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How to plan mitigation, adaptation and energy poverty actions

Covenant of Mayors Guidebook | Complementary document 4

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Abstract

The Covenant of Mayors for Climate and Energy (CoM) is an ambitious initiative for local climate and energy actions. This document complements the main document of the CoM Guidebook by providing signatories with guidance to develop effective mitigation, adaptation and energy poverty actions, and some examples of best practices to develop their sustainable energy and climate action plan (SECAP).

This complementary document 4 of the guidebook provides a structured approach to the action planning and strategies step, guiding cities through the process of designing effective actions both in short and long term to achieve their climate and energy goals. This includes explaining the role of municipalities in driving change, highlighting four key roles that cities can play in addressing climate and energy challenges. This document also provides guidance on translating the goals established in each pillar (mitigation, adaptation, and energy poverty) into concrete actions, including integrated actions that simultaneously address multiple challenges. Additionally, it offers practical advice on prioritising actions, helping cities to focus on the most impactful interventions. The document also emphasises the importance of designing a sound monitoring and evaluation scheme to track the impact, deployment, and co-benefits of actions. Furthermore, it provides relevant considerations at the pillar level, along with good practices and case studies to inspire and inform municipalities' action planning efforts.

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Finally, we thank Bagdagul Tan for the graphic design support.

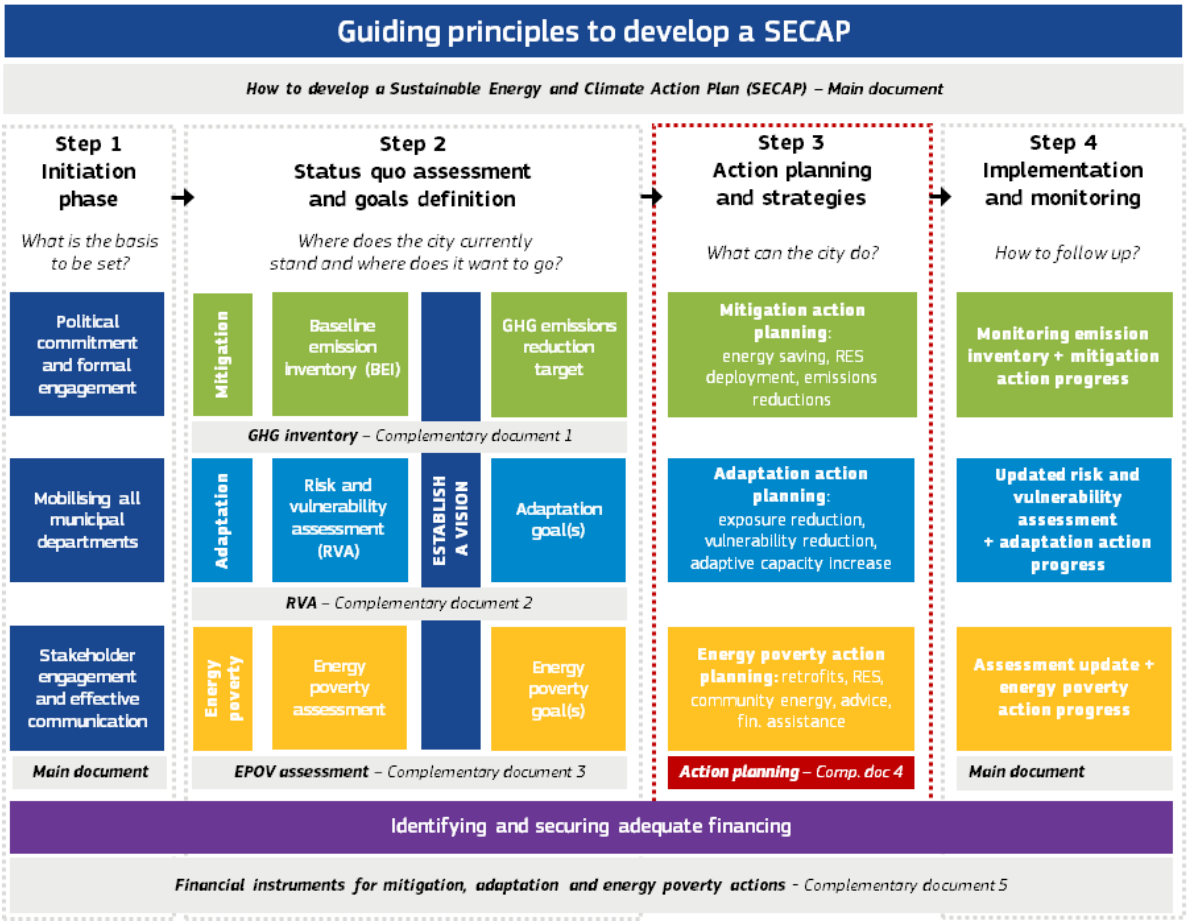
This document builds on the previous Guidebook 'How to develop a Sustainable Energy and Climate Action Plan (SECAP)' published in 2018, edited by Paolo Bertoldi, and in particular on the work done on Part 3a by Albana Kona, Valentina Palermo, Paolo Zangheri, Tiago Serrenho, Silvia Rivas, Nicola Labanca (JRC), Siir Kilkis (Scientific and Technological Research Council of Turkey -TUBITAK - Ankara), Oliver Lah (Wuppertal Institute for Climate, Environment and Energy – Wuppertal), Ryan Glancy (Aether Ltd – Oxford) and Part 3b by Marco Follador, Valentina Palermo, Silvia Rivas, Paulo Barbosa (JRC).

1 Introduction

The Covenant of Mayors guidebook "How to develop a sustainable energy and climate action plan (SECAP)" (2025) is a guidance document developed for cities that committed to ambitious climate and energy targets and provides the relevant tools to accompany them in every step of the way. It is based on and updates the previous version of the guidebook from 2018 (Andreanidou, K., Bertoldi et al., 2018; Bertoldi, 2018; Bertoldi et al., 2018).

For clarity and ease of use, the guidebook is conceived in a modular manner, with a main document ("How to develop a Sustainable Energy and Climate Action Plan (SECAP)")[1] explaining the guiding principles to define a SECAP and five complementary documents that provide details on specific topics, e.g. performing assessments, establishing goals, providing finance guidance or explaining how monitoring should be performed, as it can be seen in the Figure 1 below.

Figure 1. Covenant guidebook structure and complementary document 4 "How to plan mitigation, adaptation and energy poverty actions"



Source: JRC elaboration

[1] How to develop a Sustainable Energy and Climate Action Plan (SECAP) (2025) – main document https://publications.jrc.ec.europa.eu/repository/handle/JRC142148

This document focuses on the third step of the Sustainable Energy and Climate Action Plan (SECAP) definition process, i.e. action planning, and covers the three Covenant pillars: mitigation, adaptation and energy poverty. Building on previous steps, this document guides the process from understanding the context, to designing actions and preparing for implementation. The plan's development involves proposing a balanced action portfolio, designing individual actions, and prioritising them based on feasibility, impact and coherence. Additionally, the document offers insights to prepare for the implementation and monitoring step and provides some references to financing. To do so, a series of key topics are addressed (Figure 2), which structure the document. By following this structured approach, municipalities can create an effective SECAP that addresses their unique needs and goals, based on their specific context.

Figure 2. Main topics covered in the "How to plan mitigation, adaptation and energy poverty – complementary document 4"

Source: JRC elaboration

Finally, this document is complemented with two annexes. Annex 1 complements section 6 by summarising action-level indicators, whereas Annex 2 gathers all the actions mentioned throughout the document to facilitate the scanning of good practices.

Box 1. Actions / response / measures included in this guidebook

In the context of climate change, an action, response, or measure refers to the steps taken, or strategies implemented to mitigate GHG emissions, address and manage climate risks or alleviate energy poverty. These terms are used interchangeably throughout the guidebook.

These actions can range from policy changes and infrastructure improvements to community-based initiatives and technological innovations. To facilitate the reader's screening and understanding of the document, actions in all pillars have been classified into four categories (see section 3).

The sources of the identified actions are varied: some actions are planned or already implemented in SECAPs, others are included in climate city contracts[2], derive from other case study analysis exercises, are part of demonstration activities in research projects or are generally accepted as good practices. Most of the actions

[2] As part of the Climate-Neutral and Smart Cities Mission (https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/climate-neutral-and-smart-cities_en), 112 cities have been selected to develop their climate city contracts (CCC) to achieve climate neutrality by 2030. (https://netzerocities.eu/climate-city-contract/)

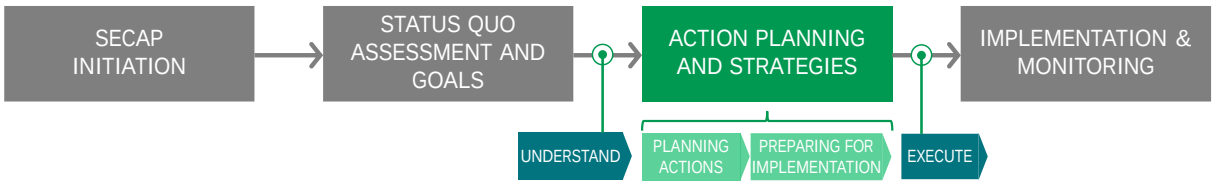
are linked to the local level, but there are some actions that relate to the regional or national level. These actions can inspire municipalities on how to collaborate with neighbouring municipalities or other governance levels.

The main objective of these real case studies is to illustrate the different concepts explained within the guidebook and inspire municipalities by showcasing examples in each of the pillars that can be adapted to the local situation and included in their SECAPs.

2 The action planning and strategies step

The action planning and strategies step within a SECAP development process consists of two sub-steps: (1) planning a balanced set of climate and energy actions and strategies and (2) preparing for the implementation and monitoring of the actions. These steps have to be necessarily preceded by a sound assessment of the status quo and the establishment of a vision and goals (Figure 3), and also provide a link to the subsequent execution step: implementation and monitoring.

Figure 3. The action planning and strategies step: planning actions and strategies at local level and preparing for implementation and monitoring



Source: JRC elaboration

Understanding the local situation: a coherent, targeted and effective action plan should build on a sound and detailed understanding of the local situation (see complementary documents 1, 2, and 3). This includes not only the governance structure and stakeholders mobilised (addressed in the initiation phase), but also the existing policies, drivers and barriers and the current mitigation, adaptation and energy poverty assessment (status quo assessment step). As it is explained in the main and other complementary documents, this is performed through the calculation of a GHG emissions inventory[3], a risk and vulnerability assessment[4], and an energy poverty assessment[5]. Detecting existing barriers (including legal, physical, social and economic barriers) as well as potential synergies/trade-offs among sectors could also determine how to envision an adequate action plan, which stakeholders are crucial and what main financial gaps exist. In addition, the financial landscape should be assessed to identify potential funding opportunities and mechanisms to address existing financing gaps (see complementary document 5). This includes exploring options such as soft and green loans, green bonds, revolving funds, public-private partnerships, and local co-funding opportunities. Evaluating the financial capacity of the municipality and other stakeholders is crucial to ensuring the feasibility and sustainability of the actions outlined in the SECAP. Aligning planned actions with available financing instruments can significantly enhance their implementation potential. Also, the decision-making power of the municipality should be assessed to understand the different roles the municipality can play to trigger action at different levels of governance (see section 3). All this analysis should be considered before defining the SECAP's objectives.

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3 See complementary document 1 "How to prepare a greenhouse gas emission inventory": https://publications.jrc.ec.europa.eu/repository/handle/JRC142296

4 See complementary document 2 "How to develop a risk and vulnerability assessment (RVA)": https://publications.jrc.ec.europa.eu/repository/handle/JRC142117

5 See complementary document 3 "How to develop an energy poverty assessment": https://publications.jrc.ec.europa.eu/repository/handle/JRC142169

Action planning and strategies: the robust understanding of the context needs to be translated into a balanced, ambitious and achievable action plan. This includes not only the action portfolio (i.e. planning actions) but also preparing the implementation and monitoring of the actions.

- Planning actions: the actions included in the SECAP need to be aligned with the goals set by the municipality in the three pillars (mitigation, adaptation, and energy poverty). Consequently, (1) all relevant emitting sectors should be addressed in relation to mitigation, (2) there should be actions targeting all relevant climate risks, and (3) actions to tackle energy poverty should be included. To do so, it is fundamental to secure the human and financial resources and involve relevant stakeholders, define a clear timeline for the implementation of the actions and estimate their potential impact. If helpful for planning, the actions may be outlined in a portfolio that entail a series of fiches, where actions are detailed. A suggested template with the relevant information to be detailed can be seen in section 5.3.
- Preparing for implementation and monitoring: creating and maintaining an enabling environment throughout the action's implementation is critical to support their deployment. This includes the regulatory framework, governance structure and engagement with residents and / or relevant stakeholders. It is recommended to account for potential disturbances during the actions' implementation that would require the municipality to readjust the path, if necessary, towards reaching the expected goals. To do so, it is necessary to set an adequate monitoring scheme. To this end, it is advisable to establish relevant indicators at action level that enable to measure (1) the action's impact, (2) the action's implementation and (3) potential co-benefits or trade-offs. By tracking the progress with an adequate frequency, the municipality can assess whether the progress falls in line with the expectations or if modifications or adjustments to the plan are needed.

Executing the plan: after planning the actions and preparing for the implementation and monitoring, it is essential to execute the plan effectively. This firstly includes submitting the SECAP to the relevant authorities and obtaining any necessary approvals. Once the SECAP is approved, the municipality should proceed with implementing the planned actions and monitoring their progress regularly.

This document focuses only on the preparation towards the executing step, emphasising the importance of a sound understanding of the local situation to develop robust action planning, and well-defined implementation strategies. By following these steps and actively monitoring and adjusting the plan, the municipality can effectively execute the SECAP and make significant progress towards its climate goals.

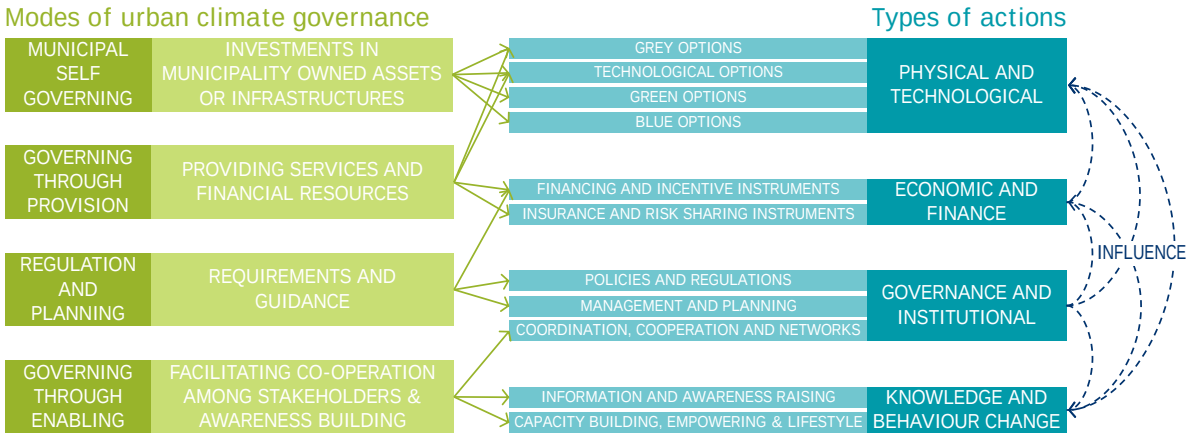
3 Role of municipalities when planning and implementing actions at local level

Effective climate and energy action at local level begins with a common understanding that there is an urgent need to curb the municipality's GHG emissions, increase resilience to climate change and alleviate energy poverty. In this context, cities have a significant potential to contribute, as they concentrate population and economic activities, and they have the power to locally shape and implement the transition to climate neutrality. Based on this understanding, political leadership may explore possibilities and discuss different options with a wide range of stakeholders to select, detail, implement and monitor local actions. In this process, municipalities have the capacity to support and mobilise action for climate and energy investments through several modes of urban climate and energy governance (Kern & Alber, 2009), which can be summarised as:

- Municipal self-governing: municipalities have the power 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 most direct impact can be obtained through investments in energy efficiency or renewable energy deployment in municipal buildings or assets. The municipality has also the authority to determine how the money is spent (e.g. green public procurement), perform modifications in its governance structure or develop expertise and capacities.
- Governing through provision: the municipality 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, such as sustainable transport, energy efficiency improvements, or green infrastructure.
- Regulation and planning (governing by authority): municipalities govern by authority through setting regulations and putting forth urban planning principles. They can revise building codes to promote energy efficiency in buildings, impose road charging to reduce congestion 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.
- Municipal enabling (governing through enabling): as a facilitator, the municipality has an active role in enabling cooperation between community actors, including those that lead to the launch of public-private partnerships to promote local energy generation or other kind of initiatives. Additionally, municipalities can support the generation of an enabling environment through the dissemination of knowledge or training activities.

Each urban climate governance mode can trigger different types of actions, which, in turn, can influence the deployment of further types of actions (main links depicted in Figure 4). It must be highlighted that further types of actions than those indicated in the figure can be triggered by each mode of urban governance (see Table 1). More modes of governance can be used and may overlap when designing the actions, particularly when these address more sectors or entail the participation of several stakeholders.

Figure 4. Modes of urban climate governance linked to main types of actions to be deployed by municipalities (non-exhaustive)



Note: the links among modes of urban climate governance and types of actions are non-exhaustive. Multiple types of actions can be triggered through each mode of urban climate governance.

Source: JRC elaboration based on modes of urban governance as defined in (Kern & Alber, 2009), and Key Type Measures defined in (Leitner et al., 2020)- Note that the KTM category E "NBS and ecosystem based approach" is merged with the "Physical and technological" category

Box 2. Types of local climate and energy actions

Drawing on the classification of key type measures defined in (Leitner et al., 2020), the following four types of actions can be defined:

Physical and technological [Phy]:

- grey options (new physical infrastructures or rehabilitation, upgrade or replacement of existing ones),
- green options (creation of new or improvement of existing green infrastructure or natural and/or semi-natural land-use management),
- blue options (creation of new or improvement of existing blue infrastructure and natural and / or semi-natural water and marine areas management),
- technological options (service / process applications, early warning systems, or ICT reliant systems for optimising processes).

Economic and finance [Eco]:

- financing and incentive instruments (creation or revision of incentive mechanisms or funding schemes),
- insurance and risk sharing instruments (creation or revision of insurance schemes and products, and contingency funds for emergencies).

Governance and institutional [Gov]:

- policies and regulations (creation or revision of policies, strategies, plans or regulations),
- management and planning (mainstreaming climate change in different domains or establishing synergies, creation of technical rules, codes and standards),
- coordination, cooperation and networks (establishment of partnerships, creation or revision of stakeholder networks).

Knowledge and behaviour change [Kno]:

- information and awareness raising (research and innovation, communication and dissemination, decision support tools and databases),
- capacity building, empowering and lifestyle practices (identification and sharing of good practices, training and knowledge transfer, and reporting on lifestyle practices and behaviours).

Throughout this document, the different types of actions will be referenced by using the abbreviations indicated above: Phy, Eco, Gov, Kno.

Overall, the barriers or issues to be tackled with each type of action under these modes of governance are different. For this reason, it is often necessary to combine multiple modes of governance and types of actions to reinforce and align incentives for particular objectives. This must be supported by an analysis of the *legal*, *physical*, *social*, *economic* or *other* barriers/issues that could be encountered in the process. The following Table 1 provides some examples of the potential barriers or issues to be tackled that could be lifted under each mode of governance and type of action.

Table 1. Modes of governance and types of actions

Mode of governance	Linked type of action	Issue to be tackled / barrier to be lifted (examples)	Action examples (linked to corresponding barrier)
Municipal self-governing	Physical & technological	Unclear energy consumption of municipal buildings *(other)*	Energy efficiency interventions in municipal buildings based on a sound energy audit *(grey option)*
	Economic & finance	High GHG emissions linked to municipal activities (use of buildings, vehicle fleet, etc) *(physical)*	Green public procurement applied to municipal and transport sectors *(financing and incentive instrument)*
	Governance & institutional	Lack of coordination among different departments *(legal)*	Reorganisation of municipal departments to facilitate mainstreaming of climate change mitigation, adaptation and energy poverty *(management and planning)*
	Knowledge & behaviour change	Lack of expertise in the energy poverty domain of municipal employees *(other)*	Training activities for municipal employees to deepen the knowledge of energy poverty and strategies to be applied in urban settings *(capacity building)*
Governing through provision	Physical & technological	Increased extreme heat affecting vulnerable populations and lack of adequate urban spaces *(physical)*	Improvement of green infrastructure to provide cool islands in densely populated areas *(green infrastructure)*
	Governance & institutional	Lack of coordination and cooperation among different stakeholders in urban infrastructure projects *(other)*	Creation of a stakeholder network to facilitate collaboration and information sharing (*coordination, cooperation and networks*)

Mode of governance	Linked type of action	Issue to be tackled / barrier to be lifted (examples)	Action examples (linked to corresponding barrier)
	Economic & finance	Lack of capacity of low-income households to perform the necessary refurbishments of their homes to keep them warm *(economic)*	Provision of grants to low-income households for the renovation of their homes *(financing and incentive instruments)*
	Knowledge & behaviour change	Inefficient use of energy by residents due to lack of knowledge *(social)*	Establishment of a municipal support office to provide guidance on efficient use of energy at home *(information and awareness raising)*
Regulation and planning (governing by authority)	Governance & institutional	Lack of strategy/plan towards high-risk hazards (e.g. floods) *(legal)*	Emergency evacuation plan against floods *(policies and regulations)*
	Economic & finance	Insufficient resources to invest in public transport *(economic)*	Setting up a congestion charge zone, accessible only upon payment of a charge. Revenues are invested in the public transport system (*insurance and risk sharing instruments)*
	Knowledge & behaviour change	Lack of specific climate change knowledge of architects / engineers in the construction sector *(social)*	Establishment of a certification scheme for technical experts on impacts of climate change before submitting any refurbishment project *(capacity building, empowering and lifestyle)*
Governing through enabling	Governance & institutional	Lack of capacity by individual stakeholders to deploy ambitious climate actions *(economic)*	Public-private partnerships for the deployment of energy efficiency projects *(coordination, cooperation and networks)*
	Knowledge & behaviour change	Lack of support and understanding of residents of climate change and related impacts of urban actions *(social)*	Establishment of an online platform to showcase the progress and impact of climate action in the city *(information and awareness raising)*

Source: JRC elaboration

4 Understanding the context

To effectively design local climate and energy actions and SECAP implementation strategies, it is necessary to duly consider the assessments performed in each pillar (mitigation, adaptation and energy poverty) and have clarity on the corresponding goals to be achieved, as explained in section 2.

Each of the pillars include specific key aspects that should be observed when defining actions (unpacked in sections 4.1, 4.2 and 4.3). Additionally, integrated actions that address more than one pillar and capitalise on synergies can be planned to accelerate impact (section 4.4).

4.1 The basis for mitigation actions

This section provides guidance for understanding the context towards the definition of mitigation actions. Recent / updated GHG emission inventories and the emission reduction target are the basis to develop climate mitigation actions. Overall GHG emissions and relative contributions of relevant sectors, activities and sources in the local territory can be observed in GHG emission inventories. In turn, the GHG emission reduction target sets the SECAP GHG mitigation objectives, i.e. the overall annual GHG emission reduction that should be achieved by the target year through the proposed mitigation actions (see complementary document 1 "How to prepare a greenhouse gas emission inventory"[6] for further information). It must be noted that, in the context of climate neutrality goals, municipalities should make all possible efforts to reduce GHG emissions at source, to keep the need for compensation to a minimum.

In this context, a GHG emission reduction should be estimated for each SECAP actions, and the overall (summed) reduction should achieve the GHG emission reduction target. Mitigation actions can focus on reducing energy demand, increasing energy efficiency, substituting energy sources (electrification) and increasing the share of renewables.

While specific sectoral targets can be defined, municipalities usually set an overarching target at municipal level. Therefore, to identify the most appropriate mitigation strategies and specific actions (or combination thereof), an understanding and analysis of GHG emissions (with details on contributing sectors, activities and sources) is crucial to define a coherent action plan. Other than the GHG emissions described in CoM inventories, it is important for the municipality to understand the associated activities and end-uses within each activity sector, and to identify important drivers, stakeholders involved, etc. Some key aspects from the status quo assessment that need to be considered when planning mitigation actions are explained in the following box.

Box 3. Key aspects from the status quo assessment to be analysed before planning mitigation actions

Analysis of existing policies (incl. SEAP and existing SECAPs): the municipality should take stock of all the previously adopted plans, strategies and policies related to energy and GHG emissions associated with the activity sectors and build on those for the definition of the SECAP mitigation actions.

[6] How to prepare a greenhouse gas emission inventory (complementary document 1): https://publications.jrc.ec.europa.eu/repository/handle/JRC142296

Share of emitting sectors: based on the results of a baseline emission inventory and of a recent emission inventory, it will be possible to determine the relative share of emissions of each sector. Understanding relative contributions, sources and drivers behind current GHG emissions can provide crucial insight to identify "hotspots" and improvement opportunities. In this context, the Covenant of Mayors identifies four key activity sectors (municipal buildings, residential buildings, tertiary (non-municipal buildings) and transport, as buildings and transport are usually the highest emitters within municipalities. However, municipalities are encouraged to analyse the emissions of all emitting sectors and duly address them with actions in the portfolio.

Type of emitting sectors: when planning mitigation actions, it is useful to distinguish between energy-related and non-energy-related emitting sectors. Energy-related sectors linked to the demand side include buildings and transport, while local production of electricity or local heat / cold production focus fully on the supply of energy. Strategies linked to these sectors are mostly aimed at increasing energy efficiency and the deployment of renewable energy sources that subsequently contribute to reducing energy consumption or shifting away from fossil fuels, and ultimately greenhouse gas (GHG) emissions. In the case of non-energy-related sectors (waste; agriculture, forest and other land use [AFOLU], industrial processes and product use [IPPU]), the strategies focus on reducing emissions through waste management and reduction, as well as sustainable land-use practices, such as reforestation.

Target to be achieved: the established target sets the level of ambition pursued by the municipality and determines the types of actions and resources that should be put in place. While some municipalities commit to a -55% CO_2 emissions reduction by 2030, others aim for climate neutrality by 2050 (e.g. Brasov, Romania[7]) or by 2030 (e.g. Climate Neutral and Smart-Cities Mission[8] or Covenant municipalities like Glasgow[9]) Additionally, besides the overarching emission reduction target, when defining mitigation actions municipalities should also keep in mind sector-specific objectives they aim to achieve. For example, the Flemish Local Energy and Climate Pact (2021)[10] established the following targets on sustainable energy: one cooperative renewable energy project (e.g. in the light of energy communities) per 500 inhabitants by 2030 and 50 collective housing renovations per 1 000 units by 2030. Such tangible targets may be particularly useful to communicate to residents the immediate impact of mitigation actions.

In this context, the municipality can define actions in the corresponding emitting sectors (see Figure 5). A variety of actions can be planned according to the sector, the type of action envisaged, and the mode of governance adopted by the municipality. Section 7.1 presents sector-specific considerations and mitigation action examples. Therefore, it is crucial to understand the achieved impact of the actions through observing the energy savings gained, and GHG emissions reduced.

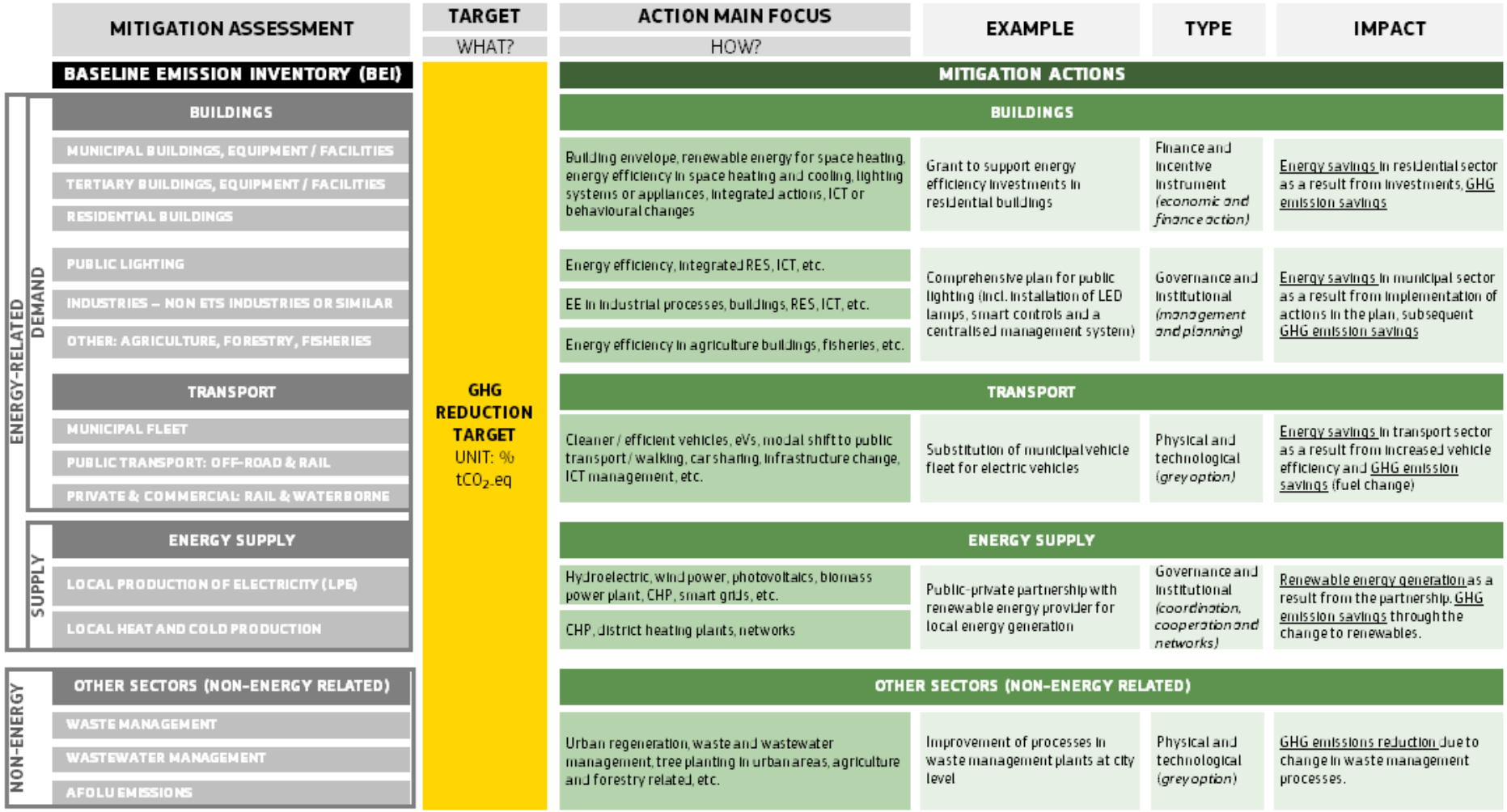
[7] Brasov, Romania - Developing and Implementing a 2050 Roadmap to Climate Neutrality: https://eu-mayors.ec.europa.eu/en/node/317

[8] EU Mission: Climate-Neutral and Smart Cities: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/climate-neutral-and-smart-cities_en

[9] Glasgow's climate plan: https://eu-mayors.ec.europa.eu/en/node/519

[10] Flemish local energy and climate pact (2021): https://climate-pact.europa.eu/organisation-and-group-pledging/browse-organisation-group-type/local-and-regional-government-authority-pledges/flemish-government-flemish-local-energy-and-climate-pact-2021_en

Figure 5. Mitigation actions overview



Source: JRC elaboration

4.2 The basis for adaptation actions

This section provides guidance for understanding the context towards the definition of adaptation actions. The risk and vulnerability assessment (RVA) and the adaptation goal(s) are the basis to develop climate adaptation actions. The first reflects the risk profile of the municipality by identifying and categorising the hazards present in the municipality, as well as highlights the vulnerable and/or exposed sectors and population groups. The second marks the ambition set by the municipality with respect to adaptation (see complementary document 2 "How to develop a risk and vulnerability assessment (RVA))"[11] for further information).

The main objective in this context is, thus, to ultimately enhance the resilience of the local territory against climate threats. Adaptation actions can focus on decreasing the level of risk, exposure or vulnerability of certain sectors or population groups.

Box 4. Key aspects from the status quo assessment to be analysed before planning adaptation actions

Existing efforts (other planning tools): considering existing efforts and other planning tools is essential when developing an adaptation plan at the municipality level. Municipalities often have multiple plans and initiatives underway that may already address some aspects of climate change adaptation, such as comprehensive plans, emergency management plans, and green infrastructure plans. 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. By understanding and building on these existing efforts, municipalities can avoid duplicating work, leverage existing resources and expertise, and ensure that climate change adaptation is integrated into broader urban planning and management initiatives. This can also help to identify potential synergies and opportunities for collaboration across different municipality departments and stakeholders, leading to more effective and efficient adaptation planning.

Two municipalities, San Lucido (Italy)[12], and Gabrovo (Bulgaria)[13] have successfully leveraged existing efforts and planning tools to develop effective adaptation plans. San Lucido established a territorial pact between four municipalities, providing capacity building and awareness raising on climate change adaptation, and creating a territorial association to facilitate cooperation and access to funding. Gabrovo, on the other hand, established a regional council for climate change adaptation, which developed an adaptation strategy promoting nature-based solutions (NBS) and improving water and soil quality, habitats and biodiversity. Both approaches demonstrate the value of collaboration, co-creation and leveraging existing resources to develop effective adaptation plans.

High-risk hazards: identifying high-risk hazards is a critical step in developing a climate change adaptation plan at the municipality level. Municipalities face a range of climate-related hazards, including floods, heatwaves, droughts, and storms, which can have devastating impacts on infrastructure, economies, and human health. By understanding the specific hazards that a municipality is most vulnerable to, municipalities can prioritise their adaptation efforts and focus on the most critical areas of need. This involves analysing data on climate trends, hazard risks, and vulnerability, as well as engaging with stakeholders and communities to understand their experiences and concerns. By identifying high-risk hazards, municipalities

[11] How to develop a risk and vulnerability assessment (RVA) (complementary document 2): https://publications.jrc.ec.europa.eu/repository/handle/JRC142117

[12] Climate resilient and integrated territorial development in San Lucido, Italy https://eu-mayors.ec.europa.eu/en/climate-adaptation-case-study-san-lucido-italy

[13] Climate change adaptation council and strategy in Gabrovo, Bulgaria: https://eu-mayors.ec.europa.eu/en/climate-adaptation-case-study-gabrovo-bulgaria

can develop targeted adaptation strategies that address the most pressing risks and minimize the likelihood and impact of climate-related disasters.

Vulnerable population groups: understanding the needs and vulnerabilities of different population groups is essential for developing effective climate change adaptation plans at the municipality level. Municipalities are home to diverse populations, including low-income communities, old residents, children, and people with disabilities, who may face unique challenges and vulnerabilities in the face of climate change. By identifying and understanding the specific needs and vulnerabilities of these groups, municipalities can develop targeted adaptation strategies that address their needs and promote social equity and justice. This involves engaging with vulnerable populations and communities to understand their experiences and concerns, as well as analysing data on socioeconomic trends and demographic characteristics. By prioritising the needs of vulnerable populations, municipalities can ensure that their adaptation efforts are inclusive, equitable, and effective.

Adaptive capacity of sectors and population groups: adaptive capacity refers to the ability of individuals, organizations, and systems to anticipate, prepare for, and respond to climate-related hazards and changes. By understanding the adaptive capacity of different sectors and population groups, municipalities can identify areas of strength and weakness and develop targeted strategies to build resilience and capacity. This involves analysing data on institutional capacity, social capital, economic resources, and human resources, as well as engaging with stakeholders and communities to understand their experiences and concerns. By building the adaptive capacity of sectors and population groups, municipalities can enhance their ability to withstand and recover from climate-related disasters and promote long-term sustainability and resilience.

Adaptation goal: by setting clear adaptation goals and defining actions that address them, municipalities can ensure that their adaptation efforts are aligned with their broader sustainability and resilience objectives, and that they are making progress towards a more climate-resilient future.

Therefore, it is crucial to understand the achieved impact of the actions and how these impacts can be measured towards achieving the adaptation goals. In this context, the municipality can define actions linked to the high-risk hazards identified in the risk and vulnerability assessment (see Figure 6). As it can be observed, a variety of actions can be planned linked to each hazard, the type of action envisaged and the role the municipality can play. Readers are encouraged to refer to section 7.2 for specific hazards and sectoral considerations and relevant adaptation action examples.

Figure 6. Adaptation actions overview

ADAPTATION ASSESSMENT	GOAL(S)	ACTION MAIN FOCUS	EXAMPLE	TYPE	IMPACT
	WHAT?	HOW?			
RISKS AND VULNERABILITIES ASSESS. (RVA)		ADAPTATION ACTIONS			
EXTREME HEAT	Eg. Reduce to zero the amount of heat(cold)-related illnesses in the community by 2030	E.g. Home insulation, emergency shelters, awareness campaigns, home visits and assessments	Establish emergency shelters in municipal / public buildings	Physical and technological	Decrease population group vulnerability
EXTREME COLD					
HEAVY PRECIPITATION	Eg. Enhance the capacity of the municipality to respond to heavy precipitation emergencies by 50% by 2028	E.g. Emergency response plan, establish an operations centre, conduct training exercises, develop a GIS system	Develop emergency response plan	Governance and institutional	Increase adaptive capacity
HEAVY RAINFALL, HEAVY SNOWFALL, FOG, HAIL					
FLOODS & SEA LEVEL RISE	Eg. Enhance the resilience of healthcare by reducing supply disruptions due to floods by 80% by 2031	E.g. Supply chain risk management, emergency stockpiling, flood-proofing measures, emergency response teams and networks	Financial support to healthcare facilities and suppliers	Economic and finance	Decrease vulnerability
FLASH / SURFACE FLOOD, RIVER FLOOD, COASTAL FLOOD, GROUNDWATER FLOOD, PERMANENT INUNDATION					
DROUGHTS & WATER SCARCITY	Eg. Reduce crop failure by 45% by 2032	E.g. Conservation agriculture, cover cropping, irrigation systems	Weather-based insurance products	Economic and finance	Decrease pop. group vulnerability (farmers)
STORMS	Eg. Ensure that all cultural heritage sites are resilient to storm damage by 2032, with no adverse impacts on their integrity	E.g. Upgrade drainage system, waterproofing, stabilisation, engage local communities in conservation efforts	Implement regulation on preservation of heritage sites	Governance and institutional	Decrease sector exposure / improve adaptive capacity
SEVERE WIND, TORNADO, CYCLONE, TROPICAL STORM, EXTRATROPICAL STORM, STORM SURGE, THUNDERSTORM					
MASS MOVEMENT	E.g. Guarantee safety and functionality of at least 80% of transport infrastructure during landslide events by 2030, with minimal/no impact on operations	E.g. climate-resilient construction standards, asset management practices, emergency response plans	Investments in maintenance and repair of transport infrastructure	Physical and technological	Decrease vulnerability / Increase sector's adaptive capacity
LANDSLIDE, AVALANCHE, ROCKFALL, SUBSIDENCE					
WILD FIRES	Eg. Decrease in at least 80% the number of wildfires in high-risk areas by 2030	E.g. Prescribed burning, forest thinning, early warning systems, enhance firefighting services, education and outreach	Implement wildfire emergency awareness campaigns	Knowledge and behaviour change	Decrease vulnerability
FOREST FIRE, LAND FIRE					
CHEMICAL CHANGE	Eg. Reduce the impacts of ocean acidification on marine biodiversity by 85% by 2030	E.g. Marine species conservation plans, establish marine-protected areas, sustainable fishing, research on ecosystems	Establish a marine-protected area and coastal bathing protocols	Governance and institutional	Decrease exposure / vulnerability
SALTWATER INTRUSION, OCEAN ACIDIFICATION, ATMOSPHERIC CO2 CONCENTRATIONS					
BIOLOGICAL HAZARDS	Eg. Reduce waterborne diseases due to heavy precipitation and flooding by 80% by 2032	E.g. Water treatment infrastructure improvement, water treatment protocols, flood protection, improve health services	Implement water treatment protocols	Governance and institutional	Decrease population group vulnerability
WATER-BORNE DISEASE, VECTOR-BORNE DISEASE, AIRBORNE DISEASE, INSECT INFESTATION					

INCREASE RESILIENCE
Several possible options: decrease exposure / vulnerability / impacts / increase adaptive capacity

UNIT: DEPENDS ON THE SELECTED GOAL

Source: JRC elaboration

4.3 The basis for energy poverty actions

This section provides guidance for understanding the context towards the definition of energy poverty actions. The main elements to be observed in this analysis are (1) the energy poverty assessment, which reflects the status quo of the municipality in different macro-areas, and (2) the energy poverty goal, which defines the ambition set by the municipality with respect to tackling energy poverty (see complementary document 3 "How to develop an energy poverty assessment").

The main objective is to improve the condition of the local population by reducing the degree of energy poverty through the positive impact expected from planned actions. Considering the multidimensionality of the energy poverty issue, actions can focus on improving affordability and reduce the degree of vulnerability of the local population by enhancing energy accessibility, promoting energy efficiency, and fostering social equity for vulnerable groups. To achieve this objective, actions can focus on different areas of intervention.

Municipalities can set an overarching energy poverty goal by committing to tackle energy poverty within the municipality boundaries. The municipality can also set a specific energy poverty target aimed at improving a specific energy poverty aspect described through the set of energy poverty indicators. The specific target contributes to monitor that the municipality is acting on its commitment to tackle energy poverty. Municipalities can set their specific target considering one or more indicators among those available when carrying out the energy poverty assessment.

To achieve the overall and specific target, it is necessary to analyse which approach, or combination of approaches, is the most appropriate. A sectoral understanding of the energy poverty conditions present in the municipality is crucial to define a coherent action plan. This includes understanding the status of the energy poverty macro-areas captured in the assessment and understanding the dynamics of each macro-area within the municipality (barriers, stakeholders involved, etc). Furthermore, before and during the planning of energy poverty actions it is important to consider six energy poverty parameters that help make policies and actions specific to energy poverty needs. The list of energy poverty parameters presented in Box 2 is completed by a list of more general aspects relevant when defining energy poverty actions.

Box 5. Energy poverty parameters to be considered before and during planning actions

ENERGY POVERTY PARAMETERS

Energy affordability: Assess the extent to which energy costs, relative to household income, exacerbate financial strain and deprivation among vulnerable households.

Energy efficiency: Evaluate the effectiveness of measures aimed to reduce energy consumption, to improve building performance and reduce energy poverty by lowering energy demand and increasing cost savings.

Energy vulnerability: Monitor and assess the risk of vulnerable groups (e.g., the old people, unemployed, single parents, persons with disabilities, and rural residents) to become energy poor due to changing socio-economic factors, with a focus on preventive actions to reduce the risk of energy poverty before it occurs.

Social impact: Track the co-benefits and improved well-being among vulnerable populations from energy poverty actions, focusing on those most affected by high energy costs, low income and high energy inefficiency.

Financial support: Monitor the allocation, targeting and effectiveness of public and private funding for energy poverty actions, including direct financial support for low-income households and funding for energy efficiency initiatives.

Stakeholder engagement: Assess the extent and timing of participation and active engagement from local stakeholders (e.g., municipalities, civil society, NGOs, and vulnerable groups themselves) in the development and implementation of energy poverty actions.

GENERAL ASPECTS FOR ENERGY POVERTY ACTIONS

Goal to be achieved: When defining energy poverty actions municipalities should keep in mind their energy poverty goal and specific energy poverty target. While the energy poverty goal is a commitment to tackle energy poverty and hence relates to any kind of action in this domain, the specific energy poverty target is relative to a more defined area of intervention. Municipalities can set their specific target(s) and monitor the progress towards it considering one or more indicators among those available when carrying out the energy poverty assessment.

Sector-level barriers and drivers: performing a systemic analysis of the energy poverty sector-level barriers is an important step to derive if there are relevant hurdles that can impede the deployment of specific actions or expected risks. Based on this analysis it is possible to devise a plan to lift those barriers or understand barriers that are out of the scope of the municipality.

Several methods to understand the sectoral context exist. For example, "The urban energy access toolkit for local governments"[14] presents a framework and a set of guiding questions to be considered by the municipality to understand and map the main types of barriers that could be faced when dealing with energy poverty. In this case the main barriers to be considered are illustrated in Figure 7.

Figure 7. Barrier types to be considered

Source: JRC elaboration adapted from "The urban energy access toolkit for local governments" [15]

Other methodologies could also be used. In the "Energy Poverty Advisory Hub Handbook 2: A guide to planning energy poverty mitigation actions" [16], the Energy Poverty Advisory Hub suggests using a PESTLE model to

[14] Urban energy access toolkit: https://www.globalcovenantofmayors.org/press/unlocking-urban-eap-new-toolkit-for-local-governments/

[15] The urban energy access toolkit for local governments https://www.globalcovenantofmayors.org/press/unlocking-urban-eap-new-toolkit-for-local-governments/

[16] "Energy Poverty Advisory Hub Handbook 2: A Guide to Planning Energy Poverty Mitigation Actions https://energy-poverty.ec.europa.eu/observatory/publications/epah-handbook-2-guide-planning-energy-poverty-mitigation-actions

analyse barriers. In this case the barriers to be considered are defined starting from political, economic, social, technological, legal, environmental dimensions. Another option consists in using SWOT analysis (strengths, weaknesses, opportunities and threats) or other collaborative explorations that can be performed with the support of stakeholders or residents.

Decision-making power in each sector and role to play: the municipality can have a different decision-making power that depends on whether its decision-making authority in a certain sector is owned, shared or unavailable. For municipalities planning energy poverty actions it is important to understand the power dimensions they have over different energy poverty related sectors and associated energy assets. Power dimensions include: set vision and policy, own and operate, set regulation, enforce regulation, control budget. The type of decision-making powers can be high powers, shared powers, low powers, and no powers. Energy assets can be categorized based on their function of energy generation, energy transmission and distribution, energy consumption. These can then also be considered based on their scale of local government district and neighbourhood scale and building level. Having analysed the status of existing power dimension, the degree of power, and the type of energy poverty sectors and assets, the municipality can consider which role can play (see section 3) and how to use this in implementing actions.

Key stakeholders: having acknowledged what is the level of agency in each of the sectors that the municipality can play, it is useful to understand who the key stakeholders are which need to be engaged for specific actions to be deployed. Since working on energy poverty can have multiple linkages with different geographical and governance scales, it is important to understand the role of stakeholders considering national, regional, municipal, and local areas of intervention, and their powers over energy assets. In the identification of key stakeholders, it is also important to consider whether other important groups, that are not traditionally engaged, should be given space and opportunities to participate and lead on interventions. An additional consideration should be the type of stakeholders, so that government, industry, civil society players are all considered.

Financing / funding: another important aspect in the decision-making process that can determine the deployment or not of a specific action is the funding sources available and the financial mechanisms that can be set in motion. For further information on financing opportunities, the "Covenant of Mayors – Europe Funding guide" [17] provides an updated list of shared management funds, funding programmes, technical assistance and advisory support, etc. Additionally, for further information on traditional and innovative financial mechanisms please refer to complementary document 5 "Financial instruments for mitigation, adaptation and energy poverty actions". A further resource in this area is the "Energy Poverty Advisory Hub Handbook 3: A guide to implementing energy poverty mitigation actions" [18] that provides information on financial planning, funding and examples of funding sources.

Synergies / trade-offs: to support accelerated climate action and reap further benefits it is beneficial to analyse if potential synergies can be exploited. Improving building efficiency, for instance, can lower emissions, enhance resilience to extreme weather, and reduce energy costs for vulnerable groups. Similarly, community-based renewable energy projects can curb emissions, enhance resilience during climate disruptions, and provide affordable energy to low-income and marginalized groups. At the same time, trade-offs may arise—for example, if investing heavily in one area limits resources for others or if affordability measures delay necessary infrastructure upgrades. By recognising these synergies and co-benefits, energy poverty measures can be integrated more effectively into broader climate strategies, ensuring that all interventions contribute to equitable, sustainable, and resilient communities.

[17] "Covenant of Mayors – Europe funding guide https://eu-mayors.ec.europa.eu/en/resources/funding_guide

[18] "Energy Poverty Advisory Hub Handbook 3: A guide to implementing energy poverty mitigation actions https://energy-poverty.ec.europa.eu/system/files/2024-10/EPAH%20implementation%20handbook_FINAL.pdf

Figure 8. Energy poverty actions overview

ENERGY POVERTY ASSESSMENT MACRO-AREA	TARGETS WHAT?	ACTION MAIN FOCUS HOW?	EXAMPLE	TYPE	IMPACT
	TACKLE ENERGY POVERTY IN 2030 + SPECIFIC TARGET(S) UNIT: DEPENDS ON THE TARGET(S)	ENERGY POVERTY SPECIFIC ACTIONS			
CLIMATE		E.g. Financial support to adapt to extreme weather; expansion of urban shelters/greenery; Buildings/house measures to ensure inside thermal comfort	Providing small loans for purchasing heat-reflecting white paint or roof panels to reduce heat absorption in homes	Economic and financing	Reduce energy costs, improve thermal comfort
FACILITIES/HOUSING		E.g. Buildings codes and certification; Energy efficiency; Energy communities; Financing and economic measures enabling energy access	Establishing minimum energy efficiency standards for property rentals	Governance and institutional	Energy affordabilty
SOCIO-ECONOMIC		E.g. Local energy offices. Energy vouchers and grants; Renewable energy communities; Awareness campaigns targeting vulnerable populations	Creation of "local energy offices' to provide advice on behavioral measures and no regret, low- cost energy efficiency interventions	Knowledge and behavioral change	Community resilience to energy poverty
MOBILITY		E.g. Free public transportation; income-base transit passes; smart mobility app targeting vulnerables; mobility community planning	Development of Smart mobility app that helps individuals with disabilities navigate the city, reducing barriers to transportation	Physical and Technological	Reduce transport barriers
		ENERGY POVERTY TRANSVERSAL ACTIONS			
POLICY AND REGULATORY FRAMEWORK		E.g. Local buildings codes and certifications; Minimum efficiency standards; social participatory energy plans; housing solidarity funds	Establishing a regulation on collective self-consumption allowing energy poor houses to consume renewables produced in municipal assets	Governance and institutional	Reduce energy costs
PARTICIPATION/AWARENESS RAISING		E.g. Local advisory points; Training and information campaigns, mobile apps; social participatory energy plans; local collection of data related with energy use	Empowering women in alleviating energy poverty through trainings, awareness campaigns and access to suitable energy technologies	Knowledge and behavioral change	Community resilience to energy poverty

Source: JRC elaboration

4.4 The basis for integrated actions: co-effects, co-benefits and trade-offs

As municipalities face the complex and interconnected challenges of climate change, sustainable development and social inequality, it has become clear that a shift from traditional siloed approaches to more comprehensive urban planning and management are necessary. When designing and implementing actions, it is essential to recognise that they can have co-effects, co-benefits, and trade-offs that can impact multiple areas, sectors, and stakeholders.

- Co-effects occur when actions impact not only their specific pillar, but also other pillars (mitigation, adaptation and energy poverty), or other areas within the same pillar (i.e. other mitigation sector, adaptation hazard, or energy poverty macro-area).
- Co-benefits are indirect benefits that extend beyond an action's immediate objectives and / or other pillars, ranging from environmental, social, economic or governance-related benefits.
- Trade-offs on the other hand involve competing interests and priorities, requiring municipalities to balance competing demands across the different areas / pillars and ensure equitable benefits among stakeholders.

Box 6. 'Maladaptation' and 'adaptigation'

When analysing co-effects, two relevant terms that appear in relation to adaptation and mitigation practices are 'maladaptation' and 'adaptigation'. Maladaptive actions are defined by the IPCC as 'actions that may lead to increased risk of adverse climate-related outcomes, including via increased greenhouse gas (GHG) emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future. Most often, maladaptation is an unintended consequence', whereas 'adaptigation' would pursue exactly the opposite: the attainment of win-win situations where not only adaptation is addressed, but there is also a focus on mitigation, on avoiding conflicts and creating synergies. IPCC Climate Change 2014 Synthesis Report mentioned the need for integration of both types of actions although it does not mention the word 'adaptigation' explicitly. Langlais (2009)[19] introduces the term, and Göpfert, Wamsler and Lang (Göpfert et al., 2019) developed a framework to assess and support the joint institutionalization of climate adaptation and mitigation in municipality administrations using the term 'adaptigation'.

If municipalities fail to consider these co-effects, co-benefits and trade-offs, they risk creating unintended consequences, such as exacerbating existing social inequalities, increasing environmental degradation, or undermining economic development. Without a deliberate approach to planning, municipalities may also miss opportunities to maximise benefits, reduce costs, and enhance overall effectiveness of their actions. Furthermore, a lack of planning can lead to fragmented and inefficient decision-making, where individual departments or stakeholders pursue their own interests without considering the broader implications.

However, by taking a more holistic approach, municipalities can develop integrated and cross-cutting actions that deliberately seek to identify and address co-effects, co-benefits and trade-offs. This requires adopting a more comprehensive approach that involves analysing the underpinning governance structure, collaboration and co-creation processes that would support the design,

[19] Adaptigation https://archive.nordregio.se/en/Metameny/About-Nordregio/Journal-of-Nordregio/2009/Journal-of-Nordregio-no-4-2009/Adaptigation/index.html

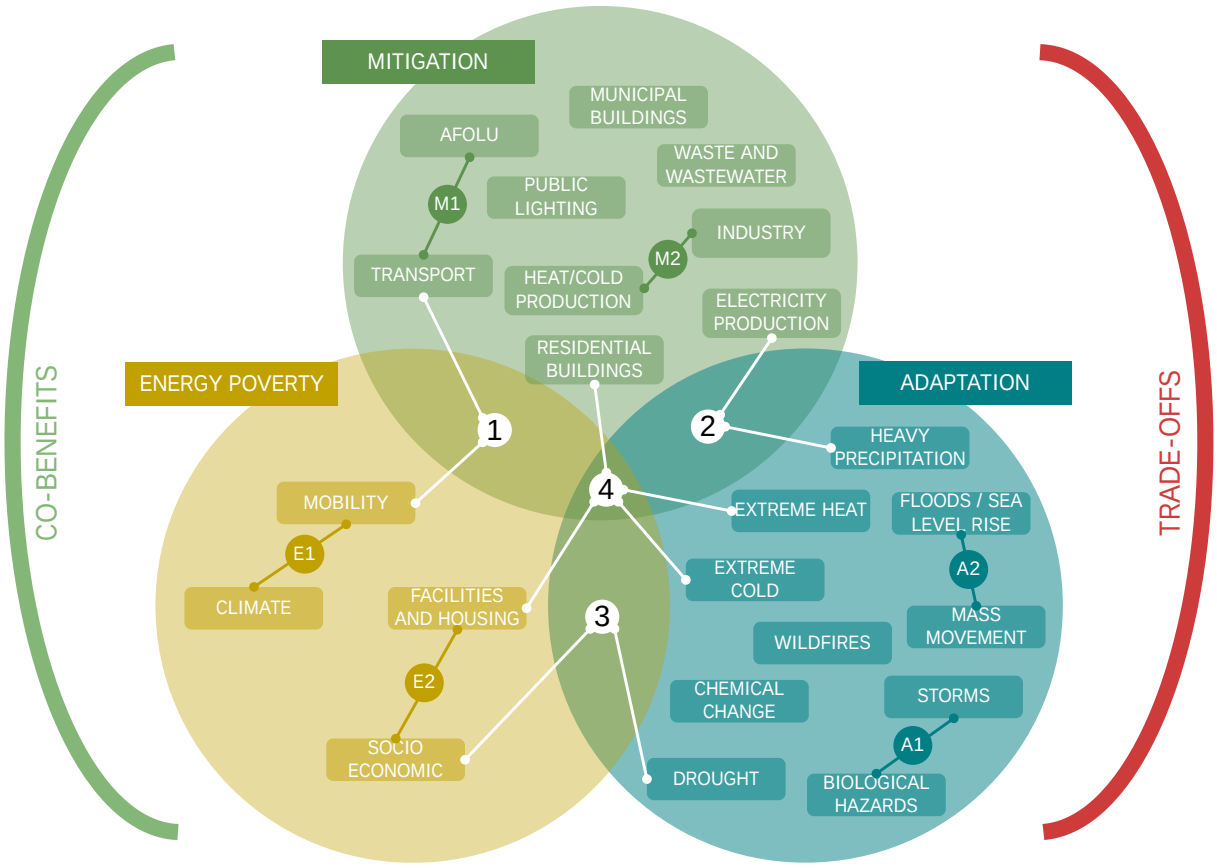
implementation and monitoring of integrated actions. Effective co-creation requires collaboration and coordination between different municipal departments, stakeholders, and community groups. This involves building trust, sharing knowledge, and aligning priorities to ensure that integrated actions are inclusive, equitable, and effective. Governance structures also play a critical role in supporting integrated actions, by providing a framework for decision-making, resource allocation, and accountability.

In this line, when planning integrated actions, it is essential to consider not only the impacts of the actions themselves, but also the interactions between co-creation groups, municipal departments, and governance structures. This involves analysing the power dynamics, interests, and priorities of different stakeholders, as well as the governance arrangements that shape decision-making and resource allocation.

Finally, integrated actions at the municipality level require a long-term perspective, focusing on sustainability and resilience in addition to short-term gains. This involves considering the potential risks and opportunities associated with integrated actions, as well as the potential for unintended consequences. Taking a long-term view will enable municipalities to plan adaptive, flexible, and responsive to changing circumstances actions, supporting the well-being and prosperity of their residents over time.

The following Figure 9 illustrates some examples of integrated actions, which are then explained in the subsequent box. Further examples and strategies can be observed in section 7.4.

Figure 9. Integrated actions examples overview



Source: JRC elaboration

Box 7. Integrated actions examples: co-effects among pillars and sectors, co-benefits and trade-offs

The mitigation pillar can benefit from integrated actions that address multiple sectors and goals. For instance, a municipality can implement a sustainable urban forestry programme that combines afforestation / reforestation efforts with urban planning and transportation strategies (see M1 in Figure 9). This action can mitigate GHGs from the AFOLU sector, while also reducing traffic congestion in the transport sector and generating air quality improvements as co-benefits. Another example is a district heating and cooling system that integrates heat and cold production with industrial processes (see M2), reducing energy consumption and GHGs, while also enhancing the competitiveness of local industries. Both actions can have co-benefits as job creation, improved air quality, and enhanced urban liveability, but may also involve trade-offs such as higher upfront costs and potential conflicts over land use.

The adaptation pillar can also benefit from integrated actions that address multiple hazards and sectors. For example, a municipality can implement a green infrastructure programme that combines urban planning and ecosystem-based adaptation strategies to reduce the impacts of storms and biological hazards such as mosquito-borne diseases (see A1). This action can enhance the resilience of urban ecosystems while also improving public health and reducing the economic impacts of storms. Another example is a mountainous terrain stabilisation project that integrates reforestation, soil reinforcement and flood control measures (see A2), reducing the risks associated with floods and mass movements while also enhancing the stability of slopes and water quality. Both actions can have co-benefits such as enhanced ecosystem services, improved public health and reduced economic losses, while they also may involve trade-offs such as increased costs and potential conflicts over land use.

Integrated actions in the energy poverty pillar can address multiple aspects of energy access and social equity. For instance, a municipality can implement a sustainable transportation programme that provides affordable and sustainable mobility options for low-income households, such as discounted travel on public transport and bike-sharing systems and incorporates flood-resistant design and emergency preparedness measures to ensure continued access to transportation during extreme weather events (see E1). This programme can help reduce energy (notably transport) poverty by decreasing transportation costs and increasing access to employment and social services, while also enhancing the municipality's resilience to climate-related hazards. Another example is a facilities and housing programme that integrates energy-efficient retrofitting with socioeconomic support services (see E2), reducing energy poverty while also enhancing the health and well-being of low-income households. Both actions have co-benefits such as job creation, improved air quality and enhanced social equity, but may also involve trade-offs such as increased costs and potential conflicts over resource allocation.

Integrated actions can also be designed to address multiple pillars, fostering synergies and co-benefits across different areas. For example, promoting electric or shared mobility (1) can address energy poverty by increasing access to affordable transportation options while also reducing GHGs in the transport sector (mitigation). Investing in renewable energy sources such as hydropower with flood-control mechanisms or solar energy with storm-resistant infrastructure, can contribute to climate change mitigation efforts (2) while also enhancing resilience to heavy precipitation events through reduced flood risk and improved disaster preparedness (adaptation). Supporting climate-resilient agriculture and water management practices can help vulnerable communities adapt to droughts (3) while also improving their socio-economic conditions and thereby reducing energy poverty. Finally, designing and retrofitting residential buildings with energy-efficient and climate-resilient features can address all three Covenant pillars, providing affordable and comfortable housing (energy poverty), reducing GHG emissions (mitigation), and enhancing resilience to extreme heat and cold events (adaptation) (4). These integrated actions can yield multiple co-benefits, such as improved public health, enhanced ecosystem services, and increased economic productivity. However, they may also involve trade-offs, such as higher upfront costs, potential land use conflicts or the need for coordinated governance and planning across different sectors and levels of government.

5 Planning actions and strategies

Once the context has been assessed and the corresponding priorities and the potential approaches to intervene in the three pillars have been analysed, the action portfolio can be designed. 5.15.25.3The action portfolio must be reviewed and adapted regularly to ensure that all changes that might occur during the implementation are considered. From the previous section, the signatory must be able to identify a list of possible actions to address the set goals. This potential portfolio of actions consists of a list of actions with their key information. Among the various combinations of actions, further reflection is needed to decide which actions to take and to define the final portfolio of actions.

It is crucial to ensure the portfolio is correctly balanced (i.e. the actions are focused on all of the areas of the municipality that require attention and not exclusively on a specific sector, see section 5.1), that actions are ambitious but feasible (section 5.2), and that they have an adequate level of maturity (i.e. that actions are well defined and are coherent, see section 5.3).

The action template in the section 5.3 can serve as a basis for municipalities to create their action portfolio. While this should not necessarily be included in the public version of the SECAP, it can be part of the technical documentation at the disposal of the municipality, as an essential tool in the implementation and monitoring phases of the SECAP.

5.1 Overall prioritisation of actions

Given a potential portfolio of actions, with detailed information, the next step in the planning process should consists of prioritising the measures to be implemented. In addition to the impact of the actions, prioritising actions must consider several aspects, such as co-effects, co-benefits and possible financial, human capacity or political opportunities, constraints and / or trade-offs. Some aspects to be analysed before prioritising actions are listed below.

Direct impact: the level of direct impact of an action indicates how closely an action aligns with and contributes to its primary objective.

Costs: besides the simple cost of the actions, the relative cost is an additional aspect to consider. The relative costs can be calculated with respect to other units of measurement, for instance, the impact of an action (e.g. CO_2 emissions that are reduced, number of vulnerable households affected, or other). The cost calculation linked to the estimated impacts can offer a powerful tool to prioritise highly cost-effective actions.

Box 8. Calculating action costs

When calculating action costs at the municipality level, several key concepts can be observed, in particular, in relation to upfront costs (CapEx), operational costs (OpEx), and special considerations related to each pillar. CapEx refers to the upfront costs of implementing a project or action, such as constructing green infrastructure or upgrading transportation systems, while OpEx includes running costs of operating and maintaining a project, such as energy consumption or maintenance costs. In the mitigation pillar, municipalities must weigh the costs of transitioning to renewable energy sources against the potential long-term savings and revenue generated, for instance, through carbon pricing mechanisms. Adaptation efforts, on the other hand, require significant upfront investment in resilient infrastructure, but can yield cost savings through innovative solutions such as green roofs, urban wetlands or smart storm water management systems, which can reduce maintenance needs and minimise the impact of extreme weather events. Meanwhile, addressing energy poverty demands a nuanced approach to cost calculation, as the benefits of

energy efficiency measures must be carefully balanced against the costs of implementation, and targeted subsidies or assistance programmes may be necessary to ensure equity and fairness.

Feasibility: it is important to consider the overall conditions and risks related with the implementation of an action and group of actions. The viability of an action is related with identified barriers and outside conditions. Many types of feasibility can be observed:

- Technical/physical: addresses the physical aspects of an action, including technological readiness, scalability and replicability, innovation, adaptability. Also, it can include other physical parameters related to the urban and space limitations, physical structure of historic sites and buildings and other potential physical barriers.
- Institutional/legal framework: municipality and resources must be taken into consideration for planning purposes. In addition, political articulation and support, legal frameworks and alignment with existing national/regional policies influence the planning and implementation of actions. This should include "non-negotiable actions", that are mandated by prior legislation and binding commitments, or other barriers driven by legislation (e.g. historic sites preservation).
- Economic: this not only includes the costs, but also aspects related with return on investments, cash flow, financial instruments used and funding opportunities. In some cases, specific funding opportunities can materialise, and if those are identified by the municipality, these could help in directing efforts.
- Social: social acceptance is a crucial prerequisite for the successful implementation of actions. Securing support is essential not only for the overall action plan, but also for some individual actions within it. Identifying the social groups directly impacted by each action and developing a targeted engagement and communication plan can help ensure the feasibility and effectiveness of the overall strategy.
- Other: other types of elements that should be considered are related with environmental concerns and limitations related with safety and security issues.

Co-effects and co-benefits (mid-long term): a highly effective action could deliver benefits beyond the targeted sector. Secondary impacts may be linked with other environmental, social or economic benefits that an action might contribute to. Actions with potential positive impacts in other areas can benefit from political and social support.

- Co-effects: beneficial impacts on other sectors / hazards / macro-areas or other pillars. More than one pillar can be simultaneously addressed by a single action. Identifying co-effects within the whole action plan is a good way of pinpointing high-priority actions.
- Environmental co-benefits: some important aspects relate to the impact on air quality, water and soil pollution, forest and biodiversity conservation, protecting ecosystems and other.
- Social co-benefits: some social benefits can be observed, as improving well-being and quality of life, equity, social inclusion, health.
- Economic co-benefits: co-benefits for local economy should be considered, such as job creation and small-business opportunities.

Trade-offs (mid-long term): the development of specific actions could lead to negative effects that go beyond the target sector. Similarly to the previously explained co-effects, action trade-offs involve competing interests of the actions with other actions, sectors, pillars or policies. For example, an adaptation action focused on increasing energy availability for cooling during heatwaves could

increase energy consumption and, therefore, may conflict with a mitigation action aimed at reducing energy consumption. Alternatively, an action aimed at improving energy efficiency or renewable energy may increase property value and may inadvertently undermine energy poverty efforts. Actions in one pillar can have unintended consequences on other pillars. These trade-offs should be identified and addressed for a highly effective plan.

Trade-offs can be classified into four main categories: environmental, social, economic and governance related. For instance, an action that aims to reduce greenhouse gas emissions (environmental benefit) may lead to job losses in a specific industry (social cost) or increase costs for certain stakeholders (economic trade-off). Conversely, an action that promotes social equity may have unintended environmental consequences, such as increased resource consumption. Actions with potential negative impacts in other areas can face political and social resistance.

Prioritising actions is highly context-specific and dependent on political priorities. Moreover, it should be conceived as a dynamic and flexible approach and can change over time. Given the complexity of municipality systems and the constant changes that might occur with it and with external factors, it is recommended that the list of actions is revisited and refined based on new information, in the context of the monitoring exercise, to reap further opportunities and learn from previous experiences. To prioritise actions, other methodologies or tools can be used, such as prioritisation matrix and online tool.

Box 9. Tools and frameworks to support the prioritisation of actions

Prioritisation can be supported through a structured approach to decision-making, allowing users to assess different criteria, such as emissions reduction, cost and social impact. This involves comparing different policy design options, evaluating multiple impacts and identifying the most beneficial actions. To facilitate this process, various tools can be employed, including the SYNERGISE+ tool[20], REGIO1st planning framework[21], Multiple Impacts Calculation tool (MICATool)[22] and Action Selection and Prioritisation (ASAP)[23] tool. The SYNERGISE+ tool facilitates decision-making for adaptation and mitigation actions within SECAPs and includes steps such as setting goals, evaluating importance and scoring actions. The REGIO1st tool provides a structured decision-support framework, including stages such as preparation, engaging stakeholders and cost-benefit analysis. The MICATool allows for quantification and monetisation of impacts and can perform a cost-benefit analysis on the quantified / monetised impacts. These are examples of tools that can help municipalities make informed decisions about which actions to prioritise, based on their specific context and goals.

5.2 Performing relevant checks on the action portfolio

Ensuring that the actions planned follow a coherent and balanced approach is key to avoid that much (or all) effort is devoted to a limited number of specific actions with high risks of implementation or low potential impact. Another step for a successful plan is to analyse the portfolio of actions to check if the combination of the selected measures can be implemented or if there are inconsistencies or high risks of execution related with it. A good set of actions should be balanced and coherent with

[20] SYNERGISE+ tool: https://h2020prospect.eu/synergise

[21] REGIO1st planning framework: https://regio1st-planning-framework.fedarene.org/get-started

[22] Multiple Impacts Calculation tool (MICATool): https://app.micatool.eu/

[23] Action Selection and Prioritisation (ASAP) tool: https://www.c40knowledgehub.org/s/article/Action-Selection-and-Prioritisation-ASAP-Tool?language=en_US

the status quo assessment step and with the objectives, while being mindful of possible limitations, challenges and barriers that the municipality may encounter.

To assess the strengths and weakness of the plan and identify blind spots, the municipality can use some guiding questions in the process of defining the actions.

The (non-exhaustive) guiding questions provided in Table 2 are related to aspects such as (1) feasibility, (2) impact (direct & indirect), (3) coherence / consistency, (4) balance, (5) other.

Table 2. Guiding questions to check the action portfolio

For all portfolio of actions:	By pillar:
Impact: Relates to the target to be achieved	
"Is the overall expected impact consistent with the set targets?"	Mitigation: "Is the sum of the expected emissions reduction from the actions sufficient to reach the goal or does it exceed the goal?"
	Adaptation: "Do the adaptation actions contribute to the defined adaptation goal(s)?"
	Energy Poverty: "Is the incidence of energy poverty reduced?" "Are the planned actions contributing to alleviate energy poverty by intervening in the multiple dimensions contributing it?"
Feasibility: Concerns the barriers/risks of implementing the actions	
"How many actions, in the portfolio of actions, are considered of high risk of implementation?" "How many actions depend on technological developments that are not controlled by the municipality?" "Has the cost of each action been quantified to ensure financial feasibility?" "Are we relying on grants (or other financial instruments) to finance the actions?" "Are the actions supported by the institutional framework?"	Mitigation: "Is all (or most) of the emission reduction associated with a limited number of actions on which the municipality has limited influence?"
	Adaptation: "Is population aware of the climate risks and the need for a plan?" "Does the municipality have climate monitoring tools in place at local scale?" "Are the environmental/architectural/urban planning/civil safety regulation and plans in the municipality a barrier for any of the actions proposed?"
	Energy Poverty: "Are the vulnerable population groups addressed aware of the actions and supporting the plan?"
Coherence: Relates to the coherence with the previous steps (assessment and target) of the plan elaboration.	
"Is the action portfolio addressing all relevant sectors identified in the assessment phase?"; "Is the action portfolio particularly focused on a sector that is not emerging as	Mitigation: "Are all emitting sectors (identified in the BEI) being addressed by the portfolio of the actions?" "Comparing the total emissions (BEI), is there any sector with a disproportionally large share in the total emissions reduction compared to the sector contribution to the total emissions accounted in the inventory?"

a critical sector from the assessment phase?"	"Are there actions focusing on sectors that are not accounted for in the emission inventory?"
	Adaptation: "Are all the identified climate hazards and vulnerable sectors (RVA) addressed by the portfolio of actions?" "Are the vulnerable populations considered in the assessment phase benefiting from planned actions?" "Are the actions covering sectors or population groups not identified as vulnerable?"
	Energy Poverty: "Are the actions covering all macro-areas identified as relevant in the assessment phase?"; "Are the actions aligned with the indicators identified as relevant in the assessment phase?"
Balance: Concerns the balance of the portfolio, avoiding that all (or most) effort is placed in specific measures, instruments or sectors.	
"Are all measures (or most) focusing on one single type of action, or on a single mode of governance?"	Mitigation: "Is there any sector contributing disproportionally to the total GHG emissions reduction target?";
	Adaptation: "Are all actions (or most) focusing on a single sector/climate hazard/vulnerable population group, neglecting other important ones?"
	Energy Poverty: "Are all measures (or most) related with a specific vulnerable population group, neglecting other vulnerable groups?" "Is one macro-area disproportionally represented by the actions, at the expense of other relevant macro-areas?"
Others: Any other aspect that should be reflected by the municipality	
"Are financial mechanisms/funding opportunities identified?" "Are actions considering specific national/regional regulations?" "Are all relevant details being addressed in the actions? Or do most of actions lack details of implementation?" "Are stakeholders adequately engaged?"	

Source: JRC elaboration

5.2.1 How to conduct an ex-ante assessment for mitigation actions

A recent GHG emission inventory allows the municipalities to understand the most emitting sectors to address to achieve the set target. When defining its mitigation actions portfolio, the municipality should conduct an ex-ante assessment, i.e. it should estimate its effectiveness in achieving the desired GHG emission reduction target. To this end, it should define a baseline scenario, describing how GHG emissions would evolve by the target year in the absence of the actions being assessed. Then, it should elaborate a policy scenario, illustrating the conditions likely to occur in the presence of the actions and estimate policy scenario emissions. Finally, it should subtract baseline emissions from policy scenario emissions, thus obtaining the expected future GHG effects of each action.

The key steps to follow for an ex-ante assessment are listed below, adapted from the Policy and action standard from the Greenhouse Gas Protocol (GPC)[24]:

Step 1. The first step consists of estimating baseline emissions:

- Define the baseline scenario: identify key drivers that affect emissions, including other policies or actions and non-policy drivers such as socioeconomic factors and market forces; describe the baseline scenario and justify why it is considered the most likely scenario; list policies, actions, and projects included in the baseline scenario and indicate any excluded policies or actions with a potentially significant effect on GHG emissions.
- Select a level of accuracy: choose a level of accuracy based on the objectives of the assessment, data availability, and capacity/resources.
- Define emissions estimation methods: identify a method for estimating baseline emissions for each sector and all relevant parameters that are necessary to apply the chosen method.
- Estimate baseline values: provide baseline values for key parameters, methodology, and assumptions used to estimate baseline values, using conservative assumptions when uncertain.
- Estimate baseline emissions: estimate baseline emissions and removals over the GHG assessment period for each sector and greenhouse gas. Provide a qualitative description when baseline emissions are not estimated.

Best practices include using high-quality data, considering policy interactions and non-policy drivers, conducting sensitivity analysis, and reporting methodology and data sources transparently.

Example: a municipality has planned a set of actions to address the emissions associated with the residential sector, by promoting the replacement of 1000 fossil fuel boilers, a shift to heat pumps and the installation of 3 MW of PV panels on rooftops. It has also planned a large scale agrivoltaic installation.

As a first step, the municipality has defined a baseline scenario. To this end, it has first identified population and heating & cooling demand as the key drivers that affect emissions in this sector. Then, it has identified natural gas consumption, electricity consumption and the emission factor for electricity as the key parameters affected by the drivers and by the local policy. Finally, it has estimated baseline values for each parameter and calculated related baseline scenario emissions (36 360 t CO_2 + 36 000 t CO_2 = 72 360 t CO_2).

Table 3. Example mitigation ex ante assessment – step 1

Key parameters	Baseline value	Emission factors	Baseline emissions
Natural gas consumption	180 000 MWh	0.202 t CO_2/MWh	36 360 t CO_2
Electricity consumption	120 000 MWh	0.300 t CO_2/MWh	36 000 t CO_2

[24] World Resources Institute: Policy and Action Standard (GPC): An accounting and reporting standard for estimating the greenhouse gas effects of policies and actions: https://ghgprotocol.org/sites/default/files/standards/Policy%20and%20Action%20Standard.pdf

National emission factor for electricity	0.300 t CO_2/MWh		

Source: JRC elaboration

Step 2. The second step consists of estimating policy scenario emissions

- Define the policy scenario: define a scenario that represents the conditions most likely to occur in the presence of the action.
- Identify parameters to be estimated: identify the parameters (e.g. diesel consumption, electricity production from renewable sources, amount of waste treated, emission factors) that are affected by the action and need to be estimated.
- Select a desired level of accuracy: choose a level of accuracy for the assessment based on the objectives, data availability, and capacity/resources.
- Estimate policy scenario values for parameters: estimate the values of the parameters identified in step 2, based on assumptions about the effect of the policy on each parameter over the assessment period (e.g. an action aimed at replacing all diesel buses with electric ones will result in reduced diesel consumption but will increase the consumption of electricity).
- Estimate policy scenario emissions: estimate the GHG emissions and removals for each source/sink category and greenhouse gas included in the GHG emission inventory.

Example: as a second step, the municipality has defined a policy scenario. To this end, it has estimated that the replacement of 1000 fossil fuel boilers will cause a reduction in natural gas consumption, that the shift to heat pumps will result in increased electricity consumption and that the installation of PV panels on rooftops will lead to a decrease in the emission factor for electricity. It has estimated policy scenario values for parameters and then calculated policy scenario emissions (23 230 t CO_2 + 13 500 t CO_2 = 36 730 t CO_2).

Table 4. Example mitigation ex ante assessment – step 2

Parameters affected by the policy	Policy scenario values for parameters	Emission factors	Policy scenario emissions
Natural gas consumption	115 000 MWh	0.202 t CO_2/MWh	23 230 t CO_2
Electricity consumption	135 000 MWh	0.100 t CO_2/MWh	13 500 t CO_2
Emission factor for electricity	0.100 t CO_2/MWh		

Source: JRC elaboration

Step 3. The third and final step consists of estimating the GHG effect of the policy or action, by calculating the difference between the policy scenario emissions and the baseline scenario emissions.

Example: The municipality has estimated that the GHG effect of the policy or action will correspond to -35 630 t CO_2 (36 730 t CO_2 - 72 360 t CO_2 = -35 630 t CO_2).

Box 10. A tool to support mitigation action development: ENEA PAESC platform

ENEA, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development, designed the PAESC platform[25] as part of the Energia Sostenibile per le Pubbliche Amministrazioni (Sustainable Energy for Public Administration) project. ENEA further implemented the platform on behalf of the Region of Sicily and the Veneto Region, to provide technical support to municipalities and local energy agencies in the implementation and management of their SECAPs.

Specifically, the system supports the preparation of GHG emission inventories by means of datasets that provide a preliminary estimate of CO_2 emissions and private energy consumption, broken down by sectors (residential, transport, tertiary) and energy source, giving the possibility to municipalities to add municipal energy consumption data in the same reference sectors[26].

The potential of these data lies both in the value of the data taken individually and in the possibility of aggregating them for further analyses not only of an energy, but also of an environmental and economic nature.

This way, supra-municipal administrations will be able to benefit from an overall view of the energy profile of a larger metropolitan area, with the opportunity to maintain a good level of detail on local energy policies.

The municipality, as main user of the platform, can consult:

- Datasets on local energy consumption estimates broken down by carrier/fuel;
- CO_2 emissions by sector (residential/tertiary/transport);
- Impact of incentive measures, such as energy savings generated by Ecobonus (Italian incentives for energy efficiency and renewable energy);
- Number of energy performance certificate (EPC) by energy class.

The platform i) uses the valuable open data shared by the Italian public authorities and ENEA (from national energy efficiency policies such as Ecobonus and EPCs); ii) compiles all these data to preliminarily estimate CO_2 emissions by sector (residential, tertiary and transport); iii) provides a collection of best practices to guide local energy managers through mitigation measures.[27]

[25] Piattaforma Paes https://www.paes.enea.it/

[26] ENEA PAES: A Web Platform for Supporting Italian Municipalities in Sustainable Energy Action Plan: https://datascience.codata.org/articles/10.5334/dsj-2023-037

[27] Piattaforma PAES: https://iris.enea.it/handle/20.500.12079/70027

5.2.2 How to conduct an ex-ante assessment for adaptation actions

A similar process can be carried out for the adaptation pillar. In this case, the status quo is reflected through the risks and vulnerabilities assessment (RVA) and allows the municipality to understand what the most prominent risks and challenges are in the short and long term. An ex-ante assessment of the proposed adaptation actions can also be performed to assess how planned actions contribute to the identified adaptation goals.

Step 1. Analysing present and future climate impacts and risks

- Identify the current and future risks and impacts: As it has been described in complementary document 2 "How to develop a risk and vulnerability assessment (RVA)"[28], the municipality should have a clear picture of what the current and future impacts and risks are in the municipality.
- Analyse key drivers that affect those risks and impacts: identify key drivers that affect the identified risks and impacts, including other policies or actions and non-policy drivers such as socioeconomic factors and market forces. Some policies that can have an impact include green space and nature protection strategies, sustainable development or water management strategies.
- Select a level of accuracy and calculation methods: choose a level of accuracy based on the objectives of the assessment, data availability, and capacity/resources. This choice can also be informed by how the RVA has been performed (see complementary document 2 "How to develop a risk and vulnerability assessment (RVA)"). Best practices include using high-quality data, considering policy interactions and non-policy drivers, conducting sensitivity analysis, and reporting methodology and data sources transparently.
- Estimate baseline values: based on the efforts already performed in the RVA, gather baseline values for key parameters, methodology, and assumptions used to estimate baseline values, using conservative assumptions when uncertain. In this context, the quantified assessment of the risk components (i.e. hazards, exposure, and vulnerability), and adaptive capacity contributes to linking the assessment performed to the adaptation goals and the outcomes that can be obtained with the implementation of the actions. Some reference indicators can be found in section 6.

Example: a municipality may identify extreme heat as the most relevant hazard, especially affecting vulnerable population groups such as older people in the short and medium term. One of the baseline values that can be addressed is the expected impact, which could be measured with the indicator "number of older people hospitalised during heatwaves". This information could be requested to the local hospitals.

[28] How to develop a risk and vulnerability assessment https://publications.jrc.ec.europa.eu/repository/handle/JRC142117

Step 2. Identification of actions linked to each hazard

— For each risk reflect on what actions would improve the baseline: to address the detected risks, several types of actions could be proposed by the municipality, ranging from more direct actions (physical and technological), supporting ones (economic and finance) or softer ones (knowledge and behaviour change). Depending on the hazard addressed and the severity, more direct action can be required.

— For each action reflect on its focus: adaptation actions can contribute to reducing exposure, reducing vulnerability of population groups or sectors, decreasing the risk, decreasing the impact, or enhancing adaptive capacity. Reflecting on the focus, and how it has been measured in the RVA can contribute to determining the impact of the corresponding action and link it to the subsequent monitoring of the action and the whole plan (see section 6). Estimated values can be provided depending on the source data available.

Example: to reduce the number of older people hospitalised during heatwaves, a municipality can plan several types of actions: from implementing cooling centres (physical action), to proposing heat awareness campaigns (knowledge and behaviour change action). "Implementing cooling centres", can contribute to reducing the exposure of older people to heatwaves. It can be measured through the number of new cooling centres implemented. On the other hand, "Heat awareness campaigns" impact can be estimated through the number of people reached. The municipality has established one cooling centre in the existing library and defined two awareness raising campaigns, one on the media during the news broadcast and one through brochures. The number of brochures delivered amount to 500 while the outreach of the media campaign was around 21% of viewers. Through the combination of these actions, the municipality estimates a reduction of 35% of hospitalisation during heatwaves.

5.2.3 How to conduct an ex-ante assessment for energy poverty actions

An ex-ante assessment for energy poverty actions enables municipalities to explore and evaluate potential interventions guiding the prioritisation and implementation phase. Building on the energy poverty assessment already conducted, this assessment helps municipalities understand the range of possible actions, their potential impacts, and key implementation considerations to inform strategic decision-making about which actions to prioritise.

The key steps to follow for an ex-ante assessment of energy poverty actions are listed below:

Step 1. Define potential action scenarios

— Identify action categories: based on the energy poverty assessment, explore different types of potential interventions that could address the specific energy poverty challenges identified (e.g., awareness campaigns, one-stop shops, financial assistance, home renovations, energy communities).

— Map action-target alignment: for each potential action type, identify which vulnerable population groups, geographic areas, characteristics influencing energy poverty (i.e., affordability, energy efficiency, thermal comfort) and macro-areas it could potentially address.

— Assess current service gaps: compare potential actions against existing services and support mechanisms to understand where new interventions could add value or fill gaps.

— Define relevant indicators: for each action type, identify what indicators would be most relevant to measure success.

Example: the municipality may identify awareness campaigns as one potential intervention to alleviate energy poverty, in particular, the development of an "energy café" in a specific area where the incidence of energy poverty is high. "Energy cafés" are public spaces where specialised agents advise on best practices for energy use at home, considering specific characteristics of those that look for information. The chosen area for that campaign is the area where most of the households are not renovated. The observed problem in this case is the higher incidence of energy expenditures to keep the houses warm in winter and cool during summer. Normally there are no campaigns targeting this specific audience. The benefits of energy efficiency measures on the energy expenditure are not always understood by the population, that may not have tools to assess them. The main indicators to assess the progress could be the 'number of households that have access to information on potential energy savings at home', 'percentage of households / persons within the municipality experiencing heating discomfort' and 'inability to keep home adequately warm/cool'.

Step 2. Estimate potential action effectiveness

- Scope potential reach: for each action type, develop rough estimates of the scale of possible impact , considering the size of the vulnerable population and realistic implementation scenarios.
- Assess impact potential: explore the potential effectiveness of different action types based on evidence from similar initiatives elsewhere, considering the range of outcomes typically achieved.
- Consider implementation requirements: evaluate what each action type would require in terms of resources, partnerships, timeframes, and administrative capacity.
- Identify implementation factors: consider factors specific to your local context that may enhance or limit the effectiveness of different action types.

Example: In the example above, awareness campaigns can potentially reach 20-40% of identified vulnerable households. Taking into account the population considered in the specific mentioned area, the municipality assumes to be able to reach 40%. By benchmarking other experiences with a similar approach, it is possible to see that awareness campaigns typically lead to a 15-30% of energy savings of participating households.

In the case of a local "energy café", preparatory work includes identifying the households to be involved in the activity, preparing them for the goal and identifying specialised staff that could serve as advisor in the local points.

Step 3. Compare action potential and feasibility

- Assess relative impact potential: compare different action types in terms of their potential to address the energy poverty priorities and reach vulnerable populations effectively.
- Evaluate implementation complexity: consider the relative difficulty, resource requirements, and timeframes associated with different action approaches.
- Identify complementary actions: explore how different action types might work together to create comprehensive support for vulnerable households. Explore different combinations that have the potential of reaching the established goal, also in synergy with ongoing or planned actions under the other pillars.

Example: After defining a number of potential actions with specific scopes and characteristics, the municipality can compare the details to select the best actions to reach the proposed goal. In addition to the "energy café", a municipality might have identified: new regulations on minimum energy

standards of rented houses; direct financial support for families in a vulnerability situation. Comparing the characteristic of all the identified actions, and their potential impact individually or in combination, the municipality can choose its best approach to reach the goal. If, for example, the goal is to reach at least 60% of the population living in an energy poverty condition, the suggested "energy café" would not be enough, hence, the municipality would need to identify more actions to complement it, or replace it, with better results.

5.3 The action template

The following Table 5 provides the general concepts that should be defined for all types of actions, an explanation on why each piece of information is relevant and where to find further guidance within the Covenant guidebook. Examples of mitigation, adaptation, energy poverty and integrated actions described according to the template can be found in sections 7.1.9, 7.2.11, 7.3.5 and 7.4.7, respectively.

Table 5. Action template (fiche) with information to be included at action level

Concept	Explanation
Action title	It is advisable to include a recognisable action title. This could include an identification code.
Main focus	This includes the specification of the emission sector (for mitigation actions); hazard-vulnerable sector-vulnerable population group (for adaptation actions); or macro-area (for energy poverty actions). Clearly identifying the focus of the action allows to show the link between the assessment performed and goals established.
	See section 3.
Action description	The action description should be clear enough to understand the scope (including the role of the municipality, the action's scale and addressed stakeholders (when applicable). It should include quantifiable indicators when feasible, as this will facilitate monitoring its deployment.
	See sections 7.1.9, 7.2.11, 7.3.5 and 7.4.7
[Mode of governance]	It is advisable to analyse the role played by the municipality (i.e. mode of governance deployed). This will inform if the expected impacts (e.g. energy savings) will be directly obtained with an action triggered by the municipality (e.g. direct investment in municipal buildings) or if third parties need to be involved to achieve a specific impact (e.g. municipality giving grants for energy efficiency investments in the residential sector).
	See section 3.
[Action type]	Effective action planning requires a multifaceted approach that combines hard measures, such as physical infrastructure and technological solutions, with soft measures, including economic and financial incentives, governance and institutional frameworks, and knowledge and behaviour change interventions. Identifying the action type and ensuring a combination of hard and soft measures enables municipalities to address complex interconnected challenges. Municipalities can take inspiration from the action type classification proposed in section 3.

Concept	Explanation
	See section 3.
Implementation timeline	The implementation timeline definition should include a start date and an end date, as well as intermediate milestones when relevant. Based on the starting and ending dates of the actions, the municipality could define a Gantt chart and monitor periodically the expected progress of each action versus the actual deployment, as well as the impact achieved in the measured timeframes.
	See main document
Responsible bodies	This includes a clear indication of the responsible actors for the implementation of the action, both inside the municipality and outside. The plan may include actions that are under the responsibility of other entities than the municipality, hence it is essential to have clarity on the roles.
	See main document.
Stakeholders involved	The involved stakeholders should be clearly mentioned. Adequate engagement of stakeholders and individuals is fundamental for the planning, implementation and monitoring of actions.
	See main document.
Costs	The total implementation cost should be estimated for each action. Also, the costs identification should clearly distinguish between the upfront costs that should be incurred for the implementation of a specific action (CapEx – capital expenditures) and, if applicable, the operating expenditures (OpEx) for a specific action. Both aspects should be contemplated at the same time to gain an understanding of the investment that is required in the long term.
	See section 5.1.
Funding sources and financing instruments	Paired with the quantification of costs, the identification of funding sources and the corresponding financing instruments to cover the action deployment can determine if a specific action can be implemented. In this context, it is important to determine the funding sources (e.g. public sector, private sector or mixed approach) as well as the financing mechanisms (e.g. grants, soft loans, green loans, green bonds, blended finance, etc.).
	See complementary document 5 "Financial instruments for mitigation, adaptation and energy poverty actions"[29]
Estimated impact / outcome	Impacts/outcomes refer to the final quantitative results that are going to be obtained when the actions have been finalised. Estimated impacts/outcomes relate to the final goal to be achieved and should be quantified. These vary depending on the pillar that is addressed, as it can be observed below. Tracking impact indicators is fundamental to ensure reaching the established goals, thus, they should be observed in every monitoring cycle.

[29] Financial instruments for mitigation, adaptation and energy poverty (complementary document 5): https://publications.jrc.ec.europa.eu/repository/handle/JRC142127

Concept	Explanation
	Mitigation actions: energy savings / renewable energy production / GHG emission reduction (among other) *Adaptation actions*: quantification of how risks have been decreased / adaptive capacity has been improved / exposure has been decreased, based on defined adaptation goals. *Energy poverty actions*: quantification of how energy poverty has been decreased, based on the chosen indicators.
	Quantitative impact indicators: Impact indicators enable to track and measure the final achievements of the actions and how these achievements are contributing to reach the goal. Impact and outcome indicators should follow the metrics related with the defined goals.
	See section 6.1 and complementary documents 1 *"How to prepare a greenhouse gas emission inventory"*[30], 2 *"How to develop a risk and vulnerability assessment (RVA)"*[31], and 3 *"How to develop an energy poverty assessment"*[32].
Implementation parameters	Implementation parameters refer to direct results of an action. They relate to the tangible achievements of an action and can help to track its deployment. The definition of these parameters will depend on the action being evaluated. Implementation parameters are not directly linked to the final goal, but measure the progress of an action. For instance, the deployment of PV panels in residential buildings could be measured by the following indicators "number of homes with PV panels", "total surface of installed PV panels", or "total installed PV capacity", among others*. Other types of actions, for instance, the deployment of a training action on climate change aspects for municipal employees could be measured by the "number of people receiving the training". *Please note that the impact of the deployment of the PV action example (e.g. "renewable energy produced", or "energy substituted") would be captured under the previous set of estimated impact.
	Quantitative implementation indicators: Implementation parameters are directly related with the action itself and measure the tangible progress and direct achievements of the action.
	See section 6.2
Other co-benefits / potential trade-offs	The assessment of additional positive effects derived from the actions' implementation (e.g. environmental, social or economic co-benefits, synergies with other pillars or actions) as well as negative effects (e.g. trade-offs, maladaptation or other negative consequences) can help municipalities understand the relevance of a specific action over others. *For instance, the economic co-benefits of PV panels in*

[30] How to prepare a greenhouse gas emission inventory (complementary document 1): https://publications.jrc.ec.europa.eu/repository/handle/JRC142296

[31] How to develop a risk and vulnerability assessment (RVA) (complementary document 2): https://publications.jrc.ec.europa.eu/repository/handle/JRC142117

[32] How to develop an energy poverty assessment (complementary document 3): https://publications.jrc.ec.europa.eu/repository/handle/JRC142169

Concept	Explanation
	residential buildings could be measured by the following indicator "increase of property values". The social / economic co-benefits of an action on training on climate change aspects for municipal employees could be measured by the "unemployment rate evolution".
	Quantitative co-benefit indicators: Monitoring co-benefits and trade-offs is an effective way of quantifying and tracking the additional effects derived from the actions.
	See section 6.3.

6 Preparing the implementation and monitoring of actions

The following step in the SECAP process is linked to the implementation of the actions, and monitoring the impact, progress and potential co-benefits / trade-offs. This section introduces some brief concepts towards preparing the implementation of actions and their monitoring, and it is then complemented by the subsections 6.1, 6.2, 6.3, and Annex 1 where guidance towards the definition of indicators is presented.

Preparing the implementation of actions

To ensure that the envisaged objectives are reached, it is important that the right environment to implement the actions is set up. Some key aspects that need to be observed before and during the implementation of the actions, are related with the following components:

Technical aspects: from the technical side, it is important to have in place mechanisms that track the progress of both the individual actions and the overall plan. Monitoring indicators should be identified to check if the actions are advancing as planned, if the timeline is feasible and if the goals are within reach. Otherwise, there might be a need to readjust the plan.

Governance: all responsibilities need to be clearly identified and reported in the plan and effectively distributed. All roles in the public administration need to be clearly explained and linked in the plan, as so the limitations of the municipal governance. In addition, the alignment between internal departments and checks on the level of expertise within each responsible areas needs to be taken into consideration. Identifying key persons to report constantly on the progress of activities is an important step on monitoring, evaluate and learn during the implementation process.

Finance resources: the costs and sources of financing for each action planned and included in the plan, as so funding opportunities should be clearly identified. In that sense, mechanisms to revise the investments and the financing instruments in place should be created to guarantee the efficient use of the resources available and their effectiveness. In addition, a continuous track of funding opportunities should be considered, with a map of potential sources and dates for applying, as well as flexible approaches to ensure to address and overcome potential issues and challenges.

Resident**s and stakeholders' engagement**: for the successful implementation of the plan, it is crucial to engage all relevant stakeholders and ensure they are actively participating. In that sense, in addition to identifying the stakeholders and their role, a monitoring mechanism on their participation is also a powerful tool for the implementation. Following up the stakeholders' participation before and during the process allows that barriers and challenges are identified faster and actions on how to overcome these barriers can be developed. It also increases the sense of belonging/ownership of the plan and its success. One suggestion is the identification of the representatives and responsible persons that should be contacted frequently to check the actions deployment related with each stakeholder. From the engagement side, constant reports and sharing of partial results can also be implemented, as so, identifying potential benefits for each stakeholder and individuals in the process. The acceptance of the plan by all parts of the society guarantees the success of the plan.

Preparing the monitoring of actions

To ensure that the envisaged objectives are reached a series milestones (indicators) need to be defined. These should enable to assess whether the planned actions are going in the right direction or if adjustments to the initial plan should be proposed. A set of auditable, reportable, and verifiable key performance indicators is an important precondition for the monitoring and evaluation as well as the continuous analysis of the municipality's achievements. The monitoring process should compare specific parameters at a certain moment with the initial and expected values for these parameters. Monitoring actions allow that a municipality observe the gaps in the implementation plan and correct it as soon as possible.

For an efficient monitoring process, measuring mechanisms and constant data collection need to be in place. The performance indicators should be identified prior the implementation, but they can be adjusted accordingly to the progress of the actions.

The types of indicators that can be useful for municipalities are organised as follows: a) impact indicators (measures the final direct benefit); b) action's deployment (measures the level of implementation of an action); and c) co-benefits and trade-offs (indirect effects from the action, which can be positive or negative). The next sections will detail each type of indicators.

Figure 10. Action-level indicators to monitor impact, actions' implementation and co-benefits or trade-offs

	ACTION EXAMPLE	ACTION-LEVEL INDICATORS TO MEASURE			
		IMPACT	IMPLEMENTATION	CO-BENEFITS	TRADE-OFFS
MITIGATION	Substitution of the municipal vehicle fleet by electric vehicles	GHG emissions reduced (Unit: tCO_2-eq/year)	Number of vehicles substituted (Unit: # municipal vehicles substituted)	Air quality increase (Unit: PM1.0 concentration)	Increase of upfront costs per vehicle (Unit: €/vehicle)
ADAPTATION	Creation of summer shelters for extreme heat	Protected inhabitants from extreme heat (Unit: # people that can be sheltered during extreme heat peaks)	Total surface of created shelters (Unit: sqm of extreme heat shelters)	Reduction in heat-related health issues among vulnerable population groups (Unit: %)	Opportunity cost of alternative uses for public space (Unit: m^2)
ENERGY POVERTY	Energy refurbishment of vulnerable households	Energy consumption per capita (Unit: MWh / year · person)	Number of vulnerable households refurbished (Unit: #households)	Increase of employment (Unit: # jobs created)	Disruption to household daily life and activities (Unit: days)

Source: JRC elaboration

Some example indicators are presented to illustrate the potential aspects that can be measured at action level. These indicators are non-exhaustive, and the monitoring needs of each municipality may vary. The municipality should carefully assess the level of monitoring required by each , ensuring that the monitoring approach is balanced, cost-effective, and aligned with the internal resources and data availability, and that it provides the most valuable (and actionable) insights. The municipality should also consider the resources required for data collection, analysis and reporting, as well as the potential costs and benefits of each indicator. By adopting a thoughtful and tailored approach to monitoring actions, the municipality can strike a balance between gaining valuable insights into the effectiveness of the action portfolio, and minimising the administrative burden associated with data collection and reporting.

6.1 Indicators to track the impact of actions

Impact indicators focus on the direct impacts related to an action and assess the contribution of the proposed action to the overall goal of the plan.

Mitigation action level indicators (impact)

For the mitigation pillar, the final impact expected is related with 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.

Some examples of indicators are listed in Table 6.

Table 6. Mitigation action level example indicators (impact)

Mitigation target	Action example	Impact indicator	Units
Reduce GHG emissions by 55% compared to the baseline year	Substitution of the municipal vehicle fleet by electric vehicles	Annual GHG emissions associated with municipal transport	t CO_2-eq
		Annual fuel consumption by the municipal vehicle fleet	MWh
	Energy retrofit of residential buildings	Total energy consumed in residential buildings	MWh
		Total fuel for heating consumed in residential buildings	MWh

Source: JRC elaboration

An additional indicator that can be used to measure the impact of mitigation actions is the financial indicator 'cost efficiency (€/t CO_2 reduced),' which can be useful for monitoring not only the results of the actions but also their financial efficiency in relation to the mitigation objectives.

Adaptation action level indicators (impact)

In the case of adaptation, the final impact expected at action level should be related to the adaptation goal(s) defined at municipal level, which depend on the local conditions (see complementary document on RVA[33] for guidance). This will help to monitor the efforts on adaptation and track the progress.

Some examples of indicators can be seen below:

[33] How to develop a risk and vulnerability assessment https://publications.jrc.ec.europa.eu/repository/handle/JRC142117

Table 7. Adaptation action level example indicators (impact)

Adaptation goal	Action example	Impact indicator	Units
Reduce the annual expected loss due to floods in the municipality by 80% by 2025	Implementation of flood protection infrastructure	Annual expected loss	€
	Establish floods early warning systems (EWS)	Number of people reached by EWS alerts	Number of people
Protect 100% of the population living in high-risk coastal areas to safer zones by 2030 to reduce exposure to sea-level rise	Financing incentives for the protection of residential buildings in highly vulnerable areas due to sea-level rise	Number of households protected	households
	Implement flood resilient construction standards	Number of buildings following the flood resilient standard	buildings

Source: JRC elaboration

Energy poverty action level indicators (impact)

For energy poverty, the final impact expected is related with the reduction of the vulnerable population facing energy poverty and/or any indicators directly related to the local observed energy poverty situation (see complementary document 3 "How to develop an energy poverty assessment"[34]). In that sense, measuring the impacts of energy poverty policies implemented actions requires to identify all final indicators related with the chosen overall and specific energy poverty target.

Some examples of indicators are:

Table 8. Energy poverty action level example indicators (impact)

Energy poverty goal	Action example	Impact indicator	Units
Reduce the number of households expending more than x% of their income in energy	Training and awareness campaigns to energy vulnerable households on energy efficient measures	F+G + H band (EPC) dwelling / total number of dwellings	share (%)
		Energy consumption (electricity + heating) per capita	MWh/y/per person
	Implementing funding for energy expenditure on vulnerable population groups	Share of energy expenses in the total income of vulnerable families	share (%)
		Savings on energy expenses on vulnerable families	cost (€)

Source: JRC elaboration

[34] How to develop an energy poverty assessment: https://publications.jrc.ec.europa.eu/repository/handle/JRC142169

6.2 Indicators to track the implementation of actions

Indicators to track the implementation of actions focus on the parameters related with the tangible deployment of the action. Normally, these types of indicators are easier to monitor compared to impact indicators, as they quantify the primary result of an action, or the steps needed to put an action in place.

Some examples of indicators to track the implementation of actions for each of the pillars can be found below.

Mitigation action level indicators (implementation)

Table 9. Mitigation action level example indicators (implementation)

Mitigation target	Action example	Implementation indicator	Units
Reduce GHG emissions by 55% compared to the baseline year	Substitution of the municipal vehicle fleet by electric vehicles	Vehicles substituted	number of vehicles
		Share of electrical vehicles in the total municipal fleet	electric vehicles/total municipal fleet (%)
	Energy retrofit of residential buildings	Total implemented measures at the households	number of measures/number households
		Number of buildings refurbished	total number of buildings targeted

Source: JRC elaboration

Adaptation action level indicators (implementation)

Examples to track the deployment of adaptation actions can be found below. Please note that deployment indicators are directly linked to the actions rather than adaptation goals; however, the table below also references the adaptation goals linked to the adaptation actions used as examples.

Table 10. Adaptation action level example indicators (implementation)

Adaptation goal	Action example	Implementation indicator	Units
Reduce the annual expected loss due to floods in the municipality by 80% by 2025	Implementation of flood protection infrastructure	Meters of flood protection infrastructure implemented	meters
	Establish floods early warning systems (EWS)	Percentage of municipal employees using the EWS	% of employees
Protect 100% of the population living in high-risk coastal areas to safer	Financing incentives for the protection of residential buildings in highly vulnerable areas due to sea-level rise	Volume of financing incentives deployed	€

zones by 2030 to reduce exposure to sea-level rise	Implement flood resilient construction standards	Number of buildings following the standard	buildings

Source: JRC elaboration

Energy poverty action level indicators (implementation)

Examples to track the deployment of energy poverty actions can be found below. Please note that deployment indicators are directly linked to the actions rather than goals; however, the table below also references the energy poverty targets linked to the actions used as examples to clarify all indicator types.

Table 11. Energy poverty action level example indicators (implementation)

Energy poverty target	Action example	Implementation indicator	Units
Reduce the number of households expending more than x% of their income in energy	Training and awareness campaigns to energy vulnerable households on energy efficient measures	Number of people participating in the campaigns	number of people
		Total training activities implemented	number of training events
	Implementing funding for energy expenditure on vulnerable population groups	Total implemented measures at the households	number of measures/number households
		Families receiving financial support	number of families

Source: JRC elaboration

6.3 Indicators to track the co-benefits and trade-offs of actions

The implementation of mitigation, adaptation and energy poverty actions can have a dual impact: it can achieve its intended objectives while also yielding additional positive outcomes (co-benefits), or negative consequences (trade-offs). These can be linked to attaining impacts in other pillar (i.e. obtaining co-effects, see section 4.4), while other can be indirect impacts related to other domains (i.e. co-benefits when positive, or trade-offs when negative). Specific co-benefits and trade-offs and their magnitude can vary depending on the context, location and implementation of the actions. A non-exhaustive classification of co-benefits and examples (Table 12 and Table 13), and trade-offs and examples (Table 14 and Table 15) are presented below.

Table 12. Classification of co-benefits (non-exhaustive)

Co-benefits		Further specification
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
	Cultural preservation and promotion	Protection and celebration of local heritage, traditions, and cultural identity
Economic	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

Co-benefits		Further specification
Governance and planning	Improved governance	Increased transparency, accountability, and civic engagement in decision-making processes
	Effective and sustainable decision-making	Integrated planning, strategic policymaking, and evidence-based decision-making
	Enhanced collaboration and partnerships	Increased cooperation among government agencies, private sector, and civil society organisations
	Capacity building and skills development	Training and capacity-building programmes for public officials, businesses, and community leaders
	Increased public participation	Inclusive and participatory planning processes, which can enhance legitimacy and ownership of sustainability initiatives
	Better data management and analysis	Improved data collection, analysis, and dissemination, which can inform decision-making and policy development
	Integration of sustainability into urban planning	Incorporation of sustainability principles and objectives into urban planning frameworks and policies

Source: JRC elaboration

These co-benefits can also be monitored at action level through specific indicators. Some examples (non-exhaustive) based on the actions mentioned in the previous subsections can be found in the table below.

Table 13. Co-benefit example indicators

Action example	Type of co-benefit	Co-benefit indicator	Units
Substitution of the municipal fleet by electric vehicles [mitigation]	Environmental	Air quality (reduced particulate matter)	$\mu g/m^3$
Refurbishment of residential buildings to high standards of efficiency [mitigation]	Social	Increased comfort	% of residents reporting improved comfort
Implementation of flood protection infrastructure [adaptation]	Economic	Number of jobs created in construction and maintenance	Number of jobs
Financing incentives for the protection of residential buildings in highly vulnerable areas due to sea-level rise [adaptation]	Social	Increase in access to basic services (healthcare, education)	% of increase in access to services
Training and awareness campaigns to vulnerable households on energy efficient measures [energy poverty]	Social	Increase in sense of community empowerment among participants	% participants reporting increased sense of control

Implementing funding for energy expenditure on vulnerable population groups [energy poverty]	Social	Reduction in energy poverty-related health issues	% of affected population

Source: JRC elaboration

Trade-offs can also be classified into environmental, social, economic and governance related.

Table 14. Classification of trade-offs (non-exhaustive)

Trade-offs		Further specification
Environmental	Land use conflicts	Infrastructure development or urban expansion may lead to the destruction of natural habitats, forests and wildlife reserves.
	Resource depletion	Over-exploitation of natural resources may compromise long-term sustainability and ecosystems.
	Increased energy consumption	Implementing new technologies or infrastructure may lead to increased energy consumption.
	Ecosystem displacement	Large-scale renewable projects (e.g. solar farms, wind farms) may displace natural ecosystems and wildlife habitats.
	Water pollution	Increased use of water for industrial or agricultural purposes may lead to water pollution, affecting aquatic ecosystems.
	Biodiversity loss	The implementation of certain actions (e.g. infrastructure development) may lead to biodiversity loss.
Social	Displacement and gentrification	Urban regeneration and infrastructure projects may lead to gentrification and displace low-income or marginalised communities, increasing social inequality.
	Increased costs for low-income households	Implementing new technologies or infrastructure may increase costs for low-income households, exacerbating energy poverty.
	Inequitable distribution of benefits	Sustainability actions may inadvertently create unequal distribution of benefits, with some groups or communities receiving more advantages than others.
	Conflicting community interests	Different community groups may have competing interests, which can be exacerbated with the deployment of certain actions and lead to conflicts and challenges in decision-making.
	Limited accessibility	New infrastructure and technologies may not be accessible or affordable for all members of the community, exacerbating social inequalities.
	Job displacement	Automation and technological advancements may displace certain jobs, particularly in industries that are heavily reliant on manual labour.
	Cultural heritage impacts	Municipality-level actions may impact cultural heritage sites, historical buildings, and traditional communities, leading to loss of cultural identity.
	Mental health impacts	The stress and uncertainty associated with sustainability initiatives, such as energy transitions or urban renewal, may have negative impacts on mental health and well-being of residents.

Trade-offs		Further specification
Economic	High upfront costs	Implementing new technologies or infrastructure may require significant upfront investments, which could become a burden to local budgets.
	Opportunity costs (prioritisation)	Investing in one project or initiative may divert resources away from other actions.
	Increased taxes or fees	Implementing new actions or policies may require increasing taxes or fees, potentially affecting local businesses and residents.
	Market distortions	Municipalities' incentives or subsidies for certain industries or technologies may create market distortions at the local level, potentially leading to inefficient allocation of resources.
	Risk of obsolete assets	Investing in infrastructure or technologies that may become obsolete or unsustainable in the long term may lead to financial losses.
	Dependence on external funding	Relying on external funding sources for sustainability initiatives may create uncertainty and vulnerability, as funding priorities can shift over time.
Governance and planning	Conflicting policy priorities	Different policy priorities may compete for resources and attention, leading to challenges in decision-making processes.
	Unintended bureaucratic burdens	Implementing new sustainability initiatives may create additional administrative tasks and bureaucratic burdens, diverting sources away from core activities (municipality) or creating social resistance (individuals).
	Over-reliance on technology	Implementing new technologies may lead to over-reliance on these systems, potentially creating vulnerabilities and single points of failure.
	Unforeseen consequences of policy interactions	Interactions between different actions and initiatives may have unforeseen consequences, such as creating new challenges or exacerbating existing ones.
	Insufficient flexibility in planning	Sustainability initiatives may be planned and implemented in a way that is inflexible and unable to adapt to changing circumstances, making it difficult to respond to new challenges or opportunities.

Source: JRC elaboration

In the same way as the co-benefits, these trade-offs can also be monitored at action level through specific indicators. Some examples (non-exhaustive) based on the actions mentioned in the previous subsections can be found in the table below.

Table 15. Trade-offs example indicators

Action example	Type of trade-off	Trade-off indicator	Units
Substitution of the municipal fleet by electric vehicles [mitigation]	Economic	Increase in upfront costs	€/vehicle
Energy retrofit of residential buildings [mitigation]	Governance	Administrative burden on municipalities	Number of permits required

Implementation of flood protection infrastructure [adaptation]	Environmental	Loss of natural habitats	Hectares of natural habitats affected
Financing incentives for the protection of residential buildings in highly vulnerable areas due to sea-level rise [adaptation]	Social	Displacement of low-income households	Number of households displaced
Training and awareness campaigns to vulnerable households on energy efficient measures [energy poverty]	Economic	Opportunity cost of public spending	€ / household
Implementing funding for energy expenditure on vulnerable population groups [energy poverty]	Governance	Administrative costs of funding distribution	€ / beneficiary

Source: JRC elaboration

7 Pillar considerations for planning of actions and strategies

This section explores mitigation, adaptation and energy poverty considerations that are useful for the design of actions (sections 7.1, 7.2 and 7.3, respectively). It also provides relevant examples of potential strategies that can be deployed at municipality level, and good practices for each pillar described through the action template introduced in section Error! Reference source not found. F inally, the section ends (section 7.4) with considerations on integrated actions, by showcasing well-known approaches and three action template fiches with integrated actions.

7.1 Mitigation actions

Mitigation actions aim at reducing GHG emissions by reducing energy consumption (or other activities that generate emissions), improving energy efficiency, or implementing energy from renewable sources. The underlying principle that should be followed when defining GHG mitigation actions is the "Energy efficiency first" principle.

Box 11. The "Energy efficiency first" principle

When planning mitigation actions, municipalities should apply the "energy efficiency first" principle (anchored in the revised Energy Efficiency Directive (EED) (European Parliament; European Council, 2023)) in all relevant scenarios and policy, planning and major investment decision. To this end, they should carry out cost-benefit analysis and prioritise demand-side solutions if they are more cost-effective than investments in energy supply infrastructure in order to achieve their policy objectives.

The EED also stresses the exemplary role of the public sector. In particular:

- Public bodies (incl. at local level) should fulfil an exemplary role as regards energy efficiency and are subject to the obligation, for the public sector as a whole, to achieve an annual reduction of the energy consumption by at least 1.9 %.
- Regional and municipalities will have to establish specific energy efficiency measures in their long-term planning tools, such as decarbonisation or sustainable energy plans.
- At least 3 % of the total floor area of heated and/or cooled buildings that are owned by public bodies shall be renovated each year to be transformed into at least nearly zero-energy buildings or zero-emission buildings.
- Public authorities will have to purchase products, services buildings and works with high energy-efficiency performance.

This section provides specific considerations for designing municipality level GHG mitigation actions. For each of the sectors of activity taking place in the territory of the municipality (buildings, public lighting, transport, industry, electricity production, heat/cold production, waste and wastewater management, and agriculture, forestry and other land-use sector), a brief context is presented and key strategies that are used to address each of the sectors are explained. Additionally, throughout the text the reader can encounter relevant references to real-life cases. Last but not least, two mitigation best-practices that follow the action template introduced in 5.3 are presented in section 7.1.9.

7.1.1 Buildings

The building sector is a critical component of urban infrastructure, accounting for a more than half of the share of energy consumption (Franco de los Rios et al., 2024) and approximately half of the total GHG emissions in EU municipalities (Melica et al., 2024), according to reported data. As municipalities strive to reduce their GHG emissions and achieve climate neutrality, the building sector offers a wealth of opportunities for mitigation actions. With a wide range of building types, from residential and commercial to public and historic, municipalities must adopt a nuanced approach to governance and regulation to effectively reduce energy consumption and promote sustainable development.

Municipalities can deploy different modes of governance to exert influence and control over the building sector. For example:

- A municipality can use its municipal self-governing power to establish green building standards for new buildings, or to invest in energy-efficient retrofits for existing public buildings.
- Through governing by provision, a municipality can offer incentives for private developers to build green buildings, or partner with private companies to finance energy-efficient upgrades for groups of buildings in a specific district.
- By exercising its regulatory powers, a municipality can revise building codes to require new buildings to meet energy efficiency standards or implement policies to encourage building owners to retrofit existing buildings that require preservation.
- Additionally, a municipality can use its municipal enabling power to educate building owners and occupants about the benefits of energy-efficient buildings, or to facilitate partnerships between building owners and private companies to finance and implement energy-efficient upgrades.

The same approach cannot be applied for all types of buildings, as depending on the type of building, different requirements, barriers or opportunities can be encountered. In this context, the Energy Performance of Buildings Directive (EPBD)[35] emphasises the importance of considering the whole-life-cycle emissions of buildings, going beyond energy efficiency to include operational and embedded energy. This approach highlights the significance of design and material choices, as well as construction and renovation methods, with supporting regulations such as the revised Construction Products Regulation[36] and Technical Guidance on climate proofing of infrastructure[37], aiming to reduce environmental impact and promote sustainability in the construction sector.

Box 12. [Buildings] Whole-life carbon metrics in the buildings sector: the TOTEM tool

A consortium of Belgian partners has developed a tool to assess the environmental impact of buildings considering the whole life cycle. TOTEM [Tool to Optimise the Total Environmental impact of Materials][38] allows to compare alternatives (demolition and reconstruction versus refurbishment, the impact of different

[35] Energy performance of buildings directive (EPDB) (recast 2024) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401275&pk_keyword=Energy&pk_content=Directive

[36] Construction products regulation: https://eur-lex.europa.eu/eli/reg/2024/3110/oj/eng

[37] EC Technical guidance on climate proofing of infrastructure https://ec.europa.eu/newsroom/cipr/items/722278/en

[38] TOTEM: Tool to Optimise the Total Environmental impact of Materials: https://www.totem-building.be/

materials) to optimise design choices. While the scientific method is adapted to the Belgian construction market, it can serve as an inspiration for other regions.

The following subsections explore some particularities of new buildings, existing buildings, public buildings, historic buildings and groups of buildings. These are followed by a classification of different types of actions that can be implemented in the building sector (sections 7.1.1.1 to 7.1.1.4).

New buildings

Planning mitigation actions for new buildings requires careful considerations of environmental, economic and social factors. One of the key challenges is balancing the need for energy efficiency and sustainability with the economic constraints of construction costs. However, this also presents an opportunity to incorporate innovative technologies and design principles that can minimise the building's environmental footprint and energy consumption leading to nearly zero energy buildings, zero emission buildings or energy positive ones. In fact, since 2020 all new buildings in the EU are required to be 'nearly-zero energy buildings'. This requirement will be strengthened in the future by pursuing 'zero-emission buildings' for new buildings owned by public bodies starting from 2028, and for all new buildings starting from 2030[39]. Against this backdrop, municipalities could set more ambitious minimum energy requirements for new buildings.

Moreover, new buildings can be designed with flexibility and adaptability in mind, allowing for future upgrades and retrofits. This requires a holistic approach that considers not only the building's energy performance, but also its overall sustainability and resilience. For instance, designing buildings with passive design elements, such as natural ventilation and daylighting, can reduce the need for mechanical systems and lower energy consumption.

Furthermore, new buildings can also be designed to meet new building codes and standards that prioritise energy efficiency and sustainability. Bioclimatic design, which considers the local climate and site conditions, can be also used to create buildings that are adapted to their environment and minimise energy consumption. By incorporating bioclimatic design principles, such as orientation, shading and insulation, buildings can be designed to reduce their reliance on mechanical systems and minimise their environmental impact. Additionally, incorporating green building materials and sustainable construction practices can reduce the building's environmental impact and promote healthier indoor air quality.

Box 13. [Buildings] The New European Bauhaus initiative and practical application: the EU-funded CrAFT cities project

The New European Bauhaus (NEB)[40] is a creative and transdisciplinary movement that aims to reimagine sustainable living in Europe and beyond. Launched in 2020, the initiative brings together residents, experts, businesses, and institutions to co-create a more sustainable, inclusive and beautiful future. The NEB is built on three inseparable values: sustainability, aesthetics, and inclusion, and seeks to transform our societies by leveraging green and digital challenges. For example, municipalities like Izmir[41] are already benefiting from

[39] Nearly-zero energy and zero-emission buildings https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-and-zero-emission-buildings_en

[40] The New European Bauhaus (NEB): About the initiative: https://new-european-bauhaus.europa.eu/about/about-initiative_en

[41] NetZeroCities: Izmir (Türkiye) climate city contract: https://netzerocities.app/resource-4184

EU-funded initiatives, such as the CrAFt Cities project[42], which aims to support municipalities in becoming climate-neutral, beautiful and inclusive. As one of the more than 70 CrAFt Cities, Izmir is creating opportunities for climate action that leaves no one behind, including artists, young people, and disadvantaged groups, demonstrating the potential of the NEB's values in action.

Existing buildings

Buildings built before 2000 represent 85% of the building stock in Europe (75% of them have a poor energy performance)[43] and pose a unique set of challenges when it comes to mitigation actions. Additionally, their rate of refurbishment should be increased, as highlighted in the Renovation Wave (European Commission, 2020). One of the main difficulties is navigating the complex web of ownership, occupancy, and stakeholder interests. This can lead to barriers to investment and implementation, particularly in cases where multiple stakeholders are involved. However, existing buildings also present opportunities for retrofitting and upgrading, which can not only reduce energy consumption, but also improve occupant comfort and health. Moreover, existing buildings could also have a rich cultural and historical significance (even if they are not officially categorised as historic buildings), which must be considered when planning mitigation actions.

To overcome the challenges of retrofitting existing buildings, it is essential to engage with stakeholders and develop a clear understanding of their needs and priorities. This can involve conducting building assessments and energy audits to identify areas of improvement and opportunities for energy savings. Additionally, developing a phased approach to retrofitting can help to minimise disruptions to occupants and ensure that the building remains functional throughout the process (and avoid potential relocations). By taking a collaborative and phased approach to retrofitting, existing buildings can be transformed into more sustainable and energy-efficient spaces that meet the needs of occupants while reducing their environmental impact.

Box 14. [Buildings] Building retrofitting approaches in Lahti (Finland), Reggio Emilia (Italy) and Breda (The Netherlands)

The municipalities of Lahti (Finland)[44], Reggio Emilia (Italy)[45] and Breda (Netherlands)[46] have launched initiatives to reduce energy consumption and CO_2 emissions. Lahti's "Energy Choice" project provides an online platform for residents to explore energy-efficient solutions, while Reggio Emilia's LEMON project retrofits social housing units and offers trainings to tenants. Breda's See2Do project showcases innovative energy-saving measures, such as thermal energy systems and LED lighting, in public buildings to inspire residents and businesses to adopt similar solutions, all contributing to their respective municipalities' goals of becoming carbon neutral by 2025, 2025 and 2044.

[42] CrAFt cities project: https://craft-cities.eu/

[43] European Commission, key facts on energy and EU buildings https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

[44] Lahti Energy Choice (Finland): supporting residents' choices for more energy efficient buildings https://eu-mayors.ec.europa.eu/en/node/258

[45] Reggio Emilia (Italy) - LEMON project - reducing greenhouse gas emissions through the energy conversion of social housing https://eu-mayors.ec.europa.eu/en/node/233

[46] Breda (Netherlands): the See2Do project encourages residents to improve energy efficiency https://eu-mayors.ec.europa.eu/en/node/271

Public buildings

Public buildings, such as schools, hospitals, and government offices, play a critical role in promoting sustainable development and reducing greenhouse gas emissions, as they can act as examples in energy refurbishment due to their visibility and influence. However, they also face unique governance and regulatory challenges. For example, public buildings are often subject to strict budget constraints and bureaucratic processes, which can limit the scope and speed of mitigation actions. On the other hand, public buildings can also serve as models for sustainability and energy efficiency, influencing the behaviour of residents 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. Municipalities can also deploy actions to reduce energy consumption and promote energy efficiency. Actions can include building retrofits, information campaigns or installation of RES. Some tried and tested practices can be found in the Housing Europe website[47].

Box 15. [Buildings] Energy efficiency interventions in public buildings and lighting systems: Turin (Italy)

The municipality of Turin (Italy) has implemented various energy efficiency interventions for its public buildings and lighting systems[48]. In partnership with the Politecnico of Turin, the municipality has collected data on energy consumption and costs to inform technical and policy decisions. Renovations, such as the energy requalification of the municipal police offices, aim to reduce energy consumption by 30% for electricity and 20% for heating and air conditioning. Additionally, the municipality has replaced 55 000 public lighting bulbs with LEDs, resulting in 50% energy savings, and is planning to expand this project to traffic signs.

Historic buildings

The historic building stock presents a complex set of challenges and opportunities for mitigation actions, requiring a nuanced approach that balances preservation with modernisation. On the one hand, they are often protected by preservation laws and regulations, which can limit the scope of retrofits and upgrades. On the other hand, historic buildings can also be upgraded and retrofitted in ways that preserve their socio-cultural and historical significance while reducing their environmental impact.

To achieve this balance, it is essential to conduct detailed assessments of the building's condition, including thermographic surveys to identify areas of heat loss and energy inefficiency, infrared scanning to detect moisture and air leakage, acoustic testing to evaluate the building's sound insulation and sound quality, materials analysis to identify the composition and condition of historical materials and structural analysis to evaluate the building's load-bearing capacity and seismic resilience. Based on the results of these assessments, specific actions can be planned that allow preserving historic materials and features. In parallel, it is essential to engage with preservation experts and stakeholders to develop a clear understanding of the building's cultural and historical significance.

[47] Housing Europe: tried and tested practices: https://www.housingeurope.eu/innovation-best-practice/tried-tested-practices/

[48] Turin (Italy) Energy efficiency interventions for public buildings and lighting systems https://eu-mayors.ec.europa.eu/en/node/218

The measures to be considered in historic buildings are similar to those applicable in regular retrofits but considering correlated barriers. The measures can include upgrading windows and doors with energy-efficient, historically compatible replacements, adding insulation to walls, floors and ceilings, and installing renewable energy systems, such as solar panels or small wind turbines. Additionally, energy-efficient lighting and HVAC systems can be implemented, and sustainable, locally sourced materials can be used for repairs and upgrades. Some examples of potential solutions for historical buildings can be explored in the HiBERtool (Historic Building Energy Retrofit Tool)[49], which can serve as inspiration for solutions related to windows, walls, ventilation or solar actions and further examples observed in the Hiberatlas[50]. Further information resources to support historic building retrofits include CEN/TC 346[51], IEA-SHC Task 59[52], the H2020 RIBuild project[53], 3ENCULT (FP7)[54] and INHERIT EU-funded project[i].

Box 16. [Buildings] Approaches to historic building retrofitting and preservation: Urbino (Italy) and Ioannina (Greece)

The municipality of Urbino, Italy, plans to link adaptation to historical building preservation[55] by engaging stakeholders in a co-implementation agenda to retrofit old country houses, known as 'casali', which are part of the municipality's UNESCO world heritage site. This initiative aims not only to help to reduce soil degradation and biodiversity loss, but also to contribute to reversing the municipality's demographic decline and enhancing the quality of life for residents, demonstrating a positive example of climate change adaptation and heritage preservation. Similarly, the municipality of Ioannina, Greece[56], is taking action to upgrade and preserve its modern monuments, aiming to reduce GHG emissions and energy consumption while maintaining their cultural and historic significance. The planned technical interventions include assessing and prioritising monuments for energy-saving potential, integrating energy-efficient technologies, promoting behavioural change, and establishing maintenance and monitoring systems. The project is currently in the research phase and is expected to be completed by 2028, contributing to the municipality's 2030 climate neutrality goals.

Groups of buildings

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 mitigation 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. Some examples of building renovation at district level

[49] HiBERtool (Historic Building Energy Retrofit Tool) https://www.tool.hiberatlas.com/en/welcome-1.html

[50] Hiberatlas (Eurac research): https://hiberatlas.eurac.edu/en/welcome-1.html

[51] CEN/TC 346 Conservation of Cultural Heritage: https://standards.cencenelec.eu/dyn/www/f?p=205:7:0::::FSP_ORG_ID:411453&cs=1CF54B40A1F71DDBD7991221E377664AE

[52] International Energy Agency – Solar Heating and Cooling Programme Task 59 Renovating Historic Buildings Towards Zero Energy. https://task59.iea-shc.org/

[53] H2020 RIBuild project – Internal insulation in Historic Buildings: https://www.ribuild.eu/home

[54] 3ENCULT EU-funded Project: https://www.3encult.eu/en/project/welcome/default.html

[55] Climate change adaptation co-implementation agenda in Urbino, Italy: https://eu-mayors.ec.europa.eu/en/climate-adaptation-case-study-urbino-italy

[56] NetZeroCities: Ioannina (Greece): climate city contract https://netzerocities.app/resource-4200

can be observed in a recent study (Rose et al., 2021). Furthermore, specific funding mechanisms are available for groups of buildings or neighbourhoods, such as the New European Bauhaus Facility[57].

Box 17. [Buildings] Groups of buildings example: Ljubljana (Slovenia). Public-private partnership for a large-scale building retrofit programme

The municipality of Ljubljana has implemented a large-scale building retrofit programme [58] in partnership with two private companies. The programme, which has retrofitted 48 buildings, including schools, kinder gardens, and administrative buildings, aims to boost efficiency through interventions such as LED lighting, modernised heating and cooling systems and insulation. The private companies provided 51% of the funding, while the municipality and EU Cohesion funds covered the remaining 49%. The programme is expected to save 8 000 MWh of energy and almost 3 000 tonnes of CO_2 annually and will generate profits for the municipality after a 15-year payback period. The approach has also had positive knock-on effects, including improved quality of life for building users, increased awareness of sustainability issues, and employment opportunities for local contractors.

Moreover, groups of buildings can also be used to test and demonstrate new technologies and approaches, creating opportunities for innovation and learning. For instance, groups of buildings can be used to pilot new energy efficiency measures, such as district-scale energy systems (see section 7.1.6), building-to-grid integration, or renewable energy communities (see section 7.1.5). These innovations can be further amplified in multifunctional neighbourhoods, where integrated land use and proximity to services reduce reliance on private vehicles and foster compact, walkable urban forms. Additionally, groups of buildings can also be used to promote community engagement and participation in sustainability initiatives, fostering a sense of ownership and responsibility among residents. By addressing the complex social, economic and environmental factors that affect groups of buildings, it is possible to create more sustainable and resilient communities.

Box 18. [Buildings] Positive energy districts and neighbourhoods (PED/PEN) and the EU-funded ATELIER project.

One notable strategy example linked to groups of buildings is that of the Positive Energy Districts and Neighbourhoods (PED/PEN). "Positive Energy Districts are energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy, mobility and ICT systems, while securing the energy supply and a good life for all in line with social, economic and environmental sustainability." (JPI Urban Europe / SET Plan Action 3.2, 2020) One PED initiative is the EU-funded ATELIER project[59], which aims to develop Positive Energy Districts in Amsterdam and Bilbao and replicate them in six other European municipalities. The project involves residents in decision-making and solution development and creates innovation hubs (ateliers) to drive sustainable solutions. Each municipality will develop a "City Vision 2050" roadmap to ensure a seamless transformation towards a more sustainable and energy-efficient urban environment.

[57] New European Bauhaus Facility: https://new-european-bauhaus.europa.eu/funding/new-european-bauhaus-facility_en

[58] Ljubljana (Slovenia) Public-private partnership for a large scale building retrofit programme https://eu-mayors.ec.europa.eu/en/node/268

[59] EU-Funded Smart City Project ATELIER: Amsterdam Bilbao citizen driven smart cities: https://smartcity-atelier.eu/

7.1.1.1 Physical and technological

The building sectors can reduce its GHG emissions through various physical and technological measures. Grey options include the use of thermal insulation materials (like high insulating windows and insulation material), low consumption energy systems such as heat pumps, and the integration of renewable production. Additionally, technological options like building management systems and smart grids in combination with renewable energy sources can optimise energy use and reduce dependence on fossil fuels. For instance, building-integrated photovoltaics and solar water heating systems can generate energy from renewable energy sources and reduce GHG emissions. Also, smart buildings can optimise building performance and operational efficiency, improve occupant comfort and, at the same time, respond to signals from the electricity grid (thus providing energy flexibility).

Box 19. [Buildings] Suceava's (Romania) digitalisation approach in the building sector

Suceava (Romania)[60] leverages digitalisation to increase energy efficiency in the building sector by implementing an integrated monitoring, control and energy reduction system, installation of sensors and automation systems, and creation of data platforms to collect and interpret energy efficiency information. These components will be integrated into the municipality's digital twin concept, enabling real-time monitoring and control of energy consumption. Additionally, the development of a smart connected municipality infrastructure will support energy renovation of buildings and sustainable urban development, promoting a more efficient and sustainable urban environment.

Individual renewable heating technologies

Heat pumps are a versatile and renewable technology crucial in decarbonising the EU's heating and cooling sector. They can be used in various settings, from residential buildings to industrial processes, and can be integrated with other low-carbon technologies, such as district heating and cooling systems. The type of heat pump selected (air, water, or ground-sourced) will depend on the heating demand, the space available, and availability of nearby renewable ambient energy. Hybrid heat pumps, or high-temperature heat pumps, are suitable for buildings that are less energy-efficient. Heat pumps generally operate at high efficiency and will reduce greenhouse gas emissions for most municipalities, except those relying significantly on coal for their power production.

Biomass and solar thermal technologies also play an essential role in the EU's low-carbon heating and cooling strategy. Biomass can be used to generate heat through combustion, while solar thermal systems harness the sun's energy to provide warmth. These technologies can be employed in various applications, from small-scale residential heating to large-scale industrial processes, and can be combined with other renewable energy sources to create hybrid systems. Biomass and solar thermal technologies will remain important for replacing fossil-based heating technologies.

The relevance of these individual renewable heating technologies for municipalities lies in their ability to address specific urban challenges, such as reducing greenhouse gas emissions, improving air quality, and enhancing energy security. They can be tailored to meet the unique needs of urban areas, such as high population densities, limited space, and diverse building stocks. By considering the specific characteristics of each technology, cities can create a customised low-carbon heating strategy that balances technical, economic, and environmental factors, ultimately contributing to a

[60] NetZeroCities: Suceava's (Romania) climate city contract: https://netzerocities.app/resource-4447

more sustainable and resilient urban energy system. Another option is to make use of centralised technologies, e.g. district heating and cooling.

Moreover, green options, such as green roofs and walls, can improve insulation and thus reduce energy consumption, whereas blue options, like rainwater harvesting and greywater reuse, can decrease the demand on potable water resources and reduce the energy needed for water treatment.

One approach that municipalities can implement to test innovative solutions and then replicate them across the municipality is the deployment of pilot actions in the building and other sectors. Piloting is essential to test and refine innovative solutions, identify potential challenges and gauge their effectiveness before scaling up, thereby reducing the risk of costly mistakes and ensuring successful implementation. By piloting actions, municipalities can also gather valuable data and insights, build stakeholder confidence, and develop best practices that can be replicated and scaled up to accelerate climate action and achieve climate neutrality goals. Municipalities can also leverage the efforts deployed in other municipalities and best practices and analyse whether similar approaches would be effective in their local contexts.

Box 20. [Buildings] Piloting actions towards climate neutrality: Leuven (Belgium) climate city contract

Leuven's (Belgium) climate city contract[61] includes deploying numerous piloting actions, known as "breakthrough projects", which aim to achieve significant CO_2 reductions and tackle systemic barriers, with the goal of upscaling and replicating these successful initiatives to drive municipality-wide transformation and achieve climate neutrality.

7.1.1.2 Economic and finance

Despite a substantial increase in public funding for energy efficiency from 2021-2027, a significant portion of the required investments must still be sourced from private capital, leveraging public financial support efficiently. At EU level, there are several funding sources for building renovation projects[62]. Based on them, further economic and finance measures can incentivise the adoption of low-carbon building practices and technologies. Financing and incentive instruments, such as green bonds, tax credits, and grants can support the development of energy-efficient and low-carbon buildings. Other incentives, such as density bonuses or tax abatements can be offered to developers and building owners who incorporate low-carbon features into their buildings. Insurance and risk-sharing instruments, like carbon credit insurance, can help building owners and occupants manage the financial risks associated with transitioning to low-carbon technologies. Moreover, economic instruments like carbon pricing and green building certification programmes can create market incentives for sustainable and low-carbon building practices. For instance, carbon pricing mechanisms can encourage building owners to invest in energy-efficient retrofits and renewable energy systems.

[61] NetZeroCities: Leuven's (Belgium) climate city contract https://netzerocities.app/resource-4188

[62] Financing for building renovations https://energy.ec.europa.eu/topics/energy-efficiency/financing/financing-building-renovations_en

Box 21. [Buildings] Examples of financial instruments in the building sector: Aradippou (Cyprus) and Riga (Latvia)

The municipalities of Aradippou (Cyprus)[63] and Riga (Latvia)[64] have developed innovative financial mechanisms to encourage energy efficiency and renewable energy investments in buildings. Aradippou's financing scheme, developed through the Horizon 2020 INNOVATE project, blends municipal grants with bank loans to reward residents for taking energy efficiency actions and reduce interest burdens. Meanwhile, Riga's programme reinvests energy savings into measures outlined in its SECAP, with EUR 4 million saved being reinvested into projects such as installing solar panels and replacing inefficient lighting systems. These initiatives demonstrate how financial mechanisms can be used to encourage energy efficiency and renewable energy investments in buildings, supporting local economies and reducing CO_2 emissions.

Moreover, municipalities can facilitate group buying approaches[65], as it is shown in the example below:

Box 22. [Buildings] Group buying approaches for heat pumps

A new buying group[66] for heat pumps has been launched in Italy as part of the European project Clear-HP. The initiative allows consumers to purchase and install air-water heat pumps at advantageous conditions by buying directly from the manufacturer. The project aims to facilitate access to heat pumps through collective purchasing campaigns and ongoing support. To participate, interested residents can register on the website and access exclusive offers and discounts on heat pumps. The initiative is expected to make heat pumps more affordable and convenient for consumers, particularly those who already have solar panels or high gas consumption.

7.1.1.3 Governance and institutional

Governance and institutional measures are essential for supporting the transition to a low-carbon building sector. Building codes and standards, such as those related to energy efficiency and green building, can be developed and implemented to ensure that new buildings are designed and constructed to minimise GHG emissions. Certification programmes and initiatives, like LEED[67], Passivhaus[68] or LEVEL(s)[69], 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.

[63] Aradippou (Cyprus) explores innovative financing solutions in energy efficiency https://eu-mayors.ec.europa.eu/en/node/235

[64] Reinvesting energy savings for a climate-neutral future in Riga (Latvia) https://eu-mayors.ec.europa.eu/en/Reinvesting-energy-savings-for-a-climate-neutral-future-in-Riga

[65] Group-buying for solar: What is it and how does it work? https://solartogether.co.uk/blog/what-is-a-group-buying-for-solar-scheme/

[66] Nasce il gruppo d'acquisto per le pompe di calore https://www.rinnovabili.it/energia/termico/gruppo-d-acquisto-pompe-di-calore/

[67] Leadership in Energy and Environmental Design (LEED) rating system: https://www.usgbc.org/leed

[68] Passive House Institute: https://passivehouse.com/

[69] European Commission: A quick introduction to Level(s): https://environment.ec.europa.eu/topics/circular-economy/levels/quick-introduction-levels_en

Box 23. [Buildings] Governance and institutional examples in the building sector: Münster (Germany) and Bologna (Italy)

The municipalities of Münster[70] and Bologna[71] demonstrate exemplary governance and institutional components in their efforts to decarbonise the stationary energy sector. Münster's holistic approach to building renovation, coupled with innovative climate programmes like the 'Standard for climate-friendly construction' showcases effective use of legal and governance levers to drive emission reduction. Meanwhile, Bologna's climate action plan exemplifies a collaborative and inclusive approach, engaging residents, stakeholders, and local government departments through initiatives like the "energy helpdesk", participatory budgeting, and the "citizens assembly for climate", providing a model for effective citizen engagement and climate governance that can be considered a best practice for other municipalities.

Adaptation of local regulation can also promote the adaptive reuse of existing buildings, as it can be seen in the example below.

Box 24. [Buildings] Dublin (Ireland): new social housing by adapting and refurbishing vacant office and commercial buildings

The Adaptive Reuse Unit in Dublin City Council's Housing and Community Services Department is transforming vacant office and commercial buildings into new social apartments, aligning with the city' sustainable housing goals[72]. By refurbishing existing buildings, the unit aims to reduce vacancy, promote efficient use of stock, and minimise carbon footprint, as "the greenest building is the one that is already built". With funding approved for five projects, the unit has already acquired two properties and is working to acquire three more, while also engaging with the private sector to address barriers to redevelopment and developing guidance to support the reuse of vacant commercial properties.

7.1.1.4 Knowledge and behavioural change

Knowledge and behavioural change are critical for reducing GHG emissions in the building sector. Information and awareness-raising measures, such as public education campaigns and training programmes, can promote the adoption of low-carbon building practices among building owners, occupants and practitioners.

To boost knowledge and behaviour change and access the diverse set of funding options available, some municipalities deploy one-stop-shops[73]. These platforms provide a streamlined and simplified process for accessing funding for energy efficiency and decarbonisation projects, reducing the administrative burden and complexity that often deter individuals and businesses from pursuing these initiatives. By offering a single point of contact for funding opportunities, one-stop-shops can increase the uptake of energy efficiency measures and facilitate the deployment of sustainable solutions, ultimately driving greater investment in climate action and sustainable development.

[70] NetZeroCities: Münster (Germany) climate city contract https://netzerocities.app/resource-4451

[71] NetZeroCities Bologna (Italy) climate city contract https://netzerocities.app/resource-4437

[72] Dublin (Ireland): Adaptive reuse to promote social housing https://www.dublincity.ie/residential/housing/housing-development/adaptive-reuse

[73] One-stop shops for residential building energy renovation in the EU https://publications.jrc.ec.europa.eu/repository/handle/JRC125380

Box 25. [Buildings] Examples of one-stop shops to support building retrofitting: Trikala (Greece) and Ljubljana (Slovenia)

Municipalities like Trikala[74] and Ljubljana[75] are deploying one-stop-shops as a key strategy to support energy efficiency and decarbonisation efforts. For example, Trikala's Climate Neutrality Hub offers a one-stop-shop for energy renovation of buildings, providing a single point of contact for residents and businesses to access streamlined services. Similarly, Ljubljana's "Save the Homes" initiative introduces one-stop-shop home renovation services, making it easier for homeowners to renovate their homes to be more energy-efficient. These one-stop-shops aim to simplify the process of energy renovation and decarbonisation, providing a convenient and efficient way for residents to access expertise, financing and other resources.

Box 26. [Buildings] Examples of stakeholder engagement in the building sector: Dublin (Ireland), Thermi (Greece), Toulouse (France) and Freiburg (Germany)

The municipalities of Dublin[76], Thermi[77], Toulouse[78] and Freiburg[79] have implemented innovative stakeholder engagement approaches to promote energy efficiency in buildings. Dublin's "Think Energy" campaign used energy ambassadors and interactive events to encourage energy-savings behaviours, while Thermi's Environmental Education Center provides a physical space for promoting environmental awareness. Toulouse's "Maison de L'Energie" one-stop-shop offers guidance on subsidies and energy audits, connecting residents with trusted professionals. Freiburg's Energy Caravan campaign provides free energy advice to homeowners in selected neighbourhoods, partnering with a non-profit organisation to facilitate the campaign.

In this context, building occupants, including tenants and residents, play a crucial role in reducing energy consumption and GHG emissions in buildings. Their daily behaviours and habits, such as turning off lights and electronics, adjusting thermostat settings, and using energy-efficient appliances, can significantly impact a building's energy performance.

Box 27. [Buildings] Behavioural change in energy efficiency: the ENCHANT project, Viken County (Norway)

The ENCHANT project in VIken County, Norway[80], demonstrates the importance of behavioural change for energy efficiency. By working with residents and using behavioural science to change habits, the county achieved significant energy savings and CO_2 reductions. The project involved 51 municipalities and targeted homeowners, businesses, and organisations, providing them with information, advice, and funding to reduce their energy consumption. The most effective tool for reducing energy consumption was providing information on how much energy people's peers had saved, which led to an increase in savings of 11.3 kWh per person per week. The project's success factors included personalised treatment, practical support, and small subsidy programmes, which helped residents make informed decisions and take action to reduce their energy consumption. As a result, the ENCHANT project enabled Viken County to save 13 000 000 kWh of energy and 1 800 000 tonnes of CO_2 emissions per year, demonstrating the potential of behavioural change initiatives to drive energy efficiency and reduce greenhouse gas emissions.

[74] NetZeroCities: Trikala (Greece) climate city contract https://netzerocities.app/resource-4453

[75] NetZeroCities: Ljubljana (Slovenia) climate city contract https://netzerocities.app/resource-4444

[76] Dublin (Ireland) Think Energy https://eu-mayors.ec.europa.eu/en/node/246

[77] Thermi (Greece) A new energy efficient environmental education centre https://eu-mayors.ec.europa.eu/en/node/199

[78] Toulouse's climate heroes, ensuring energy efficient homes (France) https://eu-mayors.ec.europa.eu/en/node/621

[79] Energy Caravan, Freiburg's path towards future- proof building stock (Germany) https://eu-mayors.ec.europa.eu/en/node/753

[80] ENCHANT: Behavioural change for energy efficiency (Viken County, Norway): https://eu-mayors.ec.europa.eu/en/node/914

Besides, tenants often face challenges in implementing energy-efficient practices, as they may not have control over the building's systems and infrastructure. Additionally, owners may not have a direct financial incentive to invest in energy-efficient measures, as they may not see a direct return on their investment in the form of lower energy bills. This is often referred to as the "split incentive" problem. To overcome these challenges, building owners and managers can work with tenants to provide education and training on energy-efficient practices, and offer incentives, such as rent discounts or rewards, for tenants who adopt energy-efficient behaviours. Moreover, social and cultural measures, such as community engagement and participation, and adequate communication, can foster a culture of sustainability and low-carbon living in the building sector, promoting the adoption of low-carbon building practices and technologies among both owners and occupants. By engaging with tenants and owners, and addressing the split incentive problem, significant opportunities for reducing GHG emissions and improving the sustainability of their buildings can be unlocked.

Box 28. [Buildings] Effective communication to drive energy efficiency actions: Porto (Portugal) and Malmö (Sweden)

Effective communication is key to promoting sustainable practices, as seen in Porto[81] and Malmö[82]. Porto uses key performance indicators (KPIs) to monitor progress, covering climate, social, environmental and economic factors, to communicate the benefits of their actions. Malmö, on the other hand, has an all-round strategy for climate-neutral buildings, involving nearly 200 organisations, and demonstrating the importance of collaboration and communication in achieving sustainability goals.

7.1.2 Public lighting

Public lighting is a vital component of urban infrastructure, providing safety, security and visibility for people and vehicles. However, while the relative share of reported energy consumption and GHG emissions linked to public lighting is low (around 1% together with municipal buildings (Franco de los Rios et al., 2024; Melica et al., 2024)), traditional public lighting systems can have a significant environmental impact, including light pollution and energy consumption. To mitigate these effects, municipalities can adopt a range of measures.

Public lighting can be made more energy efficient and sustainable through various physical and technological measures. Grey options such as LED lighting and solar-powered lighting can significantly reduce energy consumption and greenhouse gas emissions. These can be complemented with digital solutions, including the use of smart lighting systems and energy-efficient lighting controls to optimise energy use and leverage renewable energy sources to reduce the reliance on fossil fuels. For instance, smart lighting systems can adjust lighting levels and schedules based on natural light availability, occupancy and traffic patterns, reducing energy waste and improving safety. Regular maintenance, such as prompt replacement of faulty lamps and cleaning of lighting fixtures, can also play a crucial role in ensuring ongoing energy efficiency and effectiveness of public lighting systems.

Economic and financial measures can incentivise the adoption of energy-efficient public lighting technologies. Financing and incentive instruments, such as green bonds and tax credits, can support the development and implementation of sustainable public lighting projects. Insurance and risk-

[81] NetZeroCities: Porto (Portugal) climate city contract: https://netzerocities.app/resource-4452

[82] NetZeroCities: Malmö (Sweden) climate city contract: https://netzerocities.app/resource-4189

sharing instruments, like performance contracts and energy savings agreements, can help municipalities and private companies manage the financial risks associated with investing in energy-efficient public lighting. Moreover, economic instruments like carbon pricing and green tariffs can create market incentives for sustainable public lighting practices. For instance, municipalities can offer rebates or subsidies to encourage the adoption of energy-efficient lighting technologies or implement pay-as-you-save financing models to reduce the upfront costs of sustainable lighting projects.

Box 29. [Public lighting] Energy performance contracts (EPCs) in public lighting (Province of Huelva, Spain)

The province of Huelva in Spain implemented a "Grouped Tendering Process" for public lighting, allowing 9 small municipalities to bundle their projects and tender them as a group, making the projects more financially viable. The project, which included the replacement of lighting with LED technology and energy-efficient controls, achieved an average energy savings of 72.9% and guaranteed emissions reductions of 5.8 tCO_2e/year. The grouped tendering approach provided economies of scale, shorter contract durations, and lower annual fees, and is considered a successful model for small municipalities to access energy-efficient solutions through energy performance contracts. Further examples on financing models for public lighting investments can be found in a report developed within an Interreg Central Europe project: Dynamic Light[83].

Sustainable public lighting can be supported through governance and institutional measures. Policies and regulations, such as lighting standards and codes, can mandate the use of energy-efficient lighting technologies and practices. Management and planning measures, including public lighting master plans and asset management systems, can help municipalities optimise their public lighting infrastructure and reduce energy waste. Coordination, cooperation and networks among stakeholders, including municipalities, private companies, and community groups, can facilitate the sharing of knowledge, resources and best practices in sustainable public lighting.

Box 30. [Public lighting] Bundling investment for energy efficient lighting in Pivka (Slovenia) and Athens (Greece)

The municipalities of Pivka[84] and Athens[85] have demonstrated the effectiveness of bundling investments for energy efficient lighting. In Pivka, a small town in Slovenia, bundling investments with 32 other municipalities enabled the implementation of an energy performance contracting project, resulting in a 75% reduction in electricity consumption and 315 tonnes of CO_2 savings per year. Similarly, in Athens, seven municipalities collaborated to create a regional network for bundling energy efficiency projects, pooling financing resources, and leveraging private investments, leading to the retrofitting of 116 buildings and the installation of 22 000 new street light bulbs, resulting in a 40% reduction in energy consumption and 65% overall energy improvement. Both municipalities' approaches highlight the impact of bundling investments, which can facilitate access to financing, reduce costs, and increase the scalability of energy efficient lighting projects, ultimately contributing to significant energy savings and emission reductions.

[83] Interreg Central Europe-Dynamic Light. Deliverable D.T2.3.3 Guideline on finding a suitable financing model for public lighting investment: https://www.porsennaops.cz/uploads/media/default/0001/01/b98d834f21d4c7848bc431d5776105e712880b96.pdf

[84] Pivka, Slovenia: Pivka bundling investments with peers for energy efficient lighting https://eu-mayors.ec.europa.eu/en/node/311

[85] Municipalities bundling energy efficiency investments in Athens Metropolitan area (Greece) https://eu-mayors.ec.europa.eu/en/node/328

Promoting sustainable public lighting practices requires knowledge and behavioural change among municipalities. This can be achieved through public education campaigns, training programmes and capacity building initiatives that raise awareness and build skills of municipal staff in sustainable public lighting. Community engagement and participation can also be mobilised for the design and implementation of sustainable public lighting projects that respond to the needs of residents and stakeholders.

Box 31. [Public lighting] The influence of public lighting environments on local residents

The public lighting environment (PLE) plays a crucial role in residents' lives, contributing to their safety, security and visual attractiveness of urban areas. Residents' assessment is essential in designing public lighting solutions as it ensures that their needs, preferences and concerns are considered, resulting in more comprehensive and inclusive lighting designs. By incorporating residents' perspectives, municipalities can create public lighting that meets the diverse requirements of the community, promotes sustainability, and supports overall well-being. As a recent study highlights (Castilla et al., 2024), people's emotional responses to PLE, such as feelings of innovation, efficiency and sustainability, are critical in shaping their perceptions of urban lighting environments, making their involvement in the planning process vital for creating effective and people-centric lighting solutions.

7.1.3 Transport

The transport sector is a critical component of urban life, providing people with the freedom to move and access essential services. However, transport has also several negative externalities from GHG emissions, air and noise pollution, to congestion, accidents and social exclusion. Transport is a significant contributor to GHG emissions, in Europe alone the sector contributes to 29.9% of the total CO_2 emissions[86] (32% of GHG emission share in EU municipalities according to reported data (Melica et al., 2024)). To promote sustainable transportation, municipalities must consider the environmental impact of transportation and develop effective strategies to reduce emissions and other transport externalities, while ensuring equitable and accessible mobility for everyone, as well as road safety.

Box 32. [Transport] The Avoid-Shift-Improve approach in the transport sector

The Avoid-Shift-Improve (ASI) approach is a widely recognised framework originated in Germany in the 1990's for reducing GHG and improving sustainability in the transport sector. The "avoid" strategy involves reducing the need for transportation by promoting compact and mixed-use urban development (e.g. 15-minute cities), increasing telecommuting and virtual meetings, and encouraging alternative modes of transport such as walking and cycling. The "shift" strategy involves shifting from private vehicles to more efficient and sustainable modes of transport, such as public transportation, car-sharing and car-pooling. Finally, the "improve" strategy involves improving the efficiency and sustainability of existing transport modes, such as by increasing the use of electric or hybrid vehicles, using alternative fuels such as biofuels or hydrogen, optimising logistics and freight transport, and implementing intelligent transportation systems. By applying these strategies, municipalities can reduce their transport-related GHGs, improve air quality, and create more liveable and sustainable communities. This approach can be integrated into a municipality's sustainable urban mobility plan (SUMP) and SECAP to support the development of a comprehensive and effective transport strategy.

[86] EEA – transport and mobility https://www.eea.europa.eu/en/topics/in-depth/transport-and-mobility?activeTab=fa515f0c-9ab0-493c-b4cd-58a32dfaae0a

As municipalities plan actions to promote sustainable transportation, they must consider their decision-making power over various transportation modes. Municipalities can deploy different modes of governance to exert influence and control over these areas. For example, a municipality can use its municipal self-governing power to transition its municipal fleet to low or zero-emission vehicles, or to invest in energy-efficient public transportation systems. Through governing by provision, a municipality can establish public-private partnerships to finance and develop sustainable transportation infrastructure such as bike-sharing systems. By exercising its regulatory powers, a municipality can implement congestion charging or low-emission zones to reduce private vehicle use and promote more sustainable transportation options. By leveraging these modes of governance, municipalities can develop targeted strategies to promote sustainable transportation and achieve their sustainability goals.

The following paragraphs present general strategies on active mobility, municipal fleet, public transport, private transport, freight transport and some considerations on sustainable urban mobility plans (SUMPs). These are then followed by a classification on different types of actions a municipality can implement (sections 7.1.3.1 to 7.1.3.4).

Private transport and active mobility

Private vehicles are the main source of traffic congestion, and transport-related air pollution and GHG emissions in urban environment. To mitigate this, a municipality can implement policies such as congestion charging, low emission zones and parking restrictions to discourage the use of private cars. Furthermore, municipalities can encourage the use of car-sharing and car-pooling systems and provide incentives for residents to switch to low or zero-emission vehicles, such as tax breaks or free parking, ultimately reducing the GHG emission due to cars on the road.

Another approach is to promote alternative modes of transport, such as active mobility. Active mobility encompasses a range of transportation modes that rely on human power, such as walking and cycling, which offer numerous benefits for individuals, communities, and the environment. To promote active mobility, municipalities can invest in infrastructure, such as pedestrianised streets, bike lanes and cycling paths, making it safer and more enjoyable for people to walk and cycle. Additionally, municipalities can implement bike sharing systems, encourage the use of electric bicycles, and organise events and campaigns to raise awareness about the benefits of active mobility, such as improved health and reduced air pollution.

Box 33. [Transport] Triggering alternative modes of transport through car sharing initiatives: Bremen (Germany)

Bremen's car sharing initiative[87] has been highly successful, with over 22 000 active users and 7 000 cars removed from the road, freeing up street space and reducing greenhouse gas emissions. The municipality's car sharing programme has also promoted a shift towards sustainable transport modes, with 80% of users not owning a car and instead relying on walking, cycling and public transport. By providing a reliable and convenient car sharing service, Bremen has been able to reduce congestion, reclaim public space, and create a more liveable and sustainable urban environment, serving as a model for other municipalities to follow.

[87] Car sharing to reduce emissions and reclaim public space for people in Bremen (Germany) https://eu-mayors.ec.europa.eu/en/node/336

Public transport

Public transportation is a vital component of urban mobility, providing millions of people with affordable and efficient access to employment, education, and other essential services. To improve public transport, a municipality can take several actions. Firstly, it can invest in modern, efficient, and comfortable vehicles, such as electric or hybrid buses, and trams. Additionally, the municipality can optimise routes and schedules to increase frequency and reliability, making public transport a more attractive option. The municipality can also implement traffic management strategies where public transport is prioritised (e.g. implementing exclusive bus lanes), or through smart traffic management systems, which can prioritise public transport and reduce congestion. Furthermore, the municipality can invest in passenger information systems, providing users with real-time information about public transport services. The municipality can also encourage the use of public transport by implementing policies such as free public transport for certain groups, such as students, old people, or low-income families.

Municipal fleet

Municipalities rely on municipal fleets to provide essential services such as waste management, public transportation, and emergency response, but these fleets can also be a significant source of greenhouse gas emissions and air pollution. To make its municipal fleet more sustainable, a municipality can take several actions. Firstly, it can transition its fleet to electric or hybrid vehicles, which produce zero or low emissions. Additionally, the municipality can implement a car-sharing system for municipal employees, reducing the number of vehicles on the road and promoting more efficient use of resources. The municipality can also invest in alternative fuel vehicles, such as those running on biofuels or hydrogen. Furthermore, the municipality can implement a maintenance programme to ensure that vehicles are running efficiently and effectively, reducing fuel consumption and emissions.

Freight transport and urban logistics

The movement of goods and products within a municipality is a critical component of urban logistics. To improve them, several actions can be put in place. Firstly, the municipality can invest in infrastructure such as dedicated freight routes and loading / unloading areas, reducing congestion and improving the efficiency of freight transport. Also, the municipality can implement last mile freight logistics transport solutions for instance by setting up a delivery system where multiple packages are delivered to a central location, reducing the number of vehicles on the road. The municipality can also encourage and promote the use of alternative modes of transport, such as electric or hybrid vehicles, and promote the use of cargo bikes and other sustainable delivery options. Furthermore, the municipality can implement a smart traffic management system, which can prioritise freight transport and reduce congestion.

Box 34. [Transport] Reducing emissions through electric cargo bikes: Prague's 'Depot.Bike' project (Czechia)

Prague's 'Depot.Bike'[88] project aims to reduce emissions and congestion by using electric cargo bikes for deliveries. The project involves a central depot where logistics companies store packages, which are then picked up by couriers and delivered to recipients in the municipality centre by bike. This initiative has

[88] Prague reducing emissions one delivery at a time (Czechia) https://eu-mayors.ec.europa.eu/en/node/329

already shown significant results, with almost 80 000 packages delivered by bike, replacing thousands of kilometres of van travel and reducing greenhouse gas emissions.

Sustainable urban mobility plans (SUMP)

A sustainable urban mobility plan (SUMP) is a comprehensive plan that outlines a municipality's vision and strategy for sustainable urban mobility, aiming to create a more efficient, environmentally friendly, and socially equitable transportation system. To support the development of the SECAP, municipalities can leverage their existing SUMP by aligning their energy and climate actions with the mobility goals and strategies outlined in the SUMP. By doing so, municipalities can ensure that their energy and climate actions are integrated with their urban mobility planning, creating a more cohesive and effective approach to achieving their goals. Municipalities can also use their SUMP as a framework for identifying opportunities to reduce GHGs and improve energy efficiency in the transportation sector, and for developing policies and measures to support the transition to a low-carbon mobility system.

7.1.3.1 Physical and technological

The transport sector can reduce its greenhouse gas emissions through various physical and technological measures. Grey options such as electric and hybrid vehicles, can contribute to reducing greenhouse gas emissions if the electrification of the sector is paired with renewable energy sources. This can be complemented with the use of energy-efficient engines and aerodynamic designs to optimise fuel efficiency.

Furthermore, investing in infrastructure such as public transportation systems is crucial to support the adoption of these physical and technological measures, as it provides the necessary foundation for efficient and safe movement of people and goods.

Box 35. [Transport] The importance of public infrastructure to support transport actions: Barcelona (Spain)

Barcelona[89] has demonstrated the importance of having adequate transport infrastructure in place to support sustainable mobility, while prioritising values such as environmental sustainability, social equity and economic efficiency. By investing in extensive transport networks, including suburban rail, bus lanes, and bicycle paths, Barcelona has promoted a culture of sustainability, reducing congestion and emissions and enhancing the quality of life for its residents.

Additionally, alternative fuels, such as biofuels and hydrogen, and advanced public transportation systems (e.g. bus rapid transit and rail) can reduce emissions from transportation. This can also be achieved using electric vehicles and advanced public transportation systems.

The digitalisation of the transport sector, through the implementation of technological options such as intelligent transportation systems (ITS) or approaches as Mobility as a Service (MaaS), can also play a crucial role in reducing emissions. Implementing smart parking management systems can reduce congestion and lower emissions by reducing the time spent searching for parking. Moreover, the use of ITS can optimise traffic flow and reduce congestion. Overall, the combination of physical, technological and infrastructure measures, along with the digitalisation of the transport sector can help reduce GHGs and create a more sustainable and efficient transport system.

[89] NetZeroCities: Barcelona climate city contract (Spain) https://netzerocities.app/resource-4178

7.1.3.2 Economic and finance

Economic and financial measures can incentivise the adoption of low-carbon transportation technologies and practices. Financing and incentive instruments, such as green bonds and tax credits, can support the development and implementation of low-carbon transportation projects. Insurance and risk-sharing instruments, like pay-as-you-save financing, can help individuals and businesses manage the financial risks associated with investing in low-carbon transportation technologies. Other approaches such as congestion charging and integrated ticketing and charging systems can also play a crucial role in incentivising the use of low-carbon transportation modes, by making them more economically attractive and convenient. Subsidies can also be considered for low-carbon transportation options, such as bike subsidies.

However, the private sector faces significant challenges in managing the upfront costs of transitioning and deploying low-carbon transportation infrastructure, such as electric vehicle charging stations or hydrogen fuelling stations can be a major hurdle. Moreover, the costs of retrofitting existing infrastructure to support low-carbon technologies can also be substantial.

To address these challenges, innovative solutions are needed. Governments and private sector companies can collaborate to develop new financing models, such as public-private partnerships, that can help share costs and risks associated with the implementation of new transport measures.

Box 36. [Transport] Public procurement of buses fuelled by 100% biogas in Kalmar (Sweden)

The municipality of Kalmar (Sweden) has implemented a public procurement of buses fuelled by 100% biogas[90], produced from cattle manure, to achieve its goal of becoming 100% fossil fuel free by 2030. The procurement, worth EUR 500 million, consisted of approximately 400 vehicles and aimed to reduce GHG emissions by 50% compared to fossil fuels. The project was successful, with 30 companies bidding and contracts signed with 18 winning companies. The new buses entered traffic in 2017, and the results show a 75% decrease in GHG emissions and a 2% reduction in costs, exceeding initial forecasts.

7.1.3.3 Governance and institutional

Governance and institutional measures can be contained within the sustainable urban mobility plan. Policies and regulations, such as fuel efficiency standards and emissions limits, can mandate the use of low-carbon transportation technologies and practices. This type of measures is generally not under the control of the municipality but rather defined at EU (or national) level. Nonetheless, municipalities may amplify their impact through awareness raising campaigns or through the implementation of urban vehicle access regulations (UVAR) that can be applied to specific areas of the municipality.

Management and planning measures, including transportation planning and traffic management, can help optimise transportation systems and reduce emissions. Land use planning can play a crucial role in reducing transportation-related emissions. Mixed-use development, denser municipalities, and pedestrian-friendly design can reduce the need for personal vehicles.

[90] Kalmar (Sweden) Public procurement of buses with 100% renewables target https://eu-mayors.ec.europa.eu/en/node/173

Box 37. [Transport] The five-minute city: the Nordhavn district

In Copenhagen's Nordhavn district, the "five-minute city" concept[91] has been implemented, where all basic amenities are within a five-minute walk. The area, once an industrial landscape, has been redeveloped to prioritise pedestrian-friendly and environmentally sustainable design, with a focus on community and social interaction. The municipality's planners started by designing walkable streets and cycle routes, and only then considered space for cars. The result is a vibrant and diverse neighbourhood with a mix of residential, office, and retail spaces, as well as community facilities and green areas. While the area has become popular and expensive, with property prices 20% higher than the Copenhagen average, efforts are being made to include social housing and ensure that the community remains inclusive. Despite some challenges, Nordhavn is being hailed as a model for sustainable and community-focused urban design, and a potential blueprint for the future of city planning.

In addition, low emissions zones (LEZ) can also act as a deterrent and motivate people to use alternative means of transport. In this context, the promotion of multimodal travel can be observed as an efficient alternative to private vehicle use (e.g. using public transport for longer distances and (shared) bicycles to cover the first or last mile). A potential trade-off to be observed is the increase in transaction costs, which can be alleviated with the aggregated provision of services, or the simplified provision of information using ICT. For example, making available tickets through a single service provider.

Box 38. [Transport] A comprehensive governance approach in the transportation sector: Thessaloniki (Greece)

The municipality of Thessaloniki[92] has adopted a comprehensive governance approach to transform its transportation system, prioritising a shift away from private car usage and towards more sustainable modes of transport. Through a multi-faceted strategy, the municipality is leveraging a range of policy tools, including the introduction of low emission zones, promotion of electro mobility, and investment in shared electric and micro-mobility vehicles. Additionally, Thessaloniki is harnessing smart and digital solutions to optimise traffic management while also redeveloping public spaces and rethinking urban distribution, parking and logistics models. This integrated approach demonstrates the municipality's commitment to effective governance and its willingness to adopt innovative solutions to address the complex challenges of urban mobility.

Coordination, cooperation, and networks among stakeholders, including governments, industries, and NGOs, can facilitate the sharing of knowledge, resources, and best practices in low-carbon transportation.

Box 39. [Transport] Optimisation of transport demand (TDM strategies) in Limassol (Cyprus)

The municipality of Limassol[93] will implement a transportation demand management (TDM) plan to create a sustainable and efficient mobility ecosystem. The plan aims to reduce carbon emissions by promoting alternative modes of transportation, encouraging carpooling and ridesharing, and improving public transit infrastructure. Measures include congestion pricing, parking management, and incentives for sustainable travel options. The plan also involves the construction of five park and ride locations and five mobility hubs, as well as the design and operation of a platform to control transportation demand management strategies.

[91] The five-minute city: inside Denkmark's revolutionary neighbourhood: https://www.theguardian.com/lifeandstyle/2024/dec/10/the-five-minute-city-inside-denmarks-revolutionary-neighbourhood?CMP=Share_AndroidApp_Other

[92] NetZeroCities: Thessaloniki (Greece) climate city contract: https://netzerocities.app/resource-4192

[93] NetZeroCities: Limassol (Cyprus) climate city contract: https://netzerocities.app/resource-4219

The expected outcome is a reduction of 8 700 tonnes of CO_2 emissions by 2030, with a total cost of EUR 27.27 million.

7.1.3.4 Knowledge and behavioural change

Information and awareness-raising measures, such as public education campaigns and training programmes, can promote the adoption of low-carbon transportation technologies and practices among individuals, businesses and governments. Capacity building, empowering and lifestyle practices, including the development of low-carbon transportation skills and knowledge, can enable individuals and businesses to take action to reduce their emissions.

Businesses with strong sustainability practices can play a vital role in promoting low-carbon mobility by integrating sustainable transportation options into their operations and supply chains. For example, companies can adopt electric or hybrid vehicle fleets, encourage employees to use public transportation, walk or cycle to work (for instance, through walking challenges), promote sustainable transportation practices among their customers and stakeholders, or adopt teleworking practices. By doing so, businesses cannot only reduce their own carbon footprint, but also influence consumer behaviour and contribute to a cultural shift.

Box 40. [Transport] Promoting behavioural change in the transport sector: Kranj (Slovenia)

The municipality of Kranj[94] has taken a holistic approach to promoting sustainable mobility, focusing on knowledge and behavioural change through a range of initiatives that educate and encourage people to adopt more environmentally friendly transportation habits. The technical actions linked to an improved cycling and pedestrian infrastructure, integrated urban planning or the introduction of EV and hydrogen mobility are supported by the digital integration of urban mobility modes, including optimised routing systems, commuting apps and smart parking. These further support the overall goal, making transportation options more accessible, convenient and appealing, ultimately triggering behaviour change.

Other social and cultural measures, such as community engagement and participation, can also foster a culture of sustainability, promoting the adoption of low-carbon technologies or alternatives. For example, initiatives like "walk to school" and "bike to school" programmes, organised by primary schools, can raise awareness among pupils about the benefits of active mobility, including socialisation, improved health, reduced congestion, better air quality and increased safety.

7.1.4 Industry

The industry sector is one of the largest energy consumers in the EU, accounting for 25.1% of final energy consumption in 2022[95]. In EU municipalities, industry accounts for 12.5% of energy consumption and 13% of total GHG emissions, according to reported data by municipalities (Franco de los Rios et al., 2024; Melica et al., 2024). However, the industry sector also has a significant potential for reducing GHG emissions and improving energy efficiency, particularly through the adoption of RES and low-carbon technologies that can be deployed at the local level, as it will be

[94] NetZeroCities Kranj (Slovenia) climate city contract: https://netzerocities.app/resource-4443

[95] Eurostat – final energy consumption in industry – detailed statistics: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Final_energy_consumption_in_industry_-_detailed_statistics#:~:text=%2C%20renewables%2C%20etc.-,Energy%20products%20used%20in%20the%20industry%20sector,and%20biofuels%20(10.6%20%25).

explored in the following paragraphs. To support this, the EC has launched the Clean Industrial Deal[96], which aims to accelerate the transition to a low-carbon economy. While the decision-making power of municipalities in the industrial sector is limited, actions in the sector can be supported by voluntary agreements by municipalities.

The industry sector can reduce its GHG emissions through various physical and technological measures. Process electrification, integration of renewable energy sources and energy-efficient equipment can significantly reduce fossil energy consumption and emissions. Moreover, including the use of energy efficient motors and lighting (e.g. LED) can also optimise the energy use, as well as the implementation of thermal or electrical energy storage solutions, to better match renewable generation with process demand. Moreover, digital technologies can also contribute to optimising the process control, and consequently reducing energy consumption and related GHG emissions.

Box 41. [Industry] Integrating industry within a holistic energy approach: Espoo (Finland)

In Espoo's approach[97], industry is integrated as a key component of the municipality's energy system, within a holistic view that considers buildings, industry, grids, and transport as an interconnected whole, allowing the municipality to identify and leverage synergies between these sectors and optimise energy use through innovative technologies such as intelligent control and demand-side management, as well as energy storage.

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.

Box 42. [Industry] Industrial symbiosis in Kalundborg (Denmark)

The city of Kalundborg in Denmark[98] is home to an industrial symbiosis, known as "Kalundborg symbiosis", where large companies work together to share excess energy, water and materials, reducing waste and increasing resilience and profit. This symbiotic approach has been put in place for over 50 years and has resulted in significant environmental benefits, including the reduction of 586 000 t CO_2 each year and the recycling of 62 000 tonnes of residual materials. The partnership, which consists of 17 global companies, aims to promote sustainable development through local partnerships and has become a leading example of industrial symbiosis with a circular approach to production.

From the economic and finance perspective, one approach is to develop and implement green financing mechanisms, such as green bonds or green loans, which can provide companies with the necessary funding to invest in low-carbon technologies and processes. This can also be attained when establishing a system of tax incentives or other financial rewards. Dedicated funds can also be set with a focus on areas like carbon capture and storage (CCS), hydrogen fuel cells, and advanced renewable energy systems. Finally, a carbon pricing system (e.g. carbon tax) can provide a financial incentive for companies to reduce their emissions.

Moreover, several actions on the governance and institutional level can be implemented. Local industrial hubs or clusters can be used or created to foster industrial/urban symbiosis, e.g. exchanging

[96] European Comission: Clean Industrial Deal https://commission.europa.eu/topics/eu-competitiveness/clean-industrial-deal_en

[97] NetZeroCities: Espoo (Finland) Climate City Contract: https://netzerocities.app/resource-4179

[98] Industrial symbiosis in Kalundborg (Denmark): https://www.symbiosis.dk/en/

excess/waste industrial heat between industrial plants or to district heating networks in local communities. A cluster approach can also optimise the energy infrastructure (electricity, hydrogen, CO_2) upgrades needed for the transformation to climate neutral processes. Clusters can facilitate the sharing of best practices, ensure alignment with the Clean Industrial Deal, collaboration on research and development, access to funding and resources, and faster permitting, thereby facilitating the decarbonisation transition. This can be complemented by a knowledge and behavioural approach that can include capacity building activities to support the development of knowledge and skills, creating a network of low-carbon industrial ambassadors that can share their experiences and guide other companies, or establish a system of recognition and reward for companies that achieve significant emission reductions.

7.1.5 Electricity production

Electrification of energy systems is becoming increasingly important. Municipalities can play a crucial role in promoting the development and deployment of renewable energy sources, such as solar, wind, and hydro power, to reduce GHGs and improve energy security. According to reported data, around 88% of local electricity production in EU municipalities comes from renewable energy sources (Franco de los Rios et al., 2024). However, the deployment of RES at local level needs to consider factors such as land availability and land use changes, social acceptance toward renewable energy systems, local capacities and skills to carry out the installations and potential habitat disruption. To address these challenges, municipalities can promote renewable energy 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, municipalities can support the development of energy storage solutions that can be integrated with renewable energy systems, optimising the use of generated electricity.

Furthermore, the transition to a low-carbon energy system can also have significant co-benefits, such as contributing to reduce energy poverty, improving public health and creating new job opportunities in the RES sector.

7.1.5.1 Physical and technological

There is a plethora of physical and technological approaches that municipalities can deploy to produce electricity locally. The following paragraphs describe the most common renewable energy sources and approaches to support local electricity generation:

Solar energy: one of the most promising approaches to electricity production is solar energy. Solar energy can be harnessed using photovoltaic (PV) systems, which convert sunlight into electricity. PV systems can be installed on rooftops, in solar parks, or as building-integrated photovoltaics (BIPV). Solar energy is a renewable and clean source of energy, producing no greenhouse gas emissions or pollution during operation. The cost of solar power has declined by 99.6% since 1976 (PV module cost in 1976 was 106.09 USD/Watt, while in 2919 was 0.377 USD/Watt)[99][100], making solar energy more competitive with fossil fuels. Additionally, solar energy can be used both for electricity generation and heating, making it a versatile source of energy. Many municipalities are now investing in

[99] Max Roser (2023) - "Learning curves: What does it mean for a technology to follow Wright's Law?" Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/learning-curve' [Online Resource]

[100] Solar energy: https://energy.ec.europa.eu/topics/renewable-energy/solar-energy_en

large-scale solar parks, while also promoting the use of solar energy in buildings and homes and considering the use of new areas such as roads and roundabouts, railways and water bodies to optimise the use of land dedicate to PV systems.

Wind energy: tapping into the kinetic energy of wind, wind turbines have become a prominent feature of the renewable energy landscape. With the ability to generate electricity on a large scale, wind energy has become an important component of energy portfolios. From small, residential turbines to massive, commercial-scale wind farms, wind energy can be harnessed in a range of settings. The integration of wind energy into the grid has also led to the development of energy storage solutions, such as battery storage and pumped hydro storage, which can help to stabilise the grid and ensure a reliable supply of electricity.

Hydro energy: by harnessing the energy of moving water, hydroelectric power plants have been generating electricity for decades. With the ability to produce power on a large scale, hydro energy has become a reliable and renewable source of energy. However, the scale of application can vary from small, run-of-the-river plants to massive, dam-based facilities, hydro energy can be generated in a variety of ways. While there are environmental considerations to be considered (altering ecosystems or disrupting migration patterns), hydro energy remains a significant source of renewable energy.

Bioenergy: bioenergy is another approach to electricity production, which involves harnessing the energy of organic matter, such as plants and waste, to generate electricity. Bioenergy can be produced through various methods, anaerobic digestion, and gasification. Biomass can be used to generate electricity in power plants, or it can also be particularly interesting for municipalities to promote in areas with abundant agricultural residues, such as municipalities hosting large farms, where it can be used to satisfy local energy demands. Bioenergy is a renewable source of energy, but it can have environmental impacts, such as land use changes and air pollution. Additionally, bioenergy can be more expensive than other forms of renewable energy, making it less competitive in some markets.

Geothermal energy: for municipalities, geothermal can also present a significant opportunity to increase the uptake of renewables and decarbonisation of the energy sector, not only through electricity production, but it can also be applied to heating and cooling (e.g. water heating or industrial processes, among other). Geothermal is a reliable and stable source of energy, which is unaffected by weather conditions and can help to offset the risks associated to an energy system based on variable supplies of other energy sources.

Cogeneration: cogeneration is an approach that involves generating both electricity and heat from a single source. Cogeneration plants can be fuelled by a variety of sources, including natural gas, biomass and waste heat. Cogeneration can be more efficient that traditional power plants, as they can recover heat that would otherwise be wasted. Additionally, cogeneration can be used in conjunction with other forms of renewable energy, such as solar and wind energy to create a hybrid power system.

Box 43. [Electricity production] Comprehensive actions to address electricity production at local level: Malmö (Sweden) and Miskolc (Hungary)

Malmö[101] and Miskolc[102] are exemplary cases of municipalities taking proactive and comprehensive physical actions to enhance electricity production from renewable sources. Specifically, they are upgrading their electricity distribution systems to increase capacity and efficiency, implementing energy storage solutions such as batteries to stabilise the grid, and developing flexible energy systems to optimise energy production and consumption. Furthermore, they are investing in grid upgrades to support the integration of renewable energy sources and producing hydrogen as a complementary energy source, demonstrating a forward-thinking approach to sustainable energy development.

This section delves into two specific approaches and trends to support electricity production at local level (smart grids, energy storage solutions and agrivoltaics).

Smart grids

Smart grids are energy networks that can automatically monitor energy flows and adjust to changes in energy supply and demand accordingly[103]. They are a crucial component of the energy transition, enabling the efficient integration of renewable energy sources and reducing energy waste. For municipalities, smart grids offer a range of benefits, including improved energy efficiency, increased renewable energy integration, enhanced grid resilience, consumer engagement and new revenue streams. Smart grids can help municipalities optimise energy consumption and lower energy bills. Additionally, they can facilitate the integration of local renewable energy sources, such as solar and wind power into the energy mix.

To develop and implement smart grid solutions, municipalities will need to consider several key factors. These include investing in smart grid infrastructure, such as smart meters and grid management systems, as well as ensuring the security and protection of the grid against cyber threats. Municipalities will also need to engage with the public and educate them about the benefits of smart grids and how to use them effectively. Furthermore, municipalities may need to partner with other organisations, such as distribution system operator (DSO), utilities, technology companies, and community group to develop and implement smart grid solutions. By understanding these considerations, municipalities can make informed decisions about how to develop and implement smart grid solutions that meet the needs of their communities.

The EU provides various forms of support for the development of smart grids, including funding opportunities, regulatory frameworks, and technical assistance. Municipalities can draw on these resources to support the development of their smart grid projects. To move forward, municipalities should start working with DSOs to assess their current energy infrastructure and identifying areas for improvement. Municipalities should also engage with stakeholders, including residents, businesses and other organisations to develop a shared vision for their smart grid project.

[101] NetZeroCities: Malmö (Sweden) climate city contract: https://netzerocities.app/resource-4189

[102] NetZeroCities: Miskolc (Hungary) climate city contract: https://netzerocities.app/resource-4450

[103] Smart grids https://energy.ec.europa.eu/topics/markets-and-consumers/smart-grids-and-meters_en#:~:text=Smart%20grids%20are%20energy%20networks,usage%20to%20consumers%20and%20suppliers.

Energy storage solutions

Energy storage[104] (such as pumped hydro storage, battery storage, and hydrogen storage) is crucial to support increasing shares of renewable energy sources in the electricity mix. Storage helps to balance electricity supply and demand, ensuring a stable and safe grid. Municipalities can play a key role in promoting energy storage by creating an environment that encourages its development and deployment. This can be achieved by removing barriers to deployment, such as streamlining permitting procedures and providing financing options, and by promoting awareness and education about the benefits of energy storage.

Municipalities can support the development and deployment of these technologies through financial incentives or tax breaks. Additionally, municipalities can work with local businesses and organisations to develop innovative energy storage solutions that meet the specific needs of their community. For example, they can support the development of community-scale battery storage projects.

To support the development and deployment of energy storage, municipalities can also work with regional and national governments to access funding and technical assistance. Creating a supportive environment is also fundamental, and this can include developing local energy plans, setting energy storage targets, and providing training and education for residents and businesses on the benefits and opportunities of energy storage.

Agrivoltaics

Agrivoltaics, the combination of farming and solar photovoltaic electricity production, has the potential to significantly contribute to the EU's renewable energy targets. By utilising just 1% of the EU's utilised agricultural area (UAA), agrivoltaic systems could generate approximately 944 GWDC of installed capacity, exceeding the EU's 2030 target of 720 GWDC. This innovative approach allows for the simultaneous production of food and energy, mitigating concerns about land competition between solar panels and farming activities. Additionally, agrivoltaic systems can provide shading for crops, protecting them from heat stress and severe weather, while also offering opportunities for greenhouses made of semi-transparent PV panels.

The implementation of agrivoltaics at the local level requires careful consideration of various factors. Identifying suitable areas for agrivoltaic systems, such as agricultural lands, brownfields, or other underutilised areas, is a crucial step. The engagement of local stakeholders, including farmers, landowners and community groups is also essential to raise awareness about the benefits of agrivoltaics and to encourage their participation. Furthermore, the availability of funding opportunities, such as EU grants, national subsidies, or private investments, can play a significant role in supporting the development of processes, or technical assistance, can help overcome potential barriers and facilitate the adoption of agrivoltaics.

The development of agrivoltaics can have a positive impact on local communities, contributing to rural development, job creation, and income generation for local farmers and communities. The integration of agrivoltaics into local energy and agricultural plans can also help to promote energy self-sufficiency, reduce GHGs and support sustainable development. However, it is essential to address potential challenges, such as the need for clear policies and regulations, the provision of

[104] Energy storage: https://energy.ec.europa.eu/topics/research-and-technology/energy-storage_en

technical assistance, the engagement of local stakeholders, the impact of agri-PV on agricultural land practices or easing the permitting and grid connection procedures (Chatzipanagi et al., 2023).

Box 44. Agrivoltaics deployment in the Netherlands: Babberich, Wadenoijen, Almere and Culemborg

A recent study (Sirnik et al., 2024) in the Netherlands has shed light on the potential of agrivoltaics to transform the ways we think about energy production and land use. The study, which examined four built agrivoltaic cases in the central part of the country, found that carefully designed and sited agrivoltaic systems can minimise landscape changes and even enhance the aesthetic value of the surrounding area. For example, the cases in Babberich, Wadenoijen, Almere, and Culemborg demonstrated that agrivoltaics can be successfully integrated into existing agricultural landscapes with minimal impact on land use and biodiversity. By considering factors such as site selection, design, and community engagement, municipalities in the Netherlands and beyond can harness the benefits of agrivoltaics to reduce energy poverty, create new job opportunities, and promote sustainable development in their region..

7.1.5.2 Economic and finance

Economic and financial measures can incentivise the adoption of renewable electricity technologies and practices. Financing and incentive instruments such as green bonds and tax credits can support the development and implementation of electricity production projects. Insurance and risk-sharing instruments, like revenue guarantees and power purchase agreements, can help electricity producers manage the financial risks associated with investing in renewable technologies. Moreover, economic instruments like carbon pricing and renewable portfolio standards can create market incentives for renewable electricity production practices. For instance, municipalities can establish renewable portfolio standards that require electricity producers to generate a certain percentage of their power from renewable sources, while carbon pricing mechanisms can provide a financial incentive to reduce emissions in electricity production.

Box 45. [Electricity production] Innovative financial approaches for electricity production in Eilat (Israel)

Eilat[105] introduces innovative approaches to finance the deployment of electricity production in the municipality, such as Solar Bonds, which provide a novel approach to financing the installation of PV panels through the Eilat Solar Platform. By fostering a favourable financial environment, these initiatives facilitate the municipality's transition to renewable energy sources, addressing key economic and financial aspects of governance and energy access. This, in turn, underpins Eilat's strategic path towards achieving carbon neutrality, with a focus on sustainable economic development and environmentally responsible financial planning.

7.1.5.3 Governance and institutional

On the governance and institutional side, there are several options for municipalities. For instance, municipalities can implement ordinances mandating the use of renewable energy, such as solar thermal systems, and require households to purchase green electricity. These ordinances can be connected to national or regional energy laws and implemented through municipal building codes. By doing so, municipalities can promote the adoption of renewable energy technologies and reduce their reliance on non-renewable energy sources.

[105] NetZeroCities: Eilat (Israel) climate city contract: https://netzerocities.app/resource-4439

In addition to ordinances, municipalities can also adapt their urban planning regulations to support the development of distributed energy systems. This can include reviewing and revising building codes and zoning laws to allow for the installation of renewable energy systems, such as photovoltaic panels and wind turbines. Municipalities can also establish integrated urban planning processes to identify possible sites for local energy generation installations and ensure the availability and compatibility of space for these projects.

Municipalities can also take steps to facilitate the development of distributed energy systems by streamlining administrative procedures. This can include reducing local taxes for electricity production projects, declaring these projects as "public interest", and applying advantageous administrative conditions. By providing a supportive regulatory environment, municipalities can encourage the development of local energy generation and reduce barriers to the adoption of renewable energy technologies.

Box 46. [Electricity production] Facilitating electricity production through innovative governance approaches: The Hague (The Netherlands) and Prato (Italy)

The municipalities of The Hague[106] and Prato[107] exemplify innovative governance approaches to support the deployment of electricity production at urban level. The Hague's action plan demonstrates a forward-thinking commitment to energy flexibility and grid stability through strategic resource allocation and streamlined permit procedures. Meanwhile, Prato's pioneering efforts to maximise PV production on diverse surfaces, including agrivoltaic systems showcase a holistic and integrated governance strategy that prioritises sustainable area development and creative land use.

Energy communities / community-based initiatives

The rise of renewable energy communities (REC) and citizen-led cooperatives is a powerful example of community-driven climate action, enabled by the Renewable Energy Directive (RED III) (European Commission, 2023). These initiatives allow residents, businesses and municipalities to collectively invest in and manage renewable energy sources, such as solar farms and wind turbines, reducing dependence on fossil fuels and promoting energy democracy. By doing so, RECs offer multiple climate benefits, including mitigating greenhouse gas emissions, improving resilience to climate shocks, and reducing energy poverty.

To support these initiatives, municipalities can provide regulatory incentives, develop residents engagement platforms, and encourage partnerships between municipalities, cooperatives, and the private sector, ultimately scaling up community energy models and contributing to a more sustainable and equitable energy future.

Box 47. [Electricity production] Initiatives to support renewable energy communities: Marseille (France), Mouscron (Belgium), Som Energia (Spain) and Parma (Italy)

Several cities across Europe are pioneering innovative initiatives to support energy communities / community-based initiatives. For instance Marseille (France)[108], is developing a transformative energy community through citizen-led initiatives, partnerships with local energy companies, and municipal efforts, aiming to boost RES

[106] NetZeroCities: The Hague (The Netherlands) climate city contract: https://netzerocities.app/resource-4441

[107] NetZeroCities: Prato (Italy) climate city contract: https://netzerocities.app/resource-4448

[108] Marseille energy communities (France): https://eu-mayors.ec.europa.eu/en/node/889

production and create a self-sustaining energy ecosystem. Similarly, Mouscron (Belgium)[109] has established a cooperative, COOPEM, which allows individuals to purchase solar panels collectively and benefit from expert installation, resulting in the installation of over 1 100 solar panels and producing almost 300 MWh of energy. Other notable examples include Som Energia[110], a Spanish renewable energy cooperative that has engaged over 73 000 members to develop over 10MW of renewable energy capacity, generating 18.5 GWh annually, enough to power approximately 4 000 households. Additionally, the municipality of Parma (Italy)[111] has invested in REC as an initial response to promote and achieve climate neutrality, with a pilot project in Lubiana district that includes a mix of users such as schools, a library and social housing.

7.1.5.4 Knowledge and behavioural change

Raising awareness and promoting education and training are also essential for supporting the adoption of renewable energy technologies and practices. Municipalities can develop and implement awareness-raising campaigns, such as solar energy campaigns, to inform residents about the benefits of renewable energy and encourage them to participate in community-led strategies. Supporting tools, such as solar atlases and solar land registries, can also be provided to help residents and investors determine the suitability of buildings for solar installations and stimulate the potential returns of investment.

Box 48. [Electricity production] Successful awareness-raising initiatives on solar maps and tools

Several online tools are available to support awareness building and decision-making for renewable energy, including the Berlin Solar Atlas[112] (and related information[113]), Paris Solar Land Registry[114], and Photovoltaic Geographical Information System (PVGIS)[115]. These tools provide information on solar radiation, photovoltaic system performance, and suitability of roofs for solar installation, allowing users to determine the potential of solar energy in their area. PVGIS, in particular, offers free and open access to data on photovoltaic electricity generation potential for different technologies and configurations, making it a valuable resource for promoting sustainable development and renewable energy projects. At global level, the following references can be consulted: Global Wind Atlas[116] and Global Solar Atlas[117].

In addition to awareness-raising activities, municipalities can also focus on building capacity and empowering local installers and residents to increase the adoption of renewable electricity. This can involve developing training programmes and educational materials, as well as fostering community engagement and participation in renewable energy development, for example supporting renewable energy communities. Municipalities may also organise professional training programmes for installers to develop skills and knowledge in renewable energy technologies or guide residents through one-stop-shops.

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[109] Mouscron (Belgium): a city going solar: https://eu-mayors.ec.europa.eu/en/node/232

[110] Som Energia energy cooperative: https://www.somenergia.coop/es/

[111] NetZeroCities: Parma (Italy) climate city contract: https://netzerocities.app/resource-4190

[112] Energieatlas Berlin: https://energieatlas.berlin.de/

[113] Berlin solar systems 2023: https://www.berlin.de/umweltatlas/en/energy/solar-systems/continually-updated/introduction/

[114] Cadastre Solaire Paris: http://cadastresolaire.paris.fr/

[115] European Commission: Photovoltaic Geographical Information System (PVGIS): https://joint-research-centre.ec.europa.eu/photovoltaic-geographical-information-system-pvgis_en

[116] Global Wind Atlas: https://globalwindatlas.info/en/

[117] Global Solar Atlas: https://globalsolaratlas.info/

7.1.6 Heat/cold production

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 systems often rely on fossil fuels, contributing to GHGs and air pollution. Non-renewable local heat/cold production in EU municipalities reached around 98% of total local heat/cold production, representing a share of around 25% share on total heat/cold consumption (Franco de los Rios et al., 2024). However, there are alternative approaches that can provide sustainable and efficient heat and cold production, such as district heating and cooling, waste heat recovery, and the use of RES such as heat pumps, biomass, geothermal and solar thermal, as it will be observed in the following sections.

District heating / cooling

Implementing district heating and cooling 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.

The implementation of district heating and cooling offers multiple benefits, including reduced GHG emissions, improved air quality, and increased energy efficiency. There is a trend to reduce supply temperatures in district heating and cooling networks, which allows integrating more low-temperature heat sources. This allows utilising renewable energy and waste heat and cold sources such as nearby factories, it also reduces dependence on fossil fuels. Furthermore, district heating and cooling can be more cost-efficient than traditional heating and cooling systems. The use of combined heat and power (CHP) systems can also increase overall efficiency by generating both heat and electricity from a single fuel source.

Moreover, the efficiency in the generation of heat and cold should be balanced with the efficiency of the distribution network to ensure a reliable supply of energy, to minimise losses.

While implementing district heating and cooling presents several challenges, including high upfront investments and significant infrastructure changes, it also offers opportunities for innovation and collaboration. Municipalities can work with private sector companies to develop new technologies and business models, such as heat-as-a-service and cooling-as-a-service models. District heating can also exploit waste heat or excess heat (e.g. from industrial processes or from data centres[118]), thus creating additional revenue streams for some businesses, as described in the next paragraph.

Box 49. [Heat/cold production] District heating and cooling examples: Vantaa (Finland), Gothenburg (Sweden), Lahti (Finland) and Tartu (Estonia)

District heating is a key enabler for climate neutrality in municipalities, as demonstrated by the cases of Vantaa, Gothenburg, and Lahti. Vantaa's district heating network[119] has reduced CO_2 emissions by 30% through waste-to-energy and 20% by converting from natural gas to biofuel. Gothenburg's thermal energy

[118] Data centers, the new way of heating districts? https://smart-cities-marketplace.ec.europa.eu/insights/solutions/data-centers-new-way-heating-districts#:~:text=Data%20centers%20can%20replace%20existing%20heating%20plants%20in.and%20repurpose%20it%20in%20a%20district%20heating%20network.

[119] Vantaa (Finland): transforming district heating: https://eu-mayors.ec.europa.eu/en/node/816

storage tank[120] has reduced fossil fuel dependency and CO_2 emissions, with a goal of 100% renewable and recovered energy in the district heating network by 2025. Lahti's district heating restructuring[121] involves phasing out fossil fuels, increasing solar energy, and capturing CO_2 emissions. These municipalities demonstrate that district heating can be a cost-effective and efficient way to reduce GHG emissions and transition to a low-carbon economy.

Another example, in this case of district cooling, can be found in Tartu (Estonia)[122] where an efficient district cooling station has been deployed, which utilises the freshness of the municipality river to keep a district cool while reducing CO_2 emissions. The station, which opened in 2016, produces cooling using cold river water and traditional industrial equipment, and is estimated to reduce traditional cooling energy costs by 70-80%. The district cooling system has several benefits, including energy efficiency, and is expected to reduce CO_2 emissions by around 6 000 t/year. The system has been successful due to the municipality's densely populated centre, high energy density, and the use of renewable sources.

Waste heat recovery

Waste heat recovery is a valuable approach to unlocking the energy potential of urban waste heat streams. By harnessing waste heat from industrial processes, power generation, and other sources, municipalities can reduce their energy consumption and GHG emissions. Effective implementation requires a thorough understanding of the municipality's energy landscape, including the identification of potential waste heat sources and the development of a comprehensive plan to recover and utilise this energy.

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, waste heat can be used to produce fuels such as methanol and biodiesel, and to power hydrogen production through electrolysis. To complement these approaches, waste heat recovery can be integrated with energy storage technologies, such as thermal energy storage and phase change materials, batteries or hydrogen to optimise the use of waste heat, enhance flexibility and provide a stable and reliable energy supply.

Box 50. [Heat/cold production] Waste heat recovery examples: Espoo, Turin, Berlin and Stockholm

Municipalities like Espoo, Turin, Berlin and Stockholm are leading the way in harnessing waste heat to reduce GHG emissions and increase efficiency. Espoo's[123] innovative project involves recovering waste heat from a data centre to provide heat to 250 000 district heat users, reducing emissions by 40%. Stockholm's Open District Heating initiative[124] has partnered with 20 suppliers, including data centres, to recover over 100 GWh of heat annually, saving 50g CO_2 equivalent per kWh. Turin[125] exploring the recovery of waste heat from data centres, with a goal of recovering 55% of waste heat. Berlin[126] is also investing in waste heat recovery, with

[120] Gothenburg (Sweden): district heating as a key enabler for climate neutrality in Gothenburg: https://eu-mayors.ec.europa.eu/en/node/347

[121] Lahti (Finland): district heating restructuring: https://netzerocities.app/resource-4187 (page 46)

[122] Tartu (Estonia): an efficient district cooling station: https://eu-mayors.ec.europa.eu/en/node/198

[123] Espoo (Finland): Espoo Climate City Contract: https://netzerocities.app/resource-4179

[124] Stockholm (Sweden): heat recovery from data centres https://eu-mayors.ec.europa.eu/en/node/837

[125] Turin (Italy): climate city contract Citta di Torino: https://netzerocities.app/resource-4463

[126] Berlin (Germany): make new from old – innovative wastewater heat recovery for the swimming pool on Sachsendamm: https://eu-mayors.ec.europa.eu/en/node/175

a focus on using waste heat from wastewater systems to provide heat to buildings, such as the swimming pool on Sachsendamm, which uses a heat pump to recover heat from wastewater.

7.1.6.1 Strategies to address heat / cold production

The heat and cold production related emissions can be reduced through various physical and technological measures. Grey options, renewable energy sources such as biomass and geothermal, the use of high-efficiency heat pumps and district heating systems can significantly reduce emissions from heat and cold production. Other technological options concern smart heating and cooling systems, which can reduce emissions from heat production, or the use of advanced insulation materials in the pipelines to reduce heat loss. A key resource for strategies to address heat/cold production is the Heat Detox webpage[127] on the CoM EU website.

Box 51. [Heat/cold production] A comprehensive approach towards heating and cooling: Lappeenranta (Finland)

Lappeenranta presents a comprehensive plan to decarbonise the heating sector[128], with measures including investing in a large-scale district heating storage facility, implementing utility-scale solar power, and expanding and optimising the thermal network. These actions aim to improve efficiencies and phase out fossil fuels, reducing emissions from the heating sector.

As in other sectors, to incentivise the adaption of low-carbon heat and cold production technologies and practices, economic and financial measures can be implemented, such as financing and incentive instruments or other instruments.

Heat and cold production strategies can also be supported from the governance and institutional level. Municipalities may develop heat plans, remove obligations to connect buildings to natural gas networks and enforce obligations to connect buildings to district heating. Promoting coordination and cooperation among stakeholders (e.g. district heating utilities and waste-to-energy plants owners, as in the case of Bergamo[129]) is essential for the deployment of heat and cold production projects.

Box 52. [Heat/cold production] Decarbonising a former industrial hub in Bilbao (Spain)

The municipality of Bilbao, Spain, is transforming from a former industrial hub to a carbon-neutral municipality by 2050[130]. To achieve this, Bilbao is decarbonising its heating sector through in-depth renovation of public buildings, rolling out heat pump, and creating district heating and cooling networks. This transformation aims to reduce CO_2 emissions by 55% by 2030 and improve energy efficiency, ultimately enhancing the quality of life for residents and contributing to a more sustainable future.

The transition to low-carbon heat and cold production requires a fundamental shift in knowledge, behaviours, and practices. For example, advisory services for residents can focus on promoting the connection to district heating and cooling systems. Additionally, awareness-raising efforts can

[127] Heat Detox https://eu-mayors.ec.europa.eu/en/The-Cities-Heat-Detox

[128] NetZeroCities: Lappeenranta (Finland) climate city contract: https://netzerocities.app/resource-4218

[129] Bergamo Green https://www.euroheat.org/dhc/knowledge-hub/bergamo-green

[130] Decarbonising a former industrial hub in Bilbao, Spain https://eu-mayors.ec.europa.eu/en/Heat-mapping-to-decarbonise-a-former-industrial-hub

highlight the benefits of low-carbon heat and cold production, such as reduced greenhouse gas emissions, improved air quality, increased energy security and increased comfort.

Training programmes can be developed or supported to enhance the skills of workers from municipal utilities operating in the field of district heating, for example in areas such as energy auditing, thermal energy storage, and grid management. Furthermore, social and cultural measures could be targeted to increase social acceptance of heat and cold projects. For instance, heat and cold producers can collaborate with local communities to develop and implement community-scale low-carbon heat and cold production projects, such as district heating fuelled by waste heat or other renewable sources.

7.1.7 Waste and wastewater management

Waste and wastewater treatment accounts for 3% of the EU's GHG emissions. However, actions related to waste prevention and management have a significant potential to improve resource efficiency and reduce GHG emissions, and the sector is one of the largest contributors to methane (CH_4) emissions in the EU, which have increased 1990 and 2019. Addressing waste and wastewater treatment is therefore critical for achieving the EU's climate neutrality target.

Within the CoM framework, the waste and wastewater sector focuses on direct emissions from waste treatment. Thus, GHG emissions associated with the sector exclude waste flows that go through re-use, recycling and recovery, and those associated with other important waste management activities (e.g., waste prevention, waste collection, or energy use in waste treatment plants)[131]. The considerations provided here address direct GHG emissions from waste treatment, but consider also a broader scope of potential actions to improve resource efficiency and reduce the overall environmental impacts associated with waste, wastewater and water management.

To reduce direct emissions associated with the waste sector, municipalities should follow the waste hierarchy, as established in Waste Framework Directive[132] (The European Commission, 2008). The waste hierarchy provides a priority order for addressing waste management in five-steps, namely: 1) prevention, 2) preparing for re-use, 3) recycling, 4) recovery and 5) disposal. Essentially, preventing waste (i.e., reducing waste generation) is the preferred option, and disposal of waste in landfills should be the last alternative. The directive sets specific targets on municipal waste shares that shall be separated and prepared for re-use or recycled within 2025, 2030 and 2035. It is worth highlighting that a targeted revision[133] of the waste framework directive is underway addressing textile and food waste.

The Urban wastewater treatment directive (UWWTD)[134] (EC 91/271/EEC) (European Commission, 1991) has played a key role in improving the quality of EU's water systems, including rivers, lakes and seas. Recently, the proposal for a revised UWWTD (DIRECTIVE 2024/3019) (European Comission, 2024) has increased its scope and ambition to better align with the EU's policy objectives on climate action, circular economy and pollution reduction, one of the key initiatives under EU's zero pollution

[131] Waste-to-energy activities should be considered in the buildings macro-sector, while transport energy use in waste collection should be in the transport sector.

[132] Waste framework directive: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

[133] 2023 Proposal for a targeted revision of the Waste Framework Directive: https://environment.ec.europa.eu/publications/proposal-targeted-revision-waste-framework-directive_en

[134] Urban wastewater treatment directive: https://environment.ec.europa.eu/topics/water/urban-wastewater_en

action plan. Interestingly, the revision establishes rules on the generation and use of energy from RES in urban wastewater treatment plants.

Municipal solid waste

Waste prevention is the most effective way of mitigating environmental impacts associated with this sector. Actions to prevent waste generation can target a direct reduction in final consumption, but they can also change or shift consumption. For example, a municipality can actively introduce consumption choices - in the organisations, spaces and events under their influence - to reduce final products' use, to replace single-use disposable products with reusable alternatives, or to shift to products with less packaging, using more sustainable materials. It can reduce consumption also by extending products' lifetime, by providing or promoting services that can replace, partially, product consumption (e.g., tools or book lending services).

On municipal solid waste management, service coverage and quality are crucial to increase efficiency and to maximise GHG mitigation and other environmental benefits achieved through recovery, recycling and composting, for example. Optimising operations is particularly important in sorting and collection stages. Lastly, social acceptance and public engagement play a key role in the sustainable and efficient management of municipal solid waste, and these should be adequately supported with regulatory tools and incentives.

Wastewater

Implementing effective wastewater management systems, including collection, treatment, and disposal, can reduce GHG emissions and improve water and ecosystems' quality. GHG mitigation actions on wastewater can target increased efficiency of wastewater systems (incl. sewers, pumping stations, etc.) and use of RES in wastewater treatment plants, and improve sludge treatment and disposal processes. Audits and monitoring technologies are important to support investments in infrastructure and low-emission technologies, as well as the optimisation of treatment processes.

Other waste streams

Holistic and integrated actions should be complemented with actions targeting specific waste streams. Food waste, for example, offers significant opportunities in GHG mitigation – food losses across the whole supply chain are estimated account for about 20% of food consumption in the EU. While most EU municipalities have separation of some main materials (e.g., plastic, metal and glass), the separation of organic waste can be the next step for many municipalities. Awareness raising campaigns, trainings and educational materials can help increase the prevention and reduction of food waste (incl. biodegradable waste and packaging). These should target final consumers (householders), but also distributors, supermarkets, restaurants, among other stakeholders.

Construction and demolition (C&D) waste often dominates material waste flows associated with urban areas, and they are associated with very high GHG emissions (from production of construction materials to transport, and end-of-life treatment). Actions in the buildings sector to extend buildings lifetime, for example, are central to reduce C&D waste, and they can be complemented with actions specifically targeting on-site construction practices.

Some examples on how to deal with waste and wastewater are presented below. However, a potential source of inspiration for the waste management sector is the Green Best Practice Community from the European Commission.[135]

7.1.7.1 Physical and technological

Important technological advancements and innovations are available to improve separated waste collection, such as data-enabled equipment (e.g., 'smart' waste bins, sensors) and automatic collection systems (e.g., automatic collection systems). Real-time monitoring of waste generation and collection systems can support the improvement collection services and operations. Sensors can help minimising overflowing bins and littering, for example, and support the optimisation of collection activities. Integration with other urban systems and data platforms, e.g., traffic management, can improve overall efficiency and coordination.

Box 53. [Waste and wastewater] Ioannina's (Greece) pioneering approach to waste management

Ioannina is pioneering a comprehensive and innovative approach to waste management[136], envisioning an extensive network of separate waste collection that covers 21 categories of waste, including textiles, electronics, hazardous materials, and bulky items. The ambitious initiative is complemented by the development of dedicated infrastructure, such as recycling corners, green points and centres for creative reuse of materials, to facilitate the efficient collection and processing of waste. This holistic strategy demonstrates a commitment to minimising waste and promoting a circular economy, setting a new standard for innovative waste management practices.

7.1.7.2 Economic and finance

Financial mechanisms, such as grants, loans, and tax incentives, can play a crucial role in supporting the implementation of mitigation actions. At local level an important step can be to implement and improve municipal solid waste sorting, to increase the shares of waste recycling and recovery. Pay-as-you-throw (PAYT) systems[137] can be particularly effective in this context. Financial incentives on low emission technologies can also reduce GHG emissions from public and private waste and wastewater treatment facilities.

Box 54. [Waste and wastewater] Treviso's (Italy) Pay-as-you-throw system

The municipality of Treviso (Italy)[138] introduced a Pay-as-You-Throw (PAYT) system in 2014, where waste fees are calculated based on the number of household members (60%) and the amount of mixed waste collected (40%). As a result, the separate collection rate increased by 25% and mixed waste production decreased by 70%. The system, implemented by the waste management company, uses electronic devices to track and charge households based on waste production. The introduction of PAYT led to significant savings, with the average waste fee per household in 2015 being EUR 186, compared to the national average of EUR 305. A well-planned communication campaign and coordination with neighbouring municipalities were key to the system's success, helping to minimise potential side effects such as illegal dumping.

[135] European Commission, Green Best Practice Community (waste management sector): https://greenbestpractice.jrc.ec.europa.eu/sector/1

[136] NetZeroCities: Ioannina (Greece) climate city contract: https://netzerocities.app/resource-4200

[137] Pay-as-you-throw: https://greenbestpractice.jrc.ec.europa.eu/node/7

[138] Treviso's (Italy) pay-as-you-throw system: https://greenbestpractice.jrc.ec.europa.eu/node/158

7.1.7.3 Governance and institutional

As municipalities plan actions to promote sustainable waste and wastewater management, they need to consider their decision-making power and the different modes of governance that they can deploy. For example, a municipality can use its self-governing power to implement waste reduction and recycling programmes for municipal buildings and facilities, as well as for events organised or supported by the municipality.

Through governing by provision, a municipality can establish public-private partnerships to develop recycling facilities or composting programmes or provide incentives for businesses and residents to implement waste reduction and recycling practices.

Cooperation among stakeholders, including government, private sector, and community groups, can help leverage resources and expertise to support mitigation actions. The municipality can enable and support cooperation, for example, by providing infrastructure and platforms (e.g., spaces to store construction materials and tools to be re-used, online platforms to exchange co-products or materials, among others).

Box 55. [Waste and wastewater] A strong governance approach in the waste sector: Ljubljana (Slovenia)

Ljubljana's approach[139] is characterised by a robust governance framework, which enables the implementation of a comprehensive and innovative waste strategy through the establishment of various initiatives, partnerships and programmes, including the development of new technologies, introduction of a sustainable city card for vulnerable groups, and creation of dedicated facilities and services such as zero-waste stores, reuse centres and sustainable offices. Additionally, the municipality has implemented packaging return schemes, deposit systems for glassware, and local food sales spaces to reduce food waste, and has also established educational workshops and meal planning applications to promote sustainable practices among residents, all of which are guided by a clear vision and coordinated through a multi-stakeholder approach.

7.1.7.4 Knowledge and behavioural change

Final consumers play a key role in sustainable municipal solid waste management systems. Social acceptance and wide uptake of sustainable waste prevention and management practices have significant potential to reduce GHG emissions in this sector. For example, behavioural changes are important to reduce final consumption and make more sustainable consumption choices that reduce waste generation. Efficient recovery and recycling processes are also highly dependent on sorting at final consumer. As such, actions including awareness raising campaigns, educational events and trainings are important, and these should target not only households, but a wide range of intermediate and final consumers in the municipality. For example, some schools request pupils to use refillable bottles instead of disposable ones and/or organise weekly "unpackaged snack" days, which also results in eating less processed food.

Box 56. [Waste and wastewater] Kalamata's (Greece) Know-as-you-throw (KAYT) scheme

The "know as you throw" (KAYT) programme is an innovative approach planned in Kalamata (Greece)[140] that provides residents with personalised feedback and advice on their waste sorting habits through a special

[139] NetZeroCities: Ljubljana (Slovenia) climate city contract: https://netzerocities.app/resource-4444

[140] NetZeroCities: Kalamata (Greece) climate city contract: https://netzerocities.app/resource-4185

software and smart bins. Residents receive biodegradable bags with unique barcodes and personalised messages, and can accumulate reward points for proper sorting, redeemable for local products and services. The programme aims to complement the "pay as you throw" (PAYT) approach, encouraging people to improve their waste sorting habits and reduce waste sent to landfills, with the ultimate goal of creating a more circular and sustainable economy.

7.1.8 Agriculture, forestry and other land use (AFOLU)

The AFOLU sector is a critical component of the global effort to mitigate climate change, as it is responsible for 13-21% of global GHG emissions (Nabuurs et al., 2022). The sector includes a wide range of activities, such as deforestation, land-use changes, and agricultural practices, which can have significant impacts on the environment, biodiversity, and human well-being[141]. However, the AFOLU sector has also the potential to be a net sink for carbon dioxide, through practices such as sustainable agricultural practices, reforestation and afforestation. This section will explore various approaches that can be taken to reduce emissions and promote sustainable land use practices in the AFOLU sector.

Box 57. [AFOLU] Emissions in the AFOLU sector and consideration of energy-related emissions

The emissions from the AFOLU sector refer to non-energy related emissions linked to three main subsectors: livestock, land use and other AFOLU (including biomass burning without energy recovery, liming, urea application, direct and indirect N_2O from managed soils, indirect N_2O from manure management and harvested wood products). While some of the activities linked to the sector require energy supply (e.g. machinery), these energy related emissions should be reported in the stationary energy sector.

Sustainable agricultural practices

Sustainable agricultural practices are crucial for reducing the environmental impact of farming while maintaining productivity and food security. This can be achieved through techniques such as agroforestry[142], permaculture, regenerative, conservation[143] or precision agriculture[144], which prioritise soil health, biodiversity and efficient water use. Additionally, practices like crop rotation, organic farming, and integrated pest management can help reduce synthetic fertiliser and pesticide use, minimising pollution and protecting ecosystems. By adopting these sustainable agricultural practices, farmers can improve soil fertility, increase crop yields, and promote ecosystem services like pollination, and pest control, ultimately contribution to a more resilient and sustainable food system. Furthermore, sustainable agriculture can also help to mitigate climate change by reducing non-energy GHG emissions and sequestering carbon in soils. Additionally, it can be integrated with renewable energy sources within agrivoltaic approaches. To support the widespread adoption of sustainable agricultural practices, municipalities can provide incentives, training, and technical assistance to

[141] Land Use, Land-Use Change and Forestry (LULUCF) https://unfccc.int/topics/land-use/workstreams/land-use--land-use-change-and-forestry-lulucf

[142] Agroforestry: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/agro-forestry-and-crop-diversification

[143] Conservation agriculture: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/conservation-agriculture

[144] Precision agriculture: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/precision-agriculture

farmers, as well as promote policies and regulations that encourage sustainable agriculture or climate-smart urban agriculture[145].

Preservation and restoration of natural ecosystems

The preservation and restoration of natural ecosystems, such as forests, grasslands, and wetlands are essential for maintaining biodiversity, regulating the climate, and supporting ecosystem services. Efforts to protect and restore these ecosystems can involve reforestation and afforestation initiatives, habitat restoration, and the creation of protected areas like national parks and wildlife reserves. Furthermore, sustainable land-use planning and certification schemes, such as those for sustainable timber and palm oil, can help ensure that land-use activities are managed in a way that minimises harm to the environment and respects the rights of local communities. By preserving and restoring natural ecosystems, municipalities can help maintain ecosystem services like air and water filtration, soil formation and carbon sequestration, ultimately supporting both human well-being and the health of the planet. Additionally, preserving natural ecosystems can also help to protect indigenous communities and their traditional ways of life, as well as support sustainable livelihoods and economic development. To achieve this, it is essential to involve local communities, indigenous peoples, and other stakeholders in the decision-making process and to provide them with the necessary support and resources to manage and conserve their natural resources effectively. This can include initiatives like community-led conservation, ecotourism, and sustainable forest management, which can help to promote the value of natural ecosystems and support their conservation for future generations[146].

7.1.8.1 Physical and technological

The AFOLU sector can reduce its non-energy emissions through various physical and technological measures. Sustainable agricultural practices, such as agroforestry and conservation agriculture can reduce synthetic fertiliser use and improve soil health. Additionally, technologies like precision agriculture and vertical farming can optimise crop yields and reduce waste. With respect to livestock, practices such as rotational grazing and manure management can reduce methane emissions from livestock. Additionally, the implementation of precision livestock farming techniques, such as monitoring of animal health and nutrition, can help optimise livestock production and reduce waste.

In forestry, sustainable forest management practices, such as selective logging and reforestation, can reduce forest degradation and promote sustainable wood production. On the technological side, approaches like forest inventory management and remote sensing can help monitor and manage forest resources more effectively, as well as agricultural crops.

Finally, carbon sequestration can be an additional benefit of sustainable land use practices and can be promoted through initiatives such as reforestation and afforestation.

[145] Climate smart urban agriculture: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/urban-farming-and-gardening

[146] Adaptive management of natural habitats https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/adaptive-management-of-natural-habitats

Box 58. [AFOLU] Digital tools and approaches to support AFOLU and NBS measures in Antwerp (Belgium), Gothenburg (Sweden), and Prato (Italy).

The municipalities of Antwerp[147], Gothenburg[148] and Prato[149] are leveraging digital approaches to enhance their environmental sustainability and climate resilience. Antwerp's "Greentool" allows urban planners to analyse the environmental benefits of green areas, while Gothenburg is utilising geographical information systems (GIS) to identify potential trade-offs and optimise the deployment of nature-based solutions (NBS). Meanwhile, Prato is integrating precision farming and agriculture 5.0 technologies, such as precision farming and digital twins, to promote energy-efficient agriculture and modernise its farming sector. The creation of an environmental digital twin in Prato will enable data-driven impact assessment, allowing the municipality to monitor and evaluate the effectiveness of its sustainability initiatives. By combining these digital tools with AFOLU and NBS solutions, these municipalities are poised to make more informed decision, enhance their environmental performance and achieve their climate goals.

7.1.8.2 Economic and finance

Economic and financial measures can incentivise the adoption of low-emission practices in the AFOLU sector. Financial mechanisms, such as payments for ecosystem services and certification schemes can provide a financial incentive for landowners and farmers to adopt sustainable land use practices. Additionally, government subsidies and tax incentives can support the adoption of sustainable practices. Market-based instruments, such as organic and sustainable product labelling can also provide financial incentives to modify the usual agricultural practices to reduce non-energy emissions. Furthermore, private sector investment in sustainable land use practices can help scale up mitigation efforts in AFOLU.

Box 59. [AFOLU] Ljubljana (Slovenia): financial incentives to support AFOLU actions

The municipality of Ljubljana (Slovenia)[150] has developed an extremely rich strategy in the AFOLU sector, encompassing a wide range of initiatives and measures to promote sustainable land use, reduce greenhouse gas emissions and enhance environmental resilience. One key aspect of this strategy is the introduction of financial and economic incentives to encourage the adoption of advanced and environmentally friendly farming practices. This includes eligibility for financial incentives for investments in agricultural efficiency, as well as specific incentives for improving feed energy utilisation, reducing methane emissions and efficiently collecting agricultural biomass near biogas facilities. Additionally, the municipality provides incentives for sustainable farming practices that reduce methane emissions, promoting a more environmentally sustainable agricultural sector. This comprehensive approach demonstrates Ljubljana's commitment to addressing the complex challenges of the AFOLU sector, and its efforts to create a more sustainable and resilient food system.

7.1.8.3 Governance and institutional

National and subnational governments can establish policies and regulations to promote sustainable land use practices, such as organic farming standards, agroforestry incentives and sustainable forestry certification. These policies can be tailored to specific ecosystems and land uses, such as

[147] Antwerp, Belgium: a green tool to measure the environmental and ecological benefits of green areas https://eu-mayors.ec.europa.eu/en/node/164

[148] NetZeroCities: Gothenburg (Sweden) climate city contract: https://netzerocities.app/resource-4455

[149] NetZeroCities: Prato (Italy) climate city contract: https://netzerocities.app/resource-4448

[150] NetZeroCities: Ljubljana (Slovenia) climate city contract: https://netzerocities.app/resource-4444

peatlands, wetlands, and drylands, to address the unique challenges and opportunities of each environment.

Additionally, community-based initiatives and participatory governance approaches, such as community-led conservation and co-management of protected areas, can empower local communities to take ownership of sustainable land use practices and ensure that they benefit from conservation and sustainable land use efforts, including in areas with significant livestock production, such as grazing lands and pasture management. This can involve the development of community-led planning and decision-making processes, as well as the provision of technical support to help communities implement sustainable land use practices. Furthermore, governments can also establish mechanisms for monitoring and enforcing sustainable land use practices, such as certification schemes and auditing programmes, to ensure that policies and regulations are effective in promoting sustainable land use.

Box 60. [AFOLU] AFOLU sector approaches supported by governance actions in Miskolc (Hungary)

Miskolc's[151] approach to the AFOLU sector is characterised by innovative governance practices, prioritising community engagement, participatory planning and collaborative decision-making. The municipality's strategy involves reviewing and updating existing plans, such as the Green Infrastructure Development Maintenance Action Plan, and establishing new frameworks, including a comprehensive environmental monitoring system, to ensure effective governance and management of green assets.

7.1.8.4 Knowledge and behavioural change

Knowledge and behavioural change are critical for promoting low-emission practices in the AFOLU sector. Education and training programmes can help build capacity among landowners, farmers and forest managers to adopt sustainable land use practices. Awareness-raising campaigns and outreach programmes can help promote the benefits of sustainable land use practices among local communities and the public. Moreover, research and development of new technologies and practices can help improve the efficiency and effectiveness of low-emission land use practices.

Box 61. [AFOLU] Kranj and Lappenranta knowledge and behaviour change approaches in the AFOLU sector

The municipalities of Kranj (Slovenia)[152] and Lappeenranta (Finland)[153] are implementing a range of knowledge and behaviour change actions to promote sustainable practices and reduce greenhouse gas emissions. In Kranj, initiatives include promoting precision agriculture and digital technology, enhancing local food supply chains, educating and motivating young farmers, and providing financial support for jobs focused on reducing GHG emissions. Similarly, Lappeenranta is creating an enabling environment through the establishment of a working group on nature-based solutions, the deployment of interactive events like the Greenreality carnival, and the use of GIS to map and identify areas for sustainability improvements. Additionally, Lappeenranta is engaging with youth and raising awareness about sustainability aspects, empowering the next generation to act on environmental issues. By combining these efforts, both municipalities are driving behavioural change, building capacity and fostering a culture of sustainability among their residents, ultimately contributing to a more climate-resilient and environmentally conscious community.

[151] NetZeroCities: Miskolc (Hungary) climate city contract: https://netzerocities.app/resource-4450

[152] NetZeroCities: Kranj (Slovenia) climate city contract: https://netzerocities.app/resource-4443

[153] NetZeroCities: Lappeenranta (Finland) climate city contract: https://netzerocities.app/resource-4218

Box 62. [AFOLU] Izmir (Turkiye): a comprehensive approach to the AFOLU sector

Izmir's (Turkiye) approach[154] to the AFOLU sector is truly comprehensive, addressing all aspects of carbon farming and sustainable agriculture through a multi-faceted strategy that also addresses energy-related emissions. The municipality's plan encompasses a wide range of measures, including the adoption of low-carbon technologies, renewable energy solutions, climate-smart agriculture practices, and social innovation activities. Additionally, it establishes dedicated departments, training programmes, and financing mechanisms to support farmers, promoting a holistic and inclusive approach to sustainable agriculture and urban greening. This integrated package of measures serves as a model for other municipalities, demonstrating a comprehensive and exemplary approach to addressing AFOLU challenges.

7.1.9 Mitigation action fiches

This section presents two examples of mitigation best practices described with the action template. Refer to section 5.3 for explanations on how to fill in the corresponding fields of the template.

Table 16. Mitigation action fiche 1: Development and implementation of a transportation demand management plan

Concept	Explanation
Action title	Development and implementation of a transportation demand management plan (inspired by and adapted from Limassol climate city contract[155] and 2030 climate neutrality investment plan[156])
Main focus	Mitigation - transport
Action description	Under this action, the municipality will implement a comprehensive strategy to optimise transportation systems and reduce carbon emissions. This action aims to create a sustainable and efficient mobility ecosystem by promoting alternative modes of transportation, encouraging carpooling and ridesharing, improving public transit infrastructure, and implementing smart technology solutions. The transportation demand management plan includes measures such as congestion pricing, parking management, and incentives for sustainable travel options. The plan seeks to minimise the use of private vehicles, reduce traffic congestion, thus lowering greenhouse gas emissions associated with transportation activities. The action includes the construction of 5 park and ride locations, the installation of 5 mobility hubs in strategic locations and the design and operation of a platform that controls transport demand management (TDM) strategies.
[Mode of governance]	Governing through provision; Regulation and planning (governing by authority)
[Action type]	Governance and institutional
Implementation timeline	2024-2030

[154] NetZeroCities: Izmir (Turkiye) climate city contract https://netzerocities.app/resource-4184

[155] NetZeroCities: Limassol (Cyprus) climate city contract: https://netzerocities.app/resource-4219

[156] Limassol (Cyprus) investment plan https://www.limassol.org.cy/uploads/Missioncities/276dc70b5d.pdf

Concept	Explanation
Responsible bodies	Municipality; Department of Town Planning and Housing;
Stakeholders involved	Ministry of Transport Communications and Works; Residents' representatives (NGOs)
Costs	Total Costs: EUR 27.27m (Cost upfront and remaining cost: EUR 2.72m + EUR 24.54m). The total cost includes the construction of 5 park and ride locations (EUR 24.17m) and 5 mobility hubs (EUR 2.33m). It also includes the design and operation of a platform that controls TDM strategies (EUR 0.77m).
Funding sources and financing instruments	Possible funding sources can be grants, subsidies, public-private partnerships, among other.
Estimated impact / outcome	With the better planning, the municipality will be able to use less fuel and avoid an amount of CO_2 emissions in the transport sector.
	Quantitative indicator: Reduction of GHG emissions in the transport sector [tCO_2]
Implementation parameters	Track on the achievements related with the parks and ride locations built or the installation of the mobility hubs, development of the operation platform
	Quantitative indicator: number of parks-built [Number]; Total mobility hubs installed [number]; Progress on the development of the platform [%]
Other co-benefits / potential trade-offs	The action has the potential to reduce traffic congestion as it could reduce the number of cars in the street and consequently improve air quality. Also, there will be a saving related with the fuel costs that is expected to decrease.
	Quantitative indicator: Decreased mileage driven [vkm] Reduced traffic congestion [hours/day]; Economic cost savings [EUR]

Source: Inspired by Limassol climate city contract

Table 17. Mitigation action fiche 2: District heating

Concept	Explanation
Action title	District heating restructuring (inspired by and adapted from Lahti climate city contract[157])
Main focus	Energy systems; heating supply generation
Action description	Under this action, the municipality will optimise the district heating supply. The action focuses on the replacement of fossil fuels operation for more efficient and clean fuels. This will be done by phasing out fossil fuel operations, increasing the use of solar energy, capturing CO_2 emissions from the production of district heat and the increased number of buildings joining the district heating network. Additionally, the

[157] NetZeroCities: Lahti (Finland): climate city contract https://netzerocities.app/resource-4187

Concept	Explanation
	recovery of waste heat from wastewater treatment plant will be mapped to analyse its potential.
[Mode of governance]	Municipal self-governing
[Action type]	Physical and technological
Implementation timeline	2025-2030
Responsible bodies	Local energy company, Local water company, Departments of urban planning and economic development
Stakeholders involved	Municipality's subsidiaries, local businesses, residents, national and regional authorities, grid company, electricity company, research institutes.
Costs	Confidential (not available)
Funding sources and financing instruments	Possible funding sources include grants, subsidies, loans, energy performance contracts, etc.
Estimated impact / outcome	Actions are significant in terms of emission reductions.
	Quantitative indicator: CO_2eq; Fuel consumption [MWh/y]; Solar energy generated [MWh/y]
Implementation parameters	This action involves different sub-measures, that need to be closely tracked: Phasing out natural gas in district heating; carbon capture and utilisation (CCU) in operation and scaled; Increase in solar energy to 8 MWp; Mapping and analysing the potential of waste heat recovery in new sites (industry); Increased number of buildings that joined district heating network.
	Quantitative indicators: Number of boilers using natural-gas [number]; Total CCU scaled [number]; Total area of solar thermal installed [m^2]; Buildings in the district heating network [number]
Other co-benefits / potential trade-offs	The introduction of new technologies causes employment effects.
	Quantitative indicators: Unemployment rate [%]

Source: Inspired by Lahti climate city contract

7.2 Adaptation actions

Europe is experiencing several climate hazards with increasing frequency and intensity. Heatwaves especially in southern Europe, such as the one in 2022, have resulted in significant mortality rates, with estimates suggesting between 60 000 and 70 000 premature deaths[158]. Other climate hazards, such as heavy precipitation, floods, and sea level rise, have been experienced and are also expected to increase in frequency and severity, with coastal ecosystems and low-lying areas being particularly vulnerable. Similarly, droughts and water scarcity are also projected to worsen, especially in southern Europe.

Climate change does not only represent a threat in itself, but it can also be a risk multiplier that exacerbates existing risks and creates new ones. It can interact with non-climatic risk drivers, such as ecosystem fragmentation, pollution and unsustainable land use, to increase the vulnerability of ecosystems and human societies. This can lead to cascading impacts across sectors and systems, affecting food security, human health, infrastructure and the economy.

Against this backdrop, the EU has implemented various strategies and initiatives to address climate hazards, including the EU Adaptation Strategy (European Commission, 2021) or the EU Adaptation to climate change mission[159]. The EU has also introduced policies and instruments to support adaptation, such as the Critical Entities Resilience Directive[160], the Union Civil Protection Mechanism[161], and the European Regional Development Fund[162].

European Climate Risk Assessment (EUCRA) (European Environment Agency, 2024) recommends to follow a precautionary approach to climate risk assessment and management, taking into account the potential for catastrophic and unpredictable events. It also emphasises the need for a systems-approach to adaptation, which involves considering the interconnectedness between different sectors and systems. Furthermore, investing in social justice and cohesion, as well as adopting inclusive decision-making processes that involve marginalised and vulnerable groups would ensure that the actions are effective, and their benefits are equitably distributed.

Finally, the EUCRA suggests that the EU should play a stronger role in improving the analyses of major climate risks, filling knowledge gaps, and supporting the development of adaptation policies and strategies.

Within this framework, action at local level is essential to address specific climate-related challenges and increase the resilience of residents and communities and their capacity to withstand and adapt to future climate-related stresses and shocks. The successes and challenges experienced at the local level also contribute to inform and shape EU climate policies, ensuring that they are effective and tailored to the needs of European citizens.

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[158] EEA - The impacts of heat on health: surveillance and preparedness in Europe https://www.eea.europa.eu/en/analysis/publications/the-impacts-of-heat-on-health

[159] EU Adaptation to Climate Change Mission: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/adaptation-climate-change_en

[160] Critical Entities Resilience Directive (CER): https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3992

[161] EU Civil Protection Mechanism: https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/eu-civil-protection-mechanism_en

[162] European Regional Development Fund: https://ec.europa.eu/regional_policy/funding/erdf_en

The following sections present examples of strategies and actions aimed at reducing exposure and vulnerability to climate change, increasing adaptive capacity or minimising the impacts derived from climate hazards.

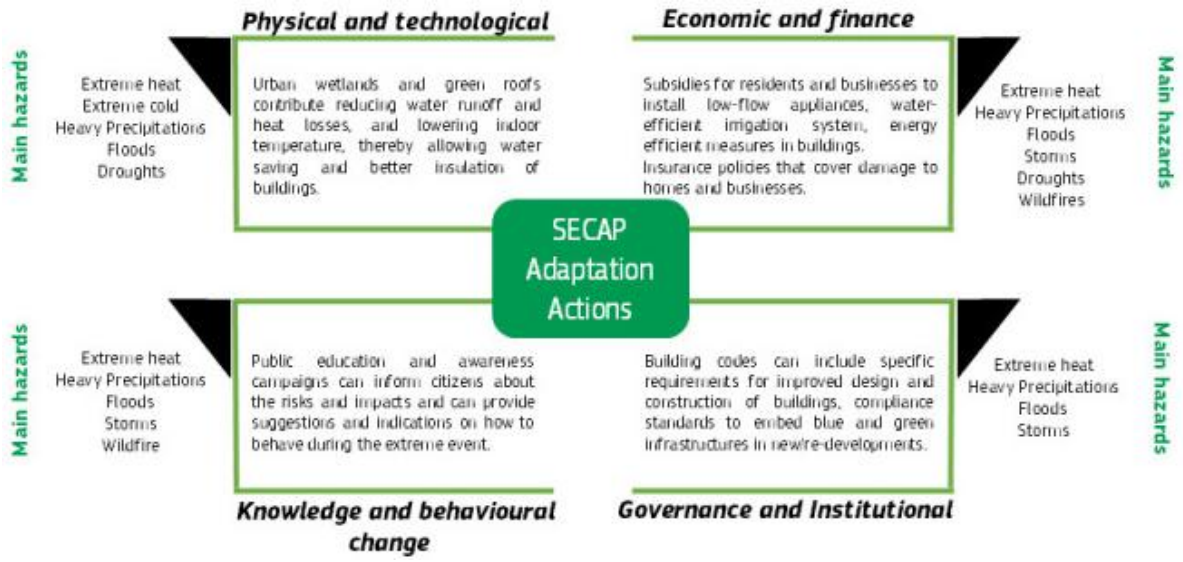
The examples selected mainly concern actions at the local level. However, examples at regional and national levels are also included, as these can serve as inspiration, can be adapted to the corresponding local contexts, and show how collaboration across levels of governance can be beneficial towards a shared goal. Best practices examples are collected and presented to serve as inspiration and then they can be adapted to specific context and needs.

Additionally, when planning adaptation actions, it is necessary to consider potential maladaptation and other unintended consequences, such as displacement effects due to gentrification and potentially counterbalance them with complementary policies. Moreover, in action planning overall, and in adaptation efforts linked especially to emergency response, it is important to recognise accessibility challenges experienced by different population groups (e.g. blind people, older people that are not familiar with technologies, ethnic groups that don't speak the local language).

As it will be observed, enhancing a municipality's resilience is not necessarily linked to major investments in infrastructure, as there are several types of actions a municipality can implement that can also be impactful. For these reasons, actions are classified according to the key action types (physical and technological, economic and finance, governance and institutional, and knowledge and behavioural change, see section 3), and examples on potential outcomes obtained from each action are derived.

While actions are specific to addressing specific hazards and contexts, the underlying policy approaches can be common across different hazards. This is especially true for policies related to governance and institutional, economic and finance, knowledge and behavioural change, for which the underlying approach can be applied to multiple hazards, with tailored details designed to meet local needs. In contrast, physical and technological actions tend to be more hazard specific. However, even specific actions can be multipurpose, allowing them to effectively address multiple hazards if properly planned and implemented (see figure below).

Figure 11. Adaptation actions examples addressing more than one hazard



Source: JRC elaboration

Within the economic and finance group, municipalities can leverage a combination of financial instruments (such as tax breaks and subsidies) and incentives for residents and businesses to install systems that protect from adverse events and minimise the vulnerabilities (for example to extreme heat and cold). Often, these systems refer to energy efficiency, thereby combining mitigation and adaptation to climate change. Subsidies and incentives are part of economic policy instruments that aim to stimulate behavioural change. Insurance products can also be developed to cover damages caused by extreme events in several sectors, for example in buildings and agriculture[163]. For instance, weather derivatives are financial tools where one party (the investor) agrees to pay another party (the buyer) if certain weather conditions happen (e.g. heating degree days, pre-defined amount of rain) rather than proof of loss. In exchange, the buyer pays an upfront fee, making it a simpler and more cost-effective option than traditional alternatives[164].

Looking at governance and institutional approaches, municipalities can design land use planning regulation and standards to regulate and influence the use and characteristics of spaces. For example, municipalities can plan interconnected and multifunctional networks of blue and green spaces (blue-green infrastructures) which reduce the negative impacts of climate change hazards such as heatwaves, floods and drought. Municipalities can define construction and design standards to ensure certain expected quality and performance levels are met. For example, standards on minimum levels of vegetation along roads, which contribute to reduce noise and increase shadowing, and construction requirements to ensure roads have permeable surfaces to reduce water run-off[165]. In addition, in building design specific minimum requirements aim to ensure energy efficiency, which ensures better indoor temperature and air quality contributing to addressing extreme heat and cold, as well as in new developments standards can be set to regulate the amount and quality of vegetation and permeable surfaces to reduce flooding and runoff issues and prevent heat island effect. Municipalities can also deploy early warning systems[166], and foster coordination, cooperation and networks among stakeholders, to facilitate information sharing and a coordinated response in case of extreme events.

Within the knowledge and behavioural change actions group, municipalities can implement policies to promote awareness to encourage behavioural change and empower residents, communities, and professionals to take proactive measures. Awareness raising is an important component of the whole climate adaptation process as it increases the knowledge and awareness[167] of communities and contributes to reducing their vulnerabilities while increasing their adaptive capacities. For example, public education and awareness campaigns can inform residents about the risks and impacts of extreme events and provide them with practical tips on preparedness and mitigation strategies. These can also focus on a specific threat or impact that is considered as the most critical for a given place, i.e. a specific heatwave, or coastal and river floods. Campaigns are

[163] Insurance as risk management tool: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/insurance-as-risk-management-tool

[164] Weather derivatives as risk management tool: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/weather-derivatives-as-risk-management-tool

[165] Climate proofed standards for road design, construction and maintenance: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/climate-proofed-standards-for-road-design-construction-and-maintenance

[166] Early warning systems https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/establishment-of-early-warning-systems

[167] Awareness raising campaigns for stakeholders' behavioural change https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/awareness-campaigns-for-behavioural-change

designed to ensure the messages are tailored to the audience and reach the targeted group, for example via social media, or school gatherings.

Municipalities are recommended to adequately define the intended outcomes in a quantitative manner when planning the actions, as this will facilitate tracking the process and establishing a clear link to the overall adaptation goals established.

7.2.1 Extreme heat

Heatwaves in Europe have intensified due to climate change, with increasing frequency, duration, and severity, particularly in southern and central regions. Rising temperatures pose health risks (World Health Organisation (WHO), 2018a, 2018b, 2021), increase energy demand for cooling, and exacerbate droughts and wildfires. Climate change is expected to increase the frequency and severity of heatwaves, making it essential to develop long-term strategies to adapt to this new reality (Masson-Delmotte et al., 2021). Some strategies to deal with extreme heat can be observed in Table 18 (Ulpiani et al., 2024). Municipalities have started dealing with heatwaves and exploring solutions to abate temperatures in urbanised areas. The pan European "Hit Refresh" Campaign [168] highlights the growing importance of the extreme heat, and maps and showcases actions undertaken by municipalities through governance changes, nature -based solutions, smart urban design and collaboration.

Table 18. [Extreme heat] Example strategies

Main focus	Objective pursued	Examples on how to reach the objective (actions)
Identify and support vulnerable populations	Decrease vulnerability	Implementing heatwave awareness and education campaigns, providing cooling centres for vulnerable populations, improving access to healthcare services.
Reduce exposure to extreme heat	Decrease exposure	Implementing green corridors in the municipality, creating urban parks and gardens, using cool pavement technologies, implementing heat-reflective roofing material.
Minimising the effects of extreme heat	Decrease impact	Investing in cooling systems in buildings, implementing heatwave early warning systems, using smart city technologies to monitor and manage urban heat (e.g. supported by GIS)
Enhance the ability to adapt to extreme heat	Increase adaptive capacity	Develop heatwave response plans, providing training and resources for emergency responders, promoting community engagement and participation in heatwave mitigation efforts, investing in climate-resilient infrastructure.
**Note: some of the examples provided not only address adaptation, but could also contribute to mitigation efforts by reducing GHG emissions, or address energy poverty*		

Source: JRC elaboration

[168] "Hit Refresh" campaign: https://eu-mayors.ec.europa.eu/en/Cities-Refresh

7.2.1.1 Physical and technological

To reduce or mitigate the effects of extreme heat, municipalities can implement shaded areas, green spaces, and public parks (green options) to reduce the urban heat island effect. These can also be combined with river restoration and maintenance, expanding water areas within the municipality or including public fountains and misting systems[169] (blue options). Municipalities can also invest in climate-proofing approaches[170], such as cool roofs, green roofs and walls to reduce the temperature inside buildings. Additionally, municipalities can implement cooling systems, use evaporative cooling technologies, and use cooling materials in building construction (grey options).

Table 19. [Extreme heat] physical and technological example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Green options	Implementing green corridors in the municipality	Green infrastructure can help mitigate the urban heat island effect by providing shade, reducing surface temperatures, and improving air quality and biodiversity. Reducing vulnerability and exposure of vulnerable populations as well as relevant sectors such as health or buildings can be enhanced.
Blue options	Establishing a network of evaporative cooling fountains and drinking water stations	Increased access to cooling spaces and water for vulnerable populations, reduced heat-related illnesses and mortality, and improved overall public health and well-being.
Grey options	Investing in cooling systems in buildings	Reduced indoor temperatures, improved thermal comfort, and increased productivity and safety for building occupants, particularly in vulnerable populations such as older people and young children[171].
Technological options	Development of a system that notifies via a phone alarm when there is a heatwave (heatwave early warning system)	Heatwave early warning systems (HEWS) can provide timely warnings to the public, healthcare services, and other stakeholders, allowing them to take necessary precautions to stay safe during heatwaves. Therefore, the exposure of vulnerable populations can be reduced.
**Note: some of the examples provided not only address adaptation, but could also contribute to mitigation efforts by reducing GHG emissions, or address energy poverty*		

Source: JRC elaboration

Box 63. [Extreme heat] Heatwave early warning system in Tatabánya (Hungary)

Tatabánya established a heat- and UV-alert system[172] through which a specific protocol is activated when extreme hot temperature is predicted. The Hungarian Meteorological Service and the National Public Health Office report warnings for heatwaves or high UV radiation to the municipalities. The municipality of Tatabánya consequently alerts the residents and the institutions and the heat protocol is activated. The

[169] Using water to cope with heat waves in cities: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/water-uses-to-cope-with-heat-waves-in-cities

[170] Climate proofing of buildings against excessive heat: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/climate-proofing-of-buildings-against-excessive-heat

[171] Potential unintended consequences (maladaptation) should be analysed when implementing cooling systems, as increased energy consumption from cooling systems might result in mitigation efforts might being affected

[172] Heatwave and UV early warning system in Tatabánya (Hungary) https://climate-adapt.eea.europa.eu/en/metadata/case-studies/tatabanya-hungary-addressing-the-impacts-of-urban-heat-waves-and-forest-fires-with-alert-measures

protocol consists of a series of activities providing advice to residents on how to prepare for the forecasted heatwave and who to contact in case of health problems. The information reaches residents rapidly and through different channels, i.e. local radio, television, local and regional media, the municipality's homepage, social media as well as mail and faxes to all authorities, institutions, public companies and employers. The heat alert system has been activated several times with an average of 3-5 alerts per year. According to the Mayor's Office, an increasing number of inhabitants are now aware of what they should do during a heatwave or UV radiation alert.

Box 64. [Extreme heat] Paving material and colour change to combat UHI in Murcia (Spain)

The LIFE HEATLAND project[173] aims to reduce the urban heat island (UHI) effect by implementing new pavements with lower solar storage. To achieve this, several actions are being implemented, including the use of more climate-resistant construction material with higher reflectance, which reduces energy consumption and GHG. These actions aim to improve the quality of life and human well-being in municipalities and can be replicated in other European urban areas. The project is being piloted in Murcia (Spain) where an innovative pavement solution is being tested and monitored to demonstrate its potential to reduce the UHI effect.

7.2.1.2 Economic and finance

Municipalities can offer incentives for residents and businesses to invest in heat-resilient infrastructure, such as tax breaks or subsidies for cool roof installations, green roofs, rain gardens, urban forestry projects, or cool pavement technologies that reduce the urban heat island effect (financing and incentive instruments). Furthermore, municipalities can establish emergency funds to support vulnerable populations during heatwaves and provide financial assistance for heat-related health or other issues (insurance and risk sharing instruments) (World Economic Forum, 2025).

Table 20. [Extreme heat] Economic and finance example actions and outcome(s) obtained

	Action example(s)	Outcome(s) obtained
Financing and incentive instruments	Offering tax incentives, low-interest loans, and grants for investments in heat-resilient construction (financing instruments) Offering additional permitted construction volume (e.g., extra cubic meters) or reducing administrative fees for building permits or expedited permitting for buildings with heat-resilient designs and materials (incentives)	Increased adoption of heat-resilient construction materials and designs, reduced damage from extreme heat events, and improved public safety, ultimately contributing to decreasing impact.
Insurance and risk sharing instruments	Developing heatwave insurance products	Reduced financial burden on individuals and businesses affected by heatwaves (e.g. farmers with reduced crop yield), increased ability to recover from extreme heat events, decreasing risk and increasing adaptive capacity.
**Note: some of the examples provided not only address adaptation, but could also contribute to mitigation efforts by reducing GHG emissions, or address energy poverty.*		

Source: JRC elaboration

[173] LIFE HEATLAND project: https://heatlandlife.eu/

Box 65. [Extreme heat] Incentives for green roofs in Bonn (Germany) and in Basel (Switzerland)

In densely built-up areas lacking sufficient green areas, green roofs are a solution to mitigate the urban heat island effect and to lower the indoor temperature of the building, thereby addressing extreme hot days. By minimising heat gains in buildings, cooling needs are reduced and hence, the associated energy use, thus contributing to climate change mitigation and adaptation.

This approach has been successfully implemented in municipalities like Bonn (Germany)[174], where fiscal incentives, such as tax reductions and precipitation fee discounts have encouraged the development of green roofs. In Bonn, owners of green roofs can request a reduction in their precipitation fee, which can decrease from 1.29€/m^2 to 1.03€/m^2 per year. Similarly, in Basel, initiatives aiming to increase the provision of green roofs in Basel[175] were initially driven by energy-saving programmes, and subsequently by biodiversity conservation. The municipality of Basel has promoted green roofs via investment in incentive programmes, which provided subsidies for green roof installation (1996-1997 up to CHF 20 (EUR 21) per m^2, then 2005-2007 up to CHF 30-40 (EUR 31.50-42) per m^2, in the latter case only for retrofitting existing buildings). The programmes were funded from the Energy Saving Fund made up of 5% of all customers' energy bills in the Basel canton. No further funding initiative was deemed necessary after that. The campaign was considered successful enough. The measure was then coupled with regulation approaches foreseen through subsequent amendments to the municipality of Basel's Building and Construction Law, requiring green roofs for renovations and new constructions. This was deemed sufficient to provide the momentum needed to the expansion of green roofs in the municipality.

7.2.1.3 Governance and institutional

Municipalities can develop and implement heat action plans, emergency response protocols (policies and regulations), regulations and standards for building design and construction to ensure they are heat-resilient, implement urban planning strategies defining heat-resistant public spaces or make available publicly used buildings as cooling centres (management and planning). Moreover, municipalities can foster partnerships with healthcare providers, emergency services, and community organisations to respond to heat-related emergencies (coordination, cooperation, and networks).

Table 21. [Extreme heat] Governance and institutional example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Policies and regulations	Building codes for heat-resilient design	Improved design and construction of buildings to mitigate the effects of extreme heat, reduced risk of heat-related illnesses and deaths, and enhanced overall resilience to extreme heat.
Management and planning	Urban heat island mitigation plan	Reduced urban heat island effect, improved air quality and enhanced overall liveability of urban areas, ultimately contributing to decreasing exposure and impact.

[174] Green the roofs of the city (Bonn, Germany): https://eu-mayors.ec.europa.eu/sites/default/files/2022-10/covenant_case_study_bonn_2018_en.pdf

[175] Green roofs in Basel, Switzerland: combining mitigation and adaptation measures: https://climate-adapt.eea.europa.eu/en/metadata/case-studies/green-roofs-in-basel-switzerland-combining-mitigation-and-adaptation-measures-1

Coordination, cooperation and networks	Interagency coordination for heatwave response	Improved coordination and communication among agencies, organisations, and stakeholders, enhanced ability to respond to heatwaves, and reduced risk of heat-related illnesses and deaths.
**Note: some of the examples provided not only address adaptation, but could also contribute to mitigation efforts by reducing GHG emissions, or address energy poverty.*		

Source: JRC elaboration

Box 66. [Extreme heat] Heatwave response plan in Luxembourg City (Luxembourg)

Luxembourg City's heatwave response plan[176] involves a coordinated effort between municipal authorities, emergency services, and healthcare providers to respond to heatwaves. It focuses on vulnerable population groups ("anyone who is aged 75 or older and lives alone (or with a disabled person), has limited autonomy, receives little assistance from relatives and friends, and does not receive long-term care insurance") and proposes a monitoring programme performed by caretakers who visit them regularly at home.

Box 67. [Extreme heat] Using a Climate Atlas to develop zoning regulations for combating the heat island effect and the creation of ventilation corridors (Stuttgart, Germany)

Stuttgart has developed a climate atlas to inform zoning regulations and urban planning[177], with the goal of combating the urban heat island effect and improving air quality. The climate atlas provides standardised climatic assessments for the region, including maps of wind patterns, cold air flows, and air pollution concentrations. Based on this information, the municipality has implemented various measures, including the preservation of open spaces, expansion of green areas, and creation of ventilation corridors. The governance and institutional component of this initiative is notable, with close collaboration between the Office for Environmental Protection and the City Planning and Renewal team, as well as public participation in greening strategies. The municipality has also established a climate change adaptation strategy and a working group to accompany its implementation. The use of the climate atlas has been instrumental in preserving over 39% of Stuttgart's surface area and expanding greenery to cover more than 60% of the municipality.

7.2.1.4 Knowledge and behavioural change

Community-led initiatives to address heat-related issues include community gardens, urban agriculture projects, and public art installations that raise awareness about heat-related issues (capacity building, empowering, and lifestyle practices). Other relevant examples can be found below.

Table 22. [Extreme heat] Knowledge and behaviour change example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Information and awareness raising	Social media campaign to promote heatwave safety tips	Increased reach and engagement of heatwave safety messages, improved awareness of preventive measures, and enhanced ability to take action to protect oneself and others from heat-related illnesses and deaths.

[176] Luxembourg City's heatwave response plan: https://www.vdl.lu/en/living/aid-and-assistance/seniors/heatwave-plan#:~:text=The%20Ministry%20of%20Health%20(Minist%C3%A8re,register%20(or%20have%20another%20person

[177] Stuttgart: combating the heat island effect and poor air quality with ventilation corridors and green-blue infrastructure https://climate-adapt.eea.europa.eu/en/metadata/case-studies/stuttgart-combating-the-heat-island-effect-and-poor-air-quality-with-green-ventilation-corridors

Capacity building, empowering, and lifestyle practices	Training programme for healthcare professionals on heat-related illnesses	Improved ability of healthcare professionals to recognise and treat heat-related illnesses, enhanced capacity to provide critical care and support to affected individuals and reduced risk of heat-related deaths. It can also help to promote a culture of safety and preparedness among healthcare professionals, and enhance their overall resilience to extreme heat events.

Source: JRC elaboration

Box 68. [Extreme heat] Categorising heat waves in Seville (Spain) and awareness raising in Lorca (Spain)

Naming and categorising heat waves in Seville [178]

The proMETEO Seville Project is a pilot initiative that aims to raise awareness among residents about the importance of heat waves and their impact on health and to promote measures that minimise their impact on people's lives. To achieve this, the project started categorising heat waves according to their level of impact on health and names those that pose a greater risk (Metzger et al., 2024), an approach applied to other meteorological phenomena such as hurricanes and storms. By naming most dangerous heat waves, public awareness can be increased, and individuals are encouraged to engage in safety behaviours. Although the effectiveness of this approach is still being studied, research suggests that naming heat waves may be associated with increased engagement in protective behaviours and can facilitate communication among community members by providing a common identifier for the extreme heat event.

Information and awareness-raising campaigns on the effects of heatwaves in Lorca [179]

The measure aims to reduce mortality associated with heat wave episodes, especially among the most vulnerable population (older people, children, and people with chronic diseases). The temperature threshold from which a heat wave can be occurring depends on geographical setting. Therefore, the Ministry of Health and Consumption provides threshold temperatures for all provincial capitals that allow the identification of heatwaves episodes. The measure consists of informing the general public about the main effects of heat waves, the possible measures to adopt to prevent the consequences of heat waves, how to act in case of suffering health effects due to high temperatures and conveying to the general public the need to adopt responsible behaviour during heat waves, such as the adaptation of work schedules, the need to avoid certain activities (for example sports) at certain times of the day.

7.2.2 Extreme cold

While overall winter temperatures are rising, extreme cold events still occur, especially northern and Eastern Europe, sometimes linked to disruptions in atmospheric circulation. Cold spells impact vulnerable populations, infrastructure, and energy systems, though their long-term frequency is expected to decline (Melica et al., 2024). See Table 23 for some extreme cold adaptation examples.

[178] Naming and categorising heat waves in Seville: https://prometeosevilla.com/proyecto-prometeo-sevilla/el-proyecto-prometeo-sevilla-olas-de-calor/ ; https://www.nature.com/articles/s41598-024-59430-8

[179] Information and awareness raising campaigns on heatwaves in Lorca (Spain): http://www.msc.es/ciudadanos/saludAmbLaboral/planAltasTemp/2007/home.htm

Table 23. [Extreme cold] Example strategies

Main focus	Objective pursued	Examples on how to reach the objective (actions)
Protect vulnerable populations from cold-related health risks	Decrease vulnerability	Providing targeted support to people living in substandard housing, older people, and people with pre-existing medical conditions, such as home insulation, warm clothing and medical care.
Reduce exposure to extreme cold in public spaces	Decrease exposure	Designing and constructing public buildings and transportation systems with cold-weather resilience in mind, such as heated bus shelters and pedestrianised areas.
Minimise disruptions to critical infrastructure and services	Decrease impact	Implementing winterisation measures for critical infrastructure, such as water treatment plants and power grids, to prevent disruptions during extreme cold events.
Enhance community resilience and preparedness	Increase adaptive capacity	Developing and implementing cold weather emergency plans, conducting education campaigns and providing training and resources for community members to prepare for and respond to extreme cold events.
**Note: some of the examples provided not only address adaptation, but could also contribute to mitigation efforts by reducing GHG emissions, or address energy poverty.*		

Source: JRC elaboration

7.2.2.1 Physical and technological

To address extreme cold, municipalities can implement various physical and technological measures. This includes public spaces and buildings that maximise natural light and reduce wind chill, such as by using southern exposures and windbreaks, or the improvement of building insulation (grey options). These options also contribute to increase energy efficiency and reduce energy consumptions. Municipalities can also invest in heating systems, such as district heating, which can be optimised through information and communication technology (ICT) solutions to manage energy distribution efficiently during extreme cold events (technological options). Additionally, ICT solutions can be used to predict energy demand, detect potential disruptions in the energy grid due to cold snaps, optimise heating system performance or create cold early warning systems (technological options). Snowmelt systems linked to blue infrastructure that allow to manage snow and ice, can reduce the impacts associated with extreme cold (blue option). Green infrastructure, such as urban forests and green roofs with insulation, can provide some benefit, including windbreaks and reduced heat loss (green options).

Table 24. [Extreme cold] Physical and technological example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Green options	Establishment of tree rows as shields against dominating winds	Exposure to extreme cold can be decreased, and wind chill effects can be reduced, ultimately decreasing exposure and impact.
Blue options	Expanding and protecting blue areas to increase their capacity to absorb snowmelt water	The risk of ice formation and freezing can be reduced, and the urban microclimate can be improved, contributing to decreasing risk and impact. Additionally, blue areas can help to regulate the urban temperature, reducing the effects of extreme cold on urban residents.

Grey options	Implementing heated sidewalks and roads (snow-melt systems)	The impact of snow and ice on the transportation sector can be decreased and pedestrian safety can be enhanced, as well as the risk of frostbite and hypothermia, decreasing the impact and risk.
Technological options	Application to predict cold snaps and potential energy grid disruptions	The risks in the energy sector (outages) associated with extreme cold can be reduced, and the reliability of the energy supply can be improved, contributing to decreasing risk and increasing adaptive capacity. This can also enable proactive measures to be taken to prevent cold-related illnesses and injuries, reducing the impact of extreme cold on urban residents.
**Note: some of the examples provided not only address adaptation, but could also contribute to mitigation efforts by reducing GHG emissions, or address energy poverty.*		

Source: JRC elaboration

Box 69. [Extreme cold] Heated sidewalks in Reykjavik (Iceland)

Heated sidewalks are walkways which make use of radiated heat to help melt snow and make sidewalks safer and convenient. In Reykjavik (Iceland) geothermal energy is used for snow melting[180]. Hot water is pumped through tubes under many of the sidewalks. The availability of geothermal energy makes the system less expensive and more climate friendly. Additionally, around two thirds of the heated water used in these systems is return water from space heaters.

7.2.2.2 Economic and finance

To adapt to extreme cold, municipalities can use financing and incentive instruments that promote energy-efficient infrastructure. Municipalities can offer tax breaks or subsidies for residents and businesses to install energy-efficient heating systems, such as heat pumps or radiant floor heating. Cities can also implement a programme to provide incentives for residents to winterise their homes with energy-efficient insulation (financing and incentive instruments). Additionally, municipalities can establish a cold snap emergency fund to support vulnerable populations during cold snaps. Moreover, fuel assistance programmes for low-income households or as cold snap insurance policies that cover damage to homes and businesses, can also be developed (insurance and risk sharing instruments).

Table 25. [Extreme cold] Economic and finance example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Financing and incentive instruments	Subsidy for the installation of heat pumps	Reduced energy consumption and greenhouse gas emissions (synergy with mitigation), improved thermal comfort for households, decreasing vulnerability and impact. Additionally, the subsidy can help to decrease the exposure of households to extreme cold events, particularly for low-income and vulnerable populations.
Insurance and risk sharing instruments	Fuel assistance programme for low-income households	Reduced financial burden on low-income households during extreme cold events, increased access to affordable heating and improved overall well-being (synergy with energy poverty), contributing to decreasing vulnerability and risk. This

[180] Heated sidewalks in Reykjavik: https://www.icelandreview.com/ask-ir/does-reykjavik-have-heated-sidewalks/

		programme can also help to decrease the impact of extreme cold events on low-income households, by providing them with the necessary resources to heat their homes and stay safe during cold snaps.
**Note: some of the examples provided not only address adaptation, but could also contribute to mitigation efforts by reducing GHG emissions, or address energy poverty.*		

Source: JRC elaboration

Box 70. [Extreme cold] Subsidised insurance for weather risks and livestock in Italy (Piedmont)

Farmers can access subsidised insurance policies supporting them against adverse weather events such as hail, frost/ice, snow and heavy precipitations, drought and livestock losses. In Italy, the policies are subsidised through national and regional funding[181].The Piedmont region has contributed to these policies through the years. Farmers can insure against two risks, such as hail and either strong wind, excess rain, or snow, with up to 60% subsidy. Deadlines vary by crop type: policies can be purchased individually or through regional defence consortia.

7.2.2.3 Governance and institutional

Governance and institutional types of actions linked to extreme cold can be paralleled to a certain extent to those applicable in the case of extreme heat (even when they would be applied in very different climatic zones), i.e. cold weather plans, regulations and standards for building infrastructure, or partnerships with healthcare providers and emergency services. Further examples can be found below.

Table 26. [Extreme cold] Governance and institutional example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Policies and regulations	Emergency response protocol	Reduce the impact on vulnerable populations, such as older people, young children, and people with pre-existing medical conditions by ensuring a timely and effective response to extreme cold events, decreasing impact and risk.
Management and planning	Implementation of ice removal strategies	Minimise disruptions to transportation and daily life, reduce the risk of accidents and injuries, and ensure public safety (decrease risk and impact). Effective ice removal strategies can also help to reduce the economic losses associated with extreme cold events.
Coordination, cooperation and networks	Coordination with public organisations for the provision of cold emergency shelters	Reduce exposure of vulnerable communities to extreme cold, provide access to warm and safe facilities, and ensure well-being of those most at risk (decrease exposure and impact). This coordination can also facilitate the sharing of resources, expertise and information, ultimately enhancing the overall response to extreme cold events.

Source: JRC elaboration

[181] Polizze agevolate su avversità atmosferiche e bestiame | Regione Piemonte: https://www.regione.piemonte.it/web/temi/agricoltura/avversita-calamita-naturali/polizze-agevolate-avversita-atmosferiche-bestiame
Polizze zootecniche agevolate - Bando 2021 | Bandi Regione Piemonte : https://bandi.regione.piemonte.it/contributi-finanziamenti/polizze-zootecniche-agevolate-bando-2021

Box 71. [Extreme cold] Extreme cold plan in Brussels region (Belgium)

Since 2022, the region of Brussels activates the "Extreme coldplan"[182] which provides shelter and support to the most vulnerable individuals during the winter period. The plan is typically activated when the Royal Meteorological Institute (IRM) forecasts daytime temperatures below -4°C for more than three consecutive days. With the collaboration of several NGOs operating in the region, various measures are planned under one umbrella, which focuses mainly on giving homeless people help or shelters. Over 2 700 emergency shelters places are at disposal of homeless individuals during specific periods, for example in 2025 the plan was launched for the month of January and then extended for another month. The measure sees the deep collaboration among many organisations (i.e. The Red Cross, Bruss'help, New Samusocial, Belfrefugees, Ukrainian Voices, Pierre d'Angle and the Ariane centre). Brussels municipalities and the Brussels-Capital Region, STIB-MIVB, responsible for the operation of public transport in the Brussels-Capital Region, allow homeless people throughout the winter when the temperature is equal to or lower than zero degrees, to recover in the stations.

Brussels set up also a cold wave plan[183] dedicated also to those who suffer from the cold due to a faulty heater, or to issues in the payments of bills, by offering space in the community centres to warm and meet people[184]. Therefore, this action could serve also to contribute to energy poverty alleviation.

7.2.2.4 Knowledge and behavioural change

To mitigate the risks associated with extreme cold, municipalities can implement targeted education and outreach initiatives to inform residents about the risks of extreme cold and provide actionable advice on cold preparedness. Other examples can be found below.

Table 27. [Extreme cold] Knowledge and behaviour change example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Information and awareness raising	Public awareness campaign on cold-related health risks	Increased knowledge and understanding of cold-related health risks, improved ability to recognise and respond to cold-related emergencies and enhanced overall resilience to extreme cold events.
Capacity building, empowering, and lifestyle practices	Participation in a research and innovation project to develop new technologies on advanced building insulation materials	Development of innovative and effective building insulation materials, improved energy efficiency, and reduced heat loss in buildings (decreasing vulnerability and impact).
**Note: some of the examples provided not only address adaptation, but could also contribute to mitigation efforts by reducing GHG emissions, or address energy poverty.*		

Source: JRC elaboration

[182] Extreme cold plan in Brussels region: https://brusselsmorning.com/brussels-launches-cold-weather-plan-for-homeless-people/63827/

[183] Wintermaatregelen per gemeente https://brusshelp.org/index.php/nl/winter-bepalingen

[184] Opening van 160 plaatsen voor daklozen in het kader van het regionaal Plan Extreme Kou https://brusshelp.org/index.php/nl/news/flash-info-nl/2834-opening-van-160-plaatsen-voor-daklozen-in-het-kader-van-het-regionaal-plan-extreme-kou

Box 72. [Extreme cold] UK – Be informed about hazards

The UK Government has structured a multi-level information campaign to make sure residents are prepared in case of hazards[185]. A set of online resources on how to be prepared in case of several hazards, including cold weather, is available online. It includes a description of the consequences of cold temperatures[186], the identification of the most vulnerable and suggests a set of actions that can be taken to be prepared. Actions include increased knowledge on the symptoms of hypothermia, check of heating and cooking appliances, advice on safe driving in the snow, extend these actions to family, friends and neighbours. In addition, this online guide provides insights into and links to the financial support available to help residents making their home more energy efficient, improving heating and managing energy bills.

These guidelines are elaborated at lower level through the websites of the local resilience forums in England and Wales and the equivalent regional resilience partnerships in Scotland. Local resilience forums are partnerships made up of representatives from local public services, including the emergency services, municipalities, the NHS, the Environment Agency and other organisations involved in emergency preparedness, who identify potential risks and produce emergency plans to either prevent or lessen the impact of any incident on the local communities. Each local resilience forum regularly publishes information online about the risks in the local area and a community risk register which sets out the different risks most likely to cause disruption in the region and aims to help communities be better informed, prepared and able to respond to an emergency.

7.2.3 Heavy precipitation

Intense rainfall events have become more frequent across Europe, increasing the risk of flash floods and infrastructure damage. Urbanisation and inadequate drainage systems amplify the impacts, highlighting the need for water management strategies. Heavy rainfall can result in pluvial floods; rivers can swell, causing fluvial floods; and groundwater can rise above the surface or flood basements (European Environment Agency, 2024). Some example strategies can be found below.

Table 28. Heavy precipitation example strategies

Objective pursued	Main focus	Examples on how to reach the objective (actions)
Protect vulnerable populations from precipitation-related hazards	Decrease vulnerability	Implementing public education campaigns on precipitation-related risks, providing emergency shelters and relief services in case of displacement, offering financial assistance for precipitation-related damages.
Reduce exposure to precipitation related risks	Decrease exposure	Implementing urban design strategies to reduce heavy precipitation runoff, such as green roofs and permeable pavements, and promoting precipitation-resilient urban planning strategies.
Reduce the impact of precipitation-related hazards	Decrease impact	Implementing watershed management strategies to reduce water runoff, promoting precipitation-resilient land use practices, and conducting regular precipitation risk assessments and mapping.

[185] UK: Be informed about hazards: https://prepare.campaign.gov.uk/check-the-risks-where-you-are/

[186] Description of consequences of cold temperatures https://prepare.campaign.gov.uk/be-informed-about-hazards/cold-weather-snow-ice/

Enhance the ability to adapt to precipitation-related changes	Increase adaptive capacity	Developing and implementing precipitation-related emergency response plans, providing training and education on precipitation risk reduction and management, and promoting community engagement and participation in precipitation risk reduction efforts.

Source: JRC elaboration

7.2.3.1 Physical and technological

To mitigate the impacts of heavy precipitation, municipalities can implement a range of physical and technological actions, as shown in Table 29. By investing in these measures, as well as infrastructure resilience, such as upgrading storm water and wastewater infrastructure, municipalities can effectively manage heavy precipitation and reduce the correlated risk of flooding.

Table 29. [Heavy precipitation] Physical and technological example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Green options	Green roofs and walls, rain gardens and urban wetlands	Reduced water runoff, and further co-benefits as improved water quality and increased urban biodiversity.
Blue options	Rainwater harvesting and greywater reuse, flood-control ponds and wetland restoration	Decreased precipitation water runoff, and further co-benefits such as reduced potable water demand and increased water efficiency.
Grey options	Permeable pavements, retention ponds and storm sewers (e.g. through combined sewer overflows (CSOs)	Reduced water runoff and increased urban resilience to heavy precipitation, increase public health and water quality of rivers.
Technological options	Smart storm water management systems, sensors and advanced weather forecasting	Optimised runoff water management (i.e. bioswales), reduced flood risk, and improved water quality

Source: JRC elaboration

Box 73. [Heavy precipitation] Protection against torrential water in Schwertberg (Austria)

The town of Schwertberg in Austria[187] has been prone to large floods due to torrential rain, prompting a EUR 4 million investment to protect against storm water flowing from surrounding slopes. The municipality has built 10 retention tanks, drainage channels, and ditches, and converted 5 hectares of hillside fields into permanent green meadows and pastures. With the help of experts and financial support from the country, state, and EU over 75% of planned measures have been implemented, retaining around 53 000 m^3 of water. The project aims to eradicate the danger of flooding, and the municipality also educates residents on simple measures to protect themselves against floods, while acknowledging that some risks remain.

[187] Protection against torrential water in Schwertberg: https://www.adapterraawards.cz/databaze/2021/hangwasserschutz-in-schwertberg

7.2.3.2 Economic and finance

To mitigate the impacts of heavy precipitation, municipalities can implement financing and incentive instruments that encourage the development of green infrastructure. Governments can offer grants or subsidies for residents and businesses to install rain gardens, green roofs, or implement green infrastructure projects. Insurance and risk sharing instruments, such as flood insurance policies that cover damage to homes and businesses, can also be developed. Additionally, municipalities can establish a flood emergency fund to support vulnerable populations after impacts linked to heavy precipitation events.

Table 30. [Heavy precipitation] Economic and finance example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Financing and incentive instruments	Offering grants for water runoff-resilient construction (e.g., rain gardens, green roofs, or green infrastructure projects)	Increased adoption of construction materials and designs that are resilient to water runoff, reduced damage from heavy precipitation events, and improved public safety, decreasing impact.
Insurance and risk sharing instruments	Establishment of a precipitation-related disaster risk transfer programme	Shared risk management among stakeholders, reduced financial burden on individuals and businesses, and increased ability to respond to and recover from heavy precipitation events, ultimately decreasing risk.

Source: JRC elaboration

Box 74. [Heavy precipitation] The economics of managing heavy rains and storm water in Copenhagen – The cloudburst management plan

Copenhagen's economic approach to managing heavy precipitation and cloudbursts[188] involves a cost-benefit analysis of different solutions to mitigate the impacts of extreme rainfall events. With heavy precipitation expected to increase by 25-55% by 2100, the municipality assessed the costs of traditional sewer systems versus a combined solution incorporating adaptation measures, such as water retention and drainage projects. The analysis revealed that the combined solution would result in a net saving of EUR 400 million over 100 years, while also reducing the risk of water runoff and associated damages. By prioritising projects based on their potential impact on flood prevention and cost-effectiveness, the municipality aims to minimise the economic and social impacts of heavy precipitation events[189], which have already caused significant damage in recent years, including a EUR 800 million loss in 2011.

Box 75. [Heavy precipitation] Financial incentives in Denmark: discounts for climate-proofing measures and reimbursements for disconnecting heavy precipitation water runoff from sewers

The Ministry of Environment of Denmark has different programmes in place to incentivise climate adaptation[190]. Homeowners can check their insurance coverage and explore discounts for climate-proofing

[188] Managing heavy rains and stormwater in Copenhagen: https://climate-adapt.eea.europa.eu/en/metadata/case-studies/the-economics-of-managing-heavy-rains-and-stormwater-in-copenhagen-2013-the-cloudburst-management-plan

[189] Klimakvarter København https://klimakvarter.dk/

[190] Ministry of Environment of Denmark: help and subsidies for climate adaptation: https://eng.klimatilpasning.dk/local-adaptation/help-and-subsidies-for-climate-adaptation

measures, such as installing backflow blockers or pump wells. Additionally, some utilities offer reimbursements or subsidies for disconnecting storm water runoff from sewers or installing dry wells, with potential savings of up to DKK 20 – 25 000 (EUR 2 680 – 3 350). These financial incentives can help mitigate the costs of heavy precipitation damage and encourage homeowners to take proactive steps to protect their properties.

7.2.3.3 Governance and institutional

Municipalities can implement a variety of effective governance and institutional actions to mitigate the impacts of heavy precipitation, which can lead to floods and other urban water management challenges, as highlighted in Table 31. Similarly to other hazards, municipalities can address risks coming from heavy precipitations through urban planning and design strategies, such as zoning regulations, planning green infrastructure, to manage heavy precipitation and create resilient public spaces.

In this context, it is relevant to highlight the Floods Directive 2007/60/EC[191], which required Member States, regions, municipalities, to cooperate to develop flood hazard and flood risk maps and attach to them the flood and landslide risk management plans. These plans should be then translated into legally binding municipality zoning regulations that restrict or prohibit construction and other activities in areas identified as being at high risk, such as floodplains (and landslide-prone slopes).

Table 31. [Heavy precipitation] Governance and institutional example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Policies and regulations	Implementation of storm water management ordinances (e.g. creation of "sponge cities" and sponge parks)	Reduced storm water runoff, improved water quality, and increased urban resilience to heavy precipitation
Management and planning	Development of water runoff maps and management plans (e.g. periodically cleaning the gutters)	Reduced flood risk, improved water management and increased public safety.
Coordination, cooperation and networks	Establishment of interagency storm water management committees	Improved storm water management, reduced flood risk, and increased public safety.

Source: JRC elaboration

Box 76. [Heavy precipitation] Governance approaches in Spain and Slovakia against torrential rain

The EGOKI project in Navarre, Spain,[192] and the Landscape and Watershed Recovery Programme for the Košice Region of Slovakia[193] demonstrate two governance approaches to address heavy precipitation, highlighting the importance of collaborative and participatory decision-making. The EGOKI project integrates climate change adaptation into urban planning in Navarre, Spain, through a joint effort between local,

[191] Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks https://eur-lex.europa.eu/eli/dir/2007/60/oj/eng

[192] EGOKI project: torrential rains sewerage planning in Navarre, Spain: https://adaptecca.es/en/casos-practicos/egoki-integrating-adaptation-climate-change-spatial-and-urban-planning

[193] Landscape and watershed recovery programme for the Košice region of Slovakia https://climate-adapt.eea.europa.eu/en/metadata/case-studies/landscape-and-watershed-recovery-programme-for-the-kosice-region-of-slovakia

regional and national authorities, while the Košice programme implements water retention measures through a multi-level governance approach, involving six independent water and land restoration advisory boards and a network of stakeholders, including state representatives, farmers, and local communities. Both approaches prioritise community engagement, participation, and coordination among different levels of government, and involve the development of tailored recommendations and guidelines to support adaptation efforts, making them effective models for addressing the impacts of heavy precipitation in other regions.

7.2.3.4 Knowledge and behavioural change

Some examples of knowledge and behavioural change actions linked to heavy precipitation can be found below.

Table 32. [Heavy precipitation] Knowledge and behavioural change example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Information and awareness raising	Development of flood risk awareness materials for vulnerable populations, such as low-income communities and older residents.	Increased awareness and understanding of heavy precipitation impact among vulnerable populations, improved ability to recognise and respond to flood events, and enhanced overall adaptive capacity to heavy precipitation.
Capacity building, empowering, and lifestyle practices	Training programme for urban planners and engineers on green infrastructure design	Improved ability of urban planners and engineers to design and implement green infrastructure, enhance capacity to manage storm water runoff, and reduced flood risk.

Source: JRC elaboration

Box 77. [Heavy precipitation] Raising awareness within the restoration of a river in Lodz (Poland)

The restoration of the Sokołówka river in Lodz (Poland) [194], involved a shift in mind set from traditional grey infrastructure to green and blue infrastructure, recognising the value of natural systems in managing water runoff and improving water quality. The project's multi-stakeholder approach, community engagement, and education efforts raised awareness among residents and stakeholders about the importance of eco-hydrology and integrated urban water management, leading to a change in behaviour and practices. The development of a blue green network concept and the creation of green spaces and parks also promoted a cultural shift towards valuing and protecting urban water systems, ultimately contributing to a more resilient and sustainable urban environment.

7.2.4 Floods and sea level rise

River and coastal floods are increasing across Europe due to changing precipitation patterns and rising sea levels, threatening urban areas and critical infrastructure. Some examples of strategies can be found below.

[194] Urban river restoration: a sustainable strategy for storm-water management in Lodz, Poland https://climate-adapt.eea.europa.eu/en/metadata/case-studies/urban-river-restoration-a-sustainable-strategy-for-storm-water-management-in-lodz-poland/#stake_holder_anchor

Table 33. [Floods and sea level rise] Example strategies

Objective pursued	Main focus	Examples on how to reach the objective (actions)
Identify and support communities at risk from flooding	Decrease vulnerability	Implementing flood risk assessments and mapping, providing flood insurance programmes for low-income households, and offering financial assistance for flood-related damages.
Reduce exposure to sea level rise risks	Decrease exposure	Implementing coastal protection infrastructure, such as seawalls and dunes, and promoting flood-resilient construction practices, such as elevated buildings and flood-proof materials, or not allowing refurbishments and new constructions in flood-prone areas
Minimise the effects of flooding	Decrease impact	Implementing flood mitigation measures, such as wetland restoration and floodplain management, and promoting flood-resilient agricultural practices, such as flood-tolerant crops and soil conservation.
Enhance the ability to adapt to flooding	Increase adaptive capacity	Developing and implementing flood emergency response plans, providing training and education on flood risk reduction and management, and promoting community engagement and participation in flood risk reduction efforts, and investing in flood resilient infrastructure and technologies.

Source: JRC elaboration

7.2.4.1 Physical and technological

To mitigate the impacts of floods and sea level rise, green infrastructure such as urban wetlands and green roofs, can play a crucial role in reducing flood risk. Coastal protection measures and safety measures[195], like barriers[196], breakwaters and groynes[197] or seawalls[198] can help enhance coastal resilience. Flood-resilient construction standards, including elevating buildings[199], roads[200], or coastal areas[201], and using flood-resistant materials can also protect infrastructure and properties. Additionally, municipalities can implement erosion control measures[202], such as dune restoration and

[195] Enhancing operational safety in offshore and inshore operations https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/enhancing-operational-safety-in-offshore-and-inshore-operations

[196] Storm surge gates and flood barriers https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/storm-surge-gates-flood-barriers

[197] Groynes, breakwaters and artificial reefs https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/groynes-breakwaters-and-artificial-reefs

[198] Seawalls and jetties https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/seawalls-and-jetties

[199] Floating and amphibious housing: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/floating-and-amphibious-housing

[200] Floating or elevated roads: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/floating-or-elevated-roads

[201] Raising and advancing coastal land https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/raising-coastal-land

[202] Restoration and management of coastal wetlands https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/restoration-and-management-of-coastal-wetlands

stabilisation[203] or beach nourishment[204], to reduce the risk of floods and sea level rise. Digital solutions combining flood modelling with 3D digital twins[205] can also be implemented.

Table 34. [Floods and sea level rise] Physical and technological example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Green options	Wetland restoration (i.e. mangrove restoration) and floodplain management	Reduced flood risk, improved water quality and increased biodiversity.
Blue options	Coastal ecosystem restoration and beach nourishment	Reduced flood risk, improved coastal resilience and increased biodiversity.
Grey options	Seawalls, flood gates and flood-resistant construction	Reduced flood risk, protected infrastructure and properties
Technological options	Early warning systems and flood forecasting	Improved flood risk management, reduced flood risk and increased public safety.

Source: JRC

Box 78. [Sea level rise] Dune protection and habitat restoration in Gran Canaria (Spain)

The Maspalomas dune system in Gran Canaria (Spain) is facing severe erosion and degradation due to climate change, tourism, and human activities. To combat this, the MASDUNAS project[206] aims to restore the dunes and protect the nature reserve through measures such as restocking sand, reintroducing native plant species, and controlling invasive species. The project also includes actions to improve public use and management of the reserve, such as marking trails and raising awareness among visitors. By conserving the dune system, the project aims to adapt to the impacts of climate change, protect biodiversity, and preserve the area's recreational and tourist value.

Box 79. [Floods] River restoration in Cascais (Portugal) and improvement and redesign of the Isar River (Munich, Germany)

The "Ribeira das Vinhas" river restoration project in Cascais (Portugal)[207], has successfully addressed key objectives of the municipality's adaptation strategy. By integrating NBS the project has reduced flood risk, lowered the average temperature in the area, and promoted biodiversity. The restoration of the 4 km greenway trail has not only improved the river's ecosystem services but also provided a car-free space for leisure and commuting, benefitting 25 000 residents. The project has resulted in a significant decrease in flooding levels, a reduction in the urban heat island effect, and has improved the municipality's technical, ad administrative capacities to work with NBS, all achieved with an investment cost of EUR 390 000.

[203] Dune construction and strengthening https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/dune-construction-and-strengthening

[204] Beach and shoreface nourishment https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/beach-and-shoreface-nourishment

[205] Coupling high-resolution flood modelling and 3d digital twins for climate change adaptation https://climate-adapt.eea.europa.eu/ro/mission/solutions/mission-stories/coupling-high-resolution-flood-modelling-story34

[206] MASDUNAS project: dune protection and habitat restoration in Gran Canaria (Spain) https://adaptecca.es/en/casos-practicos/environmental-restoration-maspalomas-dune-system-masdunas-project

[207] What a river restoration in Cascais can do: a greenway to adapt and thrive https://eu-mayors.ec.europa.eu/sites/default/files/2022-10/eumayors-case-study-2021-cascais-en.pdf

Similarly, the "Isar-Plan" in Munich, Germany[208], has demonstrated the effectiveness of river restoration in improving flood protection and recreational opportunities. The project, which restored 8 km of the Isar river, has improved flood control, attracted 30 000 people for recreation, and enhanced biodiversity. The restoration of the river involved implementing measures such as broadening the main channel bed, bank stabilisation, and the creation of rough ramps to enhance the natural development of the river state. The project also involved stakeholder engagement and cooperation, which was central to its success. With a total cost of EUR 35 million, the Isar-Plan shows that river restoration can have significant benefits for both the environment and local communities.

Box 80. [Floods] The integrated storm water management toolbox

The integrated storm water management toolbox[209] is a comprehensive resource that provides information on urban storm water management approaches and tools, specifically tailored for northern climate conditions and focusing on derived floods. The toolbox is organised into three main points: urban resilience, technical optimisation, and day-to-day values, and offers a range of tools and approaches for landscape architects, architects, urban planners and designers. It covers strategic approaches such as water sensitive urban design and low impact development, planning support tools, design solutions, and assessment methods, with the goal of promoting integrated storm water management as a key component of urban planning and development, where storm water is viewed as a resource rather than a problem.

7.2.4.2 Economic and finance

Municipalities can offer subsidies or low-interest loans to support the development of flood-resilient infrastructure, such as sea walls, levees, or green roofs; and can leverage also external financing resources to this end. Municipalities can also encourage property owners to adopt flood-proofing measures by providing tax breaks or rebates for installing flood-resistant materials and designing buildings with elevated foundations.

Table 35. [Floods and sea level rise] Economic and finance example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Financing and incentive instruments	Implementing a coastal resilience bond programme	Reduced flood risk and improved coastal protection, leading to decreased exposure to flood-related health risks.
Insurance and risk sharing instruments	Developing sea level rise insurance products with adaptive coverage	Increased ability to recover from floods and sea level rise events, and improved overall economic resilience, decreasing risk and increasing adaptive capacity.

Source: JRC

Box 81. [Floods] Blended finance in Slovakia: LIFE Living Rivers Project

The Living Rivers project in Slovakia[210] is working to improve the ecological condition of 10 water bodies and 344 km of waterways in the Danube, Hron, Ipeľ, and Belá river basins. The project uses a blended finance

[208] Improving flood protection and recreational opportunities by redesigning the Isar https://www.adapterraawards.cz/databaze/2020/isar-plan-improving-flood-protection

[209] Integrated storm water management toolbox https://www.integratedstormwater.eu/iwatertoolbox

[210] Blended finance in Slovakia: The Living Rivers project: https://livingrivers.sk/en/projekt/

approach to support environmental conservation and sustainability initiatives and is co—funded by the EU through the LIFE programme. This blended model enables the project to leverage funding from multiple sources, including public and private sector investments to achieve its goals. The project's objectives include restoring longitudinal connectivity, improving hydraulic ad morphological conditions, and promoting natural reproduction of native fish species. By using blended finance, the Living Rivers project is able to mobilise resources and expertise from a range of stakeholders, including local communities, NGOs, and government agencies, to support its conservation efforts.

Box 82. [Floods] Public-private partnerships for a flood-proof district in Bilbao (Spain)

The Zorrotzaure urban regeneration project in Bilbao (Spain)[211] aims to transform a degraded industrial area into a modern and sustainable residential neighbourhood, protecting it from increased flood risk due to climate change. A key factor in the project's implementation is the public-private partnership (PPP), which has enabled shared financing, risk management and access to expertise, making the project more feasible and attractive to private investment.

7.2.4.3 Governance and institutional

To mitigate the impacts and to prevent floods and sea level rise, effective governance measures include establishing emergency response plans and conducting regular drills to ensure a swift and effective response to flood events[212], as well as coastal zone management plans[213]. Some examples are provided in Table 36.

Table 36. [Floods and sea level rise] Governance and institutional example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Policies and regulations	Adoption of flood-resistant construction standards and zoning regulations that limit or prohibit construction in flood prone areas	Reduced flood risk, improved public safety and increased urban resilience to floods and sea level rise
Management and planning	Development of coastal protection plans and sea level rise adaptation strategies	Reduced flood risk, improved coastal resilience, and increased public safety.
Coordination, cooperation and networks	Regional cooperation on flood and sea level rise management through agreements and frameworks	Improved flood and sea level rise management, reduced flood risk, and increased trans-boundary cooperation.

Source: JRC

[211] Public-private partnerships for a flood-proof district in Bilbao (Spain) https://climate-adapt.eea.europa.eu/en/metadata/case-studies/public-private-partnership-for-a-new-flood-proof-district-in-bilbao

[212] Adaptation of flood management plans: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/adaptation-of-flood-management-plans

[213] Integration of climate change adaptation in coastal zone management plans https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/adaptation-of-integrated-coastal-management-plans

Box 83. [Floods] Lahti's (Finland) storm water approach to address related floods

Lahti (Finland)[214] is implementing a storm water management plan that incorporates both top-down and bottom-up approaches. The plan involves increasing local treatment of storm water, collecting new information on treatment solutions, and considering storm water absorption in street planning and green area design. The initiative aims to improve green infrastructure and nature-based solutions, leveraging technology and infrastructure, as well as learning and capabilities. The implementation is ongoing, with secured funding, and involves various stakeholders, including the municipality organisation, employers, landowners, national and regional authorities, and research institutes.

Box 84. [Floods] A collaborative approach to deal with storms and related floods: the I-storm network

The I-storm network[215] employs a collaborative governance approach to address storms and storm surge barriers, focusing on knowledge sharing and experience transfer among storm surge barrier managers worldwide. The network's governance structure is characterised by a decentralised, informal setup that facilitates communication and cooperation among members through annual conferences, regular meetings, and flexible communication channels. This approach enables barrier managers to address common challenges, such as climate change and flood warning systems, in a more effective and efficient manner, and to share knowledge, expertise and best practices in managing storm surge barriers.

Box 85. [Floods] Mental health support for flooded populations in Emilia-Romagna (Italy)

In May 2023, the region of Emilia-Romagna in Italy was hit by severe floods and landslides, resulting in 17 fatalities, 36 600 displaced people, and extensive damage to infrastructure and the environment. In response, a psychological support service[216] was organised to provide mental health support to affected individuals, with emergency psychologists from various associations and organisations offering proximity activities, such as listening and emotional stabilisation in affected neighbourhoods and shelters. The support was provided for six months, with daily online board meetings held to coordinate efforts and discuss the needs of the population. The intervention was successful in responding to the psychosocial needs of the affected population but was limited by the scale of the disaster and the lack of a structured emergency system for psychological support. The experience has highlighted the importance of integrating psychosocial support into emergency response efforts and has led to discussions about organising similar support services for future emergencies.

7.2.4.4 Knowledge and behavioural change

In analogy to other climate hazards, municipalities can implement knowledge and behaviour change actions to mitigate the impacts of floods and sea level rise, as shown in Table 37. Municipalities can also establish community-based initiatives, such as flood and sea level rise citizen science projects to empower residents and promote a culture of resilience.

[214] NetZeroCities: Lahti (Finland) climate city contract https://netzerocities.app/resource-4187

[215] The I-storm network: https://www.i-storm.org/

[216] Mental health support for flooded populations in Emilia-Romagna (Italy): https://climate-adapt.eea.europa.eu/en/metadata/case-studies/mental-health-support-for-people-affected-by-floods-in-emilia-romagna

Table 37. [Floods and sea level rise] Knowledge and behaviour change example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Information and awareness raising	Coastal community outreach and education programme on flood and sea level rise risk	Increased awareness and understanding of flood and sea level rise risk among coastal communities, improved ability to recognise and respond to flood and sea level rise events and enhanced overall resilience to flood and sea level rise.
Capacity building, empowering, and lifestyle practices	Capacity building programme for coastal zone managers on coast management and planning	Improved ability of coastal zone managers to adapt to floods and sea level rise, enhanced capacity to develop and implement effective adaptation plans, and reduced vulnerability to flood and sea level rise.

Source: JRC

Box 86. [Floods] Improving flood resilience through awareness, education and alliances: The Rotterdam port adaptation strategy (The Netherlands) and the FRAMES project

The Rotterdam port adaptation strategy[217] and the FRAMES project in Belgium[218] are two examples of initiatives that aim to enhance flood resilience through a multi-layered approach. The Rotterdam strategy involves a co-design approach with stakeholders to identify and prioritise measures based on their specific needs and risks, whereas the FRAMES project explores the implementation of flood resilient measures using the multi-layered water safety c

oncept (MLS) in several pilot projects in the UK, Denmark, Belgium, Germany and the Netherlands. The Belgian pilot projects, located in Geraardsbergen, Ninove, and Denderleeuw, focus on community resilience, awareness, and education, and have led to policy recommendations to intensify communication efforts, define specific responsibilities, link flood risk measures to non-flood related aspirations and explore new alliances. Both initiatives highlight the importance of a collaborative and participatory approach to flood risk management, involving multiple stakeholders and considering the shared responsibility of civic, private and public actors. By adopting a multi-layered approach, these initiatives aim to enhance flood risk resilience and promote a culture of shared responsibility, ultimately reducing the risks and impacts of floods.

7.2.5 Droughts and water scarcity

Prolonged droughts are affecting southern and central Europe, reducing water availability for agriculture, energy production[219], public water supply, river transportation and ecosystems. Climate change can intensify these events, making efficient water resource management essential (including groundwater management[220]). Some example strategies can be observed in the table below.

[217] The Rotterdam port adaptation strategy (The Netherlands): https://climate-adapt.eea.europa.eu/en/metadata/case-studies/rotterdam-port-adaptation-strategy-for-climate-resilient-transport-and-business-activities

[218] The FRAMES project: https://www.adapt2climate.be/casestudy/frames-project-belgian-pilot-projects/?lang=en

[219] Adaptation options for hydropower plants https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/adaptation-options-for-hydropower-plants

[220] Adaptation of groundwater management: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/adaptation-of-groundwater-management

Table 38. Droughts and water scarcity example strategies

Objective pursued	Main focus	Examples on how to reach the objective (actions)
Protect rural communities from drought-related livelihood losses	Decrease vulnerability	Implementing income support programmes for farmers, providing access to drought-tolerant crops and animal varieties, and offering training on climate-resilient agricultural practices.
Reduce urban water demand through efficient use	Decrease exposure	Implementing water-saving technologies, such as low-flow fixtures and greywater reuse systems, and promoting water-efficient behaviours, such as fixing leaks and using drought-tolerant landscaping.
Minimise the effect of drought (e.g. less drinkable water) on people, businesses, economy, tourism or ecosystems	Decrease impact	Implementing water-saving technologies, rainwater harvesting, conservation measures, such as habitat restoration and wildlife corridors, and promoting sustainable land use practices, such as reforestation and permaculture.
Enhance community resilience to drought and water scarcity	Increase adaptive capacity	Developing and implementing community-based drought and water scarcity management plans, providing training and education on drought and water scarcity risk reduction and management, and promoting community engagement and participation in drought and water scarcity risk reduction efforts.

Source: JRC elaboration

7.2.5.1 Physical and technological

To tackle droughts and impacts such as water scarcity, municipalities can implement water retention approaches in the agricultural sector[221]; green infrastructure, such as permeable pavements and green roofs, which can increase water retention, thus also addressing other hazards such as heavy precipitations and floods. Additionally, municipalities can implement blue infrastructure, such as artificial wetlands and floating gardens to enhance water efficiency[222] and improve water quality. Grey infrastructure, including water-efficient appliances and fixtures or deploying water reuse approaches[223], can also play a crucial role in reducing water consumption. Furthermore, municipalities can leverage technological innovations, such as advanced water metering and leak detection systems, to optimise water management and reduce water waste. Other measures, such as desalination[224] plants and water recycling facilities can also be implemented to increase water resilience and reduce dependence on scarce water resources.

[221] Improved water retention capacity in the agricultural landscape https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/improved-water-retention-in-agricultural-areas

[222] Improvement of irrigation efficiency https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/improvement-of-irrigation-efficiency

[223] Water reuse https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/water-recycling

[224] Desalination https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/desalinisation

Table 39. [Droughts and water scarcity] Physical and technological example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Green options	Urban forestry and green spaces	Improved water retention, reduced urban heat island effect and increased water efficiency
Blue options	Rainwater harvesting (e.g. rainwater tanks in the roof of buildings or other levels).	Reduced water consumption, increased adaptive capacity, increased water efficiency and improved water management.
Grey options	Water-saving technologies and greywater reuse systems	Reduced water consumption, increased water efficiency and increase water resilience.
Technological options	Smart water management systems and drought monitoring	Optimised water management, improved drought resilience and reduced water waste.

Source: JRC elaboration

Box 87. [Droughts and water scarcity] Water saving measures in the IMDEA building (Madrid, Spain)

The IMDEA building in Madrid (Spain)[225] is a prime example of a climate resilient construction that incorporates water-saving measures and synergies with other sustainability aspects. The building's design features a white roof, innovative solar shadings, and bioclimatic architecture to reduce energy consumption and minimise the urban heat island effect. Water saving systems, such as low flow sinks faucets and toilets, reduce water consumption by over 40%, while the collection and reuse of rainwater for irrigation and other purposes further minimise water waste. The building's permeable parking surface also helps to reduce storm water runoff. By integrating these water saving measures with energy-efficient systems, renewable energy sources, and sustainable materials, the IMDEA building achieves a high level of synergy between water and energy savings, reducing its environmental impact and operating costs.

7.2.5.2 Economic and finance

To adapt to droughts and water scarcity, municipalities can utilise financing and incentive instruments that promote water-efficient technologies. Municipalities can offer rebates or subsidies for residents and businesses to install low-flow appliances, water-efficient irrigation systems, or implement water conservation projects. To support this, municipalities can also implement a programme, which provides incentives for residents and businesses to retrofit their homes and buildings with water-efficient fixtures and appliances. Additionally, municipalities can implement water pricing mechanisms to encourage water conservation and reduce demand.

Table 40. [Droughts and water scarcity] Economic and finance example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Financing and incentive instruments	Water conservation tax credit programme	Reduced water consumption, increased water efficiency, and improved drought resilience (i.e. decreasing impact and risk). This programme can also help to decrease the vulnerability of water-scarce communities, by providing them with the necessary financial incentives to invest in water-saving technologies and practices. By offering tax credits for water conservation measures, this programme can encourage

[225] The IMDEA building in Madrid, Spain: https://climate-adapt.eea.europa.eu/en/metadata/case-studies/white-roof-innovative-solar-shadings-and-bioclimatic-design-in-madrid

		businesses and individuals to adopt water-efficient practices, reducing the demand on scarce water resources and mitigating the impacts of droughts.
Insurance and risk sharing instruments	Drought insurance programme for farmers	Reduced financial risk for farmers, increased ability to recover from drought-related losses and improved overall agricultural resilience, contributing to decreasing risk and increasing adaptive capacity. This programme can also help to decrease the impact of droughts on agricultural productivity, by providing farmers with the necessary financial resources to adapt to drought conditions.

Source: JRC elaboration

Box 88. [Droughts and water scarcity] A subsidised drought insurance for farmers in Austria

The Austrian government has introduced a subsidised drought insurance system for farmers[226], which combines indemnity-based insurance with weather index-based products. The system aims to provide a fairer and faster coverage of damage to farmers, reduce their dependence on public subsidies, and promote their well-being and mental health. The insurance scheme is financed by a combination of public funds, private sector contributions, and payments from individual farmers, with the government covering 55% of the insurance premium costs. The system has been successful in providing a relatively hassle-free and fast means for farmers to receive compensation for yield losses and has helped to reduce the pressure on public finances and taxpayers. However, there are limiting factors, including the growing costs of premiums and the complexity of risk management for small farmers. Despite these challenges, the system has been well-received by farmers, with over 75% of surveyed farmers expressing support for the publicly subsidised drought insurance system.

7.2.5.3 Governance and institutional

Municipalities can develop and implement water-efficient building codes and standards[227]. Furthermore, municipalities can establish partnerships with water-intensive industries, such as agriculture and manufacturing, to promote water-efficient practices and technologies. Additionally, municipalities can develop and implement emergency drought response plans[228], which can include measures such as water rationing and restriction on non-essential water uses[229].

Table 41. [Droughts and water scarcity] Governance and institutional example actions and outcome(s) obtained

	Action example	Outcome(s)
Policies and regulations	Development of water allocation plans and water rights management frameworks	Improved water management, reduced water scarcity, and increased water efficiency.

[226] A subsidised drought insurance for farmers in Austria https://climate-adapt.eea.europa.eu/en/metadata/case-studies/Subsidised-drought-insurance-for-farmers-in-Austria

[227] Water sensitive urban and building design: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/water-sensitive-urban-and-building-design

[228] Integration of climate change adaptation in drought and water conservation plans https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/adaptation-of-drought-and-water-conservation-plans

[229] Water restrictions and water rationing https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/water-restrictions-and-consumption-cuts

Management and planning	Development of water supply management plans and drought risk assessment frameworks	Reduced drought risk, improved water management and increased public safety.
Coordination, cooperation and networks	Establishment of water user associations and stakeholder engagement processes	Improved water management, reduced drought risk, and increased water efficiency.

Source: JRC

Box 89. [Droughts and water scarcity] The blue green factor (BGF) applied in Turku (Finland), and the biotope area factor used in Berlin (Germany)

The Blue Green Factor (BGF) is a factor-based policy instrument to ensure and maintain desired levels of green and blue in new development projects. As a non-economic valuation method, it scores the relative importance of different green or blue elements at a given site through assessing the ratio of the ecologically effective surface area as a factor of the total land area. This instrument allows developers and designers the freedom to decide how green or blue elements should be incorporated in the respective projects and, at the same time, can be used as evaluation criteria in public procurement or in the distribution of land. There are multiple examples of the use of BGF, one of which is Turku (Finland)[230]. A similar approach has been used in Berlin (Germany) with the biotope area factor[231].

7.2.5.4 Knowledge and behavioural change

Building a culture of water conservation and efficiency requires a shift in knowledge, attitudes and behaviours among residents, businesses and institutions. This can be achieved through targeted initiatives that promote water literacy and awareness, such as community-based workshops and public outreach programmes. Municipalities can also develop and disseminate water conservation guides and toolkits for households and businesses, providing practical tips and resources for reducing water waste. Additionally, municipalities can collaborate with community leaders to promote water-efficient lifestyles and behaviours and recognise and reward individuals and organisations that demonstrate exceptional water conservation efforts. Furthermore, municipalities can integrate water conservation and drought resilience into professional training and certification programmes, such as those for plumbers, landscapers, and architects to ensure that professionals have the skills and knowledge needed to design and implement water-efficient systems and practices.

Table 42. [Droughts and water scarcity] Knowledge and behaviour change example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Information and awareness raising	School-based education programme on water conservation and drought awareness for youth.	Increased awareness and understanding of water conservation and drought risk among youth, improved ability to recognise and adopt water-saving behaviours.

[230] Blue-green coefficient in Turku (Finland) https://www.turku.fi/rakentaminenrakentamisen-ohjeet-ja-lomakkeet/siniviherkerroin

[231] Interreg Europe: Green and blue infrastructure – A policy brief from the Policy Learning Platform for a greener Europe, September 2024, https://www.interregeurope.eu/sites/default/files/2024-09/Policy%20brief%20on%20Green%20and%20blue%20infrastructure.pdf

Capacity building, empowering, and lifestyle practices	Training programme for farmers and agricultural professionals on water-efficient irrigation practices	Improved ability of farmers and agricultural professionals to implement water-efficient irrigation practices, enhanced capacity to manage water resources.

Source: JRC elaboration

Box 90. [Droughts and water scarcity] Water conservation, flood control and awareness raising in the urban flood park "La Marjal" (Alicante, Spain)

The urban flood park "La Marjal" in Alicante (Spain)[232], is an example of a nature-based solution that combines water conservation, flood control with educational and recreational values. The park's design is based on the natural function of marshes, which regulate water cycles, and features a large temporary rainwater retention basin, a pond, and a varied topography that supports a range of plant and animal species. The park's educational value lies in its ability to raise awareness about the importance of flood control, water conservation, and biodiversity, while also promoting behavioural change through its design and features. The park's intelligent surveillance system and alarm system also serve as an educational tool, informing users about the park's flood control function and the importance of evacuation during heavy rainfall events. Additionally, the park's use of reclaimed water for irrigation and its drip irrigation system demonstrates sustainable water management practices, promoting water conservation and efficient use. Overall, it is an innovative example of how flood control can be combined with educational and recreational values, promoting behavioural change and sustainable water management practices.

Box 91. [Droughts and water scarcity] Rainwater collection with awareness raising in Debrecen (Hungary)

The municipality of Debrecen (Hungary) has implemented a rainwater collecting system[233] to address urban flooding, where rainwater-collecting barrels were distributed to inhabitants to reduce the amount of rainwater in the sewage system. This initiative, supported by an awareness raising campaign, aims to improve the exploitation of rainwater in the municipality and promote sustainable water management practices. By collecting and reusing rainwater, residents can reduce their water consumption and alleviate pressure on the municipality's drainage system, ultimately decreasing water scarcity and contributing to reducing the risk of flooding.

7.2.6 Storms

Europe faces a variety of storms, including extratropical cyclones, convective storms, severe winds, and tropical-like Mediterranean cyclones, which cause widespread damage[234]. Climate change may alter their intensity and distribution, demanding improved forecasting[235] and resilient infrastructure. Some examples of strategies to address the risk of storms are described below.

[232] Water conservation, flood control and awareness raising in the Urban Flood Park "La Marjal" (Alicante, Spain) https://adaptecca.es/en/casos-practicos/urban-flood-park-la-marjal

[233] Rainwater collecting with awareness raising in Debrecen (Hungary) https://eu-mayors.ec.europa.eu/sites/default/files/2024-01/Debrecen%2C%20Hungary_PSF%20Case%20Study.pdf

[234] Disaster risk management knowledge centre (DRMKC) – Science for disaster risk management 2017 – Chapter 3.7 Meteorological risk: extratropical cyclones, tropical cyclones and convective storms: https://drmkc.jrc.ec.europa.eu/science-for-drm/science-for-drm/science-for-disaster-risk-management-2017

[235] Using nature and data to weather coastal storms https://projects.research-and-innovation.ec.europa.eu/en/horizon-magazine/using-nature-and-data-weather-coastal-storms

Table 43. [Storms] example strategies

Objective pursued	Main focus	Examples on how to reach the objective (actions)
Reduce vulnerability to high winds	Decrease vulnerability	Buildings can be reinforced with aerodynamic shapes, strong roof and wall connections, impact-resistant materials, and reinforced openings
Reduce exposure to high winds and flying debris	Decrease exposure	To protect both buildings and people, measures include promoting storm-resilient construction practices (e.g elevating foundations, securing outdoor equipment) and using vegetation as windbreaks.
Minimise the effects of storms on critical infrastructure	Decrease impact	Implementing infrastructure hardening measures, such as storm-proofing and backup power systems, and promoting resilient design and construction practices for critical infrastructure, such as hospitals and emergency services.
Enhance community resilience to storms	Increase adaptive capacity	Developing and implementing community-based storm preparedness and response plans, providing training and education on storm risk reduction and management, and promoting community engagement and participation in storm risk reduction efforts.

Source: JRC elaboration

7.2.6.1 Physical and technological

The urban landscape can be significantly altered by the implementation of physical and technological measures to mitigate the impacts of storms. One approach is to incorporate wind-resistant design elements into buildings and infrastructure, such as reinforced roofs and walls to reduce damage from high winds. Municipalities can also invest in advanced drainage systems, such as tunnel bypass systems and storm water tunnels to quickly and efficiently manage storm water runoff. Additionally, municipalities can use impact-resistant materials and designs, such as hurricane-proof windows and doors, to protect buildings from storm damage, or other approaches to enhance the resilience of the energy sector[236].

Table 44. [Storms] Physical and technological example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Green options	Creating vegetation windbreaks	Increased resilience to wind, reduced exposure to storms
Grey options	Storm-resilient construction and infrastructure design (e.g. reinforced structure, cross-bracing, etc).	Reduced damage from storms, improved public safety and increased urban resilience.
Technological options	Storm forecasting (i.e. wind, sand, etc.) through digital tools and early warning systems	Improved storm risk management, reduced storm risk and increased public safety.

Source: JRC elaboration

[236] Adaptation options for electricity transmission and distribution networks and infrastructure https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/adaptation-options-for-electricity-transmission-and-distribution-networks-and-infrastructure

Box 92. [Storms] Best practice guidance on buildings' adaptation to high winds

The "Best practice guidance on buildings' adaptability to climate change,"[237] released on 24 May 2023, provides strategies for adapting buildings across Europe to climate risks, guiding stakeholders on enhancing performance and aligning with EU policies. It complements the "EU Technical guidance for adapting buildings to climate change," [238] which consolidates best practices for climate-resilient structures. To mitigate high winds (see section 2 of the mentioned document), buildings should feature aerodynamic designs, reinforced structures with hip roofs and cross-bracing, and impact-resistant materials. Elevating foundations, securing outdoor equipment, and planting dense vegetation as windbreaks further protect buildings and occupants.

7.2.6.2 Economic and finance

To mitigate the impacts of storms, municipalities can implement financing and incentive instruments that encourage the development of storm-resistant infrastructure or buildings. Tax breaks or subsidies can be offered for residents and businesses to install storm shutters, impact-resistant windows, or implement storm-resistant construction materials.

Table 45. [Storms] Economic and finance example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Financing and incentive instruments	Storm-resistant construction grant programme	Increased adoption of storm-resistant construction materials and designs, reduced damage from storms, and improved public safety (decrease impact and risk). This programme can also help to decrease the vulnerability of storm-prone communities, by providing them with the necessary financial resources to build storm-resistant infrastructure and reduce their exposure to storm-related hazards.
Insurance and risk sharing instruments	Storm insurance programme for local communities	The insurance and risk-sharing instruments, such as parametric insurance and catastrophe bonds, are tailored for businesses and municipalities to manage financial impacts from storm-related damages. These tools provide rapid pay-outs and facilitate risk transfer for incidents like public trees falling on cars or damaging infrastructure.

Source: JRC elaboration

Box 93. [Storms] Windstorm parametric insurance

Severe windstorms can cause widespread damage to forests, buildings, and transport and energy infrastructure. Storms were the costliest natural hazard in terms of insured losses in Europe, with the highest impacts in north-western Europe, especially in coastal areas[239]. Traditional indemnity insurance, while crucial, often falls short in addressing the full spectrum of financial exposures resulting from these events, typically focusing on direct physical damage. An innovative solution emerging to complement traditional coverage is

[237] Best practice guidance on buildings´ adaptability to climate change https://build-up.ec.europa.eu/en/resources-and-tools/publications/best-practice-guidance-buildings-adaptability-climate-change

[238] EU-level technical guidance on adapting buildings to climate change – Best practice guidance https://op.europa.eu/en/publication-detail/-/publication/b175c9cb-cc5b-11ed-a05c-01aa75ed71a1/language-en

[239] EEA – Wind-severe windstorms: https://www.eea.europa.eu/publications/europes-changing-climate-hazards-1/wind/wind-severe-windstorms

windstorm parametric insurance[240]. This type of insurance offers rapid and transparent pay-outs based on predefined triggers linked to specific parameters such as wind speed.

7.2.6.3 Governance and institutional

The development of policies and regulations, such as zoning ordinances that restrict development in high-risk areas, can increase and prioritise storm resilience. Municipalities can also establish comprehensive management and planning frameworks, including storm risk assessments, to guide decision-making and ensure a coordinated response to storms. Moreover, municipalities can foster coordination, cooperation and networks among stakeholders, including interagency agreements and memoranda of understanding to facilitate information sharing and joint planning for storm response and recovery efforts.

Table 46. [Storms] Governance and institutional example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Policies and regulations	Adoption of storm-resistant building codes and wind-borne debris regulations	Reduced damage from storms, improved public safety and increased urban resilience.
Management and planning	Development of emergency management plans, storm response protocols and preventive measures (e.g. regular maintenance of trees at risk of falling)	Improved storm response, mitigation of future risks, and increased public safety, community stability and economic continuity after high-wind events
Coordination, cooperation and networks	Establishment of a storm response coalition among local governments, emergency management agencies and community organisations	Improved coordination and communication among stakeholders, enhanced ability to respond to storms, and reduced risk of storm-related damages and injuries.

Source: JRC elaboration

Box 94. [Storms] Replacing overhead lines with underground cables in Finland

Governance and institutional collaboration play a crucial role in enhancing climate resilience, as demonstrated by Elenia's initiative in Finland[241]. Elenia, Finland's second-largest electricity distribution operator, is investing heavily in underground cabling, aiming for 75% completion by 2028. This initiative is a prime example of climate adaptation for municipalities facing high winds and related damage. By replacing overhead lines with underground cables, Elenia enhances energy supply security and minimises costs, addressing climate change impacts like extreme weather. This strategy is crucial for adapting to increased storms and tree-related risks, ensuring a resilient energy system in the face of increasing storm frequency and intensity.

[240] ECMWF Insurance impacts of European windstorms https://stories.ecmwf.int/insurance-impacts-of-european-windstorms/index.html

[241] Replacing overhead lines with underground cables in Finland https://climate-adapt.eea.europa.eu/en/metadata/case-studies/replacing-overhead-lines-with-underground-cables-in-finland

7.2.6.4 Knowledge and behavioural change

Some examples to address storms can be found below:

Table 47. [Storms] Knowledge and behavioural change example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Information and awareness raising	Social media campaign to promote storm safety tips and emergency preparedness	Increased reach and engagement of storm safety messages, improved awareness of preventive measures, and enhanced ability to take action to protect oneself and others from storm-related damages.
Capacity building, empowering, and lifestyle practices	Emergency response training programme for community leaders and emergency services	Improved ability of community leaders and emergency services to respond to storms, enhanced capacity to provide critical care and support to affected individuals, and reduced risk of storm-related injuries and fatalities.

Source: JRC elaboration

Box 95. [Storms] Awareness campaign in Denmark to inform residents on how to prepare against storms

An awareness campaign is proposed in Denmark with the aim to inform residents on how to prepare against storms by providing tips to protect their property[242]. The campaign focuses on two main areas: tree pruning and storm protection for homes and gardens. Residents are advised to prune trees to prevent them from becoming a safety hazard, and to remove diseased, dead or broken branches. Additionally, residents are encouraged to secure loose items such as garden trampolines and furniture, and to ensure that their homes and gardens are properly secured to withstand high winds and storms. The campaign also recommends getting a building surveyor to examine homes to assess whether everything is sufficiently secured, and to follow the requirements in the Danish building regulations to prevent damage and ensure safety during storms.

Box 96. [Storms] LIFE-MEDEA project: mitigating the health effects of desert dust storms using exposure-reduction approaches

The LIFE-MEDEA project focuses on the mitigation of the health effects of desert dust storms in south-east Europe[243] by expanding the knowledge on the topic. Desert dust storms pose a significant risk to populations, causing increased hospital admissions and mortality rates, and exacerbating pre-existing conditions. The project seeks to develop a strategic plan to reduce exposure to desert dust storms, create easy-to-implement recommendations, and demonstrate their effectiveness in reducing adverse health impacts, ultimately improving the well-being of vulnerable populations.

[242] Campaign to inform residents on how to prepare against storms in Denmark: https://eng.klimatilpasning.dk/local-adaptation/climate-adapt-your-property/storms

[243] LIFE-MEDEA project: Mitigating the health effects of desert dust storms using exposure-reduction approaches https://climate-adapt.eea.europa.eu/en/metadata/projects/mitigating-the-health-effects-of-desert-dust-storms-using-exposure-reduction-approaches

7.2.7 Mass movement

Landslides[244], rock falls and mudslides can be exacerbated by heavy precipitation and soil degradation and can increase in mountainous and coastal regions. These events endanger settlements, transport networks, and ecosystems, requiring enhanced monitoring and preventive measures.

Table 48. Mass movement example strategies

Objective pursued	Main focus	Examples on to reach the objective (actions)
Protect communities from landslide and rock fall risks	Decrease vulnerability	Implementing slope stabilisation measures, such as retaining walls and rock fall barriers, providing evacuation plans and emergency shelters for communities at risk, and promoting landslide-resilient construction practices, such as building design and materials.
Reduce exposure to landslide and debris flow risks	Decrease exposure	Implementing land use planning and zoning regulations to reduce development in high-risk areas.
Minimise the effects of mass movements on infrastructure and ecosystems	Decrease impact	Implementing measures to protect infrastructure, such as bridges and roads, from landslide and debris flow damage, and promoting ecological restoration and conservation practices.
Enhance community resilience to mass movements	Increase adaptive capacity	Developing and implementing community-based emergency preparedness and response plans, providing training and education on mass movement risk reduction and management. Fostering partnerships between communities, emergency responders, and scientists to support mass movement risk reduction and resilience.

Source: JRC elaboration

7.2.7.1 Physical and technological

Mass movements, such as landslides, can have devastating effects on communities. One approach is to use natural systems, such as wetlands and floodplains, to absorb and filter water, reducing the likelihood of landslides and soil erosion. In coastal areas, also cliff strengthening and stabilisation approaches[245] can be implemented. Green infrastructure, like terracing and re-vegetation, can also be employed to stabilise slopes and prevent landslides. Additionally, blue options, such as permeable pavements and urban water harvesting systems, can help to manage storm water runoff and reduce the pressure on slopes. Moreover, municipalities can utilise advanced materials and designs, such as fibre-reinforced polymers and seismic-resistant construction to build infrastructure that can withstand the forces generated by mass movements.

[244] Landslides https://climate-adapt.eea.europa.eu/en/observatory/evidence/health-effects/landslides

[245] Cliff strengthening and stabilisation https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/cliff-stabilisation

Table 49. [Mass movement] Physical and technological example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Green options	Slope stabilisation and vegetation restoration	Reduced landslide risk, improved soil stability and increased ecosystem resilience
Blue options	Drainage management and water control measures	Reduced landslide risk, improved water management and increased public safety.
Grey options	Landslide-resistant construction and infrastructure design	Reduced damage from landslides, improved public safety, and increased urban resilience.
Technological options	Landslide monitoring and early warning systems	Improved landslide risk management, reduced landslide risk, and increased public safety.

Source: JRC elaboration

Box 97. [Mass movement] Inventory of geo-hydrological phenomena in Genova municipality (Italy)

The inventory of geo-hydrological phenomena in Genova municipality (Italy)[246] provides valuable insights for risk assessment by integrating different hazard sources and the spatial distribution of exposed elements in a map. The map serves as a tool for decision-makers, stakeholders, and environmental educators, as it shows the floodable areas, landslides and deep-seated gravitational slope deformation, the urban fabric and the cultural heritage sites. The analysis shows that over 360 residential buildings are located on active landslides, and more than 2 200 on dormant ones. The high hazard level is exacerbated by increased rainfall frequency and intensity, as observed in the region. In addition to residential areas, 19 industrial buildings and 9 public buildings are located on active landslides. Roads, especially in residential and hilly areas, are highly exposed, with 18 km on active landslides and 65 km on dormant ones, as demonstrated by a 2014 event where landslides caused significant damage to buildings and roads, costing around EUR 1.2 million for emergency works. The map is a powerful tool for guiding actions on landslide risk mitigation, allowing municipalities and stakeholders to define and prioritise the interventions and allocate resources effectively.

7.2.7.2 Economic and finance

Municipalities can use various economic and financial instruments to adapt to mass movement. Grants, subsidies, low-interest loans, and tax incentives, can help residents and businesses cover the costs of implementing landslide mitigation measures, including installing retaining walls, geo-grids, or geotechnical engineering projects, or deploy public-private partnerships (PPPs) to sharing the costs and risks among private companies and the municipality.

Table 50. [Mass movement] Economic and finance example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Financing and incentive instruments	Landslide mitigation grant programme for critical infrastructure	Reduced risk of landslides, increased stability of critical infrastructure, and improved public safety.
Insurance and risk sharing instruments	Landslide risk assessment and mapping initiative	Improved understanding of landslide risks, increased accuracy of risk assessments, and

[246] Paliaga, G., Luino, F., Turconi, L., & Faccini, F. (2018). Inventory of geo-hydrological phenomena in Genova municipality (NW Italy). *Journal of Maps*, *15*(2), 28–37. https://doi.org/10.1080/17445647.2018.1535454

		enhanced decision-making for landslide mitigation and adaptation efforts.

Source: JRC elaboration

Box 98. [Mass movement] Leveraging public-private partnerships in the LIFE CITYAdaP3 project

The LIFE CITYAdaP3 project[247] aims to help European municipalities adapt to climate change by leveraging public-private partnerships and corporate social responsibility. The project will develop financing models, implement adaptation actions in four EU municipalities, and promote green infrastructures and nature-based solutions to mitigate the impacts of climate-related hazards such as landslides, floods and heatwaves. It also involves creating an e-learning course for companies to develop environmental commitments and will work to enhance the implementation of SECAPs. The project's goals include increasing private sector investment in urban adaptation improving municipality resilience to climate change, and enhancing knowledge on the benefits of adaptation actions, with expected outcomes to be achieved by 2024.

7.2.7.3 Governance and institutional

The governance of mass movement risks requires a multi-faceted approach that involves various stakeholders and institutions. One key aspect is the development of standardisation protocols and guidelines for landslide risk assessment and management, to ensure consistency and effectiveness across different agencies and departments. Municipalities can also establish clear lines of authority and decision-making processes for landslide management, to facilitate rapid response and coordination during emergency situations. Moreover, municipalities can create networks with neighbouring jurisdictions and regional authorities to facilitate information sharing and coordination on landslide risk management efforts.

Table 51. [Mass movement] Governance and institutional example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Policies and regulations	Implementation of land use regulations and zoning ordinances for landslide-prone areas	Reduced landslide risk, improved public safety, and increased urban resilience.
Management and planning	Development of landslide risk assessment and mapping frameworks	Improved landslide risk management, reduced landslide risk, and increased public safety.
Coordination, cooperation and networks	Establishment of emergency response protocols and communication networks with local communities and emergency services	Improved landslide response, reduced landslide risk, and increased public safety.

Source: JRC elaboration

[247] Leveraging public-private partnerships in the LIFE CITYAdaP3 project: https://climate-adapt.eea.europa.eu/en/metadata/projects/financing-cities-adaptation-to-climate-change-through-public-private-partnerships-and-corporate-social-responsibility

Box 99. [Mass movement] Adaptation against landslides of French transport infrastructure standards

The adaptation of French standards for the design, maintenance, and operation of transport infrastructures[248] contributes to the adaptation of the transport infrastructure to landslides and other climate-related hazards. The French Ministry of Ecology, in collaboration with Cerema, reviewed and updated transport infrastructure standards to adapt to future climate conditions, prioritising revisions based on resilience needs. The review process involved a technical working group with experts from different transport modes and phases, and climate experts provided projections and indicators to inform the revision process. The updated standards will replace existing ones and ensure that transport infrastructure can cope with future climate conditions and extreme weather events, ultimately reducing the risk of landslides and other hazards. The success factors of this approach include partnership with climate experts, mobilisation of in-house technical knowledge, a pragmatic approach and transparency.

7.2.7.4 Knowledge and behavioural change

Mass movements require a deep understanding of the complex interactions between geological, hydrological, and environmental factors. By supporting interdisciplinary research collaborations, municipalities can advance the understanding of landslide triggers and mechanisms and develop more effective early warning systems. Municipalities can also establish knowledge-sharing platforms and networks and bring together experts from various fields, including geology, engineering and emergency management, to share best practices and lessons learned from landslide events. Furthermore, municipalities can work with universities to develop and implement landslide-related curricula and training programmes for students and professionals, focusing on topics such as landslide risk assessment, mitigation and response.

Table 52. [Mass movement] Knowledge and behavioural change example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Information and awareness raising	Community-based outreach programme to educate residents on landslide risk and emergency preparedness, using interactive tools and influencing the community through local ambassadors	Increased awareness and understanding of landslide risks among community members, improved ability to recognise and respond to landslide events.
Capacity building, empowering, and lifestyle practices	Geotechnical training programme for engineers and geologists on landslide risk assessment and mitigation in collaboration with the local university	Improved ability of engineers and geologists to assess and mitigate landslide risk, enhanced capacity to design and implement effective landslide mitigation measures.

Source: JRC elaboration

Box 100. [Mass movement] Informing residents about increasing risks and how to adapt to them

The Ministry for the Ecological Transition in France has deployed an awareness campaign to inform residents about the increasing natural risks, such as landslides, floods and storms, due to climate change[249]. The

[248] Adaptation of French standards for design, maintenance and operation of transport infrastructures https://climate-adapt.eea.europa.eu/en/metadata/case-studies/adaptation-of-french-standards-for-design-maintenance-and-operation-of-transport-infrastructures

[249] Risques naturels en hausse : comment se protéger au mieux? https://www.adaptation-changement-climatique.gouv.fr/dossiers-thematiques/milieux/risques-naturels

information provided in the website highlights the importance of adapting to these risks and the measures that can be taken to reduce vulnerability. Residents are informed about the need to develop a culture of risk, understand the risks, and take individual and collective actions to prevent and manage natural risks. The campaign also highlights the role of municipalities and governments in preventing and managing natural risks, and provides guidance on how residents can adapt their homes and properties to the risks. Lastly, the campaign emphasizes the importance of nature-based solutions, urban planning, and infrastructure design in reducing the impact of natural risks. Overall, the campaign aims to educate and empower residents to take action against natural risks and promote a culture of resilience and adaptation.

Box 101. [Mass movement] Preventive relocation of households at high hydrogeological risk in Piedmont (Italy)

The Piedmont region in Northern Italy prioritises public awareness and informing residents about the risks associated with hydro-geological disasters[250], ensuring they are well-informed and involved in the decision-making process. In collaboration with local municipalities, the region has implemented a planned relocation policy, offering a voluntary buy-out scheme with public funding support to help residents move to safer areas. For buildings that cannot be relocated, the region encourages vulnerability reduction measures to mitigate risks. This collaborative approach aims to reduce people's exposure to environmental hazards and disasters by supporting them to move away from high-risk areas.

7.2.8 Wildfires

Wildfires are a significant hazard in Europe, particularly in the Mediterranean region. Several major wildfires have been experienced in the past, like the recent largest single wildfire recorded in the EU in 2023 in Greece, or the deadly 2017 wildfires in Portugal that killed more than 100 people. Some examples to address wildfires can be seen below.

Table 53. [Wildfires] Example strategies

Objective pursued	Main focus	Examples on to reach the objective (actions)
Protect communities from wildfire risks	Decrease vulnerability	Implementing wildfire risk assessments and mapping, providing fire breaks and defensible spaces around communities.
Reduce exposure to wildfire risks through land use planning	Decrease exposure	Implementing land use planning and zoning regulations to reduce development in high-risk areas, and promoting fire-resilient construction practices, such as fire-resistant materials and design.
Minimise the effects of wildfires on ecosystems and biodiversity	Decrease impact	Implementing conservation measures, such as habitat restoration and wildlife corridors, and promoting sustainable land use practices, such as prescribed burning and forest management, or offering financial assistance for fire-related damages.
Enhance community resilience to wildfires through emergency preparedness	Increase adaptive capacity	Developing and implementing community-based preparedness and response plans, providing training and education on wildfire risk reduction and management, and promoting community engagement and participation in wild fire risk reduction efforts.

Source: JRC elaboration

[250] Preventive relocation of households at high hydrogeological risk in Piedmont (Italy) https://climate-adapt.eea.europa.eu/en/metadata/case-studies/preventive-relocation-of-households-at-high-hydrogeological-risk-in-piemonte-italy

7.2.8.1 Physical and technological

The intersection of urban development and wildfire-prone areas require a thoughtful approach to physical and technological design[251]. One approach is to use advanced materials and designs, such as fire-resistant roofing and siding, to protect assets and reduce the spread of wildfires. Municipalities can also employ landscape design techniques, such as fuel breaks and defensible spaces, to create fire-resistant zones around buildings and infrastructure. Additionally, municipalities can utilise unmanned aerial vehicles (UAVs) and other remote-sensing technologies to monitor and track wildfires, providing critical information for firefighting efforts and emergency response. Smart grid technologies can be implemented to manage and control electricity infrastructure, reducing the risk of wildfires caused by power line sparks and other electrical malfunctions. Additionally, municipalities can also consider approaches for forest restoration[252] after a wildfire has occurred.

Table 54. [Wildfires] Physical and technological example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Green options	Prescribed burning and forest management (i.e. creating firebreaks, clearing vegetation and creating buffer zones around forests to prevent fires from spreading).	Reduced wildfire risk, improved forest health and increased ecosystem resilience.
Blue options	Water management and firebreak creation	Reduced wildfire risk, improved fire management, and increased public safety.
Grey options	Fire-resistant construction and infrastructure design	Reduced damage from wildfires, improved public safety, and increased urban resilience.
Technological options	Wildfire detection and monitoring systems	Improved wildfire risk management, reduced wildfire risk, and increased public safety.

Source: JRC elaboration

Box 102. [Wildfires] Prescribed fires and grazing techniques: the LIFE LANDSCAPE FIRE and LIFE Montserrat projects

The LIFE LANDSCAPE FIRE [253] and the LIFE Montserrat[254] projects share a common goal of preventing forest fires and promoting biodiversity in Mediterranean ecosystems. They use a combination of prescribed fires, grazing techniques and forest restoration to reduce forest fuel and create more resilient areas. The projects involve creating and agro-silvopastoral mosaic, which combines forestry and livestock management to improve the resilience of forests against fires and promote biodiversity. This approach also generates benefits, including job creation and local development, while promoting sustainable land management practices. The projects involve education, information, and community participation, raising awareness about

[251] Prevention of climate-related damages to forests https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/prevention-of-climate-related-damages-to-forests

[252] Forest restoration after climate related disasters https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/forest-restoration-after-climate-related-disasters

[253] The LIFE LANDSCAPE FIRE project: https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE18-ENV-PT-000361/life-landscape-fire-project-new-methodologies-for-forest-fire-prevention

[254] The LIFE Montserrat Project: https://adaptecca.es/en/casos-practicos/life-montserrat-project-silvopastoral-management-habitat-conservation-and

the importance of forest fire prevention and the benefits of silvopastoral management, and providing training and capacity building programmes for stakeholders.

Box 103. [Wildfires] Recycled water to prevent and protect against forest fires in Riba-Roja de Turia (Spain)

The municipality of Riba-Roja de Turia in Spain is building fire resilience using recycled water to prevent and protect against forest fires[255]. The project, GUARDIAN, involves creating hydraulic infrastructure to supply recycled water to the wildland-urban interface, restoring the national park, and maintaining green barriers to prevent fires. The municipality is also building green firebreaks, reducing tree density, and increasing fire-resistant vegetation. Additionally, awareness-raising workshops are being held to train residents in fire prevention, including schoolchildren and residents living near fire-risk zones. The project aims to reduce the risk of forest fires, which have become increasingly destructive due to climate change, and to provide a safe natural environment for people.

7.2.8.2 Economic and finance

To mitigate the impacts of wildfires, municipalities can implement a range of financing and incentive instruments that encourage the development of fire-resistant infrastructure. These instruments can include tax breaks or subsidies for residents and businesses to install fire-resistant roofing materials, fire-resistant siding, or implement defensible space solutions. Furthermore, public-private partnerships can be leveraged to support the development of fire-resistant infrastructure, enabling private companies to partner with municipalities to design and implement wildfire mitigation projects.

Table 55. [Wildfires] Economic and finance example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Financing and incentive instruments	Wildfire prevention and mitigation fund for communities	Increased investment in wildfire prevention and mitigation measures, reduced risk of wildfires, and improved community resilience (decreasing risk and impact).
Insurance and risk sharing instruments	Wildfire insurance programme for small business and homeowners	Reduced financial risk for small businesses and homeowners, increased ability to recover from wildfire-related losses and improved overall economic resilience.

Source: JRC elaboration

Box 104. [Wildfires] Supporting the tourism sector affected by wildfires in Portugal

The Portuguese government has introduced a measure to support tourism businesses affected by forest fires in 2022[256]. The measure, known as "Linha de apoio à tesouraria das empresas turísticas afetadas pelos incêndios em 2022", provides a cash flow support line for micro, small and medium-sized tourism businesses operating in the affected areas. The support is in the form of a reimbursable incentive, without interests, and can cover up to 50% of the company's turnover in 2019 or 2021, with a maximum amount of EUR 150 000. The financing is to be reimbursed over a period of seven years, including an 18-month grace period. The measure aims to help tourism businesses recover from the temporary reduction in tourist demand caused by the forest fires.

[255] Building fire resilience in Riba-Roja de Túria using recycled water (Spain) https://eu-mayors.ec.europa.eu/sites/default/files/2022-10/eumayors-case%20study-riba-roja-en.pdf

[256] Supporting the tourism sector affected by wildfires in Portugal https://static.eurofound.europa.eu/covid19db/cases/PT-2022-43_3398.html

7.2.8.3 Governance and institutional

Establishing a clear accountability and responsibility for wildfire risk management would ensure that all stakeholders are aware of their roles and obligations. Municipalities can also develop and implement standardised procedures for wildfire-related data collection and sharing, facilitating the exchange of critical information among emergency responders, planners and other stakeholders. Moreover, municipalities can create independent review panels or commissions to investigate and analyse wildfire events, identifying lessons learned and areas for improvement to inform future policy and decision-making, and develop fire management and evacuation plans[257].

Table 56. [Wildfires] Governance and institutional example actions and outcome(s) obtained

	Action example	Outcome(s) obtained
Policies and regulations	Adoption of fire safety regulations and building codes for wildfire-prone areas	Reduced wildfire risk, improved public safety, and increased urban resilience.
Management and planning	Development of wildfire management plans and prescribed burning programmes	Reduced wildfire risk, improved wildfire management, and increased ecosystem resilience
Coordination, cooperation and networks	Collaboration with local communities to develop wildfire prevention and management strategies	Improved wildfire prevention and management, increased community engagement and reduced wildfire risk.

Source: JRC elaboration

Box 105. [Wildfires] The Agency for the Integrated Management of Rural Fires in Portugal

The Agency for the Integrated Management of Rural Fires in Portugal[258], (AGIF) is a public institute, created in 2018, whose mission is to accelerate the transition to integrated management of rural fires, involving institutions and society, based on a model of territorial governance, around the national goal: "Protect Portugal of serious rural fires", and being the entity responsible for planning, strategic coordination and evaluation of the Integrated Rural Fire Management System (SGIFR).

7.2.8.4 Knowledge and behavioural change

By examining the cultural values and beliefs that influence wildfire risk perception and behaviour, municipalities can develop targeted interventions to promote wildfire risk reduction and mitigation. Moreover, municipalities can support the development of wildfire-related educational programmes for children and youth, focusing on topics such as fire ecology, wildfire safety and environmental stewardship. Additionally, municipalities can facilitate community-level wildfire prevention programmes, fostering a sense of collective responsibility and empowering residents to take ownership of wildfire risk management.

[257] Adaptation of fire management plans: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/adaptation-of-fire-management-plans

[258] The Agency for the Integrated Management of Rural Fires in Portugal: https://www.agif.pt/en

Table 57. [Wildfires] Knowledge and behaviour change example actions and outcome(s) obtained

	Action example	Impact obtained
Information and awareness raising	Virtual reality experience to educate residents on wildfire risk and evacuation procedures, using immersive technology to simulate wildfire scenarios	Increased awareness and understanding of wildfire risk among residents, improved ability to recognise and respond to wildfire events.
Capacity building, empowering, and lifestyle practices	Training programme for municipal employees on wildfire mitigation and response, including modules on firebreak management, emergency communication and community engagement.	Improved ability of municipal employees to respond to wildfires, enhanced capacity to implement effective wildfire mitigation measures, and reduced risk of wildfire-related injuries and fatalities.

Source: JRC elaboration

Box 106. [Wildfires] "Plantando Cara al Fuego" Project in Spain and the FIRE-RES project (Spain)

The "Plantando Cara al Fuego"[259] initiative and the FIRE-RES project[260] share a common goal of addressing the issue of forest fires through community engagement and education. "Plantando cara al fuego" focuses on involving residents in the problem of forest fires, by transferring scientific and technical knowledge and civic values to the youth population through pedagogical strategies based on Service Learning. Meanwhile, the FIRE-RES project aims to create safe model villages ("aldeas modelo") in high wildfire-risk areas, such as Galicia in northwest Spain, by implementing preventive land management, integrating traditional and innovative approaches, and engaging local communities in wildfire prevention and preparedness.

7.2.9 Chemical change

Chemical change related hazards include saltwater intrusion[261] (Lee et al., 2024), ocean acidification[262] or atmospheric CO_2 concentrations, which can result in major impacts to the environment and health. Saltwater intrusion is a growing concern in coastal regions due to its impacts on freshwater ecosystems and underground urban infrastructure. Ocean acidification, on the other hand, is a pressing global problem with severe environmental, social and economic consequences. The consequences of ocean acidification include reduced marine biodiversity, habitat destruction, and impacts on fisheries and aquaculture, which can lead to significant economic losses and threaten the livelihoods of people who depend on these industries. Despite its importance, ocean acidification remains a relatively unknown issue, and more research and policy attention are needed to address its causes and consequences (Galdies et al., 2020).

[259] Plantando cara al fuego project (Spain) [Facing the fire]: https://www.plantandocaraalfuego.org/

[260] Nurturing local resilience against wildfires with the "Aldeas Modelo" concept https://climate-adapt.eea.europa.eu/en/mission/solutions/mission-stories/nurturing-local-resilience-against-wildfires-story22

[261] Intrusion of saltwater https://www.eea.europa.eu/themes/water/glossary/intrusion-of-saltwater

[262] Ocean acidification https://www.eea.europa.eu/en/analysis/indicators/ocean-acidification

Municipalities can implement strategies and measures depending on the hazards to be addressed to reduce and prevent the associated risks[263].

Saltwater intrusion: different measures can be taken based on the level of vulnerability. In low-vulnerability areas, prevention measures such as limiting impermeabilisation, monitoring groundwater levels, and introducing water-saving technologies can delay the impact of salinisation. In medium-vulnerability areas, measures include reducing groundwater use, rearranging pumping, and increasing well pumping frequency. In high-vulnerability areas, opposition/remediation measures such as hard-engineered structures, land reclamation, coastline redesign, maintenance of shoreline and plantation of natural barriers like mangroves and restoration of coastal vegetation, and creation of wetlands and marshes can be implemented to prevent or reverse the effects of saltwater intrusion, protecting the socio-economic and environmental system from degradation. (ASTERIS project consortium, n.d.).

Ocean acidification: local communities can take a range of approaches to address ocean acidification, from education and outreach to more concrete actions such as supporting marine industries. These approaches can include assessing and addressing knowledge gaps, developing strategies to support shellfish growers and other marine industries, and implementing measures to reduce pollution and protect habitats. Additionally, communities can work together to restore wetlands and promoting sustainable fishing practices (Cooley et al., 2016).

Atmospheric CO_2 concentrations: Furthermore, municipalities can adopt emissions reduction strategies, such as alternative fuels and energy sources, and energy-efficient technologies to minimise air pollution (see actions on the mitigation section 7.1).

Governance and institutional frameworks are also effective in managing the risks associated with chemical change hazards. Municipalities can establish water quality and soil and groundwater monitoring systems to track and predict environmental quality and subsequently establish water treatment strategies. They can also develop and enforce pollution prevention and protection regulations and standards to safeguard soil and groundwater quality. By establishing collaborative planning and decision-making processes, involving multiple stakeholders, including government agencies, industries and community groups, municipalities can develop and implement comprehensive management plans.

This, in turn, can enable municipalities to foster knowledge and behavioural change by educating the public about chemical changes and their impacts, and promoting community involvement in decision-making and planning through public meetings, advisory committees, and collaborative planning. Ultimately, municipalities can build community resilience and recovery by providing support, resources and planning for preparedness and rebuilding, and by encouraging environmentally sustainable practices. Municipalities can act as a bridge between industry and residents, to ensure information sharing on risk prevention and disclose data on environmental monitoring and reporting. This can be further supported by air quality improvement strategies, including green infrastructure and urban planning, which can help minimise the risks associated with chemical changes and promote a more sustainable and resilient future.

[263] EuROpean observAtory on Disaster risk and crisis MAnagement best Practices (ROADMAP project) Seventh periodical bulletin: https://roadmap.ci3r.it/wp-content/uploads/2022/05/ROADMAP-Project-7th-Bulletin.pdf

Box 107. [Chemical change] Air quality tool in MyCovenant: "My Air Quality"

The Joint Research Centre has included a new tool "My Air Quality" within the MyCovenant reporting system. This tool estimates the progress or trade-offs between CO_2 and air pollutant emissions, using data from submitted emission inventories. Available to signatories who have submitted baseline and monitoring emission inventories, this feature aims to help medium and small-sized administrations connect their energy and climate action plans with the air quality impacts and is accessible from the signatories' dashboard without requiring additional data reporting.

7.2.10 Biological hazards

Biological hazards include vector-borne diseases, pandemics, and epidemics, among other. Europe has experienced several biological threats in recent years, such as dengue, or diseases spread by mosquitoes. Such biological hazards can be exacerbated by climate change and can have a significant impact in vulnerable populations (older people, young children and people with pre-existing conditions) and the environment and land use sectors. It is also worth noting that biological hazards can intersect with other types of hazards, such as flood hazards, particularly in the aftermath of a flood event, where the risk of waterborne diseases and other biological contaminants can increase.

To mitigate the impact of biological hazards, municipalities can employ a multi-faceted approach that encompasses physical, economic, and governance measures. Physical measures provide a physical block against the pathogens. Examples include facemask wearing to protect against respiratory disease. Furthermore, disease prevention and control strategies, including vaccination programmes and disease surveillance can help identify and contain outbreaks. Municipalities can also adopt vector-borne disease control measures, such as mosquito surveillance and larval control, to prevent the spread of diseases. Additionally, technological actions can be leveraged. For example, municipalities can utilise data analytics and digital platforms to track disease outbreaks, monitor food safety, and provide real-time information to the public.[264]

Box 108. [Biological hazards] Preventing and managing risks linked to vector-borne diseases: Czechia's TBE surveillance system, the TrIAS project and French dengue surveillance system

The Czechia's tick-borne encephalitis (TBE) surveillance system[265], the TrIAS project in Belgium[266], French dengue surveillance system[267] and Greek's West Nile Virus prevention system[268] share a common goal of preventing and managing the risks associated with vector-borne diseases. The Czechia's TBE surveillance system integrates forecasting, disease reporting and prevention, relying on effective coordination, public awareness and economic support for vaccination. The TrIAS project develops a risk assessment process based on risk modelling and mapping, considering different future climate scenarios to identify emerging species and assess the risk they pose to Belgium. The French dengue surveillance system combines human and

[264] Early warning systems for vector-borne diseases https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/early-warning-systems-for-vector-borne-diseases

[265] Tick-borne encephalitis (TBE) surveillance in Czechia https://climate-adapt.eea.europa.eu/en/metadata/case-studies/tick-borne-encephalitis-tbe-surveillance-in-czechia

[266] The TrIAS project in Belgium https://www.adapt2climate.be/casestudy/tracking-invasive-alien-species-trias/?lang=en https://www.adapt2climate.be/wp-content/uploads/2019/07/trIAS-article.pdf

[267] French dengue surveillance system: https://climate-adapt.eea.europa.eu/en/metadata/case-studies/reducing-the-risk-of-local-dengue-transmission-in-france

[268] West Nile Virus prevention in Greece https://climate-adapt.eea.europa.eu/en/metadata/case-studies/west-nile-virus-infection-prevention-and-control-measures-in-greece

entomological monitoring with prevention and control measures, including awareness-raising campaigns, epidemiological investigations, and vector control interventions. All three approaches involve stakeholder participation, education and awareness-raising, and aim to provide decision-makers with a solid scientific basis to guide them in minimising the risks and impacts of these diseases.

In addition to these physical measures, municipalities can leverage economic instruments to support businesses and residents affected by biological hazards. Public-private partnerships can also be formed to finance the development of innovative biosecurity technologies and solutions. In the event of a biological hazard, municipalities can activate emergency loan programmes to provide financial support and protection to affected stakeholders.

In terms of governance and institutional frameworks, municipalities can play a crucial role in mitigating climate-related biological risks by developing and implementing targeted policies and strategies. Municipalities can develop and implement policies, plans, and protocols to mitigate these risks, including: (1) conducting thorough risk assessments to identify vulnerabilities; (2) establishing clear communication protocols to ensure timely warnings and updates; and (3) ensuring access to personal protective equipment for healthcare workers and first responders. For example, in coastal municipalities, this might involve implementing temporary bans on bathing or swimming after heavy rainfall to prevent the spread of waterborne diseases.

Box 109. [Biological hazards] Mosquito control programme in Cagliari (Italy)

The Disinfestation Service of the Anti-Insect Center is a specialised service that fights insects and organisms that are harmful to humans, animals, and plants in the Metropolitan City of Cagliari (Italy)[269]. The service provides disinfestation and deratisation interventions in public structures and places, such as streets, schools and public buildings, and offers consultation to residents to prevent infestations. To access the service, reports can be submitted through local municipalities or directly to the Public Hygiene Service, which will evaluate the need for intervention.

By taking a proactive and comprehensive approach to biological hazards, municipalities can reduce the risk of outbreaks, minimise the economic impact, and promote community resilience. This can be achieved by fostering a culture of safety and preparedness, engaging with residents and businesses and leveraging technology and innovation to support biosecurity efforts. Targeted awareness campaigns and educational activities, including issuing boil water advisories or warnings when drinking water may be contaminated due to heavy rainfall can create a healthier[270], more sustainable, and more resilient environment for their residents.

[269] Cagliari's mosquito control programme aims to prevent the spread of mosquito-borne diseases. https://www.cittametropolitanacagliari.it/portale/page/it/disinfestazioni?contentId=SRV13890

[270] EEA – One health approach https://www.eea.europa.eu/en/topics/at-a-glance/health/one-health

Box 110. [Biological hazards] Two awareness raising and educational initiatives in Germany against biological hazards: the 'Mückenatlas' and the Planetary Health Academy

The 'Mückenatlas' citizen science project in Germany[271] and the Planetary Health Academy lecture series in Germany[272] are two awareness and educational campaigns that aim to raise awareness about the health impacts of climate change. The 'Mückenatlas' project engages residents in collecting mosquito samples to monitor the spread of disease-carrying mosquitoes, while the Planetary Health Academy provides free online lectures for healthcare professionals on climate-related medical challenges. Both initiatives aim to educate and raise awareness among the public and healthcare professionals about the health risks associated with climate change, and to encourage transformative action to address these risks. The 'Mückenatlas' project has contributed to the discovery of invasive mosquito species in Germany, while the Planetary Health Academy has reached a large audience and has led to the formation of new "Health for Future" groups, which aim to promote transformational projects on a local, national and international level.

7.2.11 Adaptation action fiches

This section presents two examples of adaptation actions fully described in the action template. Please refer to section 5.3 for explanations on how to fill in the corresponding fields of the template.

Table 58. Adaptation action fiche 1: Heat awareness campaigns

Concept	Explanation
Action title	Heat awareness campaigns, inspired and adapted from Lorca's (Spain) SECAP[273]
Main focus	Heat waves
Action description	Under this action, the municipality develops a suite of information and awareness campaign actions aimed at informing and increasing awareness of residents on heatwaves. The temperature thresholds above which a heat wave can be occurring is set by the Ministry of Health and Consumer Affairs through a methodology consolidated in the scientific literature, dangerous episodes are published on the web. The campaigns focus on four stages: conceptualisation, prevention, action and promotion: (1) inform the general public about the main effects of heatwaves; (2) communicate possible measures to be taken to prevent the consequences of heatwaves, (3) explain how to act in case of health effects due to high temperatures, and (4) describe the responsible behaviours to adopt during heatwaves, such as the adequacy of working hours, the need to avoid certain activities during peak temperature hours. In the conceptualisation phase, the responsible unit of the campaign also determines how the communication is delivered (i.e. web campaign, social media posts, radio and tv spots) and gets in close contacts with the relevant

[271] 'Mückenatlas': A citizen science project for mosquito surveillance in Germany https://climate-adapt.eea.europa.eu/en/metadata/case-studies/2018muckenatlas2019-a-citizen-science-project-for-mosquito-surveillance-in-germany

[272] The Planetary Health Academy in Germany https://climate-adapt.eea.europa.eu/en/metadata/case-studies/climate-crisis-and-health-education-of-health-professionals-for-transformative-action-germany

[273] Inspired and adapted from Lorca's (Spain) SECAP summary information (Life adaptate project) http://lifeadaptate.irradiare.com/#/city/6/secap

Concept	Explanation
	stakeholders, to define the details (such as number of spot/posts per week, time). In addition, target audiences are identified to ensure that each informative action is tailored to the specific target group.
Mode of governance	Governing through enabling
Action type	Knowledge and behaviour change
Implementation timeline	2020-2030
Responsible bodies	Department of Health and Consumer Affairs
Stakeholders involved / affected	Business and private sector NGOs & civil society, Residents
Costs	EUR 30 000
Funding sources and financing instruments	Municipality's own resources, regional funds and programmes, national funds and programmes
Impact / outcome achieved	Reduce mortality associated with heat wave events, especially among the most vulnerable population groups (older people, children, sick, etc.)
	Quantitative indicators: Mortality rate during heat waves [mortality rate]; hospitalisations due to heat waves [number]
Implementing parameters	Track the effective implementation of the campaigns and the number of people reached
	Quantitative indicators: Number of information and awareness events [number]. People participating in the campaigns [number]
Other co-benefits / potential trade-offs	Reduce the costs related with hospitalisations and care on municipal centres due to the heat waves.
	*Quantitative i*ndicator: Hospitalisations due to heat waves [number]

Source: Inspired by Lorca (Spain) SECAP

Table 59. Adaptation action fiche 2: Reinforcing river flood protection measures

Concept	Explanation
Action title	Reinforcing river flood protection measures, inspired by and adapted from case study in Smolyan (Bulgaria) [274]
Main focus	Infrastructure

[274] Inspired by and adapted from case study in Smolyan (Bulgaria) European funds for flood protection measures in Smolyan (Bulgaria): https://climate-adapt.eea.europa.eu/en/metadata/case-studies/european-funds-for-flood-protection-measures-in-smolyan-bulgaria

Concept	Explanation
Action description	The municipality took measures to prevent damages in the district's infrastructure to future floods through the cleaning and expansion of the riverbed of the river to increase its capacity for dealing with high amounts of water.Through exposure maps and assessment of vulnerable assets, it was possible to identify the priority areas for implementing the actions. Significant amounts of material were taken from critical stretches of the riverbeds. Fallen trees and overgrown vegetation were removed, while construction works were carried out to strengthen bridge structures and the existing stone walls, which are particularly relevant for the security of the main bypass road above them.
Modes of governance	Municipal self-governing
Action type	Physical and technological
Implementation timeline	2011-2013 and 2017-2022
Responsible bodies	Municipality
Stakeholders involved / affected	Municipal departments; Population affected; Engineering firms
Costs	The costs of the first project on the first phase surmounted to BGN 933 438, or EUR 477 259 (indicative).
Funding sources and financing instruments	In the first phase, 5% of total cost of the first project was provided by the municipality while the greatest part of funding came from the EU through the operational programme "Regional Development 2007 – 2013". The second phase was funded by different sources such as by the municipal budget, the operational programme 'Environment' (2014 – 2020), Cross-border Cooperation Programmes, and by the Interministerial Committee on Disasters.
Impact / outcome achieved	Preserving people's lives and health, ensuring a higher degree of protection of infrastructure (main road communications) and commercial activities, ensuring a volume of free water in riverbeds to ensure the passage of a high wave.
	Quantitative indicators: People/neighbourhoods affected by the floods [number of occurrences]
Implementation parameters	The cleaning measures took out the river a significant number of materials and tree
	Quantitative indicators: Volume of material removed from the riverbanks [m^3]
Other co-benefits / potential trade-offs	To make living and working conditions in Bulgaria more attractive; to develop tourism potential; to stimulate investments in the municipality.
	Quantitative indicators: tourists visiting [number tourists/year]; investments in the municipalities [EUR]

Source: Inspired by and adapted from case study from Smolyan - Bulgaria

7.3 Energy poverty actions

To address the full scope of the energy poverty and its complexity, policy makers need to draw upon multiple toolboxes and adopt a variety of approaches to target the specific manifestations of energy poverty in their contexts, and plan policies in different areas and sectors.

While single specific measures might be effective, the combination of different actions has the potential of increased impact. Therefore, policies planned or already in place that have a different purpose, can be relevant to address also energy poverty.

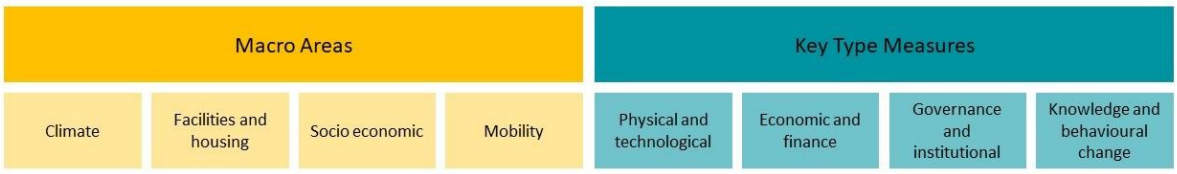
Numerous parallels and synergies can be created with energy efficiency measures primarily designed to achieve/address decarbonisation under the CoM climate change mitigation pillar. Furthermore, the collaboration with different groups of stakeholders is instrumental for planning tailored and context-specific actions through the contribution of different knowledge and areas of actions.

The following sections present policies for energy poverty and inspiring practices that have proven to be successful, also highlighting the engagement of different actors and complementarities across actions in other pillars.

Due to the multidimensional nature of energy poverty, the examples presented below may apply to multiple macro-areas simultaneously. For instance, a funding mechanism supporting housing retrofits to improve energy efficiency could be relevant to both the "facilities and housing" macro-area and "socio-economic" macro-areas. Examples are categorised according to their most prominent characteristics; thus, the funding mechanism example would be presented under the "socio-economic" macro-area as its primary focus is financial. However, examples should not be considered in an isolated way and could pertain also to other macro-areas.

As illustrated in Figure 12, the structure used to present policies and actions follows the categorisation in macro-areas used for the energy poverty assessment. Per each macro-area, four key type measures are presented with several policies and examples.

Figure 12. Categorisation of energy policies based on macro-areas and key types of measures



Source: JRC elaboration

7.3.1 Climate

This section explores energy poverty policies in the *climate* macro-area that are tailored to address geographic and demographic vulnerabilities. From mitigating summer energy poverty through cooling solutions to fostering resilience with financial tools and awareness campaigns, these energy poverty initiatives focus on targeted support for *at-risk populations*, including for example low-income households, women, and older people.

7.3.1.1 Physical and technological

Physical and technological measures for energy poverty in the *climate*macro-area aim to enhance infrastructure and leverage innovative solutions. These policies focus on reducing vulnerability to extreme climate conditions while improving energy accessibility and efficiency for vulnerable groups.

Combating summer energy poverty, that is the inability to afford cooling solutions or access safe, comfortable spaces during extreme heat, is one of the areas of intervention of these policies. In this case, measures look to prioritise investments in energy-efficient, comfortable housing and the expansion of urban greenery, such as green roofs, walls, and well-designed street vegetation that provide insulation and shade, and should be tailored to prioritise the most vulnerable.

Urban-scale interventions, such as mitigating heat islands[275] through the creation of favourable micro-climates at the street and neighbourhood level, are equally critical. This can include adding green spaces and urban shading systems to enhance cooling. Community-focused solutions are also emerging as key responses to the challenge of summer energy poverty.

Box 111. [Climate] Combating summer energy poverty in Barcelona and Madrid, Spain

As of 2021, the Barcelona's City Council[276] has established a network of 162 "climate shelters" located in parks, sports centres, museums, libraries, and schools. The shelters are distributed to ensure that 87% of the population has one within a 10-minute walk and operate during the summer months to offer relief from heat and humidity. Designed as safe, comfortable spaces, they maintain temperatures no higher than 26°C and provide water and resting areas.

In 2022, a participatory methodology was developed in Madrid[277] to co-design technical responses to summer energy poverty. Workshops combining collective mapping and neighbourhood-led walking tours engaged older residents in creating a cartography of strategies against excessive heat. Practical examples included identifying parks, libraries, and shaded plazas as climate shelters and mapping urban hotspots where intervention is urgently needed.

7.3.1.2 Economic and finance

Economic and financial measures for energy poverty in the *climate* macro-area aim to provide targeted economic support and investments. These policies focus on enabling vulnerable groups to access sustainable solutions and adapt to extreme climate conditions, for example through innovative funding and incentive mechanisms.

[275] Definition of urban heat islands: https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/urban-heat-islands-managing-extreme-heat-keep-cities-cool-2024-07-22_en

[276] Climate shelters in Barcelona: https://www.eppedia.eu/sites/default/files/2022-04/Zivzic-Tirado_2021_Summer%20EP%20in%20Mediterranean%20urban%20areas_EP-pedia.pdf

[277] Summer energy poverty in Madrid: https://www.sciencedirect.com/science/article/pii/S2214629624000409?via%3Dihub#s0090

Box 112. [Climate] Financial support for energy-poor households with disabled people in Cyprus

The Union of Cyprus Communities and the Cyprus Energy Agency provide financial aid to improve the energy efficiency of homes with disabled residents[278], reducing energy poverty and enhancing climate resilience. The programme offers subsidies for thermal insulation, energy-efficient appliances, and small-scale renovations, covering most costs with a 20% co-funding requirement.

By lowering energy consumption by at least 35% annually, the initiative helps vulnerable households cope with rising temperatures and extreme weather while reducing carbon emissions. This approach demonstrates how financial support can make climate adaptation accessible to those most at risk.

Box 113. [Climate] Looking beyond European practices: Innovative financial tools to better cope with extreme heat in Ahmedabad (India)

The Mahila Housing Trust (MHT)[279] promotes sustainable cooling solutions in Ahmeda-bad, such as passive adaptations and innovative financial tools, to address extreme heat. To help people adapt, MHT has been providing small loans over the past five years to its members for purchasing heat-reflecting white paint or roof panels to reduce heat absorption in their homes. Additionally, MHT piloted heat index insurance for low-income urban women in 2023. This parametric insurance provides automatic payouts when heat thresholds are reached, compensating for lost income. Clear data triggers, strong local distribution, and risk management mechanisms are essential for its success, ensuring vulnerable communities can adapt to rising temperatures.

7.3.1.3 Governance and institutional

Governance and institutional measures for energy poverty in the *climate* macro-area aim to foster coordination and collaboration. These policies focus on creating integrated strategies and partnerships that leverage diverse expertise, ensuring effective and innovative responses to the energy poverty challenges faced by vulnerable populations.

Box 114. [Climate] Interagency energy poverty task force

The municipality could establish an interagency energy poverty task force, bringing together experts from different departments and fields to develop and implement strategies to address energy poverty. The task force role could be formalised through an interagency agreement, ensuring coordination and collaboration across departments to reduce duplication of efforts and improve outcomes. By combining the strengths of different stakeholders, the municipality can develop a comprehensive and innovative response to energy poverty.

In a similar manner, but with a general focus on climate neutrality, in early 2023, The Hague, the Netherlands, created a municipal transition team[280] comprising policy colleagues from diverse departments, including sustainability, energy transition, mobility, circular economy, housing, smart cities, and urban planning. Acting as liaisons to their respective departments, team members facilitated knowledge sharing and ensured effective internal communication about the mission. The team met biweekly to collaborate on drafting the climate action plan. Subsequently, The Hague launched "The Hague Climate Tables" to engage stakeholders,

[278] Tackling energy poverty in households with disabled people in Cyprus: https://fedarene.org/best-practice/tackling-energy-poverty-in-households-with-disabled-people-and-supporting-social-integration/

[279] Mahila Housing Trust: https://www.centerforfinancialinclusion.org/inclusive-finance-and-extreme-heat-how-small-loans-and-parametric-insurance-can-help-vulnerable-populations-manage-through-deadly-heat-waves/

[280] Municipal transition team in the Hague: https://duurzamestad.denhaag.nl/denhaag-klimaatneutraal/the-hague-climate-agreement/

assess sustainability challenges, and foster collaboration on climate goals. The efforts made by The Hague culminated in the production of a climate city contract, that includes also actions on tackling energy poverty. While of a more general climate neutrality nature, the example from The Hague shows how interagency activities can lead to successful results having implications also on energy poverty.

7.3.1.4 Knowledge and behavioural change

Knowledge and behavioural change measures for energy poverty in the climate macro-area promote raising awareness, building capacity, and empowering communities. These policies can emphasise proactive strategies, such as education, early intervention, and engagement initiatives, to help vulnerable populations adapt to extreme climate conditions and adopt sustainable energy practices.

For these policies a key aspect is to look at energy vulnerability to take preventive action and avoid future situations of crises, anticipating and mitigating risks for vulnerable groups before they fall into energy discomfort. Policies can use this approach by focusing on early identification of at-risk households and targeted support to reduce their vulnerability to fluctuating energy costs or extreme weather conditions.

Box 115. [Climate] Heatwaves register and awareness campaign in Paris, France

The city of Paris has implemented a heatwave register[281] as part of its preventive actions targeting vulnerable populations, especially forextreme weather events during summer. Vulnerable groups—such as individuals aged 65 years and older, people over 60 who are unfit for work, and persons with disabilities —can register on this list, which is updated twice a year by the Communal Centre for Social Action. During heatwaves, which can lead to significant energy demands for cooling, registered individuals are regularly contacted by the municipalities' services to ensure they are safe and have access to cooling resources.

Box 116. [Climate] Empowering women to combat energy poverty in Mediterranean coastal areas (EmpowerMed)[282]

Women and women-led households are disproportionately impacted by energy poverty, especially in Mediterranean coastal regions, where summer energy poverty is exacerbated by inadequate cooling in poorly insulated homes. This vulnerability stems from structural inequalities, such as women spending more time at home due to traditional labour divisions and being overrepresented among those at risk of poverty and social exclusion. Additional regional challenges include precarious housing conditions, expensive electricity-based heating, arrears on utility bills, and employment insecurity, particularly in tourism and harbour-related jobs.

To address these issues, the EmpowerMed project focuses on empowering women to combat energy poverty in Mediterranean coastal areas. The initiative implements practical solutions, including training programmes and awareness campaigns, to enable vulnerable households to manage energy consumption effectively and access suitable energy technologies. By engaging women as central agents of change, EmpowerMed leverages empowerment in alleviating energy poverty and improving community resilience.

[281] Heatwave register in Paris: https://www.service-public.fr/particuliers/actualites/A14978?lang=en

[282] EmpowerMed project final report: https://www.empowermed.eu/wp-content/uploads/2023/09/EmpowerMed-report_final.pdf

7.3.1.5 Wrapping up the energy poverty policies for the climate macro-area

What makes these policies relevant to energy poverty?

The described cases are only exemplary practices for addressing energy poverty within the *climate* macro-area. They have been chosen as, unlike general climate or poverty measures, these actions focus on urgency, geography-specific risks, and targeted solutions to prevent and address specific manifestations of energy poverty (e.g. summer energy poverty). Barcelona's climate shelters emphasise energy affordability and social impact, offering accessible cooling options for vulnerable populations, particularly those at high risk during extreme heat. Ahmedabad's financial tools highlight financial support and innovative pathways to mitigate energy vulnerability, providing low-income households with resources to adapt to rising temperatures. Governance measures, like interagency task forces, ensure stakeholder engagement and the prioritisation of vulnerable populations, fostering collaboration to avoid duplication and maximise impact. Paris's heatwave register highlights the role of preventing energy poverty through proactive identification and support for vulnerable groups, such as the elderly and disabled. The EmpowerMed project targets women to address energy poverty through training programmes leveraging the role of behavioural change and empowerment.

Targeted groups:

- Older people
- Low-income households
- Women and women-led households
- Vulnerable groups exposed to extreme heat

What synergies exist between energy poverty policies in the climate macro-area mitigation and adaptation policies?

Energy poverty measures in the climate macro-area can align with general mitigation and adaptation strategies. Mitigation efforts, like energy efficiency and renewable energy sources, lower emissions and reduce energy costs for vulnerable groups. Adaptation actions, such as urban cooling systems, enhance resilience to extreme heat with implications on energy poverty, addressing both climate and social challenges.

What types of governance models can support energy poverty policies in the climate macro-area?

The energy poverty policies presented in the climate macro-area showcase diverse governance modes, enabling municipalities to adopt approaches tailored to their specific contexts and challenges. The examples presented highlight a variety of approaches available. Municipal self-governing is evident in Barcelona's climate shelters, where strategic investments in municipal buildings and assets provide immediate relief from extreme heat. Governing through provision is demonstrated in Ahmedabad's innovative financial tools, where direct funding mechanisms support sustainable cooling solutions for vulnerable populations. Paris's heatwave register highlights governing by authority, with municipalities regulating and planning proactive measures to protect vulnerable groups. Finally, the EmpowerMed project showcases governing through enabling, where municipalities foster collaboration and empower communities through training programmes and

public-private partnerships. These governance approaches ensure tailored and effective solutions to energy poverty challenges while integrating climate resilience objectives.

7.3.2 Facilities and housing

This section examines diverse policies addressing energy poverty in the *facilities and housing* macro-area. In this macro-area, policies aim to tackle energy poverty by implementing tailored policies that enhance energy efficiency and affordability within residential and urban spaces. By combining innovative infrastructure projects, financial incentives, regulatory frameworks, and community-driven initiatives, these measures address the specific needs of vulnerable populations. They promote sustainable living environments through targeted interventions, such as retrofitting buildings, enabling energy self-consumption, and fostering awareness of energy-efficient practices. Together, these approaches aim to reduce energy poverty while contributing to social equity, environmental sustainability, and long-term resilience.

7.3.2.1 Physical and technological

Physical and technological measures for energy poverty in the facilities and housing macro-area focus on enhancing infrastructure and promoting sustainable solutions. These policies aim to improve energy efficiency, reduce costs, and ensure better living conditions for vulnerable populations. By upgrading housing, modernising heating systems, and investing in efficient public utilities, these measures address energy vulnerabilities while fostering more equitable and resilient communities.

Box 117. [Facilities and housing] Sustainable and equitable housing development in Vienna, Austria

Vienna's approach to social housing, often referred to as "the Vienna Model"[283], is built on three key pillars: (1) municipal housing estates constructed and managed by the municipality of Vienna, (2) the renovation of existing buildings, and (3) subsidised new housing construction, which is the focus here.

Vienna strategically invests in new housing through the Vienna Housing Development Fund. Developers receive financial support to help keep both construction costs and rents at affordable levels. This includes a loan with a 1% interest rate, repayable over up to 40 years, which covers around 35% of the construction costs. The remaining financing comes from bank loans, developer equity, and sometimes contributions from tenants. During the repayment period, rents are set at cost-based levels. Unlike direct individual benefits, these subsidies allow the municipal government to have a direct influence on housing development.

To ensure high-quality construction and sustainability, Vienna organises property developer competitions (or property advisory boards for smaller projects with fewer than 500 units). These competitions are based on a four-pillar evaluation system—focusing on social sustainability, architecture, ecology, and economic viability. The goal is to build homes with innovative, energy-efficient designs and environmentally friendly features. An interdisciplinary jury selects the winning projects based on these criteria, ensuring that subsidies are used efficiently and that rents remain affordable, while meeting the needs of future residents. Both non-profit and commercial developers can participate in these competitions. The winning team is granted the right to purchase the land at a fixed price, which includes housing subsidies, in return for guarantees on planning standards, fixed construction costs, and stable rents.

The Vienna Model also employs additional strategies such as limited-profit housing construction, broad access to subsidised housing through inclusive allocation criteria, neighbourhood engagement, urban

[283] The Vienna Model: https://socialhousing.wien/policy/the-vienna-model

renewal, and policies aimed at preventing eviction. Subsidised housing is available to a wide range of residents—approximately 75% of the population—thanks to strong property subsidies and additional housing assistance. Relatively high-income thresholds ensure that middle-income households also have access to subsidised housing, helping to maintain a balanced social mix and avoid segregation. Funding for social housing construction is secured through the municipalities' own budget and earmarked federal funds, which are collected through a national housing tax, where both employees and employers contribute 0.5% of their income. Vienna receives approximately EUR 250 million annually from this tax, and in total, it spends around EUR 400 million a year on housing subsidies, with EUR 237 million allocated to new housing construction.

Box 118. [Facilities and housing] District heating with regulated tariff in Oslo, Norway

Oslo has implemented a district heating expansion project[284] aimed at providing efficient heating to municipal and residential buildings. The municipality has invested in upgrading its infrastructure and to ensure that end-users who are mandated to connect are not disadvantaged, tariffs are regulated to be lower than those for similar technologies. This initiative directly addresses energy poverty by providing a reliable and affordable heating source, improving the quality of life for many residents.

7.3.2.2 Economic and finance

Economic and financial measures for energy poverty in the facilities and housing sector aim to provide targeted support through innovative funding mechanisms and incentives. These policies focus on improving energy affordability and enabling vulnerable households to access energy-efficient solutions. By leveraging tax credits, grants, loans, subsidies and targeted social tariffs, these measures reduce financial barriers, promote housing upgrades, and ensure sustainable energy practices, contributing to long-term economic and social resilience.

Box 119. [Facilities and housing] Financial instruments tailored to energy poor needs in Scotland, United Kingdom

To address energy poverty a mix of financial instruments is essential to deliver both immediate support to help households afford energy costs and long-term investment in energy efficiency measures to reduce future energy bills. For example, low-income households often need fully funded grants to cover high upfront costs, while landlords may benefit more from low-interest loans to finance energy-efficient renovations. This tailored approach ensures that different groups can access the appropriate financial resources to make energy improvements without falling deeper into energy poverty. One key initiative in this space is the Home Energy Efficiency Programme for Scotland (HEEPS)[285], which combines various instruments such as grants and interest-free loans. HEEPS targets vulnerable groups through area-based schemes, offers loans for landlords to improve energy efficiency in rented properties, and provides homeowners with a mix of grants and 0% interest loans to fund energy efficiency upgrades and renewable energy installations. The programme also includes targeted support through the Warmer Homes Scotland initiative, which helps vulnerable households reduce fuel bills while improving the energy efficiency of their homes.

[284] District heating expansion project in Oslo: https://www.c40.org/case-studies/c40-good-practice-guides-oslo-broad-set-of-supportive-tools/

[285] Home Energy Efficiency Programme for Scotland: https://fundingportal.energysavingtrust.org.uk/HEEPSHEEPSABSABS/

Box 120. [Facilities and housing] Benefits for energy efficiency renovation in the Flemish region, Belgium, through tax credit and renovation loan benefits

The Flemish government provides incentives for renovation of buildings.

A property tax reduction for energy-efficient homes[286] is provided by Flemish government, if the interventions ensure the achievement of specific required levels of energy performance. The approach is applied to new constructions, renovations that are assimilated to new construction and buildings that undergo a major energy renovation.

Another benefit is that for energy renovation following a purchase[287]. Anyone who buys a house or flat with a poor energy performance (E or F label) in Flanders and carries out energy renovations to that property within five years, can take out a renovation loan from the lender in addition to the mortgage loan for the acquisition of the property. The Flemish authorities provide interest grants for this by annual reimbursing schemes.

Box 121. [Facilities and housing] Looking beyond European practices: Loans and grants for energy retrofit in energy poor areas in Toronto (Canada)

The "Taking Action on Tower Renewal Programme" (TATR)[288] provides a combination of loans and grants to eligible property owners to complete retrofits that increase energy efficiency and reduce greenhouse gas emissions while improving tenant comfort. Property owners can apply to the programme, based on building eligibility and an energy assessment, they receive funding for upgrades leading to the improvement of residents' comfort and greenhouse gas emissions reduction.

It is important to note that among the eligibility requirements, the residential rental apartment building must be in a neighbourhood improvement area (NIA) or in a Toronto community where residents live on low incomes.

The municipality covers the cost of improvements, borrowing, and a small administrative fee, adding these as a special charge on the property tax bill. Owners repay this charge over 5 to 20 years, and the payment obligation stays with the property if ownership changes. If energy improvements perform as expected after a year, the municipality may reduce the repayment term by applying a grant as loan forgiveness.

7.3.2.3 Governance and institutional

Governance and institutional measures for energy poverty in the facilities and housing macro-area focus on enhancing energy affordability and efficiency through clear regulations, planning, and collaborative frameworks. These policies aim to promote improved building performance, reduce energy costs for vulnerable households, and mitigate energy vulnerability through preventive actions. By engaging stakeholders and fostering cooperation among municipalities, housing associations, and civil society, these measures have the objective to contribute to sustainable improvements to housing conditions while addressing the specific needs of those most affected by energy poverty.

[286] Property tax reduction: https://www.vlaanderen.be/en/property-tax

[287] Energy renovation following a purchase: https://www.vlaanderen.be/en/moving-housing-and-energy/renovation-loan-with-interest-grant-for-energy-renovation-following-a-purchase

[288] Taking action on Tower Renewal Programme (TATR): https://www.toronto.ca/community-people/community-partners/apartment-building-operators/tower-renewal/taking-action-on-tower-renewal-tatr-program/

Box 122. [Facilities and housing] Local adoption of self-consumption regulation in Santa Cruz de Tenerife, Spain

The local government can establish a regulation on collective self-consumption, enabling households in a condition of energy poverty to consume energy sourced from renewables installed in municipally owned assets, (i.e. PVs on municipal buildings). The surplus energy produced by the municipal owned installed energy sources is shared with neighbouring households in need thereby, contributing to alleviating the excessive cost of electricity and representing a form of in-kind support. The municipality of Santa Cruz de Tenerife has proposed this solution locally adapting and enforcing the national legislation on self-consumption from renewables (Royal Decree 244/2019). For municipal buildings or facilities in which it is possible to install photovoltaic panels with a power surplus to their own needs, the surplus is shared with neighbouring homes. With this mode of self-consumption, the municipality seeks to alleviate the current energy deficiencies of the most vulnerable families and households[289].

Box 123. [Facilities and housing] Local adoption of energy efficiency guidelines in Szentendre, Hungary

Szentendre in Hungary plans to tackle energy poverty by incorporating minimum energy efficiency criteria into the settlement design decree and settlement regulation documents[290]. It also aims to make use of the guidelines for enhancing energy efficiency in households facing energy poverty[291] designed under the INTERREG project CO-EMEP "Improvement of cooperation for better energy management and reduction of energy poverty in HU-HR cross-border area[292] and to adopt them locally.

Box 124. [Facilities and housing] Establishing minimum energy efficiency standards for property rentals

The introduction of the energy performance certificates (EPC) has increased the knowledge and awareness of landlords and tenants on the energy performance of the properties owned or rented. However, there are seldom obligations in place for minimum energy efficiency standards for property transactions[293]. The local governments could set up a consultation process involving all relevant actors (i.e. housing associations, residents, enterprises, ESCOs…) on a proposal to put in place a regulation for both private and social rental processes, to ensure that the properties to be rented have a minimum energy performance level, i.e. from D upwards. Moreover, such requirements could be accompanied by financial incentives, EPCs' reliability, and awareness raising campaigns.

7.3.2.4 Knowledge and behavioural change

Knowledge and behavioural change measures in the facilities and housing macro-area address energy poverty through a multifaceted approach that that empowers individuals to make informed decisions about their energy consumption. These measures enable households to adopt energy-efficient practices, modify their behaviour, and make the most of available resources. By promoting awareness, education, and community engagement, municipalities can encourage residents to take an active role in reducing their energy expenditure, ultimately contributing to a more sustainable energy future.

[289] Source: SECAP of Santa Cruz de Tenerife

[290] Source: SECAP of Szentendre

[291] Energy efficiency guidelines: https://www.menea.hr/wp-content/uploads/2022/02/CO-EMEP-Guidelines-on-enhancing-energy-efficiency.pdf

[292] Cross border area: https://www.menea.hr/wp-content/uploads/2021/07/CO-EMEP_EP-definition-for-CBC-area_final.pdf

[293] Effort to boost minimum energy efficiency standards for all rented homes: https://www.gov.uk/government/news/home-upgrade-revolution-as-renters-set-for-warmer-homes-and-cheaper-bills

Box 125. [Facilities and housing] Distribution of energy saving kits in Dublin, Ireland

CODEMA, Dublin's Energy Agency, developed award-winning energy-saving kits[294] loaned by public libraries to help residents improve energy efficiency. Each kit, costing EUR 250, contains tools like thermometers, energy monitors, and guides. Launched in 2013, the initiative included training sessions and events to demystify energy-saving. A follow-up survey found that 86% of users became more mindful of energy use, achieving a 13% reduction. The project won the EU Sustainability Award in 2017.

7.3.2.5 Wrapping up the energy poverty policies for the housing and facilities macro-area

What makes these policies relevant to energy poverty?

The policies highlighted in this section demonstrate how targeted measures in the housing and facilities sector can effectively address energy poverty. These initiatives go beyond general climate mitigation or poverty interventions by focusing on energy affordability, efficiency, and vulnerability, tailored to the needs of specific populations and target groups.

For instance, Vienna's subsidised social housing model ensures affordable energy costs through cost-based rents while incorporating energy efficiency via sustainable construction practices. Financial tools, such as Scotland's Home Energy Efficiency Programmes (HEEPS), combine financial support with energy efficiency improvements, enabling low-income households to afford upgrades.

Furthermore, these policies prioritise social impact by fostering inclusion and proposing support schemes to meet the needs of affected households. In this way they target conditions that are specific to energy poverty.

Targeted groups:

- Low-income households
- Older people and persons with disabilities
- Tenants in energy-inefficient buildings or marginalised neighbourhoods.

What synergies exist between energy poverty policies in the housing and facilities macro-area and mitigation and adaptation policies?

Energy poverty measures in the *facilities and housing* macro-area can lead to positive synergies with mitigation and adaptation interventions by targeting energy efficiency and resilience within the built environment. Policies such as retrofitting homes, expanding district heating systems, and upgrading urban infrastructure can lead to reducing emissions while lowering energy costs, directly contributing to climate mitigation. At the same time, measures like minimum energy efficiency standards for rental properties enhance building performance and reduce vulnerability to extreme weather, aligning

[294] Energy saving kit (Dublin, Ireland): https://www.codema.ie/our-work/home-energy-saving-kit/

with adaptation goals. These integrated approaches ensure that interventions in *facilities and housing* strengthen the sustainability and resilience of urban living spaces.

What types of governance models can support energy poverty policies in the housing and facilities macro-area?

A range of governance approaches is available to municipalities when addressing energy poverty in the facilities and housing sector effectively as shown in the previous examples. Municipal self-governing as well as governing through provision is seen in Oslo's district heating with the municipality investing in modern infrastructure to heat municipal buildings. While regulation and planning feature in minimum energy efficiency standards and self-consumption regulations. Governing through enabling is reflected in Dublin's energy-saving kits and Szentendre's collaborative guidelines, empowering communities to address energy poverty sustainably. These governance modes highlight the flexibility of municipalities in tackling energy poverty challenges specific to the *facilities and housing* macro-area.

7.3.3 Socio economic

This section explores energy poverty measures that address the *socio-economic* macro-area by integrating affordability factors, technological solutions, and empowerment. Examples include renewable energy communities, tailored financial aid, and personalised advisory services. These initiatives specifically target energy-vulnerable groups, such as low-income households and tenants, fostering both immediate relief and long-term socio-economic resilience through tailored, inclusive approaches.

7.3.3.1 Physical and technological

Physical and technological measures for energy poverty in the *socio-economic* macro-area focus on developing infrastructure and innovative solutions that address energy poverty while fostering social cohesion and sustainability. These measures often involve renewable energy initiatives, such as energy communities, which promote energy autonomy, reduce energy costs, and support vulnerable populations. By integrating green energy technologies and optimising their performance, these interventions contribute to local development and long-term energy resilience.

Box 126. [Socio economic] Energy communities in Vaiano, Vernio e Cantagallo, Italy

Green Energy Community (GECO)[295], founded by the municipalities of Vaiano, Vernio, and Cantagallo (Tuscany, Italy), is an association aimed at establishing renewable energy communities (REC) in the Val di Bisenzio. The initiative seeks to promote sustainable energy solutions, environmental protection, and social cohesion by addressing the collective energy needs of local residents and businesses.

GECO brings together municipalities, energy service companies, and residents to drive innovation in green energy. The project prioritises those facing energy poverty by allocating part of the incentive recognised by the Gestore dei Servizi Energetici (GSE), to support them. Estra Clima, the technology partner, manages the communities and optimises their performance through a dedicated platform.

[295] Green Energy Community: https://www.estra.it/cer-geco-green-energy-community/

Through CERs, GECO fosters local development and energy autonomy, helping to decentralise energy production and create sustainable infrastructure for the long-term.

7.3.3.2 Economic and finance

Economic and finance measures for energy poverty in the *socio-economic* macro-area address energy poverty by providing targeted financial support and innovative funding mechanisms. These measures aim to reduce energy costs for vulnerable households through grants, vouchers, and subsidies while promoting sustainable energy solutions such as self-consumption photovoltaic systems. By prioritising low-income groups and reinvesting savings into revolving funds, these interventions create a sustainable cycle of support, enhancing both economic resilience and energy affordability.

Box 127. [Socio economic] Establishment of an "energy income" in Porto Torres, Italy

The Energy Income ("Reddito Energetico")[296] programme provides non-repayable grants to low-income households (determined by the economic condition index - ISEE) to install photovoltaic (PV) systems for self-consumption (without battery storage). This initiative is supported by Italy's Ministry of the Environment and Energy Security, and the National Energy Income Fund is managed by the energy service company GSE (Gestore dei Servizi Energetici).

The programme was initially launched by the Municipality of Porto Torres in Sardinia (Italy). Due to its success, the Italian government expanded it nationwide, prioritising regions in Southern Italy where the need is greatest. As part of the 2019 pilot project in Porto Torres, 50 PV systems were installed, allowing vulnerable households to save a total of EUR 9 000 on electricity bills and reduce CO_2 emissions by 65 tons. In the first year, surplus electricity fed back into the grid generated EUR 6 000 in revenue, which was reinvested into the programme's revolving fund.

Box 128. [Socio economic] Design of energy subsidies for most in need households in the UK

In case of subsidies, their structure needs to be developed suiting the needs and cases of energy poor households, i.e. subsidies should not be paid retroactively, to avoid that the households have to cover the expenses themselves[297].

The programme known as "Winter Fuel Payment"[298] from the UK government gives from £200 or £300 (EUR 230 or EUR 346 approximately) to help paying for heating for winter. The programme focuses on older population and gives the credit for those above 66 years and receives other social benefits from the government.

7.3.3.3 Governance and institutional

Governance and institutional measures for energy poverty in the *socio-economic* macro-area focus on creating frameworks that empower municipalities to address energy poverty through collaboration, regulation, and innovative funding models. The municipality can set up collaborations with enterprises, companies, NGOs to support and enable changes in vulnerable households in different ways. As

[296] Reddito energetico: https://www.futuraenergie.it/2020/08/17/reddito-energetico-il-modello-porto-torres-sara-esteso-a-tutto-il-paese/

[297] Programme to reduce energy poverty in the Czech Republic: https://www.sciencedirect.com/science/article/pii/S0301421517308650?pes=vor&utm_source=scopus&getft_integrator=scopus#bib16

[298] Winter fuel repayment: https://www.gov.uk/winter-fuel-payment

examples, agreements with NGOs can foster energy campaigns and tailored advice on energy efficiency measures; arrangements with utility companies can protect households with arrears on bills from disconnections. These measures enable municipalities to provide direct support to vulnerable households, engage stakeholders in co-designing inclusive policies, and leverage partnerships to maximise impact.

Box 129. [Socio economic] Management of the Housing Solidarity Fund at local level in Nice Côte d'Azur, France

The NOTRe law (New Territorial Organization of the Republic from August 7th, 2015) authorised the transfer of certain skills from the departments to the public inter-municipal cooperation establishment (établissement public de coopération intercommunale, EPCI). Thus, since January 1, 2017, the Nice Côte d'Azur Metropolis has been managing and administering the Housing Solidarity Fund (FSL)[299] on its territory. The FSL helps households in precarious situations who encounter difficulties in accessing or maintaining decent housing or who are unable to regularise their unpaid energy or water bills. The FSL intervenes with households by allocating aid for access to housing (deposit, guarantee to landlords), for remaining in housing (unpaid rent) and for unpaid water and energy bills (total or partial regularisation of a bill, prevention of an energy cut-off or subscription to a new contract). The implementation of the energy and water component of the FSL is the subject of agreements each year between the municipality and electricity, gas and water suppliers to constitute funds to help households. These suppliers when informed of a request, maintain the supply of water, electricity or gas, avoid prosecution and/or suspension. While the FSL mainly addresses housing policies for disadvantaged people, it represents an essential instrument as well for the alleviation of energy poverty in vulnerable households.

Box 130. [Socio economic] Co-design of social energy plans in European municipalities

To ensure that the most vulnerable populations are not only effectively reached by energy poverty actions but also have a say in how they are designed and implemented, decision-making processes should be fair, inclusive, and transparent. This goes beyond mere consultation, but ensures that everyone has equal access to participate, regardless of socio-economic or physical barriers. The ENTRACK project[300], funded under the LIFE Programme, exemplifies this principle by helping rural Mediterranean municipalities co-design social energy plans in collaboration with local stakeholders, including vulnerable groups. The project uses participatory methods such as workshops, consultations, and co-design sessions, focusing on capacity-building. It also considers how to provide logistical support to allow vulnerable groups (e.g., rural residents, older people, disabled) to participate. This includes adjusting meeting times to accommodate caregiving responsibilities, offering accessible information (e.g., plain language documents), and ensuring the most isolated communities are reached through local facilitators

Box 131. [Socio economic] Establishment of social impact bonds as innovative financing instrument

Social impact bonds (SIBs) are innovative policy instruments designed to finance interventions tackling social challenges through public-private collaboration. In a SIB, private investors provide upfront funding for programmes, with repayment by public authorities contingent on achieving predefined outcomes. This model shifts financial risk to investors, promotes efficient use of public funds, and enables scaling up small, impactful initiatives. SIBs encourage prevention, rigorous impact evaluation, and transparency while addressing funding gaps in public budgets. Despite challenges like complex collaboration and management

[299] Housing Solidarity Fund: https://www.nicecotedazur.org/services/logement/fonds-de-solidarite-pour-le-logement/

[300] ENTRACK project: https://entrack-project.eu/

costs, SIBs offer significant potential for addressing energy poverty. The WELLBASED project[301] aims to explore their application in this context.

7.3.3.4 Knowledge and behavioural change

Knowledge and behavioural change measures in the *socio-economic* macro-area play a vital role in empowering individuals and communities to take control of their energy consumption, make informed decisions, and access available resources. Through initiatives such as one-stop-shop 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, contributing to a more equitable and just energy landscape.

Box 132. [Socio economic] Local energy poverty alleviation offices in the POWERPOOR Project

The POWERPOOR project[302] develops support programmes for energy poor, facilitating experience and knowledge sharing, behavioural changes and small-scale no regret energy efficiency interventions while increasing the active participation of residents. The "energy poverty alleviation offices" are one of the key innovations of the project, directly involving and recognising the role of municipalities in addressing energy poverty. The local energy poverty offices act as a one-stop-shop of information, provide support to energy poor households both by directly proposing behavioural measures and no regret, low-cost energy efficiency interventions and by guiding them towards setting up or joining an existing energy community or cooperative and how to leverage innovative financing schemes. Additionally, in the energy poverty alleviation office, the benefits of implementing energy efficiency interventions and installing renewable energy sources are communicated, more energy efficient behaviours, practices and habits are encouraged. Twenty-two energy poverty alleviation offices have been established across eight countries. The offices are led by energy mentors who can be municipal employees, social workers, or interested individuals having followed a dedicated POWERPOOR training and certified through a POWERPOOR scheme.

Box 133. [Socio economic] Creation of "energy cafés" in Manchester, United Kingdom

The Horizon 2020-funded STEP-IN project aimed to develop a global methodology for analysing energy poverty. A central initiative, the "energy cafés"[303], provided free energy-saving advice in public spaces, allowing expert energy advisors to engage directly with people. These cafés, often held at community events or in busy locations with refreshments like tea and cake, created a relaxed environment for discussions on energy issues.

In Greater Manchester, a metropolitan region known for facing deep challenges related to poverty and inequality, STEP-IN hosted 10 "energy cafés", attracting around 271 visitors. Beyond offering practical tips on energy savings and switching to cheaper tariffs, the cafés were a platform for raising awareness about energy rights. They helped demystify energy bills and empower people to understand their energy rights and options regarding energy supply. The energy cafés also encouraged political discussions, providing a space for people to voice concerns and engage in local debates about energy policies and planning. This approach

[301] Wellbased project and social impact bonds: https://wellbased.eu/wp-content/uploads/2024/04/Rebecca_EEP-Forum_24-April_SIBs.pdf

[302] Power Poor project: https://powerpoor.eu/

[303] Energy cafés: https://eurohealthnet-magazine.eu/curbing-the-crisis-the-impact-of-energy-cafes/

not only increased awareness of energy rights but also sparked community involvement in shaping more equitable and sustainable energy solutions[304].

Box 134. [Socio economic] EcoHouse and energy advice point in Antwerp, Belgium

With the various housing offices and the EcoHouse[305] [306], Antwerp residents have a place for all kinds of customised advice and financial and technical guidance on living, buying, selling, renting and renovation. They can get inspired thanks to the many tips and concrete examples concerning less energy consumption and renewable energy. To reach target group of low-income households, adjustments on the communication needed to be made. Offering easy to implement solutions that bring immediate gains and not just complex and long-term solutions helped attract interest.

For social target groups, there are free energy scans and interest-free energy loans: 23 733 applications for energy scans, joint purchasing of green electricity, green loans and energy premiums combined were made in 2018. That is an increase of 72% compared to 2012[307].

Box 135. [Socio economic] Energy saving check in Germany

In cooperation with the Federal Association of Energy and Climate Protection Agencies in Germany, the charitable organisation Caritas introduced the "StromSparCheck" (energy saving check)[308], where currently in 150 locations throughout Germany long-term unemployed people are trained to provide energy-saving advice and low-cost technical devices free of charge to welfare recipients and low-income households. The target group is not further specified beyond that, thus not explicitly targeting energy poor (tenant) households or addressing gender-related inequalities. However, with the advised measures largely focusing on small technical fixes in the dwellings and behavioural adaptations, this initiative mostly addresses the situation of tenants (which also make up most recipients). While the project started off aiming to reduce the electricity consumption of these households, as they were directly benefiting from the resulting cost savings, it was extended later to also include activities to reduce the heating consumption. Public relations and advertising of the services involve local job centres and various other municipal and civil society organisations to reach the relevant target groups.

A similar initiative is being implemented in Barcelona, Spain. The Energy advisory points (EAP)[309] initiative to address energy poverty through building retrofits and job training.

[304] Empowering energy citizenship among energy poor: https://www.sciencedirect.com/science/article/pii/S221462962200158X?via%253Dihub

[305] EcoHouse: https://use.metropolis.org/case-studies/fighting-poverty-and-unemployment-while-reaching-city-climate-targets

[306] EcoHouse NetZzeroCities: https://netzerocities.app/resource-casestudy-2813

[307] Source: Antwerp SECAP

[308] Energy saving check: https://energy-poverty.ec.europa.eu/discover-community/epah-atlas/stromspar-check-energy-saving-check

[309] Energy advisory points: https://www.habitatge.barcelona/en/housing-services/problems-paying-your-home/energy-rights/energy-advising-points

7.3.3.5 Wrapping up the energy poverty policies for the socio-economic macro-area

What makes these policies relevant to energy poverty?

These measures address energy poverty by tackling both affordability and technological challenges, focusing on the provision of tailored information and advice that will lead to a reduction in energy consumption or increase in energy efficiency.

While these actions share similar objectives and approaches with broader energy-related campaigns, they distinguish themselves by focusing on specific energy-vulnerable groups, aiming to empower them with the knowledge and capacity to make informed decisions. Additionally, these measures integrate broader social goals, such as tackling unemployment, thereby addressing the underlying root causes of poverty and promoting long-term socio-economic stability.

Targeted groups

- Energy vulnerable population
- Lower income households
- Older people and pension beneficiaries
- Unemployed
- Tenants

What synergies exist between energy poverty policies in the socio-economic macro- area and mitigation and adaptation policies?

Energy poverty measures in the *socio-economic* macro-area align closely with mitigation and adaptation strategies, creating integrated solutions that address both immediate and long-term challenges. Incentives for energy efficiency upgrades reduce emissions and lower energy costs, supporting climate mitigation goals while improving living conditions for vulnerable households.

Community-driven initiatives, such as renewable energy communities, enhance local energy resilience and knowledge, aligning with adaptation efforts to safeguard against future climate risks.

What types of governance models can support energy poverty policies in the socio-economic macro-area?

The socio-economic macro-area showcases diverse governance modes that enable tailored and effective responses to energy poverty. Municipal self-governing is evident in initiatives like local energy offices, where municipalities invest in their own resources to provide targeted advice and support. Governing through provision is highlighted by policies such as energy vouchers and grants, which directly fund vulnerable households in the use of energy or by improving energy efficiency or adopting renewable energy solutions. Regulation and planning play a key role in frameworks like social energy plans and housing solidarity funds, ensuring that policies are inclusive, transparent, and address structural inequalities. Finally, governing through enabling is demonstrated by collaborative initiatives such as renewable energy communities and co-designed energy plans, which empower stakeholders and foster community participation. These governance approaches underscore the importance of flexibility and collaboration in addressing energy poverty within the *socio-economic* macro-area.

7.3.4 Mobility

This section explores energy poverty measures addressing the *mobility* macro-area. These measures show an increasing consideration of the end users' needs and foster inclusive and participatory approaches. For example, municipalities, in cooperation with other levels of governments, can reduce or abate public transport fees[310]. Such measures contribute to increasing social equity and alleviating energy poverty by providing affordable transport options to low-income groups while also addressing the topic of transport poverty[311] [312].

7.3.4.1 Physical and technological

Physical and technological measures for energy poverty in the *mobility* macro-area focus on leveraging innovative solutions to address energy poverty by improving transportation access and efficiency. These policies aim to reduce transport-related energy costs and enhance mobility for vulnerable populations, such as individuals with disabilities or limited access to public transport. By integrating smart technologies and optimising urban infrastructure, these measures promote equitable mobility solutions while fostering energy-conscious practices and reducing barriers to essential services.

Box 136. [Mobility] Smart mobility apps to combat transport poverty in Viana do Castelo, Portugal

Access to transportation is a critical issue for persons with disabilities, where mobility limitations hinder access to essential services and opportunities to self-develop and live a decent life. To address this challenge, the municipality of Viana do Castelo, located in northern Portugal, has developed a mobile application[313] specifically designed for people with permanent or temporary reduced mobility. This innovative solution provides users with detailed information on accessible taxi points, parking spaces, and key locations within the municipality. The app uses an optimised algorithm to calculate the shortest and most accessible routes, tailored to different mobility needs, such as for people who are deaf or visually impaired. By offering personalised navigation options, the application helps individuals with disabilities navigate the municipality more easily, improving their independence and reducing barriers to transportation. This technological solution exemplifies how smart mobility tools can enhance accessibility and combat transport poverty, ensuring that all people have equal access to urban spaces and services.

7.3.4.2 Economic and finance

Economic and finance measures in the *mobility* macro-area address energy poverty by reducing financial barriers to transportation. These types of measures can be developed and implemented by covering all citizens or tailoring only specific communities and user groups. Policies such as fare-free public transport systems, targeted subsidies, and sliding-scale ticket pricing enable vulnerable populations, including low-income households and older individuals, to access affordable and equitable mobility options. These measures promote the use of public transportation, reducing

[310] Source: Kębłowski, W. Why (not) abolish fares? Exploring the global geography of fare-free public transport. Transportation 47, 2807–2835 (2020). https://doi.org/10.1007/s11116-019-09986-6

[311] Transport poverty - Definitions, indicators, determinants, and mitigation strategies https://op.europa.eu/en/publication-detail/-/publication/0b300f5f-b125-11ef-acb1-01aa75ed71a1/language-en

[312] Energy poverty, transport poverty and living conditions - https://op.europa.eu/en/publication-detail/-/publication/166c5314-a023-11ec-83e1-01aa75ed71a1/language-en

[313] A mobile application to enhance mobility of people with permanent or temporary mobility disability – a case study in Portugal - https://www.sciencedirect.com/science/article/pii/S1877050921001290

reliance on energy-intensive private vehicles, lowering energy costs, and supporting inclusive urban mobility. By integrating socio-economic and equity considerations, they contribute to sustainable transport systems that reduce fossil fuel dependency while ensuring equitable access to opportunities for all social groups.

Box 137. [Mobility] Free public transportation options

In the last years, numerous municipalities have introduced free-public transports for their residents. This is the case, for example, of Luxembourg (LU) where all modes of public transport - buses, trains and the tram - are free of charge since 2020. In Nova Gorica (SI) and Lubin (PL) all buses in the municipalities are free. Tallinn (EE) offers a fare-free service[314] on buses, trams and trolleybuses within the municipality boundaries to -residents who register with the municipality through a validated personalised Smartcard. A similar approach has been adopted also by Torrevieja (ES), where the smart card[315] is issued to registered individuals who have no records of debts towards local administration and give also access to some museums.

However, implementing free-fare public transport on a structural basis may be challenging requiring changes in the business model and finding alternative funding sources to make up for lost ticket revenue.

In other examples, the introduction of free-fare tickets is limited to specific groups of users (including for example children, students, persons with disabilities, older people), or to specific periods (i.e. special events). In Brussels (BE), children under 12 travel for free on the transport municipal network if accompanied by a paying person or with a specific dedicated seasonal ticket.

Targeted subsidies and discounts can also be effective in supporting vulnerable and low-income groups. For instance, the Amsterdam Regional Transport Authority launched an initiative to grant residents of the region a limited number of '1.5-hour free travel' tickets to be spent on buses, trams, and metros. In Calgary (Canada), monthly passes are granted to low-income groups based on a sliding scale system[316] assigning a purchase price based on income. The less an applicant earns, the less they pay. This measure helps eliminate financial barriers and increase residents' participation in the community.

7.3.4.3 Governance and institutional

Governance and institutional measures for energy poverty in the *mobility* macro-area focus on fostering inclusive and participatory approaches to address energy poverty through improved transportation systems. These policies prioritise stakeholder engagement, co-design processes, and collaborative frameworks that empower communities, particularly marginalised groups, to contribute to the development of sustainable and accessible mobility solutions. By integrating diverse perspectives, these measures ensure that transport systems are equitable, efficient, and responsive to the needs of vulnerable populations.

[314] Free passenger transport: https://urban-mobility-observatory.transport.ec.europa.eu/resources/case-studies/free-passenger-transport-exploring-benefits-and-disadvantages_en

[315] Transport smart card in Torrevieja (Spain): https://torrevieja.com/en/smart-cards-for-torreviejas-bus-system/

[316] Calgary transit low income monthly pass sliding scale fare - https://www.calgary.ca/social-services/low-income/sliding-scale-transit-fare.html

Box 138. [Mobility] Establishing a “community mobility network” in San Casciano, Italy

The "community mobility network"[317] initiative, led by the municipality of San Casciano with the support of the Tuscany region, focused on empowering residents to address mobility challenges through participatory design. The process aimed to integrate existing public transport system with shared solutions by engaging residents, organisations, and vulnerable groups, including youth, the older people, and disabled individuals. Over 500 people participated, ensuring that the voices of the most affected were heard. The initiative not only sought to improve transport connectivity but also to foster social well-being by addressing accessibility issues, ultimately promoting social inclusion and quality of life.

Through workshops, surveys, and stakeholder engagement, residents co-designed solutions such as a new shuttle service, carpooling message boards, and private car-sharing initiatives. This process highlighted the importance of community-led actions to complement public sector efforts in creating sustainable and effective mobility systems, especially for marginalised groups. Central to this approach was the creation of a network dedicated to inclusive and sustainable mobility, which strengthened a shared governance perspective. The project, thus, highlights the importance of co-design and engagement approaches, where collaborative efforts between vulnerable communities, local institutions, and stakeholders can better address mobility and accessibility challenges.

7.3.4.4 Knowledge and behavioural change

Knowledge and behavioural change measures for energy poverty in the *mobility* macro-area focus on raising awareness and empowering vulnerable populations to adopt sustainable and equitable mobility practices. These policies emphasise the role of education, community participation, and data-driven insights to address transport poverty and energy vulnerability. By fostering inclusive dialogue and showcasing sustainable travel alternatives, these measures enable all citizens, including vulnerable groups, to actively participate in shaping fairer, more accessible mobility systems, ultimately reducing energy poverty and promoting social equity.

Box 139. [Mobility] Sustainable mobility in Barcelona, Spain

The Fair and sustainable mobility project[318], carried out from July to December 2020 with a co-financed budget of EUR 3 500 from the Barcelona City Council, aimed to address inequalities in mobility affecting vulnerable groups in Barcelona, particularly women living in suburban and mountainous areas. The project sought to explore how transport poverty and energy vulnerability intersect and promote sustainable and inclusive mobility solutions to reduce disparities. A key focus of the project was raising awareness about transport poverty. This effort involved identifying how mobility inequalities disproportionately impact marginalised groups and showcasing how sustainable travel alternatives can help address these challenges. Through various activities, the project encouraged vulnerable populations to adopt healthier, more sustainable travel practices. Simultaneously, it gathered data to better understand the mobility needs of these groups, especially those experiencing energy poverty, and created opportunities for them to voice their concerns and propose improvements. The project also promoted citizen participation, particularly among the most affected groups. By promoting inclusive dialogue and shared responsibility, it aimed to empower individuals to contribute to the development of fairer mobility systems. These efforts aimed to generate collective solutions that are environmentally sustainable and socially equitable, ensuring that mobility in Barcelona serves all its residents more effectively.

[317] Community mobility network: https://oidp.net/en/practice.php?id=1175

[318] Fair and sustainable mobility project: https://ecoserveis.net/en/donation/fair-and-sustainable-mobility/

7.3.4.5 Wrapping up the energy poverty policies for the mobility macro-area

What makes these policies relevant to energy poverty?

The policies presented in this section specifically address the intersection of energy affordability, accessibility, and social equity in the *mobility* macro-area and, unlike general climate or poverty alleviation measures, they mainly focus on removing transport-related barriers for vulnerable groups.

For example, Luxembourg's free public transportation and Calgary's income-based transit passes enhance affordability by eliminating or reducing costs for low-income households. The smart mobility app in Viana do Castelo targets vulnerability by improving accessibility for people with disabilities, offering tailored navigation solutions to meet diverse mobility needs. Initiatives like San Casciano's community mobility network demonstrate stakeholder engagement by involving marginalised groups in the design and implementation of solutions, ensuring their needs are prioritised. These efforts also promote social impact, fostering inclusion and equitable access to essential services.

Targeted groups:

- Low-income households.
- Persons with disabilities.
- Marginalised groups, including women and old people.

What synergies exist between energy poverty policies in the mobility macro-area and mitigation and adaptation policies?

Energy poverty policies in the *mobility* macro-area create strong synergies with mitigation and adaptation strategies, offering integrated solutions that address climate and social challenges simultaneously. By reducing reliance on private vehicles through fare-free public transport systems or income-based transit passes, these policies contribute to lower greenhouse gas emissions towards sustainable transport systems thereby aligning with climate mitigation goals. At the same time, initiatives like smart mobility apps and community-designed transport networks foster resilience by ensuring equitable access to essential services, for example for vulnerable groups, during extreme weather events or economic crises.

What types of governance models can be used for energy poverty policies in the mobility macro-area?

Municipalities can employ diverse governance modes to address energy poverty in the macro-area of mobility and, while implementing a specific action, multiple modes of governance can in some cases be used and overlap. For example, governing through enabling is reflected in the deployment of smart mobility solutions in Viana do Castelo, where municipalities collaborate with technology providers to empower individuals with disabilities and enhance transport accessibility. In addition, policies aiming to raise awareness and empower vulnerable populations to adopt sustainable and equitable mobility practices, such as the Fair and sustainable mobility project in Barcelona, belong to the same mode. However, individual measures are often based on a combination of several modes of governance. The policies providing free-fare public transportation system, ensuring mobility services to residents while also reducing energy costs and improving accessibility for everyone are framed within the modes of governing through provision and regulation and planning. Finally, the community mobility network in San Casciano, which uses participatory urban planning to design

inclusive transport systems integrating the existing network is an example where regulation and planning, governing through enabling and governing through provision overlap.

7.3.5 Energy poverty action fiches

This section presents two examples of energy poverty actions described with the action template. Refer to section 5.3 for explanations on how to fill in the corresponding fields of the template.

Table 60. Energy poverty action fiche 1: Energy advice points

Concept	Explanation
Action title	Energy advice points
Main focus	Energy poverty – *socio-economic* macro-area
Action description	The municipality establishes energy advice points to support residents in better understand their energy rights and improve their knowledge on services available to address energy poverty conditions. The action can monitor its progress by tracking the number of residents supported, the number of supplies regularised, and the amount of kWh saved thanks to the advice delivered.
[Mode of governance]	The mode of governance used by the municipality is a combination of "municipal self-governing" through the establishment of the advice points within the municipality facility and of "governing trough provision" through the delivery of advice services.
[Action type]	Knowledge and behavioural change
Implementation timeline	This action is typically implemented over multiple years. It can be experimented for a short period of time and then made a permanent service in case of success. For example, the municipality of Barcelona established this service in 2016 and run it as a pilot project in 2017. Following the success of the initiative it has been transformed into a permanent service.
Responsible bodies	Municipality departments to structure and run the initiative. Civil society organisations to establish outreach campaigns to targeted vulnerable groups. Engineering firms to support in the production of the technical material, training of staff responsible to deliver the energy advice.
Stakeholders involved	City council Residents Organisations coordinating the service Long-term unemployed individuals. Vulnerable groups Utility companies Civil organisations and NGOs Social workers and EngineersHousing offices

Concept	Explanation
Costs	Around 100 000 Euro to 2 M Euro, depending on the duration of the project and the level of outreach planned within the municipality, which in turn depends on the number of advice points to be established. For example, for the city of Barcelona the annual budget is of EUR M 1.89.
Funding sources and financing instruments	Municipality budget
Estimated impact / outcome	Considering the example of Barcelona that has implemented this type of action since 2017, the impact achieved can be summarised in the following results: Prevented 167 233 cases of basic utility cut-offs in the municipality (44 449 in 2023) Reduced the municipalities' cost of covering energy bills for vulnerable families from EUR 1 million to just EUR 50 000 Achieved savings of EUR 700 000 linked to energy advice delivered
	Quantitative indicators: Energy saved based on measures adopted [kWh saved]; Amount of money saved to cover the energy bills of vulnerable families [avoided cost EUR]; Number of electricity/gas supplies regularised or re-activated [Number of prevented cut-offs]
Implementation parameters	Considering the example of Barcelona that has implemented this type of action since 2017, the impact achieved can be summarised in the following results: Energy advice points attended to 222 027 people in total since their establishment Provided assistance to 87 350 households (over 14 600 in 2023 alone)
	Quantitative indicators: Total residents supported [number of residents]
Other co-benefits / potential trade-offs	Considering the example of Barcelona that has implemented this type of action since 2017, the impact achieved can be summarised in the following results: In 2020, 80% of people trained to work in energy advice points found permanent jobs after their contract with the service ended Other examples: Training and re-skilling of people currently unemployed that are hired to deliver the technical advice and work in the energy advice points. Health benefits improving home conditions for vulnerable populations. Reduced pressure on social services by reducing social support requests
	Quantitative indicators: Unemployment rate after the initiative [%]

Source: Energy advice points in Barcelona - https://www.habitatge.barcelona/en/housing-services/problems-paying-your-home/energy-rights/energy-advising-points

Table 61. Energy poverty action fiche 2: Support to women and vulnerable groups affected by energy poverty in climate sensitive regions

Concept	Explanation
Action title	Support to women and vulnerable groups affected by energy poverty in climate sensitive regions
Main focus	Energy poverty – *Climate* macro-area
Action description	Support households of women and other vulnerable groups to manage their energy consumption and improve access to appropriate energy resources in climate sensitive regions. The action can monitor its progress by tracking the number of residents supported, the amount of energy and water saved, and of CO_2 emissions avoided.
[Mode of governance]	The mode of governance used in this case is "governing through enabling", where municipalities foster collaboration and empower communities through training programmes and public-private partnerships.
[Action type]	Knowledge and behavioural change
Implementation timeline	The implementation of this action can be structured to last from 1 to multiple years depending by the degree of outreached aimed for. For example, in the case of the EmpowerMed project, actions were organised on a four years' timeframe, from 2019 until 2023.
Responsible bodies	Municipality departments or private consulting companies to structure and run the initiative. Academia, civil society organisations and private consulting companies to carry out the activities
Stakeholders involved	Local government representatives National policy makers European Union policy experts Vulnerable groups (women, children, older people, disabled persons) Social workers Engineers Health experts Energy poverty experts Utility companies (100 representatives) Non-governmental organisations (NGOs)
Costs	The total implementation cost could vary depending by the duration and, degree of outreach and geographical coverage of the actions. For example, the EmpowerMed project covered six municipalities across six different countries reaching more than 3 000 people and costed EUR M 1.95 for an implementation period of four years.
Funding sources and financing instruments	Different type of public or private funding could considered to finance this type of action.

	For example, the EmpowerMed project was financed by the European Union's Horizon 2020 research and innovation programme.
Estimated impact / outcome	Considering for example the EmpowerMed project, the impact achieved by this type of actions can be summarised with the following results: Saved over 1 100 MWh/year of energy, Saved over 7 700 m^3/year of water, Avoided 265 tonnes/year of CO_2 emissions and 315 000 EUR/year.
	Quantitative indicators: primary energy savings [kWh]; economic savings [EUR]
Implementation parameters	Considering for example the EmpowerMed project, the direct results achieved by this type of actions can be summarised with the following results: Empowered over 3 500 people, of whom over 2 100 were women, to tackle energy poverty, Avoided energy expenses 315 000 EUR/year.
	Quantitative indicators: total people empowered [number of people]; percentage of women beneficiaries [%]
Other co-benefits / potential trade-offs	Considering for example the EmpowerMed project, the impact achieved by this type of actions can be summarised with the following results: Saved over 7 700 m^3/year of water, Avoided 265 tonnes/year of CO_2 emissions. Other potential co-benefits: generate economic savings for households to be use in other essential goods; trigger investments in sustainable energy; improved health awareness and health conditions of vulnerable groups; reduction/lift of debt from vulnerable groups.
	Quantitative indicators: volume of water saved [m^3]; emissions avoided [CO_2]

Source: EmpowerMed project. https://www.empowermed.eu/wp-content/uploads/2023/09/EmpowerMed-report_final.pdf

7.4 Integrated actions

Integrated actions simultaneously address several sectors / hazards / macro-areas at the same time, or even address jointly more than one pillar by tackling mitigation (emissions reduction), adaptation (resilience), and energy poverty (equity and affordability) by leveraging systemic, multi-sectoral interventions.

Box 140. [Integrated actions] Turin (Italy): holistic approach in the development of the SECAP

Turin adopted a holistic approach when developing their SECAP, acknowledging the intricate relationships between environmental, economic, social and digital systems. This enables the municipality to monitor both direct and indirect impacts, as well as anticipate potential trade-offs and spill-over effects. By recognising its complex, multi-layer dynamics, Turin analysed and modelled its systems as interconnected components, including energy systems (generation, distribution and usage), built environment (residential, tertiary, industrial and services), mobility systems (various modes of transportation), waste and water management and green infrastructures. This comprehensive approach allows Turin to better understand the interdependencies between these systems and make informed decisions to ensure a more sustainable and resilient future.

The following sections explore some integrated approaches by focusing on the regulatory and governance level (climate mainstreaming and policy integration and integrated urban planning), bridging mitigation and adaptation with nature-based solutions and resilient infrastructure, or linking mitigation with socio-economic inclusion with circular economy and urban planning approaches. Additionally, community-led actions ensure long-term, just transitions. By embedding climate action across governance levels, municipalities can achieve synergies that maximise impact while minimising trade-offs, making them central to achieving the EU's climate neutrality and resilience goals.

7.4.1 Climate mainstreaming and policy integration

Climate mainstreaming refers to the systematic integration of climate considerations into all policy domains, ensuring that mitigation, adaptation and social equity objectives are embedded across governance levels (Pieterse & du Toit, 2025). At the EU level, frameworks such as the European Green Deal (European Commission, 2019), Fit for 55 and the Energy Efficiency Directive (EED) (European Parliament; European Council, 2023) require that climate action is not treated as stand-alone objective but a cross-cutting principle in urban development, economic planning, and social policies[319]. This approach is fully aligned with the development of SECAPs and contributes to the progress in the three main pillars.

Municipalities play a crucial role in operationalising climate mainstreaming through their governance structures. They can embed climate considerations by introducing climate-responsive budgeting, ensuring that all public expenditures are evaluated based on their contribution to emission reductions and resilience-building. Additionally, integrating climate action into zoning regulations and building codes (as advocated by the Energy Performance of Buildings Directive (EPBD)[320]and the Renovation Wave (European Commission, 2020)) ensures that new developments align with energy efficiency and climate adaptation goals. Moreover, cities can establish dedicated climate governance units, mainstream climate requirements in procurement processes, and foster inter-departmental coordination to prevent siloed approaches. Many municipalities, such as Barcelona, Rome, and Athens, have begun to appoint a chief resilience officer, a high-level official responsible for developing and implementing strategies addressing climate adaptation issues like climate impact, disaster preparedness, and social cohesion to ensure the municipalities are well-prepared for future challenges.

Beyond administrative measures, municipalities can leverage public-private partnerships and multi-stakeholder collaboration to enhance climate integration. For example, by incentivising district-scale retrofitting, municipalities can simultaneously improve energy efficiency, ensure climate resilience and lower costs for vulnerable populations. Furthermore, municipalities can incorporate climate risk assessments into urban planning processes to align with the EU Climate Adaptation Strategy, the National Energy and Climate Plans (NECPs), and the National Adaptation Plans (NAPs) ensuring infrastructure and social programmes are designed to withstand future climate risks.

[319] Towards 'just resilience': leaving no one behind when adapting to climate change https://www.eea.europa.eu/publications/just-resilience-leaving-no-one-behind

[320] Energy performance of buildings directive (EPBD) recast 2024 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401275&pk_keyword=Energy&pk_content=Directive

Notably, the recent focus at the EU level on the housing and energy nexus is crucial in addressing the intertwined challenges of climate change, energy efficiency and social equity. Efforts to ensure housing affordability, including considerations on running costs and the leave no one behind (LNOB) principle, are underway through initiatives such as the Housing Task Force and the upcoming public consultation on the Affordable Housing Plan (2026)[321].

Climate mainstreaming is inherently an integrated approach as it avoids fragmented policymaking and maximises co-benefits across sectors. By embedding mitigation, adaptation and energy poverty strategies into urban policies, municipalities can enhance their ability to attract funding, comply with EU regulations, and create liveable, climate-resilient communities. In this context, policy coherence and institutional capacity can significantly influence the success of climate mainstreaming, which should be paired with an adequate multi-level governance approach to align urban policies with national and EU climate targets.

Box 141. [Integrated actions] Mainstreaming climate action in Thessaloniki (Greece) and in Valencia (Spain)

Thessaloniki has developed and submitted a climate city contract[322], which integrates climate adaptation and mitigation measures into urban planning[323]. This contract provides a roadmap for achieving climate neutrality and mainstreaming adaptation and was developed through multi-stakeholder workshops. The municipality has explored various funding sources, including local, regional, national and EU grants, as well as public-private partnerships, to support the implementation of climate actions. With the climate city contract in place, the municipality is now well-positioned to create a transparent roadmap for sustainable investments in climate mitigation and adaptation.

In Valencia (Spain), a measurement and evaluation (M&E) system is being developed to support climate change mainstreaming[324]. This platform has the potential to accelerate the implementation of climate change solutions by providing a space for local enterprises to share their services with municipalities. By leveraging the M&E system, the exchange of ideas can be facilitated, as well as resources and expertise, ultimately driving climate action forward.

Further resources to support climate mainstreaming in the municipality context include the EU Covenant of Mayors resource library[325], Climate Adapt platform[326] from the EEA, which provides data on urban adaptation policies, climate risks and local best practices. The Mission on Climate-Neutral and Smart Cities[327] and the NetZeroCities knowledge repository[328] provide innovative climate city contracts

[321] Affordable Housing Initiative: https://single-market-economy.ec.europa.eu/sectors/proximity-and-social-economy/social-economy-eu/affordable-housing-initiative_en

[322] NetZeroCities: Climate City Contract: Thessaloniki: https://netzerocities.app/resource-4192

[323] Integrating adaptation in the Climate City Contract, Thessaloniki, Greece: Case Study https://eu-mayors.ec.europa.eu/en/climate-adaptation-case-study-thessaloniki-greece

[324] Measurement and Evaluation system for climate change mainstreaming (Valencia, Spain) https://eu-mayors.ec.europa.eu/sites/default/files/2024-01/Vale%CC%80ncia%2C%20Spain%20%28Region%29_PSF%20Case%20Study.pdf

[325] EU Covenant of Mayors Resource Library: https://eu-mayors.ec.europa.eu/en/resources/library/

[326] Climate Adapt platform: https://climate-adapt.eea.europa.eu/en

[327] EU Mission: Climate Neutral and Smart Cities: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/climate-neutral-and-smart-cities_en

[328] NetZeroCities knowledge repository: https://netzerocities.app/knowledge

and resources where climate action is mainstreamed across policies towards achieving climate neutrality by 2030. Last but not least, another resource is the Adaptation Mission platform (solutions)[329] where adaptation stories, Mission case studies and other resources can be found.

7.4.2 Integrated urban planning and design

Integrated urban planning[330] ensures that climate mitigation, adaptation and social equity are considered holistically in municipality development, rather than being addressed in isolation. By integrating climate priorities into spatial planning, zoning and transport policies, municipalities can create compact, energy-efficient, and resilient urban environments that reduce emissions while enhancing liveability and social inclusion (Wamsler et al., 2014).

Municipalities can support integrated planning by adopting climate-conscious land-use policies, prioritising dense, mixed-use developments that promote sustainable mobility solutions. The Renovation Wave (European Commission, 2020) and the Energy Efficiency Directive (EED) (European Commission, 2023) highlight the importance of energy-efficient building retrofits, which can be strategically linked to urban renewal projects to maximise climate benefits. Further, municipalities can establish low-emission zones (LEZs) and pedestrianised areas to simultaneously improve air quality, reduce emission, enhance urban resilience and improve liveability.

Box 142. [Integrated actions] Integrated urban planning in Lille (France) and Palma de Mallorca (Spain)

The municipalities of Lille[331] and Palma de Mallorca[332] have implemented innovative urban planning and design approaches to adapt to climate change. In Lille, the redevelopment of a 25 hectare industrial site along the Haute Deûle river incorporated a water cycle management system, green spaces and sustainable buildings to mitigate flood risks and reduce carbon emissions. The project prioritised social diversity, biodiversity, and low-carbon mobility, resulting in a resilient and sustainable eco-district. Similarly, in Palma de Mallorca, the "climate adaptive school paths" project aims to create comfortable and accessible public spaces for children, incorporating nature-based solutions such as permeable pavements, increased vegetation, and landscaping. Both projects demonstrate a holistic approach to urban planning, integrating environmental, social and economic considerations to create thriving and resilient municipalities. Key features of these approaches include green infrastructure, sustainable water management, low-carbon transportation, and community engagement, which can be replicated in other municipalities to address the challenges of climate change.

A key element of integrated urban planning is the alignment of energy, water, transport and green infrastructure. One example on how to address this is through positive energy districts (PEDs), where local renewable energy generation exceeds consumption, and the scale tackled allows for the piloting of innovative solutions. Such initiatives, supported by Horizon Europe's Smart Cities and Communities projects, can contribute to the three covenant pillars. Moreover, planning policies that mandate green infrastructure, such as permeable surfaces, flood-resilient urban designs, a

[329] Adaptation Mission platform- solutions portal: https://climate-adapt.eea.europa.eu/en/mission/solutions

[330] Integration of climate change adaptation in land use planning https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/adaptation-of-integrated-land-use-planning

[331] Lille, France - The banks of the Haute Deûle, an eco-district along the waterway https://eu-mayors.ec.europa.eu/en/node/200

[332] Creating climate-adaptive school paths with schools in Palma de Mallorca, Spain https://eu-mayors.ec.europa.eu/en/climate-adaptation-case-study-palma-de-mallorca-spain

determined amount of tree canopy or a minimum distance to a green area, ensure that new developments are climate-proof while also enhancing biodiversity and social well-being. Planning and implementing nature-based solutions can also positively impact summer energy poverty by helping regulate the microclimate and reducing the need for cooling.

In addition, the integration of climate action within urban planning is particularly relevant for addressing energy poverty. Retrofitting social housing, implementing district heating systems, and improving public transport accessibility directly enhance affordability and quality of life for vulnerable populations.

Further resources on integrated urban planning and design include the European Urban Initiative (EUI), which supports urban innovation and climate integrated planning and provides information on case studies; URBACT, a knowledge sharing platform helping municipalities implement sustainable urban policies or the New European Bauhaus (NEB) website, which links urban regeneration, aesthetics and sustainability. Other resources include the C40 Climate action guide for urban planners[333], and the Cities and Climate Action from UN Habitat [334].

7.4.3 Circular economy approaches

Applying circular economy approaches can be a relevant strategy for climate action[335], focusing on reducing waste, maximising resource efficiency, and lowering carbon emissions. The EU Circular Economy Action plan[336] and the Waste Framework Directive[337] set the foundation for municipalities to integrate circular principles into urban systems, ensuring suitable material use and minimising environmental impacts. Circular economy practices contribute to mitigation by reducing resource extraction and energy-intensive production, to adaptation by creating resilient local supply chains, and to energy poverty alleviation by promoting affordability and resource efficiency.

Box 143. [Integrated actions] Lahti's circularity approach (Finland)

Lahti's waste approach[338] incorporates economic and financial measures and is characterised by a comprehensive portfolio of actions that prioritise circular economy and sustainable consumption, including the development of circular procurement procedures, recycling and reuse of construction and demolition waste, and multi-use of buildings, showcasing a strategic focus on resource efficiency and cost-effectiveness.

Municipalities can implement circular strategies by designing policies for waste reduction, reuse and recycling. For instance, mandatory construction material reuse policies can significantly lower embodied carbon in buildings, aligning with the EPBD's emphasis on life-cycle sustainability.

[333] C40 – Climate action guide for urban planners https://www.c40knowledgehub.org/s/article/Climate-action-guide-for-urban-planners?language=en_US

[334] UN Habitat - Cities and climate action: https://unhabitat.org/world-cities-report-2024-cities-and-climate-action

[335] Capturing the climate change mitigation benefits of circular economy and waste sector policies and measures https://www.eea.europa.eu/publications/capturing-the-climate-change-mitigation

[336] Circular economy action plan: https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

[337] Waste Framework Directive: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

[338] NetZeroCities: Lahti (Finland) climate city contract: https://netzerocities.app/resource-4187

Box 144. [Integrated actions] Roskilde (Denmark) material banks platform

Roskilde (Denmark) has implemented a material bank approach[339] that involves the systematic collection, storage and reuse of building materials from demolition and construction projects. This approach aims to reduce waste, promote sustainability, and support the circular economy by keeping materials in use for as long as possible. The material bank operates through a virtual platform, a physical storage area and pop-up material banks, allowing for the exchange of information and materials between stakeholders, and enabling the reuse of materials in new construction projects, thereby minimising the need for new, raw materials and reducing environmental impacts.

Additionally, local governments can support waste-to-energy initiatives, where organic waste is transformed into biogas, reducing emissions while providing low-cost energy alternatives for vulnerable communities.

Box 145. [Integrated actions] Circular economy approaches in Milan (Italy)

The municipality of Milan[340] has fully integrated circular economy principles into its action plan, featuring a range of creative and comprehensive approaches to address key challenges. These include reducing food waste, implementing sustainable building methods, and improving waste sorting in diverse neighbourhoods, as well as initiatives like recycling glass in nightlife areas, promoting the use of imperfect produce, and constructing modular bike paths from recycled materials. A notable achievement is the development of a monitoring system to track the outcomes and impacts of product and waste repair, recovery and reuse activities across the municipality.

Urban circular economy projects also include sustainable food systems, such as urban farming and food-sharing networks, which enhance food security while lowering emissions from food transport and waste. Circular economy strategies can contribute to systemic resilience while creating economic opportunities in low-carbon urban transitions.

Box 146. [Integrated actions] Circular economy approaches in Brussels-Capital Region (Belgium)

The Brussels-Capital Region is transitioning towards a circular economy[341] through its "shifting economy" strategy, which aims to create a decarbonised, regenerative, and social economy. The municipality has adopted the doughnut model as a guiding framework, which prioritises both ecological sustainability and social equity. To achieve this, the region has defined "exemplary business models" that generate positive economic, environmental and social impacts, and has set a target for 2030 that all regional economic instruments will only support businesses that meet these standards. The municipality also provides support to businesses in their transition towards sustainability and circularity and uses success stories to raise awareness and convince businesses to adopt sustainable practices. By reforming economic policies and developing a supportive framework for businesses, Brussels aims to create new economic opportunities, preserve natural and human capital, and promote high-quality employment, ultimately contributing to a more circular and equitable economy.

[339] Material banks and marketplaces in Roskilde (Denmark): https://cityloops.eu/fileadmin/user_upload/Materials/Tools/Material_Banks_and_marketplaces/Material_banks_and_marketplaces_-_Demo_Report_Extract_Roskilde.pdf

[340] NetZeroCities: Milan (Italy) climate city contract: https://netzerocities.app/resource-4445

[341] The Brussels Donut: Shifting the economy towards an ecological and fair transition https://eu-mayors.ec.europa.eu/en/The-Brussels-Donut-Shifting-the-economy-towards-an-ecological-and-fair-transition

Further resources linked to circular economy approaches include the Circular Cities and Regions Initiative (CCRI)[342], an EU initiative to integrate circular economy in urban areas, which provides case studies on urban circular solutions. Ellen MacArthur Foundation provides specific content for circular cities[343] including relevant resources and case studies. Last but not least, it is worth to highlight the European Circular Cities Declaration (ICLEI)[344] that aims to accelerate the transition from a linear to a circular economy in Europe. It includes the Circular Cities Declaration Report 2024[345] including insights on the implementation of circular economy across European municipalities.

7.4.4 Nature-based solutions

Nature-based solutions (NBS) are an essential component of integrated urban climate strategies, providing multiple environmental, social and economic benefits. These solutions leverage natural systems to address climate change impacts, aligning with initiatives such as the EU Biodiversity Strategy[346], the Nature Restoration Law[347], and the Climate Adaptation Strategy[348]. By adequately managing natural habitats[349], incorporating urban forests, green roofs and façades, wetlands and permeable pavements, cities can reduce urban heat islands, manage storm water, enhance carbon sequestration and improve air quality.

Box 147. [Integrated actions] NBS in Bologna (Italy), Bonn (Germany), Zabok (Croatia), Piastów (Poland) and Prague (Czechia)

Nature-based solutions can integrate multiple benefits, such as mitigating urban heat island effect, promoting biodiversity, and enhancing community well-being. Bologna (Italy)[350] is developing a green bus stop (bus stops covered with living green canopies) demonstrator and a portfolio of NBS for the Impronta Verde area, while Bonn (Germany)[351] has implemented a green roof initiative with tax incentives, resulting in 148 green rooftops covering 44 000 m^2. Zabok (Croatia)[352] is planting trees on urban land to provide shade and promote biodiversity, and Piastów (Poland)[353] is creating pocket parks and a summer street to address extreme heat, droughts and heavy precipitation. Meanwhile, Prague[354] has transformed a 6-hectare field into a gentle agriculture project, Plužiny, with fruit trees and organic farming, providing a diverse landscape, shaded areas for walking, and ecological benefits, while harvesting crops for local kindergartens, schools and

[342] Circular Cities and Regions Initiative (CCRI) https://circular-cities-and-regions.ec.europa.eu/

[343] Ellen MacArthur Foundation: circular cities: https://www.ellenmacarthurfoundation.org/topics/cities/overview

[344] Circular Cities Declaration: https://circularcitiesdeclaration.eu/

[345] Circular Cities Declaration Report 2024: https://circularcitiesdeclaration.eu/about/ccd-report

[346] Biodiversity Strategy for 2030: https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

[347] Nature Restoration Regulation: https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-regulation_en

[348] EU Adaptation Strategy: https://climate.ec.europa.eu/eu-action/adaptation-climate-change/eu-adaptation-strategy_en

[349] Adaptive management of natural habitats: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/adaptive-management-of-natural-habitats

[350] Pilot development and finalising NBS plans in Bologna Italy https://eu-mayors.ec.europa.eu/en/climate-adaptation-case-study-bologna-italy

[351] Bonn, Germany - Green the roofs of the city https://eu-mayors.ec.europa.eu/en/node/210

[352] Planting trees on urban land in Zabok, Croatia https://eu-mayors.ec.europa.eu/en/climate-adaptation-case-study-zabok-croatia

[353] Pocket park and summer street in Piastów, Poland https://eu-mayors.ec.europa.eu/en/climate-adaptation-case-study-piastow-poland

[354] Gentle agriculture project in Prague (Czechia) https://www.adapterraawards.cz/databaze/2020/pluziny-setrne-zemedelstvi-v-praze

retirement homes. By adopting a holistic approach, these municipalities are demonstrating how NBS can be designed to achieve synergistic benefits, including reduced CO_2 emissions, improved water management, and increased ecological value, while also providing social and economic advantages for residents.

Municipalities can mainstream NBS by integrating them into urban planning regulations, requiring green infrastructure in new developments, and investing in ecological restoration projects. For example, green corridors that connect parks and forests enhance biodiversity while providing cooling benefits and improving public health. Similarly, blue infrastructure, such as restored rivers and wetlands[355], help municipalities adapt to floods and water scarcity, reinforcing both mitigation and adaptation efforts.

Box 148. [Integrated actions] NBS actions in Kranj (Slovenia)

Kranj (Slovenia)[356] showcases a strong commitment to managing its green and blue infrastructure, with a clear strategy to enhance biodiversity. This is evident in is innovative planning approaches, such as requiring green roofs for new buildings above a certain size, supporting urban gardens, and utilising spatial planning tools. Additionally, the municipality has outlined an impressive array of initiatives to promote sustainable agriculture, including plan and low-emission livestock production, with the goal of increasing local food production and self-sufficiency.

NBS also play a key role in addressing energy poverty, particularly by reducing cooling and heating demand. Green roofs and tree shading lower indoor temperatures in summer, decreasing reliance on air conditioning, while urban forests act as windbreaks in winter, reducing heating needs. NBS can provide cost-effective climate solutions while enhancing social cohesion and environmental justice.

Box 149. [Integrated actions] NBS to recover contaminated land in Baia Mare (Romania)

The EU-funded SPIRE project[357] in Baia Mare leverages phytoremediation to address historic soil contamination from industrial heavy metals. By using plants to extract, stabilise or volatilise pollutants, this approach offers a non-invasive cost-effective alternative to traditional remediation methods. Backed by scientific evidence, the project demonstrates the feasibility and scalability of harnessing nature's restorative power for long-term environmental recovery. Local communities actively participate in transforming underused urban spaces into safe, green areas through collaborative decision-making and landscaping, turning the initiative into a model for inclusive, sustainable urban renewal.

The effective adoption of NBS in urban and rural areas depends as well on the dissemination of knowledge and awareness among farmers, policymakers and local communities, enabling them to understand the benefits of e.g. soil regeneration, biodiversity restoration and adaptation potential, among others.

[355] Rehabilitation and restoration of rivers and floodplains https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/rehabilitation-and-restoration-of-rivers

[356] NetZeroCities: Kranj (Slovenia) climate city contract: https://netzerocities.app/resource-4443

[357] Re-naturing cities through phytoremediation: https://www.uia-initiative.eu/en/news/renaturing-cities-through-phytoremediation-how-nature-based-solutions-can-make-difference

Box 150. [Integrated actions] Raising awareness and knowledge in NBS: Torino (Italy) and Navas de San Juan (Spain)

Two examples of awareness raising and knowledge building can be found in Torino (Italy)[358] and Navas de San Juan (Spain)[359]. Torino has implemented a training programme to enhance knowledge and skills in nature-based solutions and the New European Bauhaus principles, resulting in increased awareness of the technical and legal framework behind adaptation and the importance of cooperation to achieve climate goals. Similarly, the municipality of Navas de San Juan (Spain) is seeking to raise awareness and disseminate its regenerative agriculture practices through European recognition and participation in forums, building on its pilots in private olive grove plots to reverse climate change.

There are vast resources on nature-based solutions available. Some references include the EU-funded projects NetworkNature[360], Connecting Nature[361], Nature4Cities[362] or CLEVER Cities[363], which can provide relevant resources for NBS research and projects, or land-use based adaptation and mitigation measures, like RethinkAction[364], to name a few. The European Commission's website on nature-based solutions[365] gathers a variety of resources. The Guidelines for co-creation and co-governance of nature-based solutions (European Comission et al., 2023) are also noteworthy.

7.4.5 Climate-resilient infrastructure

Climate-resilient infrastructure ensures that municipalities can withstand extreme weather events while supporting the transition to low-carbon energy systems. The EU Climate Adaptation Strategy and the Trans-European Transport Network (TEN-T)[366] emphasise the importance of investing in infrastructure that is both sustainable and robust against climate impacts. This includes flood-resistant transport systems, decentralised energy networks and robust building infrastructure, and is particularly relevant for critical infrastructure in the municipality.

Municipalities can enhance infrastructure resilience by upgrading energy grids to accommodate distributed renewable energy generation, ensuring reliability in the face of climate-induced disruptions. Similarly, nature-based flood management systems, such as permeable pavements and green areas, protect urban areas while reinforcing natural hydrological cycles. These strategies directly address energy poverty by ensuring that vulnerable communities have access to affordable, reliable and sustainable energy and mobility solutions.

As municipalities continue to grow and evolve, it is imperative to prioritise future-proofing critical infrastructure to ensure the resilience and sustainability of urban ecosystems. By incorporating

[358] Training for resilience in nature-based solutions in Torino, Italy https://eu-mayors.ec.europa.eu/en/climate-adaptation-case-study-torino-italy

[359] NBS Awareness with farmers in Navas de San Juan, Spain https://eu-mayors.ec.europa.eu/en/climate-adaptation-case-study-navas-de-san-juan-spain

[360] NetworkNature: https://networknature.eu/

[361] Connecting Nature: https://connectingnature.eu/

[362] Nature4Cities https://www.nature4cities.eu/

[363] CLEVER Cities https://clevercities.eu/

[364] RethinkAction project: https://rethinkaction.eu/

[365] European Commission: nature-based solutions: https://research-and-innovation.ec.europa.eu/research-area/environment/nature-based-solutions_en

[366] Trans-European transport network (TEN-T) https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t_en

forward-thinking design principles, adaptive technologies and climate-resilient materials, municipalities can reduce the risks associated with emerging challenges and create infrastructures that are better equipped to withstand the stresses of the future. Future-proofing critical infrastructure not only protects the significant investments made in urban development, but also safeguards the health, safety and well-being of residents.

Municipalities aiming to delve deeper into climate-resilient infrastructure can consult relevant reports such as the Technical Guidance on the climate proofing of infrastructure[367], or EU-funded projects such as the RESIN project: climate resilient cities and infrastructure[368].

7.4.6 Community-led climate action

Community-led climate action plays a critical role in ensuring that urban climate policies are socially inclusive, equitable, and responsive to local needs. The Just Transition Mechanism[369], the Social Climate Fund[370] and the European Climate Pact[371] emphasise the importance of citizen engagement, cooperatives and organisations in accelerating the energy transition. By fostering local participation, municipalities can ensure that climate policies not only reduce emissions and enhance resilience, but also generate social and economic benefits for all residents and boost public acceptability.

Another key aspect of community-led action is intergenerational participation, ensuring that all age groups, youth, working-age adults and older people, are actively involved in decision-making and implementation. Youth movements, such as Fridays for Future, have demonstrated the power of civic activism in pushing for ambitious climate policies. Schools and universities can integrate climate education and hands-on projects, such as urban gardening, energy efficiency campaigns, and local climate monitoring, empowering young people as agents of change. Meanwhile, older people often possess invaluable local knowledge on cost-efficient traditional climate-resilient practices (e.g. cooling techniques and water conservation methods), which can be integrated into urban adaptation strategies. By creating intergenerational dialogue platforms, municipalities can bridge knowledge gaps and enhance social cohesion, fostering inclusive climate governance.

Other interesting community-led climate actions are renewable energy communities (REC), as explained before (section 7.1.5), numerous benefits can be reaped in the three covenant pillars.

Beyond energy, other community-led climate action can be proposed, such as urban food cooperatives (to promote local, sustainable agriculture and reduce food waste), community-led resilience hubs (to provide shelter, emergency resources and social services during extreme weather events), or participatory budgeting programmes, where municipalities can vote on climate-related municipal investments, ensuring alignment with local needs.

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[367] Technical guidance on the climate proofing of infrastructure: https://op.europa.eu/en/publication-detail/-/publication/23a24b21-16d0-11ec-b4fe-01aa75ed71a1/language-en

[368] Climate resilient cities and infrastructure (RESIN) https://climate-adapt.eea.europa.eu/en/metadata/projects/climate-resilient-cities-and-infrastructure

[369] The Just Transition Mechanism: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en

[370] Social climate fund: https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/social-climate-fund_en

[371] European Climate Pact: https://climate-pact.europa.eu/index_en

Box 151. [Integrated actions] Community gardens in Berlin (Germany)

In Berlin (Germany), community gardens[372] are transforming urban spaces into vibrant green oases, providing residents with fresh produce and a sense of community. These collective gardens not only beautify the municipality and contribute to climate protection, but also foster social connections among neighbours who may have previously lived anonymously alongside each other. By sharing knowledge, time, and resources, urban gardeners are building stronger, more supportive communities, making the municipality a more liveable and sustainable place.

Community-driven approaches improve public acceptance, mobilise local knowledge and contribute to social innovation in climate governance. By fostering community ownership and participation, municipalities can drive the bottom-up transformation needed to achieve a climate-neutral and resilient future.

Further information on energy communities include the information on energy communities[373] from the European Commission, or the Communities for Climate (C4C)[374]. Additional resources on energy communities or community-led actions can be found in the European Climate Initiative (EUKI) website[375], which support community-led climate action projects in Europe.

7.4.7 Integrated actions fiches

This section presents three examples of integrated actions described with the action template.

Table 62. Integrated action fiche 1: green infrastructure

Concept	Explanation
Action title	Green areas and green roofs (Inspired by and adapted from 2030 climate nutrality action plan of Kranj (Slovenia)[376)]
Main focus	Mitigation – AFOLU Adaptation - extreme heat, floods
Action description	With the ambition to sustain and where possible, increase the carbon sequestration capacity of the urban green and blue areas, while at the same time contribute to the residents well-being, reducing heat islands, reducing flood risk and improve connectivity of habitats, the action foresees: (1) implementation of green-roof concepts and solutions among private and public investors on buildings with larger roofs; (2) improvements of major green and nature protected areas; (3) extending green areas; (4) new approach in maintenance of green public areas; and (5) nature-based solutions for increased biodiversity, sequestration and flood prevention.

[372] Community gardens in Berlin (Germany) https://www.berlin.de/en/urban-gardening/community-gardens/

[373] Energy communities: https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumers-and-prosumers/energy-communities_en

[374] Igniting change: renewable energy projects in C4C https://ec.europa.eu/regional_policy/whats-new/panorama/2025/03/26-03-2025-igniting-change-renewable-energy-projects-in-c4c_en

[375] European Climate Initiative (EUKI) https://www.euki.de/en/more-about-euki/

[376] NetZeroCities: Kranj (Slovenia) climate city contract: https://netzerocities.app/resource-4443

Concept	Explanation
[Mode of governance]	Municipal self-governing
[Action type]	Physical and technological
Implementation timeline	[Unavailble]
Responsible bodies	Municipal bodies
Stakeholders involved	Private investors, local communities, NGOs, National Institute of Nature Conservation, Local Tourism Board, National Forest Service, National Water Agency, public utility company and regional development agency of Gorenjska
Costs	Total costs: EUR 5 000 000 or EUR 74 074/t CO_2
Funding sources and financing instruments	Funding sources could include grants, loans, or public-private partnerships among other.
Estimated impact / outcome	Carbon sequestration (68 t CO_2/year sequestration) Reduce heat island effects Flood prevention
	Quantitative indicators: GHG emissions (tCO_2/y); temperature at detected heat islands (°C)
Implementation parameters	50 000 m^2 of additional and improved green areas and green roofs (20 000 m^2 open public green areas + 30 000 m^2 new green roofs)
	Quantitative indicators: areas of green roofs (m^2); area of open public green and blue areas (km^2); green areas protected (km^2); total number of green shelters (number); regenerated urban areas (km^2)
Other co-benefits / potential trade-offs	Increased quality of life/ liveability
	Quantitative indicators: resident's satisfaction [average score from 1 (lowest) to 4 (highest)]

Source: Kranj (Slovenia) climate city contract

The action of implementing green areas and green roofs allows addressing at the same time climate mitigation and climate adaptation priorities, while also generating social benefits. Green areas can offer a shelter during heat waves, while also constituting carbon sinks, improving air quality and increasing biodiversity. Similarly, green roofs can (1) provide insulation and reduce the amount of energy needed to moderate the temperature of a building; (2) reduce the urban heat island effect; (3) contribute to storm water management; (4) protect/increase biodiversity; (5) serve as community hubs, thus improving social cohesion.

Table 63. Integrated action fiche 2: renewable energy communities

Concept	Explanation
Action title	Renewable energy communities
Main focus	Energy poverty – socio-economic macro-area Mitigation – local electricity generation
Action description	Create renewable energy communities targeting population at risk of energy poverty. The action can monitor its progress by tracking the number of communities created and the number of households involved, the level of energy savings achieved, and the capacity of renewable energies installed.
[Mode of governance]	The mode of governance used in this case can be for example "governing through enabling" by facilitating the formation of these new entities, and "regulation and planning" by creating the regulatory conditions necessary for the establishment and operation of energy communities.
[Action type]	Physical and technological
Implementation timeline	The implementation of this action can include a short timeframe for the preparation and establishment of the energy community that can be estimated in one year or less, and a longer period ranging from one and more years for the operation and functioning of the energy community. For example, the project Green Energy Community (GECO)[377] had a timeline of three years from 2019 to 2022. As this was a demonstration project the timeline was limited in time. A functional energy community is expected to have a longer lifetime.
Responsible bodies	• Municipality departments • National Energy for Sustainable Development • Academia • Environmental Agency
Stakeholders involved	• Local governments • Research institutions • SME from the private sector • Civil society organisations and NGOs
Costs	The total implementation cost could vary depending by the size of the energy community and this could influence both the initial capital investment as well as the operational costs. For example, the GECO project was developed with a total budget of EUR 2.2 million
Funding sources and financing instruments	Different type of public or private funding could considered to finance this type of action.

[377] Interreg Europe GECO Green Energy Community https://www.interregeurope.eu/good-practices/geco-green-energy-community

Concept	Explanation
	For example, for the GECO project used funding from the facility European EIT Climate KIC.
Estimated impact / outcome	Considering for example the GECO project, the impact achieved by this type of actions can be summarised with the following results [12] • Installation of 14 MW of new power generated by photovoltaic plants, • Production of over 15.4 million kWh/year from renewable energy sources • Avoiding the emission of 58 000 tonnes of tCO_2/year into the atmosphere Quantitative indicators • Share energy community members at risk of being energy poor [%] • Annual energy generation [MWh/y] • Self-consumption rate [%] • Energy savings [MWh/y]
Implementation parameters	• Installed renewable energy capacity [MWp]
Other co-benefits / potential trade-offs	Other co-benefits associated with this type of actions include: economic savings for households, improved social cohesion, job creation, community engagement, awareness and education Quantitative indicators • Electricity energy saved per household per year [kWh] • Strengthening of social networks [% of residents who report feeling connected to their community] • Number of jobs created [number]

Source: Interreg Europe GECO Green Energy Community

The action of creating an energy community using renewable energy sources is relevant for both mitigation and energy poverty sectors because it reduces greenhouse gas emissions through renewable energy generation while simultaneously improving energy access and affordability for vulnerable populations at risk of energy poverty.

Table 64. Integrated action fiche 3: Climate shelters for local population and energy poverty vulnerable groups

Concept	Explanation
Action title	Climate shelters for local population and energy poverty vulnerable groups
Main focus	Energy poverty - climate macro-area Adaptation – extreme heat
Action description	Create a network of climate shelters to protect the local population from extreme climate events with particular focus on the energy poverty vulnerable groups.

Concept	Explanation
	The action can monitor its progress by tracking the number of climate shelters established, the percentage of population within 10 minutes distance from a shelter and the type of protections services offered by the shelter.
[Mode of governance]	The mode of governance used in this case is "municipal self-governing", where municipalities invest to create protected areas for communities and local population.
[Action type]	Physical and technological
Implementation timeline	This type of action can be structured with an initial period of technical feasibility followed by creation of the needed physical infrastructure and dissemination and sensitisation phases. For example, the project "GBG_AS2C - Blue, Green & Grey - Adapting Schools to Climate Change" [378] had a timeline of around 4 years covering the period 2019-2022.
Responsible bodies	Barcelona City Council Public Health Agency of Barcelona - sectoral agency
Stakeholders involved	Barcelona Consortium of Education Barcelona Cycle of Water – (public service provider) Barcelona Institute for Global Health - Higher Education and Research Institute Institute for Environmental Science and Technology UAB - Higher Education and Research Institute Vila Olimpica School
Costs	The total implementation cost could vary depending on the number of climate shelters to be established and the duration of their opening time. For example, for Barcelona the project "GBG_AS2C - Blue, Green & Grey - Adapting Schools to Climate Change" had a cost of almost 5 M Euro for the period 2019-2022 and it was financed with 1 M Euro from the municipality budget and with 4 M Euro with EU funding programme Urban Innovation Action. The average cost for each school covered by the project and converted in a climate shelter was of around EUR 200 000 on average.
Funding sources and financing instruments	Different type of public or private funding could considered to finance this type of action. For example, the city of Barcelona used both municipality funds and European funds.
Estimated impact / outcome	Considering for example Barcelona, the impact achieved by this type of actions can be summarised with the following results: • 88% of Barcelona inhabitants have a climate shelter less than a 10-minute walk from home, and 44% have one under a 5-minute walk.

[378] GBG_AS2C - Blue, Green & Grey_Adapting schools to climate change: https://www.uia-initiative.eu/en/uia-cities/barcelona-call3

Concept	Explanation
	• The network grew from 70 locations in 2020 to over 360 in 2024 shelters available during summer and over 130 in winter. • At least 4 500 children benefited from the initial pilot project, which also transformed 3 000 m^2 of schoolyards, and added 4 500 m^2 of urban green space.
	Quantitative indicators: • Percentage of residents with a climate shelter less than a 10-minute walk from home [%]. • Percentage of residents with a climate shelter less than a 5-minute walk from home [%]. • Number of climate shelters available in summer [number of shelters] • Number of climate shelters available in winter [number] • Number of children impacted by the project [number of children] • Surface of schoolyards impacted [square meters] • Surface of urban green space [square meters] • Decreased average temperature in the climate shelter's locations [degrees C]
Implementation parameters	Quantitative indicators • Number of climate shelters available in summer [number of shelters] • Number of climate shelters available in winter [number] • Number of children impacted by the project [number of children] • Surface of schoolyards impacted [square meters] • Surface of urban green space [square meters] • Surface of shaded areas in schools' courtyards, sand boxes and sportive areas and other locations used as climate shelters [square meters]
Other co-benefits / potential trade-offs	Other co-benefits associated with this type of actions include health benefits, economic benefits, or community engagement.
	Quantitative indicators • Air pollution reduction [tonnes of pollutants reduced per year] • Percentage of population reporting improved mental health [%] • Number of people engaging in physical activity per week [number] • Number of heat-related illnesses per 100 000 inhabitants per year [number] • Job creation [number of jobs] • Community event participation in impacted areas [number of attendees per event] • Community satisfaction [percentage of population satisfied with community initiatives measured with surveys]

Source: GBG_AS2C - Blue, Green & Grey - Adapting Schools to Climate Change

This action of creating a network of climate shelters is relevant for both adaptation and energy poverty sectors because it provides climate resilience by offering protection from extreme weather events, while also addressing energy poverty by ensuring vulnerable groups have access to safe, cool spaces during heatwaves, potentially reducing their need for energy-intensive cooling.

8 Conclusions

This document has provided a series of steps to guide in the design of actions and prepare the subsequent implementation. It has also observed the particularities of the different Covenant pillars (mitigation, adaptation and energy poverty) and has introduced guidance towards planning integrated actions to accelerate the transition. While planning local-level energy and climate actions, the following aspects are fundamental:

Well-conceived and targeted actions. The actions defined by municipalities need to be well conceived and targeted, demonstrating a clear understanding of the needs and challenges faced by the local community and the ambition pursued, which has been explored in previous steps (emissions inventories, RVA and energy poverty assessments). By taking a nuanced and informed approach that carefully considers the municipality's unique circumstances and the needs of its residents and stakeholders, municipalities can define a set of actions that are tailored to the local context, increasing the likelihood of success.

Adequate definition and planning of actions, timelines and uncertainties. When defining the action plan, establishing clear scopes and timelines, as well as considering uncertainties becomes crucial. By clearly outlining what needs to be done, when, how and by whom, the municipality can establish a roadmap for success that minimises the risks of delays or setbacks. The incorporation of contingency plans and flexibility into the timeline can also demonstrate a pragmatic understanding of the complexities and uncertainties inherent in urban planning, and in a changing environment.

Support and engagement of residents and stakeholders. Effective climate action should be achieved in a collective manner. Municipalities' efforts to engage and support residents and stakeholders are a crucial factor in the development of its actions. By fostering a sense of ownership and inclusivity, not only can municipalities tap into knowledge and expertise of the local community and increase trust, but also leverage private investment, resulting in a more comprehensive, effective and impactful plan.

Commitment not only to definition, but also implementation and monitoring. The commitment to specific goals does not end with the definition of the action plan. While the definition of actions is essential, it is only the first step towards creating meaningful change. Municipalities should put their plan into practice and continuously assess and adjust the approach as needed in view of achieving tangible results. By establishing a robust monitoring system, the municipality can track its progress, identify areas for improvement and make data-driven decisions to optimise its efforts and ensure reaching the envisaged targets and goals.

Adoption of a systemic view and promotion of synergies. Promoting synergies and adopting a systemic view are fundamental to accelerate implementation and maximise benefits. By understanding and leveraging the interconnectedness of actions to address sectors, hazards or macro-areas, it is possible to identify opportunities to leverage resources in a more efficient manner and achieve a greater impact.

Attention to co-benefits and trade-offs. Recognising that every action has the potential to create both positive and negative secondary consequences is vital. Minimising harm and maximising benefits is critical towards ensuring impact and boosting acceptability of actions. Municipalities should balance competing priorities (economic, social or environmental) and seek to create win-win solutions whenever possible.

By acknowledging and addressing these key aspects, municipalities can be well positioned to develop and implement effective climate action plans towards a more just and resilient community, where the needs of all stakeholders are considered.

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List of abbreviations and definitions

Abbreviations	Definitions
AFOLU	Agriculture, forestry and other land use
AGIF	Agency for the Integrated Management of Rural Fires in Portugal
ASI	Avoid-shift-improve
BIPV	Building-integrated photovoltaics
BGF	Blue Green Factor
CapEx	Capital expenditures
CER	Critical entities resilience directive
CCS	Carbon capture and storage
CCRI	Circular Cities and Regions Initiative
CCU	Carbon capture and utilisation
CHP	Combined heat and power
CoM	Covenant of Mayors for Climate and Energy
CSO	Combined sewer overflow
C&D	Construction and demolition
DRMKC	Disaster risk management knowledge centre
DSO	Distribution System Operator
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
EEA	European Environment Agency
EED	Energy Efficiency Directive
EIT	European Institute of Innovation and Technology
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Contracts / Energy Performance Certificate
EPCI	Èstablissement public de coopération intercommunale - public inter-municipal cooperation establishment
ESCO	Energy service companies
EU	European Union
EUI	European Urban Initiative
EUCRA	European Climate Risk Assessment
EWS	Early warning system
FSL	Housing Solidarity Fund
GHG	Greenhouse gas emission
GIS	Geographic information systems
GPC	Greenhouse Gas Protocol
GWDC	Gigawatts direct current
HEWS	Heatwave Early Warning Systems
HVAC	Heating, Ventilation and air conditioning
ICT	Information and communication technologies
IFI	International financial institutions
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial processes and product use
IRM	Royal Meteorological Institute
ITS	Intelligent Transportation Systems
JRC	Joint Research Centre
KAYT	Know as you throw
KIC	Knowledge and innovation community

Abbreviations	Definitions
KPI	Key performance indicator
KTM	Key type measure
LEED	Leadership in Energy and Environmental Design
LEZ	Low emission zone
MaaS	Mobility as a service
MLS	Multi-layered water safety concept
M&E	Measurement and evaluation
NAP	National adaptation plan
NECP	National energy and climate plan
NBS	Nature-based solution
NGO	Non-governmental organisation
NEB	New European Bauhaus
NECP	National energy and climate plan
LED	Light emitting diodes
LEZ	Low emission zones
LNOB	Leave no one behind
LULUCF	Land use, land-use change and forestry
OpEx	Operational expenditures
PAYT	Pay as you throw
PED	Positive energy districts
PEN	Positive energy neighbourhoods
PESTLE	Political, Economic, Social, Technological, Legal and Environmental
PLE	Public lighting environment
PPP	Public-private partnership
PV	Photovoltaics
REC	Renewable energy communities
RES	Renewable energy sources
RVA	Risk and vulnerability assessment
SECAP	Sustainable energy and climate action plan
SGIFR	Integrated Rural Fire Management System in Portugal
SIB	Social impact bonds
SME	Small-medium enterprise
SUMP	Sustainable urban mobility plan
TBE	Tick-borne encephalitis
TDM	Transport demand management
TEN-T	Trans-European Transport Network
UAA	Utilised agricultural area
UAV	Unmanned aerial vehicles
UHI	Urban heat island
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UV	Ultraviolet
UWWTD	Urban wastewater treatment directive
WHO	World Health Organisation

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Annex 1. Summary of action-level indicators (examples)

The following table provides an overview of the different indicators that can be used at action level to measure the impact, track the implementation process and assess potential co-benefits. For each category of indicators two examples are provided per action, with the objective to showcase the differences among the types of indicators.

Table 65. Summary of action-level indicators (examples): impact, deployment, co-benefits and trade-offs

Objective	Action example [pillar]	Impact indicators	Implementation indicators	Co-benefits indicators	Trade-offs indicators
		Indicator(s) [Unit]	Indicator(s) [Unit]	[Type] - Indicator(s) [Unit]	[Type] - Indicator(s) [Unit]
Reduce GHG emissions by 55% compared to the baseline year	Substitution of the municipal vehicle fleet by electric vehicles [mitigation]	- GHG emissions for the municipal vehicle fleet [tCO_2eq] - Annual fuel consumption by the municipal vehicle fleet [MWh]c	- Vehicles substituted [Number of vehicles] - Share of electrical vehicles in the total municipal fleet [electric vehicles/total municipal fleet (%)]	- [Env] - Air quality (reduced particulate matter) [$\mu g/m^3$] - [Eco] - Reduction in municipal fleet operational costs [€/year]	- [Eco] – Increase in upfront costs [€/vehicle] - [Soc] – Job displacement in traditional automotive industry [Number of jobs lost]
	Energy retrofit of residential buildings [mitigation]	- Total energy consumed in residential buildings [MWh] - Total fuel for heating consumed in residential buildings [MWh]	- Total implemented measures at the households [number of measures/number households] - Number of buildings refurbished [total number or in share of the buildings target]	- [Soc] - Increased comfort [% of residents reporting improved comfort] - [Eco] - Increase in property values of refurbished buildings [% increase in property value]	- [Gov] – Administrative burden on municipalities [Number of permits required] - [Soc] – Disruption to household life during refurbishment [Number of households temporarily relocated]

	Discontinuation of active open-air landfills [mitigation]	- Types of waste treatment by process (e.g. incineration, landfills, biological treatment) [Share of all process types (%)] - Total waste not disposed in open-air landfills [tonne/y]	- Efficient waste treatment facilities built [Number of new facilities] - Total landfills discontinued [Number of discontinued landfills]	- [Soc] - Reduction in odour and noise pollution-related complaints from nearby residents [% reduction in complaints] - [Eco] - Increase in revenue from recycling and composting activities [€/year]	- [Eco] – Increase in waste management costs [€/tonne of waste] - [Gov] – Complexity of alternative waste management infrastructure [Number of facilities required]
Reduce the annual expected loss due to floods in the city by 80% by 2025	Implementation of flood protection infrastructure [adaptation]	- Annual expected loss avoided [€] - Number of people protected from flooding [number of people]	- Meters of flood protection infrastructure implemented [meters] - Total investment in flood protection infrastructure [€]	- [Eco] - Number of jobs created in construction and maintenance [Number of jobs] - [Soc] - Improvement in public safety and sense of security among residents in protected areas [% of residents reporting increased sense of safety]	- [Env] – Loss of natural habitats [Hectares of natural habitats affected] - [Soc] – Impact on community character and aesthetics [% of residents reporting negative impact on community character]
	Establish floods early warning systems (EWS) [adaptation]	- Infrastructure protected due to EWS [Infrastructure] - Reduction in flood-related casualties [number of people]	- Percentage of municipal employees using the EWS [% of employees] - Total coverage area of EWS [km^2]	- [Soc] - Increase in public awareness and preparedness for floods [% of population aware and prepared] - [Gov] - Increased public trust in government's disaster management capabilities [% of population trusting government]	- [Soc] – Public anxiety and stress from false alarms [Number of false alarms per year] - [Env] – Impact on wildlife from increased infrastructure [Hectares of natural habitats affected]

Protect 100% of the population living in high-risk coastal areas to safer zones by 2030 to reduce exposure to sea-level rise	Financing incentives for the protection of residential buildings in highly vulnerable areas due to sea-level rise [adaptation]	- Number of households protected [households] - Reduction in population exposed to sea level rise-related flooding [number of people]	- Volume of financing incentives deployed [€] - Number of households that have received financing incentives for relocation [number of households]	- [Soc] - Increase in access to basic services (healthcare, education) [% of relocated population] - [Soc] - Increase in economic opportunities and job creation in relocated communities [% increase in employment rate]	- [Soc] – Displacement of low-income households [Number of households displaced] - [Gov] – Complexity of incentive scheme administration [Number of bureaucratic steps for households to access incentives]
	Implement flood resilient construction standards [adaptation]	- Number of buildings following the standard that have been affected by floods [Buildings] - Reduction in flood-related damages to buildings and infrastructure [€/year]	- Number of existing buildings following the standard [Buildings] - Number of building permits issued for new construction in compliance with flood resilient construction standards [Number of permits]	- [Eco] - Increase in property values due to flood resilient construction [€/m^2] - [Soc] - Improved public health and safety due to reduced flood risk [% of population benefiting from improved health and safety]	- [Eco] – Increase in upfront construction costs [% of increase in upfront costs] - [Soc] – Potential displacement of low-income households [Number of households displaced due to increased costs]
Enhance the resilience of the energy sector by reducing the risk of power outages due to extreme weather events (floods, storms, extreme heat) by 30% by 2032	Implementation of energy storage [adaptation /mitigation]	- Number of power outages [Outages] - Number of affected customers [Customers]	- Energy storage capacity implemented [kWh] - Percentage of critical infrastructure with energy storage [%]	- [Eco] - New revenue streams [€/year] - [Eco] - Jobs created [Jobs]	- [Env] – Resource extraction for battery production [Tonnes of lithium extracted] - [Gov] – Complexity of grid integration [Number of regulatory hurdles to overcome]

Reduce the number of households expending more than x% of their income in energy	Training and awareness campaigns to vulnerable households on energy efficient measures [energy poverty]	- F+G + H band (EPC) dwelling / total number of dwellings [Share (%)] - Energy consumption (electricity + heating) per capita [MWh/y/per person]	- Number of people participating in the campaigns [number of people] - Total training activities implemented [number of training events]	- [Soc] - Increase in sense of community empowerment among participants [% participants reporting increased sense of control] - [Eco] - Increased local business revenues from energy efficiency services [€/year]	- [Eco] – Opportunity cost of public spending [€/household] - [Gov] – Difficulty in reaching hard-to-reach households [% of eligible households not reached by campaigns]
	Implementing funding for energy expenditure on vulnerable population groups [energy poverty]	- Share of energy expenses in the total income of vulnerable families [Share (%)] - Savings on energy expensed on vulnerable families [Cost (€)]	- Total implemented measures at the households [number of measures/number households] - Families receiving financial support [number of families]	- [Soc] - Reduction in energy poverty-related health issues [% of affected population] - [Soc] - Increased public trust in government's commitment to address energy poverty [% of population]	- [Gov] – Administrative costs of funding distribution [€/ beneficiary] - [Eco] – Opportunity cost of alternative social spending [€/beneficiary that could have been spent on alternative social programmes]
Reduce the commuting time to access essential services	Increase cycling routes in suburbs / rural areas [energy poverty/mitigation]	- People not having access to essential services within 1 hour by walking, cycling or public transport / total population [Share (%)] - Average time to reach essential services [Hour or minutes]	- Extension of cycling paths built [Km] - People using bicycles to reach their destination [number of people]	- [Soc] - Improved public health due to increased physical activity [% of healthy residents] - [Eco] - Increased local businesses revenues from cycling-related services [€/year]	- [Eco] – Diversion of funds from other transportation projects [€/km of cycling route] - [Env] – Land use changes due to cycling infrastructure [Hectares of natural habitats affected]

Annex 2. Summary of case studies / best practices included in the guidebook

The following table includes a summary of the case studies presented in this document, to be used as a quick reference for municipalities to search among them and find inspiration. The table is also available in excel format for ease of use[379]. The table is organised as follows:

— Covenant pillar scope [mitigation / adaptation / energy poverty]: under these columns the scope addressed by each case study is showcased. I.e. in the case of mitigation, the main mitigation sectors are reported, in the case of adaptation the main hazard, and in the case of energy poverty, macro-areas. The main scope of a case study (i.e. why the action has been selected in the guidebook) is marked with a green background, but other scopes could be also addressed. These are indicated as well, with a white background, although this listing is not exhaustive. In some cases, all sectors or macro-areas under one pillar are marked with "overall": this indicates overall planning, rather than a specific action".

— Case study identification [Name of action / Municipality and country / size / clim]: the title of the case study is provided, together with a hyperlink to further information, and identification of the corresponding municipality and country. In some cases, the identified actions relate to a higher level (e.g. regional / national level). In this cases, N/A is reported. Additionally, an indication of the municipality size (XS, S, M, L, XL), and the climate zone (according to Köppen Geiger) is included.

- Municipality sizes: XS (<10 001 inhabitants), S (10 001 – 50 000 inhabitants), M (50 001 – 100 000 inhabitants), L (100 001 – 500 000 inhabitants), XL (500 001 – 1 000 000 inhabitants) and XXL (> 1 000 000 inhabitants).
- Köppen Geiger climate zone classification: through three letters, the climate classification system indicates (1) the main climate group, (2) the precipitation pattern and (3) (if used) the temperature variation. The five main climate categories, shown in the first letter, are the following: (A) tropical climates, (B) dry climates, (C) temperate (mesothermal) climates, (D) continental (microthermal) climates, and (E) polar climates. In the examples presented in the guidebook, the climate categories are B, C and D, detailed below:

Table 66. Köppen Geiger classification of the climate zones addressed in the guidebook

Dry climates	Temperate climates	Continental climates
BSh: hot semi arid	Cfa: humid subtropical	Dfa: hot-summer humid continental
BSk: cool semi arid	Cfb: oceanic and subtropical highland	Dfb: warm-summer humid continental
BWh: hot desert	Cfc: subpolar oceanic	
	Csa: hot summer mediterranean	
	Csb: warm summer mediterranean	

Source: extracted from World Map of the Köppen-Geiger climate classification updated[380]

[379] Actions included in the guidebook, Excel format: https://publications.jrc.ec.europa.eu/repository/handle/JRC142138

[380] World Map of the Köppen-Geiger climate classification updated: https://opus.bibliothek.uni-augsburg.de/opus4/frontdoor/deliver/index/docId/40083/file/metz_Vol_15_No_3_p259-263_World_Map_of_the_Koppen_Geiger_climate_classification_updated_55034.pdf

— Type of action characterisation [Phy / Eco / Gov / Kno]: the case studies are further characterised by indicating the type of measures (as described in section 3) that they entail. One or more types can be indicated, among the following: Physical and technological (Phy), Economic and Finance (Eco), Governance and institutional (Gov) or Knowledge and behavioural change (Kno). Similarly to the pillar scope columns, the main type of action (i.e. why the action has been selected in the guidebook) is marked with a green background. However, since many of the case studies are not individual actions but entail different types of action, these are indicated as well, with a white background. It should be noted that this listing is not exhaustive and additional types of action may also be relevant.

— Section [Sect.]: indicates the section where the action has been described within the document.

Table 67. Actions included in the guidebook

Mitigation	Adapt.	Energy pov.	Name of the action	Municipality and country		Size	Clim.	Phy	Eco	Gov	Kno	Sect
(overall)	N/A	N/A	Developing and implementing a 2050 roadmap to climate neutrality	Brasov	RO	L	Dfb			x		4.1
(overall)	N/A	N/A	Glasgow's climate plan	Glasgow	UK	XXL	Cfb			x	x	4.1
(overall)	N/A	N/A	Flemish local energy and climate pact	(Flemish region)	BE	N/A	Cfb			x		4.1
N/A	(overall)	N/A	Climate resilient and integrated territorial development in San Lucido	San Lucido	IT	XS	Csa			x		4.2
N/A	(overall)	N/A	Climate change adaptation council and strategy in Gabrovo	Gabrovo	BG	S	Cfa			x	x	4.2
Buildings	N/A	N/A	TOTEM [Tool to Optimise the Total Environmental impact of Materials]	N/A	BE	N/A	N/A	x				7.1.1
Buildings	N/A	N/A	Izmir (New European Bauhaus application through CrAFt Cities project)	Izmir	TR	XXL	Csa	x				7.1.1
Buildings	N/A	N/A	Lahti Energy Choice: Supporting citizens' choices for more energy efficient buildings	Lahti	FI	L	Dfb		x			7.1.1
Buildings	N/A	Facilities and housing	LEMON project: reducing greenhouse gas emissions through the energy conversion of social housing	(Reggio Emilia)	IT	N/A	Cfa			x		7.1.1
Buildings	N/A	N/A	See2Do project: encouraging residents to improve energy efficiency	Breda	NL	L	Cfb			x		7.1.1
Buildings; Public lighting	N/A	N/A	Energy efficiency interventions for public buildings and lighting systems	Turin	IT	XL	Cfa		x	x		7.1.1
Buildings	Ex. heat, heavy precip, floods, droughts, mass mov.	N/A	Climate change adaptation co-implementation agenda	Urbino	IT	XS	Cfa	x				7.1.1
Buildings	N/A	N/A	Upgrade and preservation of modern monuments	Ioannina	GR	M	Csa	x		x		7.1.1
Buildings	N/A	N/A	Public-private partnership for a large-scale building retrofit programme	Ljubljana	SI	L	Cfa	x	x	x		7.1.1
Buildings	N/A	N/A	Positive energy districts and neighbourhoods - ATELIER project	N/A	N/A	N/A	N/A	x				7.1.1
Buildings	N/A	N/A	Digital twin concept for the building sector	Suceava	RO	M	Dfb	x			x	7.1.1.1
Buildings	N/A	N/A	Piloting actions towards climate neutrality	Leuven	BE	L	Cfb	x		x	x	7.1.1.1
Buildings	N/A	N/A	Innovative financing solutions in energy efficiency	Aradippou	CY	S	BSh		x			7.1.1.2
Buildings	N/A	N/A	Reinvesting energy savings for a climate-neutral future	Riga	LT	XL	Dfb		x			7.1.1.2
Buildings	N/A	N/A	Group buying approaches for heat pumps	N/A	IT	N/A	N/A		x	x		7.1.1.2
Buildings	N/A	N/A	Standard for climate-friendly construction	Münster	DE	L	Cfb			x		7.1.1.3
Buildings	N/A	N/A	Energy Helpdesk, participatory budgeting, and the Citizens Assembly for Climate	Bologna	IT	XL	Cfa			x	x	7.1.1.3
Buildings	N/A	N/A	New social housing by adapting and refurbishing vacant office and commercial buildings	Dublin	IE	XS	Cfb			x		7.1.1.3
Buildings	N/A	N/A	Climate neutrality hub: one-stop-shop for energy renovation of buildings	Trikala	GR	M	Csa	x			x	7.1.1.4
Buildings	N/A	Facilities and housing	"Save the homes" one-stop-shop home renovation services	Ljubljana	SI	L	Cfa	x	x	x	x	7.1.1.4
Buildings	N/A	N/A	"Think energy" campaign to encourage energy savings behaviour	Dublin	IE	XL	Cfb			x	x	7.1.1.4
Buildings	N/A	N/A	A new energy efficient environmental education centre	Thermi	GR	S	BSk			x	x	7.1.1.4
Buildings	N/A	N/A	"Maison de L'Energie" one-stop-shop to ensure energy efficient homes	Toulouse	FR	XXL	Cfa		x		x	7.1.1.4

Mitigation	Adapt.	Energy pov.	Name of the action	Municipality and country		Size	Clim.	Phy	Eco	Gov	Kno	Sect
Buildings	N/A	N/A	Energy caravan campaign: Freiburgs's path towards future-proof building stock	Freiburg	DE	L	Cfb			x	x	7.1.1.4
Buildings	N/A	N/A	ENCHANT project: behavioural change for energy efficiency	Viken County	NO	XXL	N/A				x	7.1.1.4
Buildings	N/A	N/A	KPIs to communicate action's benefits	Porto	PT	L	Csb				x	7.1.1.4
Buildings	N/A	N/A	All-round strategy for communication and collaboration	Malmö	SE	L	Cfb				x	7.1.1.4
Pub. lighting	N/A	N/A	Grouped tendering process for public lighting	Huelva	ES	L	Csa	x	x			7.1.2
Pub. lighting	N/A	N/A	Bundling investments for public lighting (32 municipalities)	Pivka	SI	XS	Cfb	x	x			7.1.2
Pub. lighting	N/A	N/A	Bundling investments for public lighting (7 municipalities)	Athens	GR	XL	Csa	x	x			7.1.2
Transport	N/A	N/A	Car sharing initiative	Bremen	DE	XL	Cfb	x		x		7.1.3
Transport	N/A	N/A	'Depot.Bike' project: electric cargo bikes	Prague	CZ	XXL	Cfb		x			7.1.3
Transport	N/A	N/A	Public infrastructure to support transport actions	Barcelona	ES	XXL	BSk	x	x		x	7.1.3.1
Transport	N/A	N/A	Public procurement of buses fuelled by 100% biogas	Kalmar	SE	S	Cfb	x	x			7.1.3.2
Transport	N/A	Mobility	Copenhagen's Nordhavn district, the "five-minute city" concept	Copenhagen	DK	XXL	Cfb	x		x		7.1.3.3
Transport	N/A	N/A	A comprehensive governance approach in the transportation sector	Thessaloniki	GR	L	BSk			x		7.1.3.3
Transport	N/A	N/A	Optimisation of transport demand (TDM strategies)	Limassol	CY	L	Csa		x	x	x	7.1.3.3
Transport	N/A	N/A	Promoting behavioural change in the transport sector	Kranj	SI	M	Dfb			x	x	7.1.3.4
Industry	N/A	N/A	Integrating industry within a holistic energy approach	Espoo	FI	L	Dfb	x		x		7.1.4
Industry	N/A	N/A	Industrial symbiosis in Kalundborg	Kalundborg	DK	S	Cfb	x		x		7.1.4
Elect. prod.	N/A	N/A	Comprehensive actions to address electricity production at local level in Malmö	Malmö	SE	L	Cfb	x	x			7.1.5.1
Elect. prod.	N/A	N/A	Comprehensive actions to address electricity production at local level in Miskolc	Miskolc	HU	L	Dfa/ Dfb	x	x			7.1.5.1
Elect. prod.	N/A	N/A	Agrivoltaics deployment in the Netherlands: Babberich, Wadenoijen, Almere and Culemborg	N/A	N/A	N/A	N/A	x		x		7.1.5.1
Elect. prod.	N/A	N/A	Innovative financial approaches for electricity production	Eilat	IL	M	BWh		x			7.1.5.2
Elect. prod.	N/A	N/A	Strategic resource allocation and streamlined permit procedures for electricity production	The Hague	NL	XL	Cfb	x	x	x		7.1.5.3
Elect. prod.	N/A	N/A	Maximising PV production on diverse surfaces	Prato	IT	L	Csa	x		x		7.1.5.3
Elect. prod.	N/A	Socio eco.	Marseille energy communities	Marseille	FR	XL	BSk			x	x	7.1.5.3
Elect. prod.	N/A	Socio eco.	A city going solar	Mouscron	BE	M	Cfb		x	x		7.1.5.3
Elect. prod.	N/A	Socio eco.	Som Energia energy cooperative	N/A	ES	N/A	N/A		x	x		7.1.5.3
Elect. prod.	N/A	Socio eco.	Pilot project in Lubiana district: renewable energy communities	Parma	IT	L	Cfa			x		7.1.5.3
Elect. prod.	N/A	N/A	Berlin Solar Atlas	Berlin	DE	XXL	Cfb	x			x	7.1.5.4
Elect. prod.	N/A	N/A	Paris Solar Registry	Paris	FR	XXL	Cfb	x			x	7.1.5.4
Elect. prod.	N/A	N/A	PVGIS	N/A	N/A	N/A	N/A	x			x	7.1.5.4
Elect. prod.	N/A	N/A	Global wind atlas	N/A	N/A	N/A	N/A	x			x	7.1.5.4
Elect. prod.	N/A	N/A	Global solar atlas	N/A	N/A	N/A	N/A	x			x	7.1.5.4
H&C prod.	N/A	N/A	Vantaa's district heating network	Vantaa	FI	L	Dfb	x				7.1.6
H&C prod.	N/A	N/A	Gothenburg's thermal energy storage tank	Gothenburg	SE	XL	Cfb	x				7.1.6
H&C prod.	N/A	N/A	Lahti's district heating restructuring	Lahti	FI	L	Dfb	x				7.1.6
H&C prod.	N/A	N/A	An efficient district cooling station	Tartu	EE	L	Dfb	x				7.1.6

Mitigation	Adapt.	Energy pov.	Name of the action	Municipality and country		Size	Clim.	Phy	Eco	Gov	Kno	Sect
H&C prod.	N/A	N/A	Recovering waste heat from a data centre	Espoo	FI	L	Dfb	x				7.1.6
H&C prod.	N/A	N/A	Stockholm's open district heating initiative	Stockholm	SE	XL	Dfb			x	x	7.1.6
H&C prod.	N/A	N/A	Recovery of waste heat from data centres	Turin	IT	XL	Cfa	x				7.1.6
H&C prod.	N/A	N/A	Using waste heat from wastewater systems	Berlin	DE	XXL	Cfb	x				7.1.6
H&C prod.	N/A	N/A	A comprehensive plan to decarbonise the heating sector	Lappeenranta	FI	M	Dfb	x		x		7.1.6.1
H&C prod.	N/A	N/A	Bergamo green initiative promoting coordination and cooperation in district heating	Bergamo	IT	L	Cfa			x		7.1.6.1
H&C prod.	N/A	N/A	Decarbonising a former industrial hub	Bilbao	ES	XL	Cfb	x		x		7.1.6.1
Waste/WW	N/A	N/A	Pioneering approach to waste management	Ioannina	GR	M	Csa	x		x	x	7.1.7.1
Waste/WW	N/A	N/A	Pay-as-you-throw system	Treviso	IT	M	Cfa		x	x	x	7.1.7.2
Waste/WW	N/A	Socio eco.	A strong governance approach in the waste sector	Ljubljana	SI	L	Cfa	x	x	x	x	7.1.7.3
Waste/WW	N/A	N/A	Know-as-you-throw (KAYT) scheme	Kalamata	GR	M	Csa		x		x	7.1.7.4
AFOLU	N/A	N/A	"Greentool" to analyse environmental benefits of green areas	Antwerp	BE	XL	Cfb	x			x	7.1.8.1
AFOLU	N/A	N/A	GIS to identify potential trade-offs and optimise nature-based solutions	Gothenburg	SE	XL	Cfb	x			x	7.1.8.1
AFOLU	N/A	N/A	Agriculture 5.0 and environmental digital twin	Prato	IT	L	Csa	x			x	7.1.8.1
AFOLU	N/A	N/A	Economic incentives for advanced and environmentally friendly farming practices	Ljubljana	SI	L	Cfa		x			7.1.8.2
AFOLU	N/A	N/A	AFOLU community engagement, participatory planning and collaborative decision-making	Miskolc	HU	L	Dfa/ Dfb			x	x	7.1.8.3
AFOLU	N/A	N/A	Education and motivation of young farmers	Kranj	SI	M	Dfb		x	x	x	7.1.8.4
AFOLU	N/A	N/A	Working group on nature-based solutions and interactive events like the Greenreality carnival	Lappeenranta	FI	M	Dfb	x			x	7.1.8.4
AFOLU	N/A	N/A	A comprehensive approach to the AFOLU sector	Izmir	TR	XXL	Csa	x	x	x	x	7.1.8.4
N/A	Extreme heat	N/A	Heatwave and UV early warning system	Tatabánya	HU	M	Cfa	x			x	7.2.1.1
N/A	Extreme heat	N/A	Paving material and colour change to combat UHI (LIFE HEATLAND project)	Murcia	ES	L	BWh	x			x	7.2.1.1
N/A	Extreme heat	N/A	Tax reductions and precipitation fee discounts to support green roofs	Bonn	DE	L	Cfb	x	x			7.2.1.2
N/A	Extreme heat	N/A	Incentives for green roofs	Basel	CH	L	Cfb	x	x		x	7.2.1.2
N/A	Extreme heat	N/A	Heatwave response plan	Luxembourg	LU	L	Cfb			x		7.2.1.3
N/A	Extreme heat	N/A	Using a climate atlas to develop zoning regulations for combating the heat island effect and the creation of ventilation corridors	Stuttgart	DE	XL	Cfb	x		x	x	7.2.1.4
N/A	Extreme heat	N/A	Naming and categorising heat waves (proMETEO Seville Project)	Seville	ES	XL	Csa			x	x	7.2.1.4
N/A	Extreme heat	N/A	Information and awareness-raising campaigns on the effects of heatwaves	Lorca	ES	M	BWk				x	7.2.1.4
N/A	Extreme cold	N/A	Heated sidewalks	Reykjavik	IS	L	Cfc	x				7.2.2.1
N/A	Extreme cold	N/A	Subsidised insurance for weather risks and livestock	(Piedmont region)	IT	N/A	(Cfa)		x			7.2.2.2
N/A	Extreme cold	Climate, Socio eco.	Extreme cold plan	Brussels	BE	XXL	Cfb			x		7.2.2.3
N/A	Extreme cold	Climate, Socio eco.	Be informed about hazards	N/A	UK	N/A	N/A			x	x	7.2.2.4
N/A	Heavy precip.	N/A	Protection against torrential water	Schwertberg	AT	XS	Cfb	x			x	7.2.3.1
N/A	Heavy precipitation	Socio economic	The cloudburst management plan: the economics of managing heavy rains and storm water	Copenhagen	DK	XXL	Cfb		x		x	7.2.3.2

Mitigation	Adapt.	Energy pov.	Name of the action	Municipality and country		Size	Clim.	Phy	Eco	Gov	Kno	Sect
N/A	Heavy precipitation	N/A	Discounts for climate-proofing measures and reimbursements for disconnecting heavy precipitation water runoff from sewers	N/A	DK	N/A	N/A		x			7.2.3.2
N/A	Heavy precip.	Socio eco.	EGOKI project: joint effort against torrential rain	(Navarre)	ES	N/A	(Cfb)	x		x	x	7.2.3.3
N/A	Heavy precip.	Socio eco.	Landscape and watershed recovery programme for the Košice region	(Košice)	SK	N/A	Dfb	x		x	x	7.2.3.3
N/A	Heavy precip.	N/A	Raising awareness within the restoration of a river (Sokołówka river)	Lodz	PL	XL	Dfb	x		x	x	7.2.3.4
N/A	Sea level rise	N/A	Dune protection and habitat restoration (MAS Dunas project)	Gran Canaria	ES	N/A	N/A	x			x	7.2.4.1
N/A	Floods	N/A	"Ribeira das Vinhas" river restoration project in Cascais	Cascais	PT	L	Csb	x		x	x	7.2.4.1
N/A	Floods	N/A	Improvement and redesign of the Isar River	Munich	DE	XXL	Dfb	x		x		7.2.4.1
N/A	Floods	N/A	The integrated storm water management toolbox	N/A	N/A	N/A	N/A	x			x	7.2.4.1
N/A	Floods	N/A	Blended finance in Slovakia: LIFE Living Rivers Project	(region around Danube)	SK	N/A	Dfb	x	x			7.2.4.2
N/A	Floods	N/A	Public-private partnerships for a flood-proof district in Bilbao (Zorrotzaure)	Bilbao	ES	XL	Cfb	x	x			7.2.4.2
N/A	Floods	N/A	Lahti's storm water approach	Lahti	FI	L	Dfb	x		x	x	7.2.4.3
N/A	Floods	N/A	A collaborative approach to deal with storms: the I-storm network	N/A	N/A	N/A	N/A			x	x	7.2.4.3
N/A	Floods	N/A	Mental health support for flooded populations in Emilia-Romagna	(Emilia-Romagna)	IT	N/A	(Csa)			x	x	7.2.4.4
N/A	Floods	N/A	Rotterdam port adaptation strategy	Rotterdam	NL	XL	Cfb			x	x	7.2.4.4
N/A	Floods	N/A	FRAMES project: implementation of flood resilient measures with the use of Multi-Layered Water Safety Concept	(pilots in BE)	BE	N/A	Cfb	x		x	x	7.2.4.4
N/A	Droughts / water scarc.	N/A	Water saving measures in the IMDEA building	Madrid	ES	XXL	BSk	x				7.2.5.1
N/A	Droughts / water scarc.	N/A	A subsidised drought insurance for farmers in Austria	N/A	AT	N/A	N/A		x			7.2.5.2
N/A	Droughts / water scarc.	N/A	Blue green area factor applied in Turku	Turku	FI	L	Dfb			x	x	7.2.5.3
N/A	Droughts / water scarc.	N/A	Biotope area Factor applied in Berlin	Berlin	DE	XXL	Cfb			x	x	7.2.5.3
N/A	Droughts / water scarc.	N/A	Water conservation, flood control and awareness raising in the Urban Flood Park "La Marjal"	Alicante	ES	L	BWh	x			x	7.2.5.4
N/A	Droughts / water scarc.	N/A	Rainwater collection with awareness raising	Debrecen	HU	L	Dfa	x			x	7.2.5.4
N/A	Storms	N/A	Best practice guidance on buildings' adaptation to high winds	N/A	N/A	N/A	N/A	x				7.2.6.1
N/A	Storms	N/A	Windstorm parametric insurance	N/A	N/A	N/A	N/A		x			7.2.6.2
N/A	Storms	N/A	Replacing overhead lines with underground cables in Finland: Elenia's initiative	N/A	FI	N/A	N/A	x		x		7.2.6.3
N/A	Storms	N/A	Awareness campaign in Denmark to inform residents on how to prepare against storms	N/A	DK	N/A	N/A			x	x	7.2.6.4
N/A	Storms	N/A	LIFE-MEDEA project: mitigating the health effects of desert dust storms using exposure-reduction approaches	(southEast EU)	N/A	N/A	(Csa)				x	7.2.6.4
N/A	Mass movem.	N/A	Inventory of geo-hydrological phenomena in Genova municipality	Genova	IT	XL	Csa	x			x	7.2.7.1

Mitigation	Adapt.	Energy pov.	Name of the action	Municipality and country		Size	Clim.	Phy	Eco	Gov	Kno	Sect
N/A	Mass movem, floods; extreme heat	N/A	Leveraging public-private partnerships in the LIFE CITYAdaP3 project	N/A	N/A	N/A	N/A		x	x	x	7.2.7.2
N/A	Mass movem.	N/A	Adaptation against landslides of French transport infrastructure standards	N/A	FR	N/A	N/A			x		7.2.7.3
N/A	Mass movem; floods; storms	N/A	Informing citizens about increasing risks and how to adapt to them	N/A	FR	N/A	N/A			x	x	7.2.7.4
N/A	Mass movement	Socio economic	Preventive relocation of households at high hydrogeological risk in Piedmont	(Piedmont region)	IT	N/A	(Cfa)	x	x	x	x	7.2.7.4
N/A	Wildfires	Socio economic	Prescribed fires and grazing techniques: the LIFE LANDSCAPE FIRE	(Mediterranean region)	N/A	N/A	(Csa)	x		x	x	7.2.8.1
N/A	Wildfires	Socio economic	Prescribed fires and grazing techniques: the LIFE Montserrat project	(Mediterranean region)	N/A	N/A	(Csa)	x		x	x	7.2.8.1
N/A	Wildfires	N/A	Recycled water to prevent and protect against forest fires in Riba-Roja de Turia	Riba Roja de Túria	ES	N/A	BSk	x		x	x	7.2.8.1
N/A	Wildfires	Socio eco.	Supporting the tourism sector affected by wildfires in Portugal	N/A	PT	N/A	N/A		x			7.2.8.2
N/A	Wildfires	N/A	The Agency for the Integrated Management of Rural Fires in Portugal	N/A	PT	N/A	N/A			x		7.2.8.3
N/A	Wildfires	N/A	"Plantando Cara al Fuego" Project in Spain	N/A	ES	N/A	N/A			x	x	7.2.8.4
N/A	Wildfires	Socio economic	The FIRE-RES project: innovative technologies and socio-ecological-economic solutions for fire resilient territories in Europe	N/A	N/A	N/A	N/A	x			x	7.2.8.4
N/A	Wildfires	N/A	Nurturing local resilience against wildfires with the "Aldeas Modelo" concept (Galicia)	N/A	ES	N/A	N/A			x	x	7.2.8.4
N/A	Chemical ch.	N/A	Air quality tool in MyCovenant: "My Air Quality"	N/A	N/A	N/A	N/A		x		x	7.2.9
N/A	Biological	N/A	Czechia's tick-borne encephalitis (TBE) surveillance system	N/A	CZ	N/A	N/A	x		x	x	7.2.10
N/A	Biological	N/A	TrIAS project in Belgium: Tracking invasive alien species	N/A	BE	N/A	N/A				x	7.2.10
N/A	Biological	N/A	French dengue surveillance system	N/A	FR	N/A	N/A	x		x	x	7.2.10
N/A	Biological	N/A	Greek's West Nile virus prevention system	N/A	GR	N/A	N/A	x		x	x	7.2.10
N/A	Biological	N/A	Mosquito control programme in Cagliari	Cagliari	IT	L	Csa	x		x	x	7.2.10
N/A	Biological	N/A	'Mückenatlas' (mosquito atlas) citizen science project in Germany	N/A	DE	N/A	N/A	x			x	7.2.10
N/A	Biological	N/A	Planetary health academy lecture series	N/A	DE	N/A	N/A				x	7.2.10
N/A	Floods	N/A	Reinforcing river flood protection measures	Smolyan	BU	S	Dfb	x				7.2.11
N/A	Extreme heat	Climate	Climate shelters to combat summer energy poverty	Barcelona	ES	XXL	BSk	x				7.3.1.1
N/A	Extreme heat	Climate	Cartography of strategies against excessive heat	Madrid	ES	XXL	BSk	x				7.3.1.1
Buildings	Extreme heat	Climate	Financial support for energy-poor households with disabled people in Cyprus	N/A	CY	N/A	N/A	x	x			7.3.1.2
N/A	Extreme heat	Climate	Innovative financial tools to better cope with extreme heat in Ahmedabad: Mahila Housing Trust	Ahmedabad	IN	XXL	BSh	x	x		x	7.3.1.2
N/A	N/A	Climate	Municipal transition team and "The Hague Climate Tables"	The Hague	NL	XL	Cfb			x		7.3.1.3
N/A	Extreme heat	Climate	Heatwaves register and awareness campaign in Paris	Paris	FR	XXL	Cfb	x		x	x	7.3.1.4
Buildings	Extreme heat	Climate	Empowering women to combat energy poverty in Mediterranean coastal areas (EmpowerMed)	(Mediterranean region)	N/A	N/A	(Csa)				x	7.3.1.4
Buildings	N/A	Facilities and housing	Sustainable and equitable housing development in Vienna	Vienna	AT	XXL	Cfb	x	x		x	7.3.2.1

Mitigation	Adapt.	Energy pov.	Name of the action	Municipality and country		Size	Clim.	Phy	Eco	Gov	Kno	Sect
H&C prod.	N/A	Facilities and housing	District heating with regulated tariff in Oslo	Oslo	NO	XL	Dfb	x	x			7.3.2.1
Buildings; Elect. prod.	N/A	Facilities and housing	Home Energy Efficiency Programme for Scotland	N/A	UK	N/A	Cfb/ Cfc		x			7.3.2.2
Buildings	N/A	Facilities and housing	Benefits for energy efficiency renovation in the Flemish region	(Flemish Region)	BE	N/A	Cfb		x			7.3.2.2
Buildings	N/A	Facilities and housing	Loans and grants for energy retrofit in energy poor areas in Toronto: "Taking Action on Tower Renewal programme" (TATR)	Toronto	CA	XXL	Dfb		x			7.3.2.2
Buildings	N/A	Facilities and housing	Local adoption of self-consumption regulation in Santa Cruz de Tenerife	Santa Cruz de Tenerife	ES	L	BSh			x		7.3.2.3
Buildings	N/A	Facilities and housing	Local adoption of energy efficiency guidelines in Szentendre	Szentendre	HU	S	Dfa			x		7.3.2.3
Buildings	N/A	Facilities and housing	Establishing minimum energy efficiency standards for property rentals	N/A	N/A	N/A	N/A			x		7.3.2.3
Buildings	N/A	Facilities and housing	Distribution of energy saving kits in Dublin	Dublin	IE	XL	Cfb				x	7.3.2.4
Elect. prod.	N/A	Socio eco.	Energy communities in Vaiano, Vernio e Cantagallo	N/A	IT	N/A	N/A	x				7.3.3.1
N/A	N/A	Socio eco.	Establishment of an "energy income" in Porto Torres ("Reddito Energetico")	Porto Torres	IT	S	Csa		x			7.3.3.2
N/A	N/A	Socio eco.	Programme to reduce energy poverty in the Czech Republic	N/A	CZ	N/A	N/A		x			7.3.3.2
Buildings	Extreme cold	Socio economic	Design of energy subsidies for most in need households in the UK: "winter fuel payment"	N/A	UK	N/A	N/A		x			7.3.3.2
Buildings	N/A	Socio economic	Management of the Housing Solidarity Fund at local level in Nice Côte d'Azur	Nice Côte d'Azur	FR	L	Csa			x		7.3.3.3
N/A	N/A	Socio economic	Co-design of social energy plans in European municipalities: ENTRACK project	(Mediterranean region)	N/A	N/A	(Csa)			x	x	7.3.3.3
N/A	N/A	Socio economic	Establishment of social impact bonds as innovative financing instrument: WELLBASED project	N/A	N/A	N/A	N/A		x	x	x	7.3.3.3
N/A	N/A	Socio eco.	Local energy poverty alleviation offices in the POWERPOOR Project	N/A	N/A	N/A	N/A				x	7.3.3.4
N/A	N/A	Socio eco.	Creation of "Energy cafés" in Manchester: STEP-IN project	Manchester	UK	XXL	Cfb				x	7.3.3.4
Buildings; Elect. prod.	N/A	Socio economic	EcoHouse and energy advice point in Antwerp	Antwerp	BE	XL	Cfb				x	7.3.3.4
N/A	N/A	Socio eco.	Energy saving check in Germany "StromSparCheck" (energy saving check)	N/A	DE	N/A	N/A				x	7.3.3.4
N/A	N/A	Socio eco.	Energy advice points (EAP) in Barcelona	Barcelona	ES	XXL	BSk				x	7.3.3.4
Transport	N/A	Mobility	Smart mobility apps to combat transport poverty in Viana do Castelo	Viana do Castelo	PT	M	Csb	x				7.3.4.1
Transport	N/A	Mobility	Free-fare services in Tallinn	Tallinn	EE	L	Dfb		x			7.3.4.2
Transport	N/A	Mobility	Free buses in Nova Gorica	Nova Gorica	SI	S	Cfa		x			7.3.4.2
Transport	N/A	Mobility	Free buses in Lubin	Lubin	PL	M	Dfb		x			7.3.4.2
Transport	N/A	Mobility	Smart card in Torrevieja to access museums	Torrevieja	ES	M	BWh		x			7.3.4.2
Transport	N/A	Mobility	1,5-hour free travel in buses, trams and metros in Amsterdam	Amsterdam	NL	XXL	Cfb		x			7.3.4.2
Transport	N/A	Mobility	Monthly passes based on a sliding scale system in Calgary	Calgary	CA	XXL	Dfb		x			7.3.4.2
Transport	N/A	Mobility	Establishing a "community mobility network"	San Casciano	IT	S	Csa			x		7.3.4.3
Transport	N/A	Mobility	Sustainable mobility in Barcelona: Fair and Sustainable Mobility project	Barcelona	ES	XXL	BSk				x	7.3.4.4

Mitigation	Adapt.	Energy pov.	Name of the action	Municipality and country		Size	Clim.	Phy	Eco	Gov	Kno	Sect
(overall)	(overall)	(overall)	Holistic approach in the development of sustainable plans	Turin	IT	XL	Cfa	x	x	x	x	7.4
(overall)	(overall)	N/A	Mainstreaming climate action in Thessaloniki	Thessaloniki	GR	L	BSk			x		7.4.1
(overall)	(overall)	(overall)	Measurement and evaluation (M&E) system to support climate change mainstreaming	Valencia	ES	XL	BSh			x	x	7.4.1
(overall)	(overall)	(overall)	Integrated urban planning in Lille	Lille	FR	XXL	Cfb			x		7.4.2
(overall)	(overall)	(overall)	Integrated urban planning in Palma de Mallorca	Palma de Mallorca	ES	L	BSh			x	x	7.4.2
Waste/WW; Buildings	N/A	N/A	Lahti's circularity approach	Lahti	FI	L	Dfb	x		x		7.4.3
Waste/WW; Buildings	N/A	N/A	Materials bank platform for the systematic collection, storage and reuse of building materials	Roskilde	DK	M	Cfb	x		x	x	7.4.3
Waste/WW: Transport	N/A	Socio economic	Circular economy approaches in Milan	Milan	IT	XXL	Cfa	x		x		7.4.3
(overall planning)	N/A	Socio economic	Circular economy approaches in Brussels-Capital Region	Brussels	BE	XXL	Cfb			x		7.4.3
AFOLU	Extreme heat	Mobility	Pilot development and finalising NBS plans in Bologna	Bologna	IT	XL	Cfa	x				7.4.4
AFOLU; Buildings	Extreme heat; droughts; heavy precip.	N/A	Green the roofs of the city in Bonn	Bonn	DE	L	Cfb	x				7.4.4
AFOLU	Extreme heat; droughts; heavy precip.	N/A	Planting trees on urban land in Zabok	Zabok	HR	XS	Cfa	x				7.4.4
AFOLU	Extreme heat; droughts; heavy precip.	N/A	Pocket park and summer street in Piastów	Piastów	PL	S	Dfb	x				7.4.4
AFOLU	N/A	Socio eco.	Gentle agriculture project in Prague	Prague	CZ	XXL	Cfb	x			x	7.4.4
AFOLU	Extreme heat; droughts; heavy precip.	Socio economic	NBS actions in Kranj	Kranj	SI	M	Dfb	x		x		7.4.4
AFOLU	N/A	N/A	NBS to recover contaminated land	Baia Mare	RO	L	Dfb	x				7.4.4
AFOLU	N/A	N/A	Training programme to enhance knowledge and skills in nature-based solutions (NBS) and the New European Bauhaus principles	Turin	IT	XL	Cfa				x	7.4.4
AFOLU	N/A	N/A	Raising awareness on regenerative agriculture practices	Navas de San Juan	ES	XS	BSk				x	7.4.4
AFOLU	(various)	N/A	RESIN project: climate resilient cities and infrastructure	N/A	N/A	N/A	N/A			x	x	7.4.5
AFOLU	N/A	Socio eco.	Community gardens in Berlin	Berlin	DE	XXL	Cfb	x			x	7.4.6

Source: JRC elaboration

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