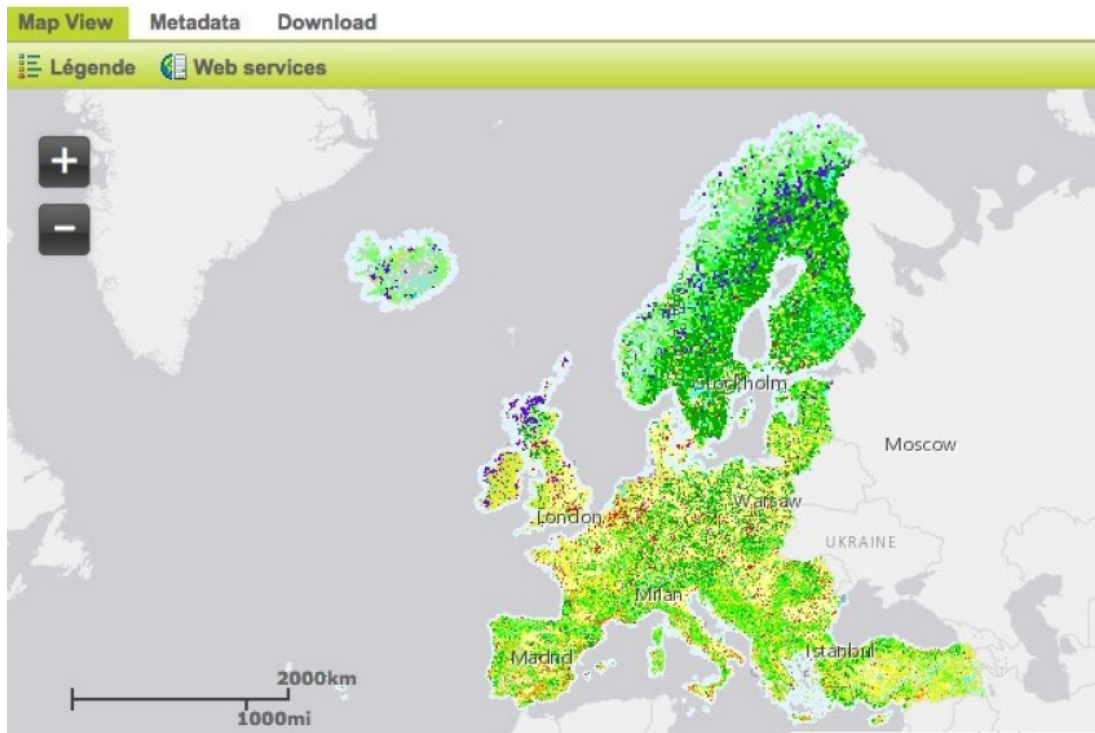
## MAIN ADVANTAGES

Possible to find energy poverty indicators organised by topics for each European country.

## MAIN DISADVANTAGES

- In this tool, available EU datasets are used, so some data is unavailable for specific years or countries.
- Most of the data is available at the national level (not local).

# Copernicus Land Monitoring Service



## SOURCE

<https://land.copernicus.eu/en/dataset-catalog>

## DEVELOPER

Copernicus Programme of the EU, implemented by the European Space Agency (ESA) and the European Environment Agency (EEA)

## TYPE OF RESOURCES

Database

## SHORT DESCRIPTION

The Copernicus Land Monitoring Service provides geospatial information on land cover and land use across Europe. It offers harmonized land cover and land use datasets to support spatial and environmental planning, aiding in the selection of optimal sites for cold storage facilities.

## PHASE OF THE H&C PLAN

- **Baseline assessment:** The Building Height Raster and Urban Atlas Land Cover - land use vector shapefile can be used in energy simulation tools to evaluate H&C demand and consumption

## AVAILABLE FOR FREE/LICENSE

Database

## USER FRIENDLINESS

Entirely free

## OUTPUT OF THE TOOL

- Building Height Raster [m]
- Destination use of buildings Vector

## REQUIRED INPUT

Selected area

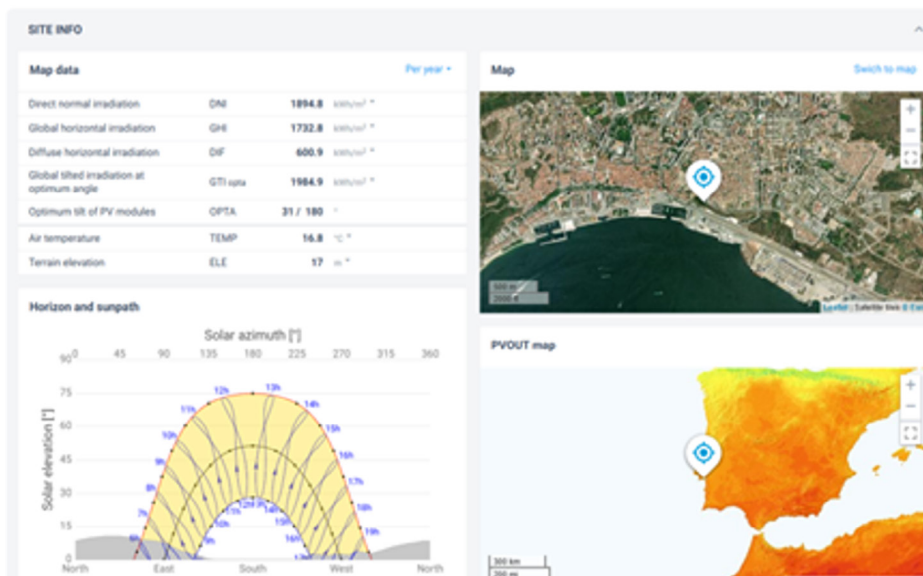
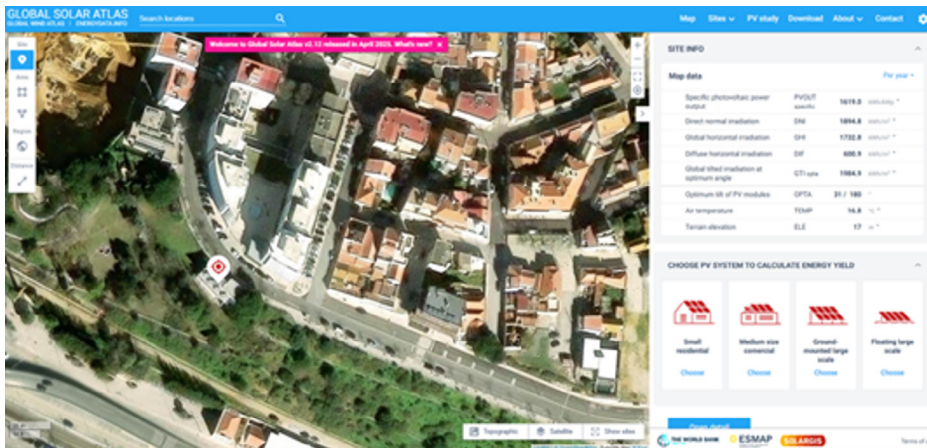
## MAIN ADVANTAGES

- Geospatial coverage of Europe: detailed land use and land cover data for cities and peri-urban zones
- Free and official EU dataset: ensures harmonization and relevant data
- Essential for urban energy planning: inputs for zoning, demand estimation, green space assessment

## MAIN DISADVANTAGES

- The datasets are periodically updated but not real-time or dynamic.
- Outputs must be used in other platforms to simulate energy systems or cooling strategies

# Global Solar Atlas



## SOURCE

<https://globalsolaratlas.info/map>

## DEVELOPER

Solargis

## TYPE OF RESOURCES

Energy simulation tool

## SHORT DESCRIPTION

Developed by the World Bank Group with the International Solar Alliance (ISA) and Solargis, it provides calculations and global geospatial data on solar energy potential.

## PHASE OF THE H&C PLAN

Intervention and decarbonisation scenarios: renewable energy sources

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

User-friendly

## OUTPUT OF THE TOOL

Irradiation (direct normal, global horizontal, diffuse horizontal) [kWh/m<sup>2</sup>]

## REQUIRED INPUT

Location

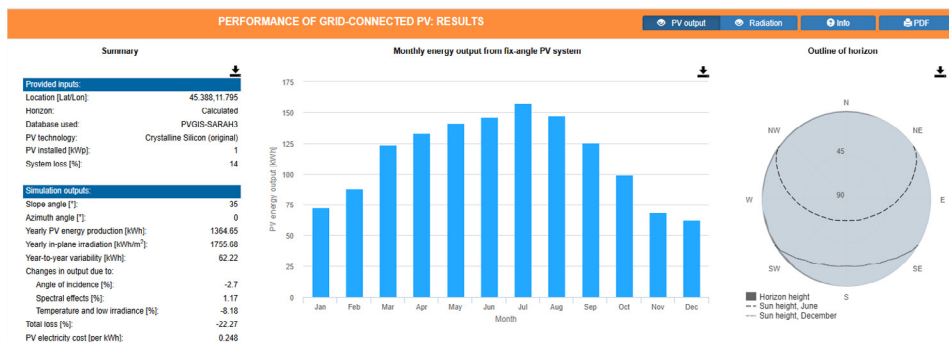
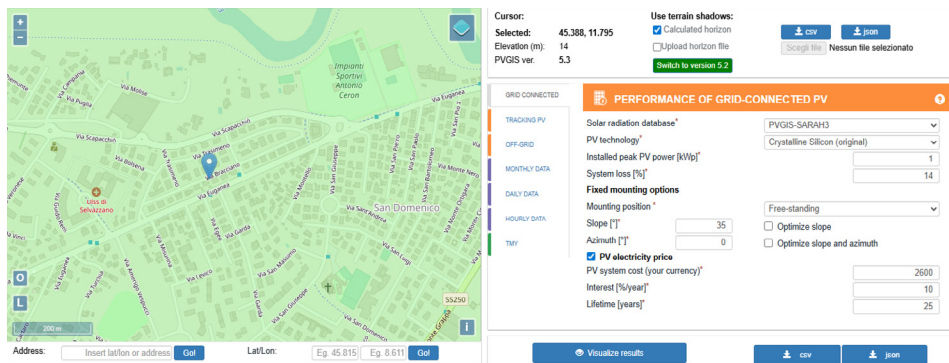
## MAIN ADVANTAGES

Very user-friendly tool

## MAIN DISADVANTAGES

- The calculation of the output of the photovoltaic system is very approximate.
- Photovoltaic electricity prices are not provided.

# PVGIS



## SOURCE

[https://re.jrc.ec.europa.eu/pvg\\_tools/en/](https://re.jrc.ec.europa.eu/pvg_tools/en/)

## DEVELOPER

European Commission's Joint Research Centre

## TYPE OF RESOURCES

Energy simulation tool (RES)

## SHORT DESCRIPTION

Web application that allows the user to obtain data on solar radiation and photovoltaic (PV) system energy production, including cost of PV electricity anywhere in most parts of the world. It provides estimates on monthly and yearly electricity production of a PV (fixed PV connected to the electricity grid, free-standing or on a building, tracking PV, or Off-grid), by selecting the location and some parameters.

## PHASE OF THE H&C PLAN

Intervention and decarbonisation scenarios: Renewable energy sources

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

User-friendly

## TUTORIALS AVAILABLE

<https://www.youtube.com/watch?v=Zm4NLbvOwjw>

## OUTPUT OF THE TOOL

- Monthly and yearly electricity production [kWh]
- Monthly and yearly in-plane irradiation for fixed angle [kWh/m²]
- PV electricity cost [€/kWh]

## REQUIRED INPUT

- Location PV technology Installed capacity System Loss-Mounting options
- Location Slope and Azimuth angle
- PV system cost Interest Lifetime

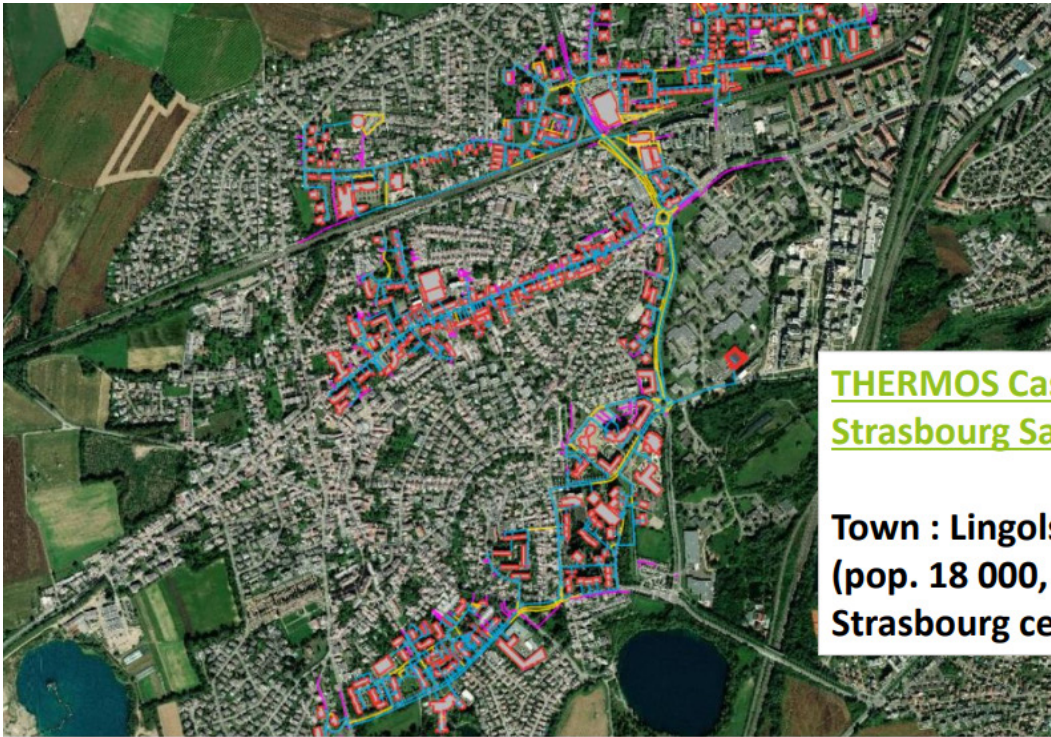
## MAIN ADVANTAGES

Allow to download hourly values

## MAIN DISADVANTAGES

Limited choice among PV technologies (Crystalline silicon, CIS, CdTe).

# THERMOS



## **THERMOS Case Study : Strasbourg Satellite Town**

**Town : Lingolsheim  
(pop. 18 000, 6km from  
Strasbourg centre)**

### **SOURCE**

<https://www.thermos-project.eu/thermos-tool/tool-access/>

### **DEVELOPER**

THERMOS EU-funded project

### **TYPE OF RESOURCES**

Energy simulation tool (DHCN)

### **SHORT DESCRIPTION**

THERMOS is web-based energy planning software that provides accurate heat and cold network options analysis instantly within one web-based. The software is designed to optimise local district energy network planning processes and sustainable energy master planning to facilitate the deployment of new low-carbon heating and cooling systems and a fast upgrade, refurbishment, and expansion of existing systems.

### **PHASE OF THE H&C PLAN**

Intervention and decarbonisation scenarios: Enhancement of distribution grids

### **AVAILABLE FOR FREE/LICENSE**

Entirely free

### **USER FRIENDLINESS**

Need for practice

### **TUTORIALS AVAILABLE**

<https://www.thermos-project.eu/tool-support/training-materials/>

### **OUTPUT OF THE TOOL**

- Space heating and cooling demand of buildings [MWh/yr]
- Optimised DHCN design (including supply model) Network heat losses [kWh]
- GHG emissions [t/yr]
- DHCN costs (total and specific) and revenues [€]

### **REQUIRED INPUT**

- Selected area
- Excess heat from industrial sites wastewater treatment plants

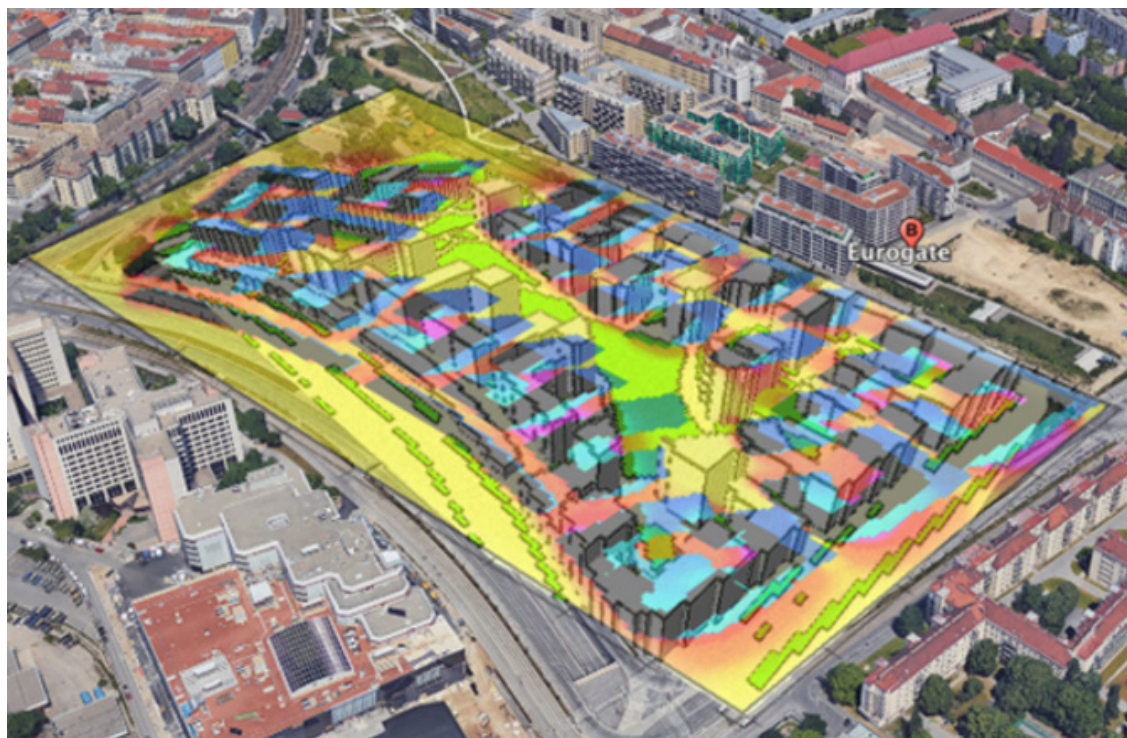
### **MAIN ADVANTAGES**

Free and open Source

### **MAIN DISADVANTAGES**

It cannot consider buildings connected to the network as prosumers.

# GREENPASS®



## SOURCE

<https://www.greenpass.io/>

## DEVELOPER

GreenPass

## TYPE OF RESOURCES

Energy simulation tool (buildings)

## SHORT DESCRIPTION

GREENPASS offers a solution to quantify and measure the effects of green infrastructures on urban areas, enabling the efficient planning of climate resilient livable cities. It is an artificial intelligence-based platform for analyzing climate-resilient properties in compliance with the EU taxonomy.

## PHASE OF THE H&C PLAN

Baseline assessment: Assessment of local vulnerabilities

## AVAILABLE FOR FREE/LICENSE

Licence needed

## USER FRIENDLINESS

Need for practice

## TUTORIALS AVAILABLE

<https://support.greenpass.io/portal/en/home>

## OUTPUT OF THE TOOL

- Outdoor Thermal Comfort (climate heat islands) [%]
- Mitigation and adaptation recommended measures
- Implementation costs mitigation and adaptation measures [€]

## REQUIRED INPUT

- Selected area
- GIS file of buildings height
- Presence and type of nature-based solutions

## MAIN ADVANTAGES

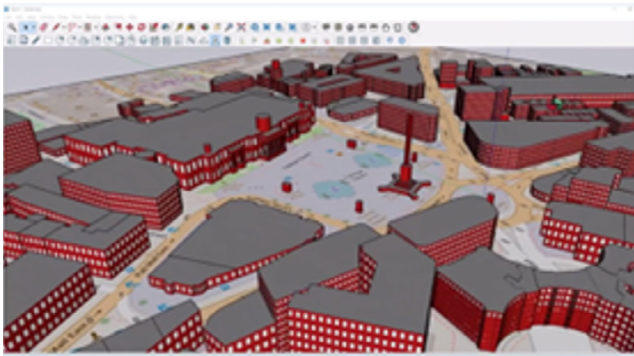
Use of nature based solutions

## MAIN DISADVANTAGES

Not free



# IES iCD (Intelligent Community Design)



## SOURCE

<https://www.iesve.com/products/icd>

## DEVELOPER

IES

## TYPE OF RESOURCES

Energy simulation tool (buildings)

## SHORT DESCRIPTION

It is a 3D urban planning tool that allows for the development of the baseline scenario and the application of requalification scenarios at the urban level through dynamic energy simulation.

## PHASE OF THE H&C PLAN

- **Baseline assessment:** H&C demand and consumption
- **Intervention and decarbonisation scenarios:** simulating building retrofits, renewable energy sources.
- **Evaluation and comparison of different scenarios—road-map:** energy, emissions and economic comparison.

## AVAILABLE FOR FREE/LICENSE

Not free

## USER FRIENDLINESS

Need for practice

## TUTORIALS AVAILABLE

<https://www.iesve.com/support/icd>

## OUTPUT OF THE TOOL

- Outdoor Thermal Comfort (climate heat islands) [°C]
- Buildings energy consumptions (heating, cooling, DHW, electricity, lighting) [MWh/yr]
- Annual and monthly site energy consumption (heating, cooling, DHW, electricity, lighting) [MWh]
- Primary energy demand per scenario comparison [GWh]
- CO<sub>2</sub> missions per scenario comparison [kgCO<sub>2</sub>]

## REQUIRED INPUT

- Selected area
- GIS file of buildings height
- GIS file of destination use of building

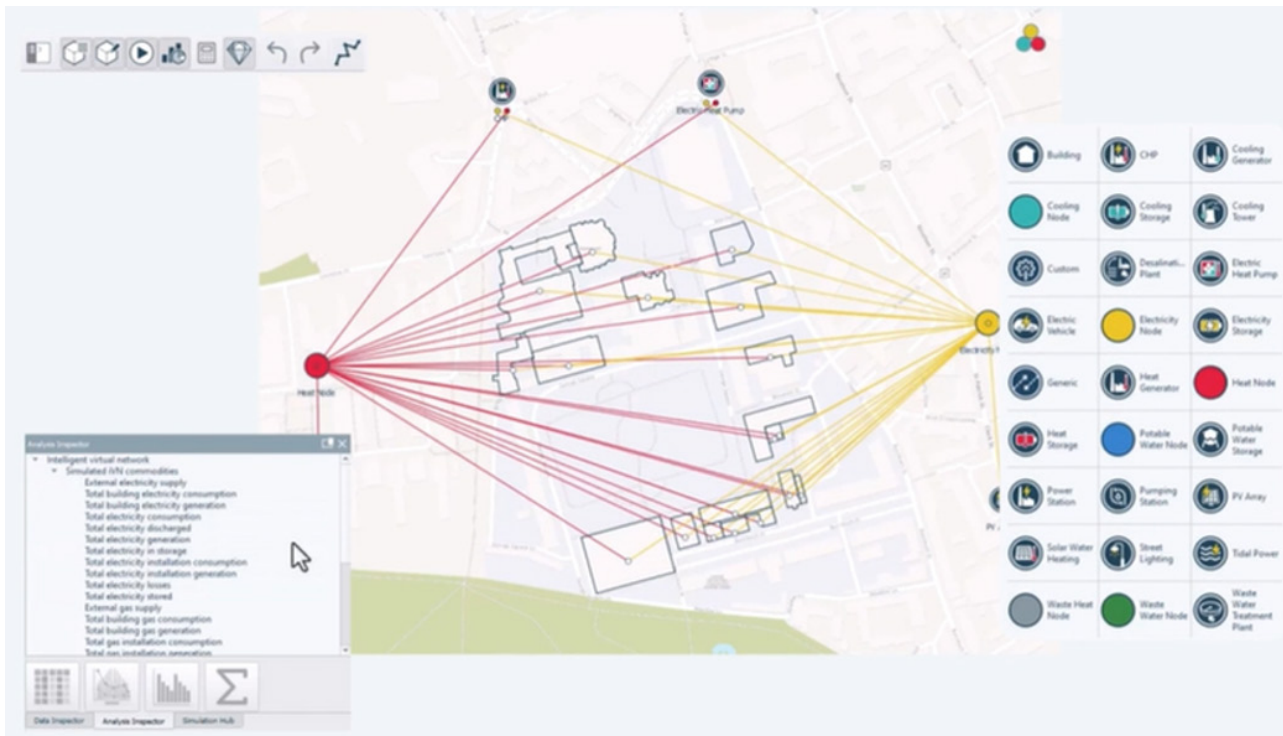
## MAIN ADVANTAGES

- Ready-made report available
- Possible to import data (building geometry, use) from OpenStreetMap
- Possible to use the internal database based on ASHRAE 90.1-2016 Standard

## MAIN DISADVANTAGES

Like all Urban Building Energy Models (UBEMs), accuracy can be affected by simplifications necessary for large-scale analysis

# IES iCD (Intelligent Virtual Network)



## SOURCE

<https://www.iesve.com/products/ivn>

## DEVELOPER

IES

## TYPE OF RESOURCES

Energy simulation tool (buildings)

## SHORT DESCRIPTION

IES iVN is a software solution used for local energy decarbonisation and feasibility studies for new or existing communities, campuses. It allows engineers and planners to design, model, and optimize integrated energy networks—including electricity, heating, cooling, and water—by simulating how they interact with each other and with the energy demands of the connected buildings.

## PHASE OF THE H&C PLAN

Evaluation and comparison of different scenarios – Roadmap: Impact of energy communities

## AVAILABLE FOR FREE/LICENSE

Not free

## USER FRIENDLINESS

Need for practice

## TUTORIALS AVAILABLE

<https://www.iesve.com/support/ivn>

## OUTPUT OF THE TOOL

Self-consumption of electricity produced by PV for the HP installed in the considered buildings

## REQUIRED INPUT

Energy simulation performed with iCD

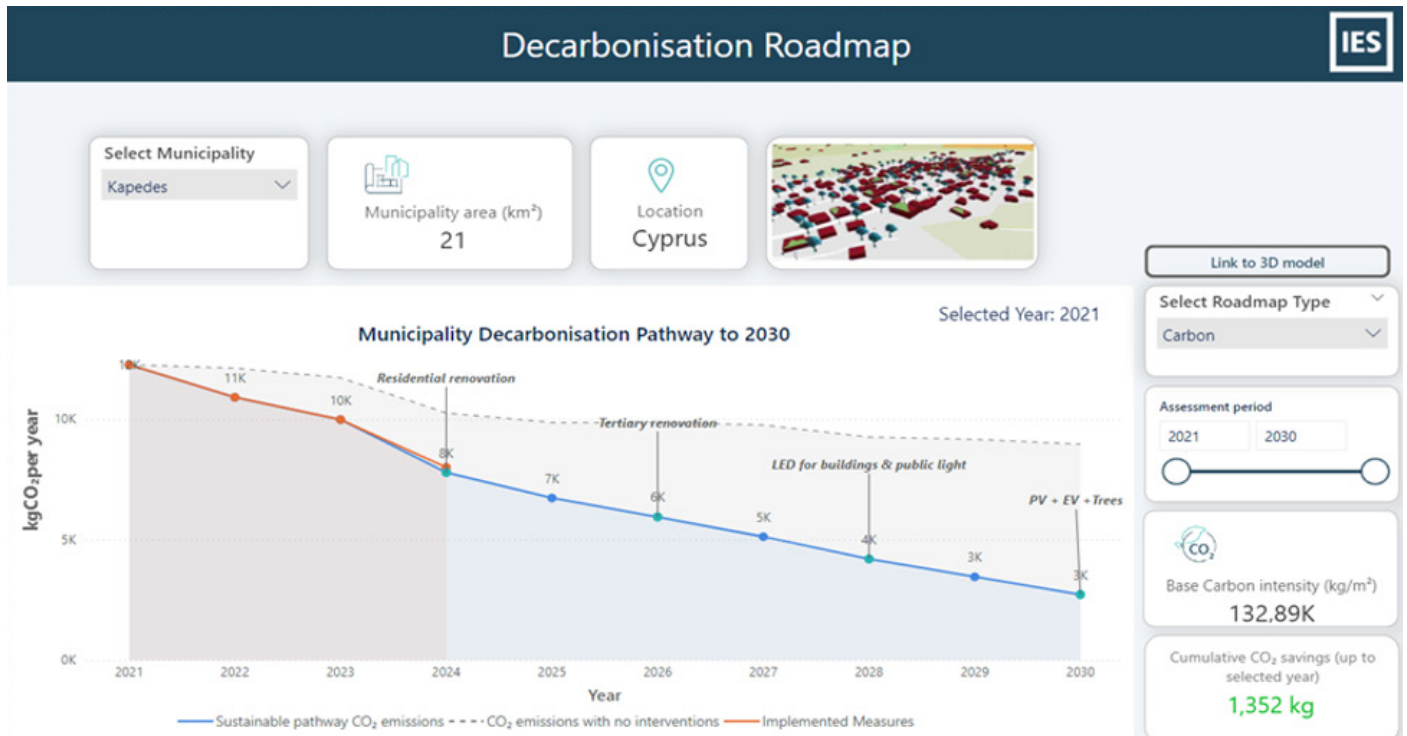
## MAIN ADVANTAGES

- Holistic and integrated network modeling for the different energy vectors
- Comprehensive analysis and reporting

## MAIN DISADVANTAGES

- Complexity and learning curve
- Data dependency
- Cost and access

# Power BI



## SOURCE

<https://www.microsoft.com/it-it/power-platform/products/power-bi?market=it>

## DEVELOPER

Microsoft

## TYPE OF RESOURCES

Planning tool

## SHORT DESCRIPTION

It is an interactive data-visualisation and analytics solution based on Microsoft Power BI, designed to support energy system analysis and decision-making. It integrates and processes large energy-related datasets to present key indicators, trends and scenarios through intuitive dashboards and reports. The tool enables users to monitor performance, compare scenarios, and support strategic planning by translating complex technical and economic data into clear, accessible insights for policymakers, planners, engineers and other energy stakeholders.

## PHASE OF THE H&C PLAN

Evaluation and comparison of different scenarios – Roadmap: Roadmap development

## AVAILABLE FOR FREE/LICENSE

License needed

## USER FRIENDLINESS

User-friendly

## TUTORIALS AVAILABLE

<https://learn.microsoft.com/en-us/training/modules/get-started-with-power-bi/>

## OUTPUT OF THE TOOL

- Visualisation of different roadmaps related to primary energy demand [MWh/yr]
- Visualisation of different roadmaps related to CO<sub>2</sub> emissions [kgCO<sub>2</sub>/yr]

## REQUIRED INPUT

- Primary energy demand results from iCD
- CO<sub>2</sub> emissions results from iCD

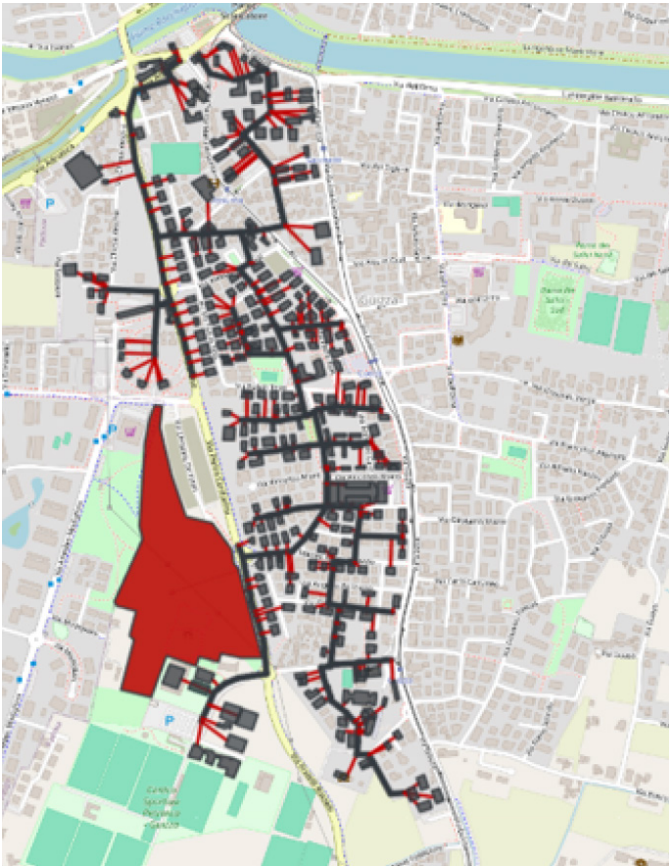
## MAIN ADVANTAGES

- Intuitive and interactive dashboard
- Graphical outputs for stakeholders: useful for municipal reporting and decision-making
- Supports scenario comparison

## MAIN DISADVANTAGES

- Commercial software: requires licensing.
- It is primarily a decision-support and visualisation tool rather than a standalone simulation or optimisation engine.

# nPro



## SOURCE

<https://app.npro.energy/>

## DEVELOPER

nPro Energy

## TYPE OF RESOURCES

Energy simulation tool (DHCN)

## SHORT DESCRIPTION

nPro is a modular, flexible software tool that simplifies and accelerates the traditional, manual planning of districts. It was specifically developed for the early planning phase, where only limited information about a district and energy system is available.

## PHASE OF THE H&C PLAN

**Intervention and decarbonisation scenarios:** renewable energy sources, enhancement of distribution grids  
**Evaluation and comparison of different scenarios – Roadmap:** energy, emission and economic comparison

## AVAILABLE FOR FREE/LICENSE

License needed

## USER FRIENDLINESS

Need for practice

## TUTORIALS AVAILABLE

[https://www.youtube.com/@npro\\_energy%20/videos](https://www.youtube.com/@npro_energy%20/videos)

## OUTPUT OF THE TOOL

- Space heating and cooling demand of buildings [MWh/yr]
- Optimised DHCN design (including supply model)
- Network heat losses [kWh]
- CO2 emissions [tCO2/yr]
- DHCN costs (total and specific) and revenues [€]
- Heat extraction/(injection) from borehole field (hourly profile) [MWh]
- Solar thermal plant heat production (hourly profile) [MWh]

## REQUIRED INPUT

- Selected area
- GIS file buildings geometry and consumptions
- Excess heat from industrial sites, wastewater treatment plants
- Geothermal borehole field specifications (for geothermal HP)
- Slope and Azimuth angle (for solar thermal plant)

## MAIN ADVANTAGES

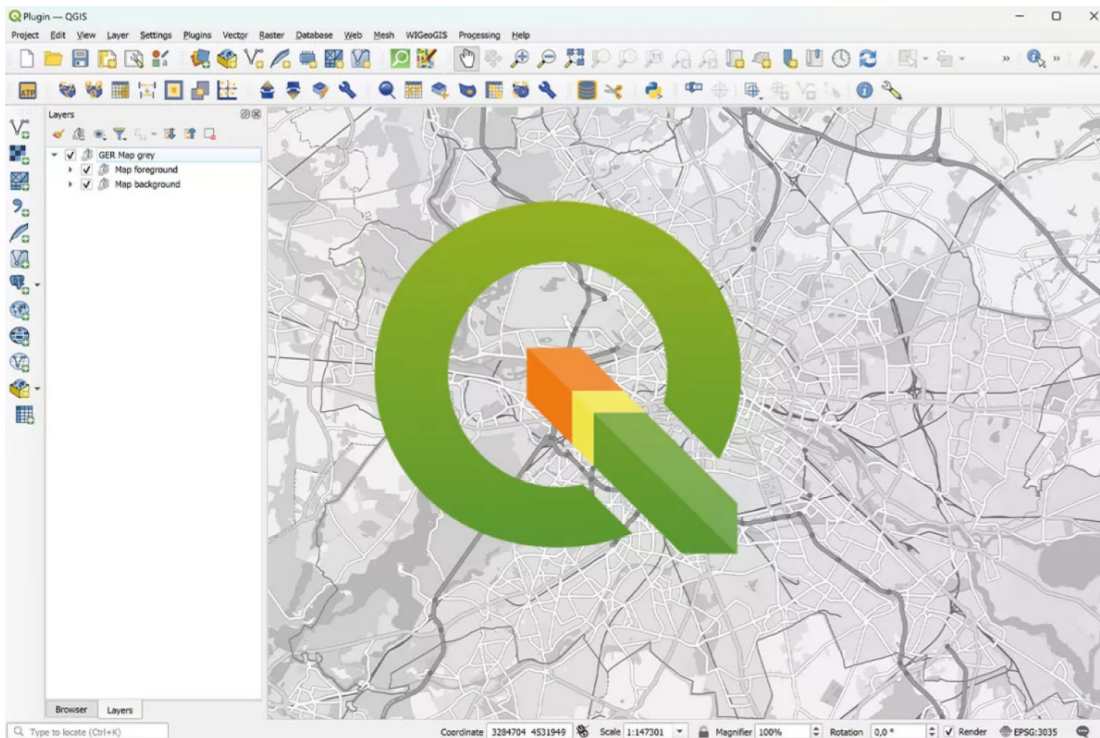
- Scenario-based planning: models different energy futures including district cooling and RES integration
- Graphical outputs for stakeholders: useful for municipal reporting and decision-making
- Ready-made report available
- It can consider buildings connected to the network as prosumers.

## MAIN DISADVANTAGES

- Commercial software: requires licensing, which may be a barrier for smaller municipalities
- Users must understand energy system modeling principles to fully utilize it



# QGIS (Quantum Geographic Information System)



## SOURCE

<https://qgis.org/>

## DEVELOPER

QGIS Development Team

## TYPE OF RESOURCES

Planning tool

## SHORT DESCRIPTION

It is a free, open-source geographic information system that allows users to create, edit, analyse and visualise spatial and geospatial data through an intuitive interface, supporting a wide range of data formats and tools for mapping, spatial analysis and decision support.

## PHASE OF THE H&C PLAN

Baseline assessment: H&C demand and consumption

## AVAILABLE FOR FREE/LICENSE

Free

## USER FRIENDLINESS

Need for practice

## TUTORIALS AVAILABLE

[https://docs.qgis.org/3.40/en/docs/training\\_manual/index.html](https://docs.qgis.org/3.40/en/docs/training_manual/index.html)

## OUTPUT OF THE TOOL

- GIS file of buildings height
- GIS file of destination use of buildings

## REQUIRED INPUT

- Building height Raster
- Destination use of buildings Vector

## MAIN ADVANTAGES

- It is free and open-source
- It supports a large variety of spatial data formats and standards, ensuring strong interoperability
- It has a large and active user and developer community that continuously improves the software and provides extensive documentation

## MAIN DISADVANTAGES

- The learning curve can be steep for new users due to the wide range of tools and options

# SYNERGISE+

**PROSPECT+**

**SYNERGISE+ | SECAP Prioritisation Tool**  
Aligning sustainable actions with local goals and priorities

Dear Decision-Maker,

We applaud your efforts to enhance your city's resilience to climate change while respecting local goals and preferences. Our adaptive framework is a tool designed to assist you in prioritizing both mitigation and adaptation actions for investment.

It is based on extensive research, but its true strength lies in engaging key stakeholders to collaboratively establish common goals and values for your community. Customizing the framework to local preferences ensures the effective implementation of plans. This exercise is designed as a participative guide helping stakeholders make informed decisions about sustainable actions to achieve local goals and preferences. Additionally, it facilitates checking compliance with the EU Taxonomy for sustainable activities.

The SYNERGISE+ tool can be used both in the phase of developing a SECAP or with existing SECAPs to understand which actions to implement first. It is a practical aid when details are scarce. It recognizes that it can be difficult and time-consuming to measure the full benefits of each action and to compare different benefits, such as energy savings and nature conservation, against each other to decide which ones are right for your local context. Instead, the tool helps you make a qualitative analysis of the impacts of each action. The goal is to encourage greater impacts by helping you recognise and take advantage of synergies among some adaptation and mitigation actions and to consider new actions that go beyond your current SECAP.

Thank you for your commitment to a climate-resilient future!

The PROSPECT+ project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 101023271

Tool last updated: July 10, 2024

## SOURCE

<https://www.h2020prospect.eu/synergie>

## DEVELOPER

PROSPECT+ project EU funded

## TYPE OF RESOURCES

Planning tool

## SHORT DESCRIPTION

A practical Excel-based tool designed to help decision-makers prioritize actions from Sustainable Energy and Climate Action Plans (SECAPs).

The tool helps in aligning local goals and preferences with climate resilience objectives and facilitates qualitative analysis of mitigation and adaptation actions with the information cities already have on all the actions.

It is designed to be a comprehensive tool, guiding cities through the range of decision-making options from simple to complex, helping them create a tailored approach that fits their unique needs and preferences.

## PHASE OF THE H&C PLAN

- Actions prioritization and target scenario set-up – evaluation of multiple impacts and selection of the most beneficial actions, comparison of different policy design.
- Roadmap preparation

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

User-friendly

## TUTORIALS AVAILABLE

[https://h2020prospect.eu/sites/default/files/tools/SYNERGISE%2B/PROSPECT%2B\\_D5.4\\_decision-making\\_guide\\_Final\\_v02.pdf](https://h2020prospect.eu/sites/default/files/tools/SYNERGISE%2B/PROSPECT%2B_D5.4_decision-making_guide_Final_v02.pdf)

## OUTPUT OF THE TOOL

The results of using the SYNERGISE+ Tool are displayed in multiple ways and gives different rankings and visual interpretations which guide decision-makers to understanding the wide-ranging effect of their actions and to detecting what is going well in their SECAP, and what could be improved.

## REQUIRED INPUT

Have a SECAP or other sustainable plans at hand and have a list of key stakeholders to involve in the decision-making process.

## MAIN ADVANTAGES

The guide aims to enhance decision-making at two critical stages:

- planning - helping cities select actions for Sustainable Energy and Climate Action Plans – SECAPs)
- implementation - helping cities that face budget limitations in prioritising investments based on specific criteria.

## MAIN DISADVANTAGES

Have a SECAP and know its contents very well.

# REGIO1st



## SOURCE

● <https://regio1st-planning-framework.fedarene.org/tools>

## DEVELOPER

● REGIO1ST project EU funded

## TYPE OF RESOURCES

● Planning tool

## SHORT DESCRIPTION

The Regio1st Planning Framework provides a comprehensive, structured approach to develop and implement sustainable, cost-effective regional energy strategies while prioritizing energy savings in buildings, system flexibilities and other energy efficiency solutions in line with the Energy Efficiency First (EE1st) principle.

## PHASE OF THE H&C PLAN

Streamlines the overall energy planning process

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

User-friendly

## TUTORIALS AVAILABLE

[https://regio1st-planning-framework.eu.buildspaceproject.eu/sites/default/files/manual/D2.2%20Regio1st%20Planning%20Framework%20Guiding%20document\\_final.pdf](https://regio1st-planning-framework.eu.buildspaceproject.eu/sites/default/files/manual/D2.2%20Regio1st%20Planning%20Framework%20Guiding%20document_final.pdf)

<https://regio1st-planning-framework.fedarene.org/training-material>

<https://regio1st-planning-framework.fedarene.org/video-tutorials>

## OUTPUT OF THE TOOL

A comprehensive roadmap to develop and implement sustainable, cost-effective, and energy-efficient regional strategies and plans that align with the Energy Efficiency First principle

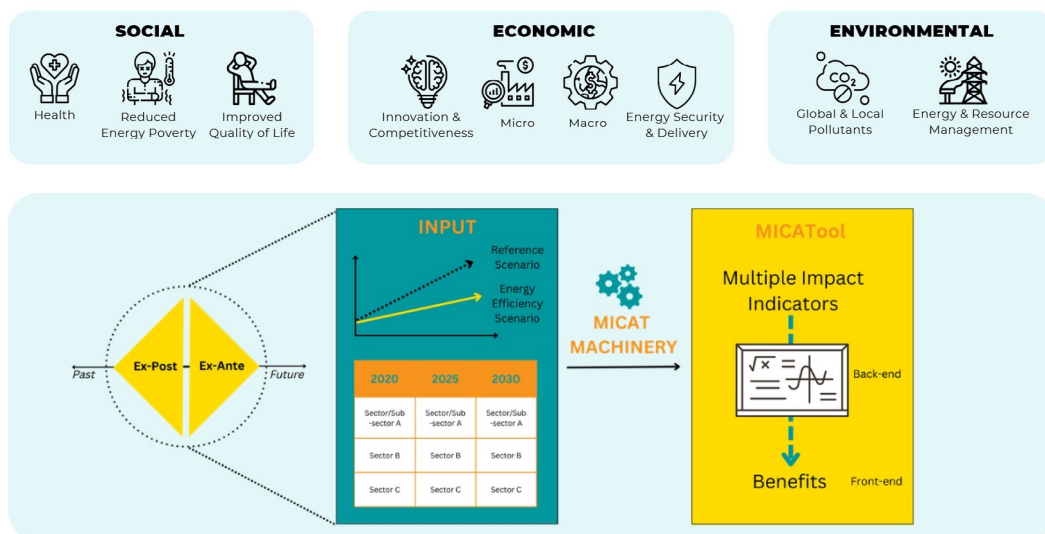
## MAIN ADVANTAGES

- Provides a comprehensive roadmap for regional energy planners to develop and implement sustainable, cost-effective, and energy-efficient strategies and plans that align with the Energy Efficiency First principle.
- Provides a structured decision-support framework, including stages such as preparation, engaging stakeholders and cost-benefit analysis.
- Includes tools that can assist planners through different stages of the process such as data collection, scenario modelling, cost-benefit analysis, social cost-benefit analysis, multi-criteria decision analysis

## MAIN DISADVANTAGES

For regional public authorities and/or regional agencies only

# MICATool



## SOURCE

<https://ieecp.org/wp-content/uploads/2023/11/RE-energising-Europe-MICAT.pdf>

## DEVELOPER

MICAT project EU funded

## TYPE OF RESOURCES

Planning tool

## SHORT DESCRIPTION

A publicly available, easy-to-use online tool which enables the holistic analyses and quantification of multiple impacts associated with energy efficiency.

Allows for robust analyses to be carried out on the basis of different policy scenarios in order to compare and assess the relevance of a number of social, economic, and environmental indicators and impacts.

## PHASE OF THE H&C PLAN

- Actions prioritization and target scenario set-up – evaluation of multiple impacts and selection of the most beneficial actions, comparison of different policy design.
- SLHCP monitoring

## AVAILABLE FOR FREE/LICENSE

Entirely free

## USER FRIENDLINESS

Relatively user-friendly

## TUTORIALS AVAILABLE

<https://doc.micatool.eu/index.html>

## OUTPUT OF THE TOOL

SThree concrete implementation concepts for Multiple Impact analyses: specific analyses on import dependencies, energy system resilience, and biodiversity impacts. Simplified analyses for different data and policy scenarios, in order to compare and assess the relevance of the

multiple impacts, and strengthen reporting and monitoring on energy efficiency within Sustainable Energy and Climate Action Plans (SECAPs).

## REQUIRED INPUT

The energy savings of measures and the RES plant power have to be inputted

## MAIN ADVANTAGES

Provide a comprehensive multiple impact analysis of use cases or scenarios

### Social indicators

- Reduction in energy poverty
- Health impacts due to improved indoor climate
- Reduced excess cold weather mortality linked to indoor cold
- Reduced mortality due to reduced air pollution
- Avoided lost working days due to air pollution

### Economic indicators

- Impact on GDP
- Employment effects
- Impact on energy intensity
- Asset value of buildings
- Turnover of energy efficiency goods
- Import dependence
- Supplier diversity
- Avoided investments in additional capacity

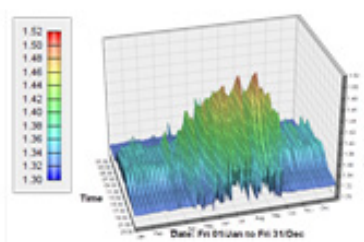
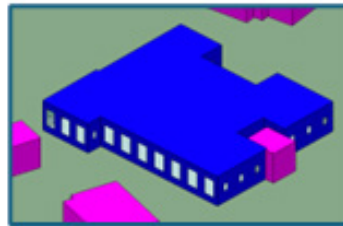
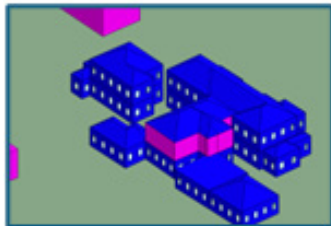
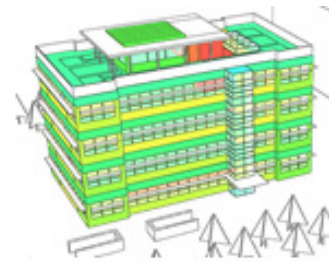
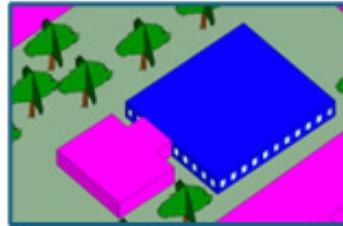
### Ecologic indicators

- Energy savings
- Impact on RES targets
- Greenhouse gas savings
- Reduction in air pollution

## MAIN DISADVANTAGES

Information and quantitative data concerning intervention scenarios requested as inputs

# Data Driven Tool



| Scenario<br>DN<br>DO NOTHING | Scenario<br>DM<br>N/A | Scenario<br>1 <sup>1</sup><br>SERRAMENTI | Scenario<br>2 <sup>2</sup><br>IMPIANTO | Scenario<br>3<br>PV | Scenario<br>4<br>IMPIANTO+PV | Scenario<br>5 <sup>3</sup><br>INV+IMP+PV |
|------------------------------|-----------------------|------------------------------------------|----------------------------------------|---------------------|------------------------------|------------------------------------------|
| D                            | -                     | D                                        | B                                      | B                   | A4                           | A4                                       |
| -                            | -                     | 3,2%                                     | 47,4%                                  | 51,6%               | 99,8%                        | 112,1%                                   |
| -                            | -                     | -                                        | -                                      | 51.530              | 51.530                       | 51.530                                   |
| 32.285                       | -                     | 31.497                                   | 28.400                                 | 4.459               | 124                          | -6.506                                   |
| -                            | -                     | 63.260                                   | 122.299                                | 61.072              | 192.753                      | 517.670                                  |
| -                            | -                     | 25.304                                   | 79.494                                 | 0                   | 79.494                       | 209.461                                  |
| 16.675                       | -                     | 16.675                                   | 8.900                                  | 43.394              | 35.419                       | 35.419                                   |
| -                            | -                     | 176                                      | -306                                   | 8.425               | 8.254                        | 10.262                                   |
| -                            | -                     | -15,5%                                   | -11,5%                                 | 12,5%               | 2,6%                         | -4,4%                                    |
| -                            | -                     | >50                                      | >50                                    | 6                   | 13                           | 34                                       |
| -                            | -                     | -722.734                                 | -941.725                               | 657.148             | -426.409                     | -3.858.407                               |
| -                            | -                     | 226.443                                  | 242.019                                | 99.213              | 110.975                      | 381.884                                  |

## DEVELOPER

R2M Solution

## TYPE OF RESOURCES

Planning tool

## SHORT DESCRIPTION

The tool addresses the lack of granular municipal data by relying on an internal database. Building datasets are used to train machine learning algorithms that classify buildings into clusters, each represented by an archetype. Energy simulations are run on these archetypes in advance, covering a wide range of efficiency measures. When a user inputs a new building, the system assigns it to the closest cluster and extrapolates results from the corresponding archetype.

## PHASE OF THE H&C PLAN

**Baseline assessment:** H&C demand and consumption

**Intervention and decarbonisation scenarios:** renewable energy source, enhancement of distribution grids

**Evaluation and comparison of different scenarios - roadmap:** energy, emission and economic comparison

## AVAILABLE FOR FREE/LICENSE

Free

## USER FRIENDLINESS

User-friendly

## OUTPUT OF THE TOOL

- Baseline estimation
- Heating energy savings and cooling demand reduction
- Renewable Energy Integration

## REQUIRED INPUT

- Buildings' destination of use
- Heated and cooled volume
- Years of construction and renovation (if any)
- HVAC system, and heating (and cooling) schedule

## MAIN ADVANTAGES

- It will be free and open-source
- It will estimate energy savings and the impact of interventions for the specific building, ensuring robust outputs even when municipal input data is limited

## MAIN DISADVANTAGES

It is under development

