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PART 3 – Policies, key actions, good practices for mitigation and adaptation to climate change and Financing SECAP(s)

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Contents

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1 Introduction

Part 3 of the Guidebook is dedicated to the description of policies and measures that can be implemented at local level by local authorities in a wide range of sectors of activity. The aim of this Part is to guide local authorities in drafting the Sustainable Energy and Climate Action Plan (SECAP) with model policies and successful/replicable measures.

This Part includes a collection of policies and measures addressing both Mitigation (Part 3a) and Adaptation (Part 3b), while Part 3c aims at providing an overview of existing financial mechanisms and funding programs for the implementation of sustainable actions comprised in the SECAP.

Part 3a focuses on the improvement of energy efficiency and the reduction of greenhouse gas emissions (GHG) in cities. It deals with buildings, public lighting, land use planning, transport, local energy generation systems and waste/water management, which are core areas for mitigation actions at local level.

Moreover, different modes of governance to address Climate Change in cities, emerged from almost 10 years of experience through Covenant of Mayors initiative, are outlined within this part.

In Part 3b, a multi-level framework for the implementation of urban adaptation is defined. Urban adaptation is a competence of local authorities and should be defined according to peculiarities and needs of each city. This part summarizes the main recommendations emerging from national, regional and local policies and initiatives targeted to adaptation.

Adaptation and mitigation should be a core element in urban planning in order to increase the capacity for coping with Climate Change impacts in the long term at local level. Moreover, since cities are hosting multiple actors (such as utility companies, financial institutions, citizens, urban developers, community cooperatives, organizations and research institutions), local authorities need to create multilevel interactions in order to develop a politically endorsed action plan.

Best practices in terms of policies and measures as outlined in Part 3a and Part 3b have been successfully implemented by several cities in Europe. Each policy/measure is not described in full detail; rather a collection of references and links to more specific documents from reliable sources is given.

Part 3c mainstreams the most common financial barriers that arise in implementing mitigation and adaptation measures in cities and describes several financial instruments that can support both urban adaptation and mitigation measures. The final chapter also provides some recommendations about financing.

PART 3 A Policies, key actions and good practices for mitigation to climate change

2 Local Authorities' policies to support Sustainable Energy and Climate Action Plans

The transition towards a more sustainable urban environment at the local level begins with a common understanding that there is significant potential to curb the city's CO_2 emissions. This understanding provides a basis upon which political leadership instigates a process of exploring possibilities and discussing different options with a wide range of stakeholders towards selecting, detailing, implementing and monitoring local action. In this process, local authorities (LAs) have the capacity to support and mobilize action for local energy generation investments through several modes of urban climate governance.

In the following four modes of urban energy and climate governance are investigated and a policy matrix that summarizes the scope of each mode along with the main tools, the barriers that require to be addressed, and exemplary actions to support local energy sustainability is provided. The modes of urban energy and climate governance ([1]) can be mainly summarised as:

- Municipal self-governing
- Municipal enabling (governing through enabling)
- Governing through provision
- Regulation and planning (governing by authority)

Overall, the barriers that can be addressed with each main tool under these modes of governance are different. For this reason, it is often necessary to combine multiple modes of governance to reinforce and align incentives for particular objectives. This must be supported by an analysis of the legal, physical, social and economic barriers hindering local energy generation prior to considering corrective actions and measures.

2.1 Municipal self-governing

Local authorities (LAs) have the capacity to govern their own activities and undertake strategic investments in municipality-owned assets ([2]), which include investments in energy efficiency and local energy generation based on renewable energy sources. The main tools that are used by local authorities in this capacity are energy audits, demonstration projects in public facilities and public procurement, which can be used to better manage the local authority estate. Through these tools, local authority can provide technical validation and stimulate energy efficiency and demand for renewable energy and/or its purchase from district networks (**Table 1**). Moreover, this mode of governance also relies on reorganisation and institutional innovation. Awareness raising among public servants and transversal communication among different departments are key measures to implement SECAPs and progress towards sustainability.

(1) Modes of urban climate governance are based on definitions in Kern and Alber, OECD and IEA
(2) Kern K., Alber, G. (2009) "Governing Climate Change in cities: Modes of urban climate governance in multi-level systems" In: The international conference on Competitive Cities and Climate Change, Milan, Italy, 9 - 10 October, 2009. - Paris: OECD - p. 171 - 196

Table 1. Municipal self-governing mode of urban climate governance

Mode of urban climate governance ([1])	Tools	Barrier addressed	Action examples
Municipal self-governing: Strategic investments in municipality-owned assets to increase local energy generation	Energy management of local authority estate	Lack of transparent and consistent monitoring and control of energy use; Disincentive for energy efficiency efforts in budget; Difficulty for public entities to contract and manage energy service providers	Establish standards for monitoring and management of energy to improve efficiency in a systematic and sustainable way; Adopt high energy efficiency performance standard for public buildings;
	Demonstration projects in public facilities	Need for technical validation and demonstration of performances	Town halls with solar energy façades and PV powered schools Counter of emission avoided publicly shown; Showcases of obtained results to raise citizen awareness.
	Green public procurement	Need to stimulate demand for energy efficiency renewable energy and/or the purchase of district heating/cooling; Need for National implementation of core criteria as a reference for green public procurement procedures; Deficiency in national and regional platform of public procurement.	Green public procurement for purchasing energy efficient appliances and clean vehicles; Low-carbon, distributed energy supply in public buildings and schools; Municipal purchases of certified green electricity; Contract to connect LA buildings to DH/C networks; Clean and sustainable procurement of the LA fleet.
	Institutional reorganisation	Allocation of competencies split in different departments.	Allocation of competencies split in different departments.

2.2 Municipal enabling (governing through enabling)

As a facilitator, the local authority 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 ([3]). Moreover, the involvement of a range of different partners increases the democracy of the processes. The LA also has a crucial role in engaging in awareness and capacity building campaigns that promote energy efficiency in buildings, sustainable transport and behaviour, utilization of renewable energy sources and the deployment of local energy generation technologies.

These tools can be actively used within the capacity of local authorities to overcome any lack of business models to leverage financial resources as well as inadequate knowledge and skills (**Table 2**).

(3)"The state of European Cities 2016".EU, UN-Habitat 2016

Table 2. Municipal enabling mode of urban climate governance

Mode of urban climate governance ([1])	Tools	Barrier addressed	Action examples
Governing through enabling: Facilitating co-operation among stakeholders and awareness building	Labels and certificates in the building sector	Lack of reliable and credible advice on the building performance and awareness of energy savings potential	Implement all national and/or regional provisions; Promote the adoption of additional voluntary schemes.
	Partnership with transport service providers	Fragmentation of modes	Integrated ticketing and charging
	Public-private partnerships	Lack of business models to leverage financial resources Budget constraints in LA	Public-private partnership for anaerobic digestion of biowaste for CHP-based district heating; Co-financing between local and regional authorities and private investors for public energy upgrading.
	Awareness raising/training	Inadequate knowledge and skills that may hinder undertaking renewable energy projects Need for capacity building of LA staff	Promotional campaigns, such as solar energy campaigns, and supporting tools based solar land registries; Communication campaigns to promote behavioural changes; Effective communication on public transport; Promote competitions, awards and contests for climate protection and GHG reduction efforts; Provide guidelines for energy efficiency improvement in buildings; Networking with other LA , regional / national authorities, universities to ease the access to funding opportunities; Showcases of obtained results to raise citizen awareness; Appropriate training activities for LA staff.
	Community cooperatives for local energy projects	Need to overcome perceptions of risk as a barrier to citizen involvement	Supporting tools and information sessions for citizen empowerment

2.3 Governing through provision

The Local Authority is a provider of urban services and as such, has control or influence over infrastructure development. Within this capacity, the local authority can effectively guide development in a way that increases energy efficiency in all urban sectors, support transition to sustainable transport as well as promote local energy production (**Table 3**).

Table 3. Governing through provision mode of urban climate governance

Mode of urban climate governance ([1])	Tools	Barrier addressed	Action examples
Governing through provision: Providing services and financial resources	Public sector financial management and procurement policies	Split incentives and difficulties to access them; Fragmentation in processes and actors of the building trade Budget constraints	Revise budgetary rules to allow retention of energy cost savings for other justified public spending; Revise public procurement rules (GPP) to allow for contracting of energy service providers and adopt EE purchase requirements;
	Direct infrastructure investments for transport	Congestion and high energy consumptions and related emissions due to private transport modes Low density territories	Reliable and affordable public transport infrastructure (light rail system and bus rapid transit); Fine tune public transport to the characteristics of the territory (density, type of fluxes).
	Financial incentives in transport	High cost and low financial sustainability of electric mobility	LA incentives for purchasing clean vehicles and electric bikes.
	Direct energy infrastructure investments	Insufficient energy infrastructure to provide access to renewable energy	Investments in the modernization and expansion of district heating networks; Minimum quotas for renewable energy supply or co-generation provided by LA owned utilities; Renewable energy sources in public housing.
	Incentives and grants to local energy generation	Insufficient financial incentive; Constrains of local budget; Competition with other investment priorities. Presence of market failures for related technological options	Use public funds (also national) to leverage private and commercial investments; Third party financing; Energy services companies (ESCO); City Council subsidies for renewable energy.

2.4 Regulation and planning (governing by authority)

In addition to capacities as implementer, enabler, and provider, local authorities govern by authority through setting regulations and putting forth urban planning principles ([4]).

Among other tools, local authorities can revise building codes to promote the improvement of 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. In the context of local energy generation, this mode of governing involves setting requirements on the mandatory use of renewable energy and ruling on strategic energy planning decisions. Based on such tools as ordinances and strategic energy planning, local authorities can assist in addressing certain shortcomings for supporting niche markets and emerging technologies as well as insufficient guidance to inform decision-making for local energy generation (**Table 4**).

Table 4. Policy matrix for local energy generation organized by mode of urban climate governance

Mode of urban climate governance ([1])	Tools	Barrier addressed	Action examples
Regulation and planning: Requirements and guidance in support of energy efficiency and local energy generation	Mandatory standards and building codes	Fragmentation and gaps in the regulatory action of public planning; Urban planners lacking of skills to include energy and climate issues in their work	Prepare a comprehensive plan to improve energy efficiency in buildings; Develop building codes that addresses energy efficient buildings with minimum energy requirements (stricter than national ones); Introduce subsidies and bonus (e.g. reduction in development fees, expedited permit process or allowances for extra building floor/volume) for high efficiency buildings; Establish a supporting program to assist in the retrofitting of old buildings; Capacity building on climate and energy for urban planners.
	Regulation, controls and sanctions		
	Zoning, urban regeneration and mixed used developments	Sprawl and brownfields	Creating mixed-use developments; Review the public transport considering mobility patterns of different types of users; Smart intermodal mobility planning; Encourage renovation of existing buildings.
	Regulation and pricing in the transport sector	Difficulty in promoting the use of public and collective transport; Congestion and space of the city dedicated to cars	Road pricing and congestion charges; Parking management (taking also into consideration the introduction of clean vehicles).

(4)OECD (2010), Cities and Climate Change, OECD Publishing, Paris, https://doi.org/10.1787/9789264091375-en

	Ordinances on the mandatory use of renewable energy	Lack of support for niche markets or emerging technologies	Mandatory installation of solar water heating/solar PV systems in new buildings; Construction of nearly or net-zero-energy buildings.
	Revision of administrative procedures for energy projects	Uncertainty of administrative procedures	Advantageous conditions to projects in the "Public Interest".
	Strategic energy planning to support local energy generation	Insufficient guidance and access to data to better inform decision-making	Local maps with heat demand density and industrial waste heat; Land use planning for large-scale solar plants and wind turbines.

3 Public Procurement

3.1 Green Public Procurement

Public procurement refers to the process by which public authorities, such as government departments or local authorities, purchase work, goods or services from companies ([5]). Public procurement and the way procurement processes are shaped and priorities are set in the procurement decisions, offer a significant opportunity for local authorities to improve their overall energy consumption performance.

Green public procurement is the process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured ([6]). This means that public contracting authorities take environmental considerations into account when procuring goods, services or works. Sustainable public procurement goes even further and means that the contracting authorities take into account the three pillars of sustainable development – the effects on environment, society and economy - when procuring goods, services or works.

Energy efficient public procurement allows improving energy efficiency by setting it as relevant criteria in the tendering and decision-making processes related to goods, services or works. It applies to the design, construction and management of buildings, the procurement of energy consuming equipment, such as heating systems, vehicles and electrical equipment, and also to the direct purchase of energy, e.g. electricity. It includes practices such as life-cycle costing ([7]), the setting of minimum energy-efficiency standards, the use of energy efficient criteria in the tendering process, and measures to promote energy efficiency across organisations.

Energy-efficient procurement offers public authorities, and their communities, social, economic and environmental benefits:

- By using less energy, public authorities will reduce unnecessary costs, and save money.
- Some energy-efficient goods, such as light bulbs, have a longer lifetime and are of higher quality than their cheaper alternatives. Purchasing them will reduce valuable time and effort involved in frequently replacing equipment.
- Reducing CO_2 emissions as a result of energy-efficient procurement will help public authorities to decrease their carbon footprint.
- Through leading by example, public authorities help to convince the general public and private businesses of the importance of energy efficiency and support the development of green economy.

The interest in developing Green Public Procurement regards not only its impact in terms of CO_2 emission reduction, whose average (see "Collection of statistical information on Green Public Procurement in the EU" ([8]) carried out for the European Commission-DG Environment) is 25%, but also in terms of its financial impact, whose average is 1,2% of savings. Here are some examples of energy-efficient measures proposed in high-priority product groups **(Table 5**).

(5) https://ec.europa.eu/growth/index_en
(6) http://ec.europa.eu/environment/gpp/what_en.htm
(7) Life-cycle costing refers to the total cost of ownership over the life of an asset. This includes acquisition (delivery, installation, commissioning), operation (energy, spares), maintenance, conversion and decommissioning costs.
(8) This study can be downloaded from http://ec.europa.eu/environment/gpp/study_en.htm
The report presents the statistical information and conclusions about the investigation done in the 7 most advanced European Countries in Green Public Procurement. It was found that the CO_2 emissions savings was in the range -47%/-9% and the financial impact was in the range -5.7%/+0.31%.

In the transport sector, the Directive 2009/33/EC on the promotion of clean and energy efficient vehicles requires that lifetime impacts of energy consumption, CO_2 and pollutant emissions are taken into account in all purchases of public transport vehicles. As reported in the following table, a public procurement may require environmental specifications for the LA fleet. Moreover, since purchases of public vehicles represent a market of high visibility, a general application of this directive can promote a broader market introduction of clean and energy efficient vehicles in the cities and reduce their costs through economies of scale, resulting in a progressive improvement of the whole vehicle fleet.

Table 5. Examples of energy-efficient measures proposed in high-priority product groups

Product group	Examples of Public procurement requirement
Public transport	Purchase low-emission buses and public fleet vehicles. The buses have to be equipped with driving-style meters to monitor fuel usage.
Electricity	Increase the share of electricity from renewable sources going beyond national support schemes. This measure can be completed by including the purchase of energy-efficiency services. For example ESCOs.
IT products	Purchase of environmentally friendly IT goods that meet the highest EU energy standards for energy performance. Provide training to users on how to save energy using their IT devices.
Building construction/renovation	Use of localised renewable energy sources (RES) Impose high efficiency standards that reduce the building's energy consumption (see 1.1)

Green, sustainable or energy-efficient public procurement are highly recommended. However, in the context of the Covenant of Mayors, only measures related to energy-efficient public procurement will be reflected in the CO_2 emission inventories, since the initiative focuses on the energy consumption and emissions occurring within the city. Nevertheless, a comprehensive GPP policy will be considered as a good way to enhance sustainable governance.

Box 1. Increase sustainability in buildings through Public Procurements: Torino, Italy

The Local authority of Torino, as a partner of the European Project named "Procurement of Lighting Innovation and Technology in Europe", decided to focus on the study and acquisition of innovative solutions for the indoor lighting of school buildings. Indoor lighting was considered a critical aspect, because of the large dimension of the public building stock (more than 700 buildings, half of which schools), and of the high expenditure for electric lighting. Furthermore, the choice of school buildings is also grounded on the potential it has in terms of replicability and educational value. The environmental requirements of the tender were not only referred to the lighting performances, but embraced a larger "environmental" comfort performance concept (e.g. reduction of CO_2 emissions; reduction of energy use; classrooms acoustics; quality of air; thermal conditions, etc.)).

Deambrogio,E., Allegretti, S., Turi, P., Zuccarello, F., P. Lariccia, C. Aghemo, A. Pellegrino (2017). "Increase Sustainability in Buildings Through Public Procurements: The PROLITE project for Lighting Retrofit in Schools," Energy Procedia, vol. 111: 328–337

3.2 Joint Public Procurement

"Joint procurement" (JP) ([9]) means combining the procurement actions of two or more contracting authorities. The key defining characteristic is that there should be only one tender published on behalf of all participating authorities. Such JP activities are not new – in countries such as the UK and Sweden public authorities have been buying together for a number of years – though, in many European countries, especially in the South, there is often very little or no experience in this area.

There are several very clear benefits for contracting authorities engaging in JP arrangements:

- Lower prices: Combining purchasing activities leads to economies of scale. This is of particular importance in the case of a renewable energy project whose costs may be higher than conventional projects.
- Administrative cost savings: The total administrative work for the group of authorities involved in preparing and carrying out one rather than several tenders can be substantially reduced.
- Skills and expertise: Joining the procurement actions of several authorities also enables the pooling of different skills and expertise between the authorities.

This model for Public Procurement requires agreement and collaboration among different contracting authorities. Therefore, a clear agreement on needs, capacities, responsibilities and the common and individual legal framework of each part is a must.

Box 2. Joint procurement of clean vehicles in Stockholm, Sweden

The City of Stockholm and other Public Administrations organised a joint procurement of clean cars. The local authority worked to introduce a large number of clean vehicles. The initiative resulted in a two-year framework agreement involving six vehicle suppliers. Over 800 Electric Vehicles (EV) have been purchased thanks to this agreement. Sweden is a country with good conditions for EVs. Electricity is affordable and is generated mainly from hydro or nuclear plants, which do not produce CO_2 emissions. The infrastructure and distribution system for electricity is also well established. Approximately 65 % of Swedes have easy access to charging/electric outlets near home or work. Splitting the procurement into multiple stages was positive and renewed competition tendering, introduced after a change in legislation, was a new method in vehicle agreements.

http://www.eltis.org

3.3 Green Electricity Purchasing

The liberalisation of the European energy market offers local authorities the opportunity of choosing their energy provider. According to the Directive 2001/77/EC, amended by Directive 2009/28/EC, electricity produced from renewable energy sources or Green Electricity can be defined as: "electricity produced by plants using only renewable energy sources, as well as the proportion of electricity produced from renewable energy sources in hybrid plants also using conventional energy sources and including renewable electricity used for filling storage systems, and excluding electricity produced as a result of storage systems".

In order to ensure that the electricity supplied comes from a renewable energy source, consumers have the possibility to request guarantees of origin certificates of the electricity. The supplier has also the possibility to provide independent proof of the fact

(9) Guidelines for the implementation of Green Public Procurement and Joint Public Procurement can be found in the webpage of LEAP project www.iclei-europe.org/index.php?id=3113. This project is funded by the European Commission's DG ENV through a project LIFE. http://ec.europa.eu/environment/life/index.htm

that a corresponding quantity of electricity has been generated from renewable sources, or produced by means of high-efficiency cogeneration ([10]).

Box 3. Green energy purchase: Geetbets, Belgium

The electric energy used in municipal buildings and for public lighting of Geetbets is provided by Certified Green Electricity. This is bought through a purchase organised by Infrax, the company that operates, maintains, and develops electricity, natural gas, cable television, and communication networks in Belgium.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

Price differences between conventional and green electricity depend on the status of liberalisation, the features of the national support schemes and the existence of green electricity suppliers. Green electricity is often more expensive, although price differences are narrowing substantially, and there are cases where green electricity is even available at a cheaper rate. Green electricity has proven to be a product group which is available for public procurement on a competitive basis.

(10) Further information on www.procuraplus.org

4 Information measures and public awareness

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

In the CoM framework, local authorities are integrating policies aiming at increasing public awareness (such as information and benefit campaigns) towards a behavioural change in energy use in their territories.

This chapter aims at guiding local authorities in the preparation and successful implementation of this kind of measures that allow improving the impact of their information and training campaigns.

4.1 Type of measure

Measures targeting different groups and covering several sectors are frequently selected from local authorities in their Sustainable Energy and Climate Actions Plans.

Table 6 shows exemplary measures implemented in seven LAs. At European level, measures under the heading "Information campaigns" are one of the most favoured areas of intervention.

The most common tools on which the measures rely include:

- the lately developed: web based platforms are the most popular selected way of communication. Several EU MS describe the added value of unifying the topics under one umbrella web. It is also recommended to keep the messages as simple and funny as it can be (see Austrian Klimaaktiv or the Finnish MOTIVA platforms)
- the classic mass info campaigns: In general the scope and messages to be communicated are extremely varied. There is a need for tailor-made targeted messages for specific audiences. However, they must target specific areas of society, and the message need to be repeated to be effective. (see German EnergiEffizienz, or the French "j'éco-réenove, j'économise)
- based on active communication on-line tools: to calculate CO_2 reduction or energy savings estimations.(see the Belgian "Energy guzzlers tool")
- database containing examples of energy efficiency applications: illustrated examples of energy renovated houses, energy efficient expert list. These kinds of measures targeting users with previous knowledge on the topic may be very effective. (see the Danish illustrated catalogues)
- energy days, dedicated moments and spots to specific topics enable to raise the attention of public on themes that may be daily neglected (helpdesk and info points).

"Training measures" may have a great impact on community since they target more enthusiastic or empathic audience (students, energy related workers). However, these measures are not very common, because they are more difficult to set and organize, requiring specific skills. Three most common training measures are:

- General training to adults, targeting sectors or general ones
- Education and awareness raising at schools
- Ecodriving, general (adults, students) or professional (drivers, energy related workers) ones.

Table 6. Exemplary information actions at local level

City	Measure
Pilea Hortiaris	Pilot demonstrative project on energy efficiency measures and RES technologies in Public Schools
Turin	Yearly training courses targeting citizens and LA staff on energy behaviour
Dublin	Mobility manager & eco driving campaign
Tallin	Working with citizens and stakeholders program. Advices for the renovation of the residential, tertiary buildings, includes additional thermal insulation and heat and ventilations systems
Larnaka	Bicycle motion day (yearly)
Sonderborg	Network of energy advisors from the construction industry for spreading information about the benefits of the energy renovation through marketing methods which involve direct contact with the homeowner such as: "tupperware" method (small/medium gatherings organized for example in a private home involving the neighbours) and consultancy caravan.
Burgas	Behavioural change for use of private cars; Expanding of parking "blue zone"; Traffic lights "green wave"

Source: Rivas et al, 2015 ([11])

4.2 Planning implementing and monitoring an information measure

4.2.1 Planning

Literature and experience show the relevance of an optimal planning of information measures to be implemented. A carefully designed strategic plan to develop measures improves effectiveness ([12]). The recommended planning steps are:

- setting the measure/program goals in line with policy goals
- analyse the determinants of desired behavioural change
- analyse the market segmentation and choice of target groups
- choice of instruments
- planning the organization and management
- risk analysis and backup plan
- programmer testing and pilot campaigning
- planning the resources
- planning the monitoring and evaluation

(11) Rivas Calvete, S., Cuniberti B., Bertoldi P. (2016). "Effective information measures to promote energy use reduction in EU Member States". JRC 100661; EUR 27997 EN; doi:10.2790/581788.

(12) Case studies on innovative communication campaign packages on EE Global CCS institute study. Available at:https://hub.globalccsinstitute.com/publications/energy-efficiency-recipe-success/case-studies-innovative-communication-campaign-packages-energy-efficiency

One of the most important factors to be considered in the planning phase is the selection of the communication channel. This is based on:

- cost-efficiency,
- media brands,
- media coverage and access,
- cultural factors,
- long-term view and repetition.

In particular, the repetition is a frequently underestimated factor, which is on the contrary, a key to initiate the process for a change in the behaviour. Repetition or further development of the campaign is recommended in order to keep the message in the minds of the target group.

However, pure information does not necessarily result in behavioural changes: information materials must be accompanied by actions allowing people reproducing a new behaviour.

Finally, the suitability of the selected communication tools is another important element. Often it is much more effective to write a personal letter than to use anonymous direct mailing. Face-to-face contacts are more appropriate than telephone calls. Pictures and films are livelier than brochures and texts and leave a more lasting impression.

4.2.2 Implementing

The effectiveness of information campaign relies mostly on the effectiveness of delivered messages. They must be simple, adequate to the targeted group, easy to understand and inspiring. Three main aspects need to be considered ([13]):

- Emotions and rational arguments: Emotions are a very appropriate way to raise awareness. Once the target group is aware of the problem (e.g. motorised transport) and also of their own role, it makes sense to provide also rational arguments that support a change of behaviour. Strategies for behaviour change would be more effective if they would target the factors influencing the behaviour.
- Tone: pessimistic and catastrophic messages are not translated in a positive behavioural change. Experience shows that the message needs to be funny and must engage the audience. It needs to be tailored, positive and based on principles of cooperation and self-responsibility. The main pillars of this type of communication are: information, Consultation, Cooperation and self-responsibility.
- Feasibility: Maybe the most important aspect to be addressed to ensure the effectiveness of measures. Citizens need to be informed and motivated, but they absolutely need to be able to adopt the measures. The role of the authorities is to provide opportunities for feasible actions. It should also be considered that only reliable information can enable the implementation of effective solutions.

4.2.3 Monitoring and evaluation

The monitoring and evaluation phase of any kind of measure is crucial. It must be integrated in the planning phase, especially when trying to adapt or modify human behaviour. The evaluation of the effectiveness of the measure needs to:

- choose an evaluation method. A current challenge is to find better ways to evaluate the effectiveness of the measures, to develop new indicators for societal progress

(13) Stewart Barr et al.(2005).The household energy gap: examining the divide between habitual- and purchase-related conservation behaviours. Energy Policy 33 pp. 1425–1444

allowing to measure if higher awareness is translated into more energy efficient individual behaviours;

- collect the data;
- conduct the evaluation and report results;
- disseminate the results to improve the effectiveness of future programs.

Even if there is still not an harmonised world-wide method for comparing energy behavioural measures, literature gives several examples that can be easily adopted by Local Authorities: "comparison before the program and after"; the use of statistical analysis like the *Difference in differences* (DDI) "comparing the average change over time in the outcome variable for the treatment group, compared to the average change over time for the control group" or the *Randomized control trial* (RCT) "the people being studied are randomly allocated one or other of the different treatments under study" Schulz K.F. et al. (2010). **Table 7** shows strengths emerged from information measures implemented in CoM framework.

Table 7. Strengths/ tips on information campaign of the Covenant signatories

Strengths
✓ unifying information in web pages (information hubs) ✓ the development of active communication tools is growing ✓ generation of datasets targeting audience with energy knowledge ✓ easier and more engaging access to energy information through energy days and info-points

4.3 Overall recommendations

There is still a lack of knowledge among end-consumers of the existing economic potential associated with energy savings and solutions available. Furthermore, the low level of knowledge is not due to the inadequacy of available information. On the contrary, it depends on the way the information is provided. It might be deduced that previous approaches such as the price-based approach (save money) and the environmental approach (save the planet) were not completely successful.

Based on the fact that human behaviour and decision making are the core of the Climate Change problem, and that solutions should come from that, *the social* approach could succeed where other approaches failed. The social approach aims at integrating the social norms (referring to the perception of what is commonly done in a situation) and it may drive information and awareness measures for changing the energy behaviour towards sustainable practices.

Improvements are still necessary: people need to be inspired, to be engaged, to have fun when receiving the message. This must be carefully selected and keep as simple as possible. **Table 8** summarizes these considerations.

Table 8. Overall recommendations [(14)]

CITY PLANNERS SHOULD CONSIDER
✓ emphasize energy use/Climate Change as a real, actual local and personal risk ✓ facilitate more affective and experiential engagement (personal stories) ✓ leverage relevant social group norms ✓ frame policy solutions on what can be gained from immediate action ✓ appeal to intrinsically valued long-term goals and outcomes

(14) JRC–source based ,among others, on Van der Linden et al. (2015) work

5 Buildings

5.1 Municipal policies for energy efficiency in buildings

In the European Union, residential and commercial buildings consume approximately 40 % of primary energy and are responsible for 24 % of greenhouse emissions in Europe.

The energy roadmap for 2050 ([15]), suggests that the EU should cut greenhouse gas emissions (GHG) to 80 % below 1990 levels, where all sectors need to contribute to the low-carbon transition according to their technological and economic potential.

The roadmap foresees that the emissions in the building sector can be almost completely cut – by around 90 % in 2050 - through:

- passive housing technology in new buildings;
- refurbishing old buildings to improve energy efficiency;
- substituting fossil fuels with electricity and renewables for heating/cooling and cooking.

The Energy Performance of Buildings Directive (EPBD) ([16]), together with the Energy Efficiency Directive (EED) ([17]) and the Renewable Energy Directive (RED) ([18]) set out a package of measures that create the conditions for significant and long term improvements in the energy performance of Europe's building stock. The EPBD is a key regulatory instrument which is meant to boost the energy performance of the building sector. In the frame of its implementation the EU Member States (MSs) were asked to develop appropriate specific policies for their national situations and provide the necessary financing to foster the transition to Nearly Zero-Energy Buildings (NZEB) ([19]). In particular, in the framework of the EPBD recast it is required that by the end of 2020, all new buildings are NZEBs. This timeframe becomes stricter (from 2019 onwards) for the buildings occupied and owned by public authorities.

Moreover the EPBD recast asked MSs to calculate cost-optimal levels of minimum energy performance requirements adapted to the local climate for new and existing buildings by using the comparative methodology framework([20]). On the 30th November 2016, the European Commission presented a proposal for a revision of the EPBD recast, in the framework of the Clean Energy for all Europeans package that aims to deliver on the EU 2030 energy and climate goals.

The main proposals of revision include the strengthening of initiatives aimed at the restructuring of existing building stock (long-term building renovation strategies and mechanisms to support the smart financing of renovations), as well as new provisions regarding the smartness of buildings (an indicator will be introduced by the Commission through delegated acts), the regular inspections or control of heating and air-conditioning systems ([21]), and on-site infrastructure for electro-mobility. Moreover a 'Smart Finance

(15) Energy Roadmap 2050. (2011). *EC COM (2011) 0885*
(16) Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings, http://data.europa.eu/eli/dir/2010/31/oj
(17) Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy Efficiency, http://data.europa.eu/eli/dir/2012/27/oj
(18) Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of the use of Energy from Renewable Sources, http://data.europa.eu/eli/dir/2009/28/oj
(19) D'Agostino D., Zangheri P., Development of the NZEBs concept in Member States, EUR 28252 EN, doi:10.2788/278314
(20) Guidelines accompanying Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements
(21) In particular for non-residential buildings with total primary energy use of over 250 MWh and for residential buildings with a centralised technical building system of a cumulated effective rated output of over 100 kW

for Smart Buildings' initiative was presented alongside the revised EPBD. It analyses how to stimulate public and private investment in the energy efficiency of buildings ([22]).

The philosophy underpinning the Covenant of Mayors (CoM) is that, based on the emission related to final energy consumption (mainly in the buildings and transport sector), local authorities are able to tailor the necessary actions for implementing energy savings and increasing the renewable energy deployment in their territories. The reduction of final energy consumption in the building sector contributes to Climate Change mitigation and to reduce the dependence on fossil energy sources.

First and foremost, as highlighted in the EED, the local authority itself assumes an exemplary role in the implementation of these actions. Committing to highly efficient buildings in their own facilities is one way local authorities can reduce emissions. Public buildings represent a field where large reductions in energy consumption can be achieved. By developing energy efficiency projects in their buildings, local authorities set an example to the local community, inspiring citizens to adopt sustainable and low-carbon practice.

Moreover, local authorities empowered with the jurisdiction to build upon national efficiency policies in the building sector can implement codes and regulation with more stringent requirements than national ones. Through these regulations, integrated actions to improve energy efficiency in the buildings are provided and the use of renewable sources for space heating and cooling is fostered.

Box 4. Municipal regulation on buildings: Vila Nova de Gaia, Portugal

Vila Nova de Gaia is the most populous city in the Northern Region of Portugal. Along with Porto and 12 other municipalities, Vila Nova de Gaia is part of the Porto Metropolitan Area. The local authority's competencies in climate and energy matters are limited to its legal area and to its own facilities. Regarding legislation, the local authority is limited to their urban-planning regulations. One of the measures implemented by the municipality and Gaiurb - Urbanismo e Habitação, EEM (the company responsible for Urbanism, Social Housing and Urban Rehabilitation of the Municipality of Vila Nova de Gaia) is the "Municipal Regulation of Urbanistic Fees and Compensation", which introduces a new policy at local level on the promotion of sustainable construction. Implemented in 2010, the purpose of this measure is to give a boost to the sustainable construction processes and environmental protection mechanisms. Therefore, those who opt for sustainable construction certification will enjoy a full or partial tax reduction.

http://www.covenantofmayors.eu/IMG/pdf/Vila_Nova_de_Gaia_2016.pdf

To achieve the carbon reduction goals, local authorities must work with national and regional/provincial governments, as well as with other stakeholders (e.g. building owners, energy utilities, energy service traders and banks) and design specific measures in the action plan that are also able to remove and addresses the main common barriers in the building sector.

Box 5. Environmental education in schools: Trieste, Italy

The city of Trieste has activated an environmental education project in schools. The main activities regard: training on environmental and energy issues, consumption monitoring and calculation of an overall indicator of environmental sustainability.

The implementation involved 3 Schools in 2012-13, with positive results to be extended. The Local authority has also activated a series of educational activities with the collaboration with external bodies such as the ASS, the Education Laboratory Environmental (LaReA) of ARPA FVG and WWF.

The purpose of this activity is to raise awareness among students and teachers on environmental question, by also showing the results of CO_2 emissions reduction due to school buildings.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

(22) A complete summary of EU legislation can be found on http://europa.eu/legislation_summaries/energy/index_en.htm

These may include: regulatory and institutional barriers, financial challenges, market inefficiencies, and, lastly, the lack of knowledge and know-how.

Box 6. Voucher for Energy Certificates: Verona, Italy

Non-refundable vouchers are granted to private individuals who provide the energy certification for their dwellings without having the regulatory obligation.

The energy certification has the function of certifying the energy performance of buildings, increasing the awareness and the knowledge on the consumptions of buildings. The energy certificate is valid for ten years and must be updated when there are interventions that modify the energy performance of the building or of the heating systems.

http://www.covenantofmayors.eu/about/covenant-community/signatories/key-actions.html?scity_id=1843

This chapter aims at overviewing the key municipal policies and strategies to improve the energy performance of the building stock. It also gives broader insights on specific potential measures that may be implemented either for existing buildings or for new construction and provides a collection of best practices that highlights the role of local authority in steering the changes in the building sector.

To address the major barriers and to scaling up energy efficiency in existing, it is important for a local authority to outline a clear and comprehensive overview of the main issues, opportunities, and options available. A key first step is to carry out a sectorial assessment that can cover either the entire building sector or a certain specific segment.

An overview of the most common policies and related tools available to increase energy efficiency in buildings is reported in **Table 9**, which also includes indications of the barriers that the measures intend to address, and the potential role of the local authority in their implementation.

Box 7.

I) Think Energy Awareness Campaign: Dublin, Republic of Ireland

Think Energy aims to educate and inspire staff in local authority buildings to become more energy efficient by understanding more about the building that they work in and learning how their own behaviour can play a significant role in reducing the overall energy. The campaign ran for 12 months with the aim of inspiring the behaviour of the staff for years afterwards.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

II) Energy management for public buildings: Frankfurt, Germany

Approximately 1000 municipal buildings are operated and used by the City of Frankfurt. 10 employees control the energy performance of the buildings, invest in energy saving measurements, run a 50/50 campaign with the local facility service of the buildings for energy saving, and an education program for building operators, invest in CHP, PV, LED-lighting, renewable energy production, connection to district heating, etc.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

Table 9. Policy matrix for on energy efficiency in buildings organized by mode of urban climate governance

Mode of urban climate governance ([1])	**Policies and tools**	**Addressed Barrier**	**Illustrative Measures**	**Local potentials (What local authority can do)**
Municipal self-governing: Strategies for municipality-owned assets to reduce final energy consumption and to inspire community engagement	Energy management of local authority estate Demonstration projects in public facilities Green Public procurement Institutional reorganisation	Lack of transparent and consistent monitoring and control of energy use; Disincentive for energy efficiency efforts in budget supported public entities; Difficulty for public entities to contract energy service providers; Need for technical validation and demonstration; Allocation of competencies split in different departments.	Undertaking of cost-effective energy efficient investment in public buildings and LA's facilities (town-hall, schools…) such as: - energy audits; - energy management systems; - retrofit facilities for energy efficiency improvement; Energy services companies (ESCO); Integration of tasks into interdepartmental units.	Establish standards for monitoring and management of energy to improve efficiency in a systematic and sustainable way; Adopt high energy efficiency performance standard for new buildings; Procurement of energy efficient appliances; Showcases of obtained results to raise citizen awareness.
Regulation and planning: Requirements and guidance in support of energy efficiency in buildings	Mandatory standards and codes Regulation, controls and sanctions	Fragmentation and gaps in the regulatory action of public planning; Disincentive for energy utilities to invest in demand-side activities to lost sales.	Minimal environmental criteria; Minimum performance standard for buildings and appliances; Decouple energy utility revenue from sales.	Prepare a comprehensive plan to improve energy efficiency in the buildings; Develop building codes that addresses energy efficient buildings with minimum energy requirements (stricter than national ones); Introduce subsidies and bonus (e.g. reduction in development fees, expedited permit process or allowances for extra building floor/volume) for building with high energy performance; Establish a supporting program to assist in the retrofitting of old buildings.

Mode of urban climate governance ([1])	**Policies and tools**	**Addressed Barrier**	**Illustrative Measures**	**Local potentials (What local authority can do)**
Governing through enabling: Facilitating co-operation among stakeholders and awareness raising	Labels and certificates	Lack of reliable and credible advice on the building performance and awareness of energy savings potential	Energy Performance Certificates (EPCs); Energy label for appliances and materials; Voluntary certification schemes.	Implement all national and/or regional provisions; Promote the adoption of additional voluntary schemes.
	Public-private Partnerships	Segmentation of knowledge , skills and actions	Organize working groups that bring together companies and investors with the necessary expertise to develop strategies for energy saving in buildings.	The involvement of a range of different partners increases the democracy of the processes.
	Capacity building, education and awareness raising	Inadequate knowledge and skills for standards and building codes compliance. Lack of internal competencies in small LA.	Institution of local energy/environmental agencies; Energy efficiency training to design, engineering, building operations and maintenance staff; Public campaign to promote efficient use of energy; Dissemination of best practices and achieved results.	Ensures that municipal staff receive appropriate training; Promote competitions, awards and contests for climate protection and GHG reduction efforts; Provide guidelines for energy efficiency improvement in buildings.

Mode of urban climate governance ([1])	**Policies and tools**	**Addressed Barrier**	**Illustrative Measures**	**Local potentials (What local authority can do)**
Governing through provision: Providing services and financial resources for buildings energy efficiency projects	Public sector financial management and procurement policies	Split incentives; Fragmentation of the building trade.	Use Revise budgetary rules to allow retention of energy cost savings for other justified public spending; Revise public procurement rules to allow for contracting of energy service providers and adopt EE purchase requirements;	Make adjustments based on the local peculiarities to address energy efficiency in buildings.
	Financial facilitation	Insufficient financial incentive for citizens; Constrains of local budget; Competition with other investment priorities.	Subsidies for energy efficiency investments; Develop a dedicated energy efficiency fund and/or credit-line; Establish a partial risk guarantee.	Use public funds (also national) to leverage private and commercial investments; Third party financing; Energy services companies (ESCO)

5.2 Specific considerations related to different kinds of buildings

In accordance with the new EPBD approach, the demand for energy in buildings is linked to a significant number of parameters related to constructive design and the usage of the facilities. The main variables on which it is convenient to undertake actions to reduce the energy consumption are:

- Geometry, orientation, urban design and functional design of the building;
- Usage patterns and levels of indoor comfort;
- Building envelope, such as insulation, windows and solar protections;
- Equipment and systems, such as type of heat boilers, air conditioners and lighting;
- On-site energy production and renewable energy sources (RES), such as photovoltaic (PV) and thermal collectors;
- Building automation and control systems, able to continuously monitoring, analysing and adjusting the energy usage.

For each of these domains, both the current design capacity and the available technology options allow applying the energy efficiency principle, the importance of which is indisputable at global level. In addition to cutting emissions and energy bills, energy efficiency brings relevant additional benefits (i.e. better and healthier comfort conditions, new jobs and greater energy security). Moreover, according to the types of buildings and their conditions, the identified variables differently influence the energy performance, therefore, implying specific energy efficiency measures. However, although the benefits of efficient buildings are obvious, time and resources to be allocated are frequently significant barriers for the local administrations. At this level, it is crucial to find potential common allies, able to share policy best practices and exemplary applications.

In the following paragraphs, an insight on status, strategies and tools for specific kinds of buildings, namely new buildings, existing buildings and historic buildings, is provided.

5.2.1 New buildings

Newly constructed buildings represent the best opportunity to reach very low energy consumptions (or even positive levels, where energy production exceeds consumption), introducing energy efficiency technologies that can result very cost-effective over the course of their life cycle (also 30-50 years).

These results can most effectively be achieved by introducing regulatory policies (minimum energy performance standards) at national, regional or local level (i.e. building energy efficiency codes). Another valuable option in this framework is incentivising owners, investors and developers to exceed the current minimum energy performance standards. To this aim, the current energy certification scheme (or other voluntary rating systems) can be used to apply incentives whether financial (e.g. tax discounts) or not (e.g. volumetric increments).

Whether a well-designed and constructed new building achieves expected energy savings will largely depend also on user behaviour and operational management. As a consequence, the use of information and communication technologies (ICT) should be recommended in large new buildings, particularly the non-residential ones. 'Smart buildings' refer to more efficient buildings whose design, construction and operation is integrating ICT techniques like "Building Management Systems" (BMS) that run heating, cooling, ventilation or lighting systems according to the occupants' needs, or software that switches off all PCs and monitors after everyone has gone home. BMSs can be used to collect data allowing the identification of additional opportunities for efficiency improvements.

5.2.1.1 Nearly Zero Energy Buildings (NZEBs)

The implementation of NZEBs as the building target from 2018 onwards represents one of the biggest opportunities to increase energy savings and minimize greenhouse gas emissions. In accordance with the EPBD, a NZEB is a building that "has a very high energy performance with the nearly zero or very low amount of energy required covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby". However, in the EPBD there are neither minimum nor maximum requirements for NZEBs, leaving the Member States free to set their own specifications. Moreover, specific topics on NEZB are still under discussion at international level such as boundaries and calculation methodologies. The Member States included information on building regulations for new/existing buildings in their templates and national plans and has defined NZEBs for both residential and non-residential buildings. Furthermore, they provided the inclusion of specific subcategories (such as apartment blocks, offices, educational buildings, hospitals, hotels, wholesale and retail buildings) in their national definitions. For RES generation the options considered by all countries are: solar thermal, geothermal, passive solar and passive cooling, heat recovery and PV ([23]). A final energy saving of above 90% is expected for new constructions and renovations with the NZEB approach ([24,25]). Therefore, local authorities may take the opportunity to enhance the advancement of NZEBs by providing incentivising policies and stricter requirements in their building regulations, and helping in the dissemination of the advantages both in term of economy and energy savings, that this kind of buildings are able to provide.

Box 8. Viikki Environment House: Helsinki, Finland

Viikki Environment House was the first nearly zero energy office building built in Finland. It was completed in 2011. The building has been awarded with several prizes. The design of the building envelope and building service systems are based on maximal energy efficiency. The building is equipped with solar panels on the roof and integrated to facade, ground source cooling and micro wind turbines. Building is heated with district heating.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

5.2.2 Existing buildings undergoing major refurbishments

In most European cities, the building stock shows very low renovation rates. The retrofitting of existing structures and the replacement of old energy-consuming systems is often considered one of the most valuable strategies to achieve high energy savings, since more than 40 % of the building stock consists of buildings dating more than 50 years ago which show a huge potential for improvement. The most common strategy for the energy refurbishment consists in minimizing thermal losses through the envelope, but the control of the solar heat gains and the reduction of cooling loads are also beneficial. However, it has generally been difficult to develop bankable retrofitting projects and secure the necessary long-term financing to undertake them. Moreover the current difficulties are due also to regulatory and market failures, as well as the general lack of understanding among households and building owners of their energy use, and potential savings related to different energy efficiency measures.

Encouraging retrofits of buildings in the residential sector is generally more challenging than in other sectors because of the highly disaggregated nature of home ownership and the small size of individual investments and returns. In the past, most efforts have focused on equipment replacement (such as incandescent lamps and refrigerators), encouraging or requiring the energy utilities to carry out demand-side management

(23) D'Agostino D., Zangheri P., Development of the NZEBs concept in Member States, EUR 28252 EN, doi:10.2788/278314
(24) BPIE (2011). Europe's buildings under the microscope. A country-by-country review of the energy performance of buildings. Brussels
(25) D'Agostino D., and Parker D. S., A model for cost-optimal simulation of new Nearly Zero Energy Buildings (NZEBs) in Europe, EUR 28551 EN, doi:10.2760/001562

programs. Frequently, local authorities provide forms of incentives and subsidies to boost the implementation of energy measures and retrofit of buildings among citizens.

Box 9.

I) Encourage citizens to implement environmentally friendly measures by giving grants: Neerpelt, The Netherlands

Grants were assigned by the local authorities to encourage citizens to implement environmentally friendly measures in and around their homes, sited in Neerpelt. The considered measures were the following:

- Insulating materials (glass, roof, wall, floor and basement) for existing homes (721 grants distributed). To stimulate this measure additional premiums were provided under specific circumstances;

- E-level new house -who has an E-level lower than the norm get a grant (41 grants distributed);

- Energy Audit in existing homes (5 grants paid).

In case of combination of two or three measures within the same year, the local authority gives an additional bonus up to 25%.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

II) Insulation of lofts and cavities wall across all housing sectors: South Tyneside, United Kingdom

In the 4 years 2010-2014 South Tyneside Council worked with partners to install loft and cavity wall insulation in respectively 5326 and 4268 homes, respectively in both the private and social housing sectors. The bulk of this work has been carried out by *South Tyneside Warm Zone* and is now being carried forward by a new regional energy efficiency retrofit programme 'Warm Up North'.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

III) ECORENO'V: housing energy refurbishment platform: Grand Lyon, France

Lyon Metropole's eco-refurbishment platform was launched in 2015 after a 2-year experimentation phase. The experimentation phase helped setting the right objectives in terms of energy performance, level of grants and mobilization of partners. Écoréno'v is a service of the Métropole de Lyon, supported by the Auvergne-Rhône-Alpes region and ADEME to advise and support projects of eco-renovation of private housing. ECORENO'V is now operational with more than 1200 private lodgements financed.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

Social housing is included in the building sector and it is crucial for the overall improvement of energy efficiency al local level. The retrofitting of existing buildings within the social housing stock allows reaching an important reduction of consumption due to an old building stock in many countries. Furthermore, the social housing refurbishment may address also fuel poverty and energy access issues. As a consequence, the refurbishment of Social Housing building stock is an integrated policy that while dealing with Climate Change achieves other policy objectives.

Larger margins for the local authorities to intervene are possible in the sector of the private-owned commercial buildings. Here the use of a combination of regulatory and incentive instruments can help to overcome financing barriers and scale up investments. For instance, the national financial incentives could be used to encourage comprehensive retrofit projects, preventing the sporadic implementation of partial retrofit projects by market participants.

5.2.3 Public Buildings

The buildings owned, controlled or managed by the local authority itself are those on which the local authority has the greatest control. Therefore, it is expected that the local

authority should lead by example by testing new policy measures and initiating cost-effective activities that increase the efficiency of its own buildings.

Focusing on the existing ones, a retrofit programme of public buildings should be set up, defining the scope and depth of a retrofit scheme, the delivery mechanism of the retrofit program, and the financing and repayment arrangements for the project. These issues are usually addressed through a market study that involves consultation with stakeholders (e.g. the government departments, schools, and hospitals that own or operate the buildings that are to be retrofitted) as well as with energy service providers and potential financiers. The choice of which retrofit option to apply is based on the local climatic conditions and on detailed energy audits.

Depending on the complexity of the programme and the financing arrangements, the local administrators may follow several commonly used contracting models. The guaranteed-savings contracts are an interesting option. They only require Energy Services Companies (ESCOs) to implement the retrofit projects, and can guarantee a stable stream of annual energy cost savings to repay the financers.

Box 10. The new town hall of Seraing: Seraing, Belgium

The City of Seraing has chosen to group all public departments in a new entirely passive administrative building of about 4,500 m². It is one of the first buildings of this type and size to meet the challenge of passive criteria both in terms of heating and cooling in the Walloon Region. In addition to specific technical characteristics related to energy efficiency, the building is also equipped with photovoltaic solar panels. The design process placed the energy topic at its core and it was developed through a close collaboration between architects and experts in building energy. The building is in use since May 2014 and its specific energy consumption is expected to be 60% less than similar buildings, built according to building standards of K45.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

5.2.4 Historic Buildings

Historic buildings possess cultural, architectural, historical, social and other values. For these buildings, the primary purpose is the preservation and transmission to future generations, under the best possible conditions. As a consequence, specific methods and procedures are required to deal with them. The energy retrofits for historic buildings must be the result of a balanced process that involves multiple expertises with a mutual feedback: from architectural to technical aspects, from the cultural to the political ones. Moreover, the retrofit, when carefully and holistically developed, may be also considered as a tool to preserve these buildings for future generation, while addressing the current environmental and energy current needs. In order to promote tailored retrofit approaches designed for the specificities of the building, multiple criteria and methods have been developed. However, there are some methodological points that are in common in the available retrofit strategies: a preliminary deep assessment of the building, the cooperation between different institutions and professionalisms, the development of a decision making process, the choice of strategies and technologies to be used with a case to case approach. The following list provides a framework that contains some of the common criteria and assessment methods used in retrofit strategies, which can be furtherly detailed with specific insights and elaborations linked to the peculiarities of the building and its surroundings ([26]).

(26) Webb, A. (2017). Energy retrofit in historic and traditional buildings: a review of problems and methods. Renewable and sustainable energy review 77:748-759

- Assessment methods:

These methods are used for a preliminary investigation of the building with the aim of increasing the general knowledge of its performance, components and construction procedures. Some measures are developed in the site of the building. They mainly refer to microclimate, thermal comfort and the building envelope. There are also laboratory tests and simulations to foreseen the performance of the building under certain circumstances.

- Energy consumption, Energy production and Energy supply:

Measures to reduce the energy consumption of the buildings usually affect the building envelope, the HVAC system and the occupant's behaviour. However, it must be considered that historic and traditional buildings were often designed taking into account the local climatic conditions, and hence, they may have a good energy performance. Some typologies of retrofits are usually excluded a priori because they impact the aesthetic and technology compatibility of the building. The introduction of renewable energy production in this kind of buildings needs preliminary investigations to choose both the suitable technology with a special focus on the up-to-date techniques ([27]) (such as PV modules integrated into elements of building envelope) and the best application solution that may allow a good visual integration in the architecture. Biomass boilers and CHPs are forms of energy supply with no or low visual impact on the building.

5.3 Measures for energy efficient buildings

All the processes that are involved in the energy efficiency of buildings, from the design and the construction, to the renovation and operation, recognize the provision of healthy and comfortable environments to its occupants as the main purpose of any buildings. The 'sustainable comfort' can be defined as achieving good comfort conditions with no or limited use of resource energy and through the use of environmentally non-harmful materials.

In this framework, a ten-step approach is provided to improve the energy efficiency of buildings, which implies also adopting measures on both thermal and electric energy (e.g. through reducing the wall transmittance in the former and using efficient appliances in the latter). The approach leaves ample freedom to designers while supporting them in adopting solutions that also take into consideration local specificities of climate, culture, locally available materials:

1. Define explicitly the building objectives, with particular focus on the thermal comfort.
2. Assess the microclimatic factors and intervene on the site layout and features which can affect the comfort indoor.
3. Control the heat gains at the external surface of the building envelope.
4. Control and modulate heat transfer through the building envelope.
5. Control the internal gains from appliances and lighting.
6. Allow for local and individual adaptation.
7. Use passive means and strategies ([28]) to deliver and remove thermal energy to/from the building.
8. Use active heating and cooling systems assisted by natural (and renewable) energy sources.

(27) Moschella, A., Salemi, A., Lo Faro, A., Sanfilippo, G. Detommaso, M., Privitera, A. (2015). Historic Buildings in Mediterranean area and solar thermal technologies: architectural integration vs preservation criteria. Energy Proceedia 42:416-425

(28) This does not exclude the use of a fan or a pump when their application might enhance the performance.

9. Use high efficiency active conventional heating and cooling plants, if still necessary.
10. Train building managers and occupants on how to use, monitor the performance of and adequately operate and maintain the building.

The first two points refer to the comfort requirements and the multiple interactions between indoor and outdoor environments. Steps 3 and 4 include all technologies and strategies associated to the building envelope from which the net thermal energy needs for heating and cooling ([29]) depend. Steps 5 and 6 have to do with the way a building is used and occupied. Points 7, 8 and 9 provide a sustainable approach to reach low levels of delivered (or final) energy consumption ([30]) implementing appropriate system solutions. The last step includes all strategies needed to verify and adapt the building performance during the real-life operation.

Mostly, the suitability of energy-efficient solutions mainly depends on the micro-climate conditions and their cost-effectiveness. The economic issue is related to the maturity of the local market (of materials, technologies and jobs) and to the construction type (i.e. new building or building retrofit). The tables below provide an overview of the prevailing technologies and strategies, which could be considered for cold and intermediate/warm climates (**Table 10**) in accordance to the methodological step (introduced above) and the building type.

(29) Energy needed for heating and cooling means heat to be delivered to or extracted from a conditioned space to maintain intended temperature conditions during a given period of time.
(30) Energy, expressed per energy carrier, supplied to the technical building systems through the system boundary, to satisfy the uses taken into account (heating, cooling, ventilation, domestic hot water, lighting, appliances, etc.).

Table 10. Building technologies and strategies for cold, warm and intermediate climates, according to methodological step and construction type

Cold Climate (Heating degree days > 3 350)		**Warm and intermediate Climate** (Heating degree days < 3 350)	
New building	**Renovation**	**New building**	**Renovation**
- Summer Adaptive comfort - Optimised distribution of internal spaces		- Summer Adaptive comfort - Optimised distribution of internal spaces	
- Main building axis oriented east-west and optimised distribution of internal spaces		- Main building axis oriented east-west - Cool materials and finishing for urban surfaces - Inclusion of greening strategies in the design (vegetation and surface water)	- Cool materials and finishing for urban surfaces - Inclusion of greening strategies in the design
- Triple or double-glazed low-e windows	- Double-glazed low-e windows - Exterior storm windows with low-e coating - Internal insulated shades	- Architectural shading - Reflective (cool) roof - Ventilated roof, double-skin façades - Double-glazed low-e or windows with low g-value - Exterior window shading/blinds and dynamic shading - Finishing material - Low heat conductivity building materials	- Reflective (cool) roof - Double-glazed windows with low g-value - Exterior window shading/blinds and dynamic shading - Window film reducing g-value - Finishing material - Low heat conductivity building materials
- Highly insulated roof, external walls and basement - Reduction of thermal bridge - Windows and doors with high airtightness levels	- Medium-highly insulated roof, external walls and basement - Main envelope joints thermal bridge free - Windows and doors with good airtightness levels	- Medium-highly insulated roof and external walls - Optimised thermal mass inertia	- Medium insulated roof and external walls - phase-change materials
- Daylighting solutions - Efficient lighting sources & syst - Efficient appliances & equip. - Smart shutdown logics	- Efficient lighting sources and systems - Efficient appliances and equipment - Smart shutdown logics	- Daylighting solutions - Very efficient lighting sources and systems - Very efficient appliances and equipment - Smart shutdown logics	- Very efficient lighting sources and systems - Very efficient appliances and equipment - Smart shutdown logics

Cold Climate (Heating degree days > 3 350)		**Warm and intermediate Climate** (Heating degree days < 3 350)	
New building	**Renovation**	**New building**	**Renovation**
- Openable windows - Flexible dressing code	- Openable windows - Flexible dressing code	- Openable windows - Ceiling fan - Low thermal insulation furniture - Flexible dressing code	- Openable windows - Ceiling fan - Low thermal insulation furniture - Flexible dressing code
- Architectural features - Dynamic glass/shades - Comfort daytime and night ventilation - Ground heat exchanger	- Dynamic glass/shades - Comfort daytime and night ventilation	- Architectural features - Dynamic glass/shades - Comfort daytime and night ventilation - Ground heat exchanger - Direct or indirect evaporative cooling - Radiative cooling - Open groundwater or surface water systems	- Dynamic glass/shades - Comfort daytime and night ventilation
- Ground source heat pump	- Ground source heat pump	- Ground source heat pump - Solar cooling systems	- Ground source heat pump - Solar cooling systems
- Very efficient HVAC systems - Condensing boiler - Highly insulated distribution plant - Straight distribution ducts layout and efficient fans/pumps	- Very efficient HVAC systems - Condensing boiler - Highly insulated distribution plant - Straight distribution ducts layout and efficient fans/pumps	- Very efficient HVAC systems - Condensing boiler - Insulated distribution plant - Straight distribution ducts layout and efficient fans/pumps	- Very efficient HVAC systems - Condensing boiler - Insulated distribution plant - Straight distribution ducts layout and efficient fans/pumps
- Exhaustive building manuals - Monitoring plan - Maintenance plan	- Clear and exhaustive building manuals - Monitoring plan - Maintenance plan	- Clear and exhaustive building manuals - Monitoring plan - Maintenance plan	- Clear and exhaustive building manuals - Monitoring plan - Maintenance plan

5.3.1 Improvement of the envelope and other aspects

One of the most common strategies for energy retrofit of buildings usually consists in reducing both thermal losses through the envelope and cooling loads, and in controlling the solar heat gains.

The losses of energy through the envelope may be reduced through the implementation of several measures that affects glazing and frames and the walls and roofs characteristics.

- Gains and losses of energy through windows are four to five times higher than the rest of the surfaces. Both daylight provision and gaining or protecting from solar radiation penetration must be taken into account in the choice of appropriate glazing. New technologies with decreased values of transmittance for glazing are available: double-glazed with low emissivity coating, low-Emissivity Argon filled double glazing and triple glazing (respectively up to 1.1 W/(m^2·K) and 0.7 W/(m^2·K)). Moreover, since the characteristics of frames affect the global window performance, it is necessary to consider also the replacements of these elements in the energy retrofitting of the building. In this regard, thermal break aluminium, plastic and wooden frames show good performances.
- Either internal or external thermal insulation of walls reduces their transmittance values according to specific needs and location of the buildings. Commonly-used types of insulation in building construction include: Fibreglass, Polyurethane foam, Polystyrene foam, Cellulose insulation and Rock wool. These materials also contribute to reduce the effect of thermal bridge and to improve sound insulation and thermal inertia.
- The abatement of cooling loads is achieved by reducing solar radiation penetration through the use of shading devices. These comprise: movable devices which can be controlled either manually or automatically; internal and external blinds which help control lighting level and uniformity, and allow stopping solar radiation before penetrating into the room when arranged externally.
- An increased energy performance of buildings is achievable by operating on the heating system. The overall efficiency of the space heating system includes the efficiency of the generator and the losses of distribution, emission and inaccurate control systems.

Box 11.

I) Complex retrofit of residential buildings: Warsaw, Poland

In the city, a significant potential for reducing CO_2 emissions lays in the housing sector through complex thermal retrofitting activities, replacement of indoor lighting and equipment used at home with more energy efficient units. The comprehensive thermal retrofit of residential buildings was developed to the extent and in standard close to the Thermal Retrofit Act. In 2011-12 over 400 buildings was subject to retrofitting thanks to the thermomodernization bonus. It is a form of state help for an investor who carries out thermomodernization enterprise. It is paid out by Bank Gospodarstwa Krajowego at 25% of the loan used for such an enterprise. An investor who carries out a thermomodernization enterprise only pays off 75% of the amount used for the loan.

https://www.covenantofmayors.eu/plans-and-actions/good-practices.html

II) Energy Efficient Retrofitting Concerto/act2: Hannover, Germany

Included in the project, a total of 52 buildings in Hannover (with 398 dwelling units and around 24,000 m² of living space) underwent energy efficiency refurbishment and three municipal school buildings with together 8.532 m² have been energetically retrofitted. With an insulation thickness of 14-16 cm for the outer walls and 20 cm for the top-floor ceilings, the statutory requirements for new buildings were either met or exceeded. To complement these insulation measures, conversion to environmentally friendly heating systems (pellet heating and district heating from biomass) took place. The consumption data analysed indicate heat energy savings that, at 50-65%, are far higher than those for buildings refurbished in the usual way. It was demonstrated that a consumption reduction from more than 250 kWh/m²y to 70-100 kWh/m²y is achievable.

https://www.covenantofmayors.eu/plans-and-actions/good-practices.html

III) External wall insulation at Boavista Neighbourhood: Lisbon, Portugal

Promoted by Lisbon Local Authority, this program joined various stakeholders with the local housing organization and the local community association, committing to achieve improved energy performance, through an Integrated Model for Sustainable Innovation. This project provides the Boavista Neighbourhood (10,000 inhabitants), with full refurbishment and energy performance increases.

https://www.covenantofmayors.eu/plans-and-actions/good-practices.html

5.3.2 Lighting

5.3.2.1 Domestic and professional buildings lighting

A set of options in the lighting sector allows reaching up to 50% of savings. The most common measure is the replacement of lamps with more efficient ones (lower consumption with the same performance). Moreover, correcting the misuse of the lighting appliances shows to be a significant contribution in the saving options. In this perspective, the systems that can control and modulate the light sources (presence detectors, brightness sensors, dimmers, lighting systems) have a large impact on total lighting energy use. Savings may be also achieved by using high-quality and high-precision optical appliances that guarantee a high performance of the whole system and by implementing a careful lighting design process. The lighting influence on energy consumption varies according to the types of buildings. In particular, tertiary buildings and offices show the highest energy consumption due to lighting and, hence, may be the target where energy saving strategies may be implemented to yield more efficient results. On the contrary, lighting in residential buildings have a lower impact on the overall energy consumption which implies a limited selection of measures to be implemented, in particular in existing buildings. However, despite being accessible, there is a number of barriers that limits the implementation of efficient lighting; among these, the unawareness of saving potentials and the higher initial cost of efficient lighting systems ([31]).

5.3.2.2 Characteristic parameters and definitions

Luminous flux: is the measure of perceived power of light in the unit time [lm].

Luminous efficiency: is the parameter that allows an evaluation of the energy efficiency of the lamp. It gives an idea of the amount of absorbed electricity that is transformed into light. It represents the relationship between the luminous flux of the lamp and the electric power supply [lm/W].

(31) The Greenlight project's webpage contains wider information about lighting http://www.eu-greenlight.org/index.htm Further information on lighting technologies and policies in OECD countries can be found in the document "Lights Labour's Lost: Policies for Energy-Efficient Lighting". Can be downloaded from https://www.iea.org/publications/freepublications/publication/light2006.pdf

Colour Rendering Index (CRI): ranging from 0 to 100, it indicates how faithfully a light source reveals colours of objects in comparison with an ideal or natural light source. The higher the colour rendering index, the less colour shift or distortion occurs (**Table 11**).

Incandescent lamps: typically emit 12 lm/W, representing energy-to light conversion efficiency of 5%. As part of the implementation process of the Directive 2005/32/EC on Ecodesign of Energy Using Products, on 18th March 2008, the Commission adopted the regulation 244/2009 on non-directional household lamps which would replace inefficient incandescent bulbs by more efficient alternatives between 2009 and 2012. From September 2009 and by the end of 2012, lamps at several wattage levels had to be at least class C (improved incandescent bulbs with halogen technology instead of conventional incandescent bulbs).

Halogen lamps: are incandescent lamps with small sizes that allow their use in compact optical systems for projectors and illumination. They will be banned from September 2018.

CFL (Compact Fluorescent Lamps) have attracted great interest in households as they can easily be adapted to the existing installation. Due to their Mercury contents, this kind of lamp requires well-planned recycling management. They show a luminous efficiency of about 40-60 lm/Watt.

LED (Light Emitting Diodes) originally used in electronics are now widespread also as lighting systems. These lamps are energy efficient (class A) and characterized by a high life span. They show a luminous efficiency between about 50-100 lm/Watt.

Lighting controls are devices that regulate the operation of the lighting system in response to an external signal (manual contact, occupancy, clock, light level). Energy-efficient control systems include:

- Localised manual switch
- Occupancy linking control
- Time scheduling control
- Day lighting responsive control

Table 11. Light requirements according to the use of building

Colour Rendering Index required	Recommended lamp	Luminous efficiency
Very important 90-100 e.g.: Art Galleries, precision works Luminous flux:1000 lm	26 mm-diameter (T8) linear fluorescent lamp	77-100 lm/W
	Compact fluorescent lamp (CFL)	45-87 lm/W
	Very-low voltage tungsten halogen lamp	12-22 lm/W
	LED	35-80 lm/W
Important 80-89 e.g.: Offices, schools, industrial areas Luminous flux:500 lm	26 mm-diameter (T8) linear fluorescent lamp	77-100 lm/W
	Compact fluorescent lamp (CFL)	45-87 lm/W
	Fitting-based induction lamp	71 lm/W
	Metal halide lamps	65-120 lm/W
	"White sodium" high pressure sodium lamp	57-76 lm/W

5.3.3 Strategies for efficient lighting in buildings

Indoor illumination of tertiary-sector buildings uses the largest proportion of lighting electrical energy. On average, lighting accounts for 34 % of tertiary-sector electricity consumption and 14 % of residential consumption in OECD countries ([31]).

Strategies for improving the energy efficiency in lighting vary if either a new building or an existing one is considered. In the first case, more incisive results can be achieved, since architectural issues contribute to the lighting needs of spaces. Building modification to optimise use of natural light is restricted to initial construction and renovation. Natural light during daylight hours limit the use of artificial light, hence reducing electrical consumption and thermal load, and improve comfort. Alongside, 1) the planimetrical distribution of the building, 2) the geometric configuration 3) and the type of windows determine the natural light penetration in rooms.

In addition, these are the factors that influence the energy demand due to lighting in both new and existing buildings:

- the choice of the type of lamp;
- the displacement of lamps;
- and the relation between lamp and luminaires.

In a typical lighting system, only 30% of the lumens emitted by the lamp contribute to the lit environment. There is a huge amount of losses due to the luminaire, the light absorption on surrounding surfaces and the light redirection to avoidable areas. In existing buildings, the most common strategy is the replacement of old inefficient lamps, with new performing ones. Moreover, when estimating a building's lighting needs, various spaces shall be considered separately, both quantitatively and qualitatively (**Table 12**).

Table 12. Light requirements according to the use of building

Colour Rendering Index required	Recommended lamp	Luminous efficiency [lm/W]
Very important 90-100 e.g.: Art Galleries, precision works Luminous flux:1000 lm	26 mm-diameter (T8) linear fluorescent lamp	77-100
	Compact fluorescent lamp (CFL)	45-87
	LED	35-80
Important 80-89 e.g.: Offices, schools, industrial areas Luminous flux:500 lm	26 mm-diameter (T8) linear fluorescent lamp	77-100
	Compact fluorescent lamp (CFL)	45-87
	Metal halide lamps	65-120
	"White sodium" high pressure sodium lamp	57-76

Depending on the type of work developed, the frequency of use and the physical conditions of such spaces, the lighting installations will require different designs. Moreover, sensors and other control devices are frequently used tools for the design and the management of low consumption lighting systems with simple payback of 2-3 years. As a side-effect of the energy saving in lighting, designers should take into account the reduction of cooling needs due to the decrease of heat emitted by bulbs.

The following table (**Table 13**) reports the amount of electricity saved by replacing a 60 W incandescent lamp whose luminous flux is 900 Lumen by a halogen, CFL and LED.

Table 13. Amount of electricity saved by replacing a 60W incandescent lamp whose luminous flux is 800 Lumen by a CFL, LED or halogens

	Incandescent lamps	Incandescent Halogen lamp	CFL	LED
Luminous efficiency	15	22,5	47,5	67,5
Luminous flux (lm)	900	900	900	900
Power (W) = Energy consumption per hour (kWh)	60	43	16	10
Energy saved (%)	-	-28,3%	-73,3	-83,3%

Source: https://ledpro.it/tabella-comparazione-led/.

Recommended illumination levels for correct design of the lighting system in domestic environments are reported in

Table 14.

Table 14. Recommended illumination levels for correct design of the lighting system in domestic environments

Building area/room	Luminous flux
Enterclose	50-150 lux
Reading/studying area	200-500 lux
Writing area	300-750 lux
Dinner area	100-200 lux
Kitchen	200-500 lux
Bathroom: general	50-150 lux
Bathroom: mirror area	200-500 lux
Bedroom: general	50-150 lux
Bedroom: wardrobe area	200-500 lux

Source: ENEA, risparmio energetico con l'illuminazione. Sviluppo Sostenibile, 5 ENEA-Unità RES RELPROM Lungotevere Thaon di Revel, 76 - 000196 Roma

5.3.4 Other measures in buildings

Other simple measures may contribute in the reduction of energy consumption in buildings and in configuring sustainable buildings simultaneously. Along with lower environmental impact, sustainable buildings are relatively low cost to run and in the long term, more valuable properties ([32]). Some of the policies described below may need to be supported by specific political strategies adopted by the local authorities.

Behaviour and building management: adequate behaviour of building occupants may also generate significant savings. Information and motivation campaigns could be organised in order to get support of the occupants. In such cases, it is important that a good example is also given by the hierarchy and by the authorities in charge of the building

(32) LEVEL(s) PROJECT http://ec.europa.eu/environment/eussd/buildings.htm

management. There are numerous social approaches that may help in achieving a behaviour change: Sharing the savings between occupants and the local authority could be a good way of motivating action; cooperating to reach a common environmental goal (families in the same building can work together); competitive approaches provide motivation among occupants especially if publicly recognised. Publicly displaying the energy certificate of the building is an example of sharing that may induce the mentioned approaches among citizens. Moreover, special efforts must be concentrated to lower the rebound effect. Expected energy savings might be reduced by behavioural reactions, which induces an increase in the usage of energy-consuming technologies, made less expensive by efficiency itself.

Some student-oriented projects ([33]) aimed at teaching them good practices have been developed or are now under development. These projects propose including positive-energy patterns in curricula in order to make students aware of the benefits of energy-efficient behaviour. These initiatives are not only focused on students, but also on parents. In fact, the idea is to bring energy efficiency to the home from school. Significant energy saving reductions through motivation and information in a citizen competition can be seen from the IEE Project Energy Neighbourhood http://www.energyneighbourhoods.eu/gb/

Box 12. Fifty-Fifty Project in Hamburg: Hamburg, Germany

Fifty-Fifty is an energy and water saving programme tested in 1994 in Hamburg in a number of schools. The key element of the Fifty-Fifty Project is a system of financial incentives that enable the schools to share the saving in energy and water costs achieved. There is an agreement between the local authority and the schools; teachers and pupils are encouraged to reduce their energy and water consumption simply by changing their behaviours. Fifty per cent of the money saved is returned to the school, where it can be reinvested into new energy saving devices, equipment, materials and extra-curricular activities. For instance, the Blankenese School bought solar panels with the money they saved on energy consumption and installed them themselves.

www.energy-cities.eu/

The management of technical installations in buildings may lead to energy savings: make sure heating is turned off during week-ends and holidays, make sure lighting is off after work, fine tuning of the heating/cooling operation, adequate set points for heating and cooling. For simple buildings, a technician or an energy manager could be appointed for such tasks. For complex buildings, the help of a specialised company may be necessary. Therefore, it may be necessary to renew or set up a new contract with a competent maintenance company with adequate requirements in terms of energy performance. Be aware that the way the contract is drafted could highly influence the motivation of such a company to effectively find out ways of reducing energy consumption.

Box 13. Sensitizing local residents by dissemination of good examples from local authority: Lille, Belgium

Habits and technologies are deeply embedded in social structures. The 4E strategy ('exemplify, enable, engage, encourage') is used by the local authority to realize a successful promotion with the aim of changing behaviour towards a more sustainable lifestyle.

- 'Enable'- facilitating: By removing barriers, providing information and facilities, offering training to learn skills. If people are asked to change they must know how to.

- 'Exemplify'- the head takes the lead: By looking for good examples, implementing them and bringing them to the attention of the population.

(33) Further information on energy efficiency at school available on www.pees-project.eu
Project supported by Intelligent Energy Europe. A Scientific research on energy efficiency at school has been performed in Greece. Results can be found in the article: Effective education for energy efficiency - Nikolaos Zografakis, Angeliki N. Menegaki, Konstantinos P.Tsagarakis. Published in Energy Policy 36 (2008) 3226-3232

- 'Engage' - involvement of target groups: superficial information and one-off campaigns do not lead to permanent behavioural changes. A broader initiative must be developed for the involvement of citizens and action, cooperation and consultation, personal contacts and enthusiasm, media campaigns, networks.

- 'Encourage' - give the right signals: the local authority has various instruments to stimulate (or impose) behavioural change: price signals (premiums, taxes), rewards, recognition and social pressure, regulations, fines, penalties.

Examples of measures within this strategy are: launching a sensitizing, local energy tool with which each family can position its energy consumption in relation to all other families in the municipality; promoting new (bottom-up) initiatives, establishing an energy master network and providing permanent support.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

Monitoring: implement a daily/weekly/monthly monitoring system of energy consumption in main buildings/facilities, allowing the identification of anomalies and taking immediate corrective action. Specific tools and software exist for this purpose.

Retro-commissioning: improve the efficiency of equipment and systems in existing buildings. It frequently addresses issues developed throughout the building's life. It consists in the adaptation and regulation of the technical installations to the current uses and owner's requirement (bring equipment to its proper operational state, improve indoor air quality, increase equipment lifespan, improve maintenance operations and others). The Retro-commissioning ([34]) requires small investments related to the control and regulation of the technical installations which, however, may generate significant savings. Maintenance: good maintenance of the HVAC systems may also reduce the energy consumption with low budgets.

Location: buildings in winter climates are especially suitable to incorporating passive solar heating strategies that will reduce the heating loads. In contrast, buildings located in summer climates will require active protection against solar radiation in order to minimise cooling loads. Natural ventilation strategies help to increase the comfort in buildings and, hence, wind characteristics and building shapes should be studied in detail.

Hours of Operation: The most energy-intensive building types are those in continuous use, such as hospitals. In these buildings, the balance of heating and heat removal (cooling) may be dramatically different from that of an office building with typical working hours. For example, the around-the-clock generation of heat by lights, people, and equipment will greatly reduce the amount of heating energy used and may even warrant a change in the heating system. Intensive building use also increases the need for well-controlled, high-efficiency lighting systems. Hours of use can also enhance the cost effectiveness of low-energy design strategies. In contrast, buildings scheduled for operations during abbreviated hours, should be designed with limited use clearly in mind.

Most of these measures, along with renewable energy production, are frequently implemented in low energy buildings. The energy-saving potential for this type of building is in the range 60-70%.

5.3.4.1 Additional Demand Side Management Measures

Utilities are able to meet their customers' energy needs in a number of different ways. Demand side management (DSM) can be defined as measures taken by the utility to reduce energy demand through improvements in the way in which energy is used. DSM promotes energy efficiency and encourages the choice of energy sources by consumers ([35]). DSM measures may be implemented by both the utilities and by public

(34) Book: Energy Efficiency Guide for Existing Commercial Buildings: The Business Case for Building Owners and Managers published by ASHRAE
(35) Kelly, A., Marvin, S. (1995). Demand-side management in the electricity sector: Implications for town planning in the UK. Landuse Policy, 12:205-221

institutions. Measures include insulation programmes, high efficiency motors and lighting, timers on water heaters, direct load control, differential tariff pricing and interruptible service, information campaigns (replacement of obsolete electrical equipment, energy labelling and other measures) ([36]).

The purchase of green electricity by the public administration, households and companies, is a great incentive for companies to invest in the diversification of clean energy generation power plants. There is some experience of local authorities buying green electricity from power plants owned by a local company.

The Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 ([37]) obliges domestic appliance producers to label their products, offering to the customers the possibility to know the energy efficiency of these devices. The appliances included in this regulation are 15 product groups – including some of the most energy-consuming home appliances like refrigerators or washing machines. The new regulation has established a new grading structure, with the labels being now from A (high efficiency) to G (low efficiency).

5.3.4.2 Energy Audits and measurements

Energy audit is defined as a systematic inspection of energy use and energy consumption of a site, buildings, system or organisation with the objectives of establishing energy flows, identifying the potential for energy efficiency improvements and reporting them to the energy user.

The purpose of energy audits is to perform an analysis of energy flows in buildings or processes that allows understanding how efficient the use of energy is. In addition, it should propose corrective measures in those areas with poor energy performance. Energy audits are generally carried out in public and tertiary buildings in order to understand the current state of the energy consumptions and implement methods and actions to improve the overall energy performance of building (including behaviour issues and appliances). The characteristics of the building or equipment to be audited, as well as the energy consumption and performance data, are collected by means of surveys, measurements or energy consumption bills provided by utilities and operators or simulations performed, using validated software. As measurement and data acquisition are an important issue in energy-efficiency projects, the way to do it has to be planned in advance.

Some benefits arising from the realization of energy audits may include the identification of the greatest opportunities for energy savings, thus offering the opportunity to reduce the energy costs of buildings and organizations, improving profitability and competitiveness. Energy audits also can identify potential for improvement in business and production processes and thereby contribute to improved productivity, help organizations reduce the environmental impact of their activities and project a positive image to costumers and the wider community.

The Energy Efficiency Directive ([38]) addresses energy audits and energy management systems, with Annex VI of the Directive defining the minimum criteria that must be fulfilled by audits:

- Audits must be based on measured up-to-date energy consumption data;
- They must contain a detailed review of the energy consumption profile of relevant buildings, operations or installations;

(36) Demand Side Management Information available on the International Energy Agency Demand Side Management webpage www.ieadsm.org. The Topten websites provide a selection of best appliances from the energy point of view www.topten.info (project supported by Intelligent Energy Europe)
(37) http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32017R1369
(38) Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2012/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, OJ L 315, 14.11.2012, p.1.

- They should, where possible address life-cycle costs (or returns on investment) rather than simple payback periods;
- Audits should be proportionate, and sufficiently representative to form a clear picture of energy performance and to enable identification of the most significant measures.

Although Annex VI provides minimum criteria for energy audits, it still lacks specific information about required or recommended audit processes, types of data needed or levels of detail in audit reports. In order to ensure that an audit is of high quality, the adherence to international standards for energy audits can provide a consistent approach and ensure that audits undertaken are of a high quality. The sets of standards EN 16247 give out the specific guidelines for the realization of energy audits, such as the requirements for energy audits for buildings or groups of buildings, industrial processes or transportation systems. The global scope of the set of standards guidelines, which tackles these different sectors, allow for both public authorities and private companies to have a complete energy audit performed within their scope of activity.

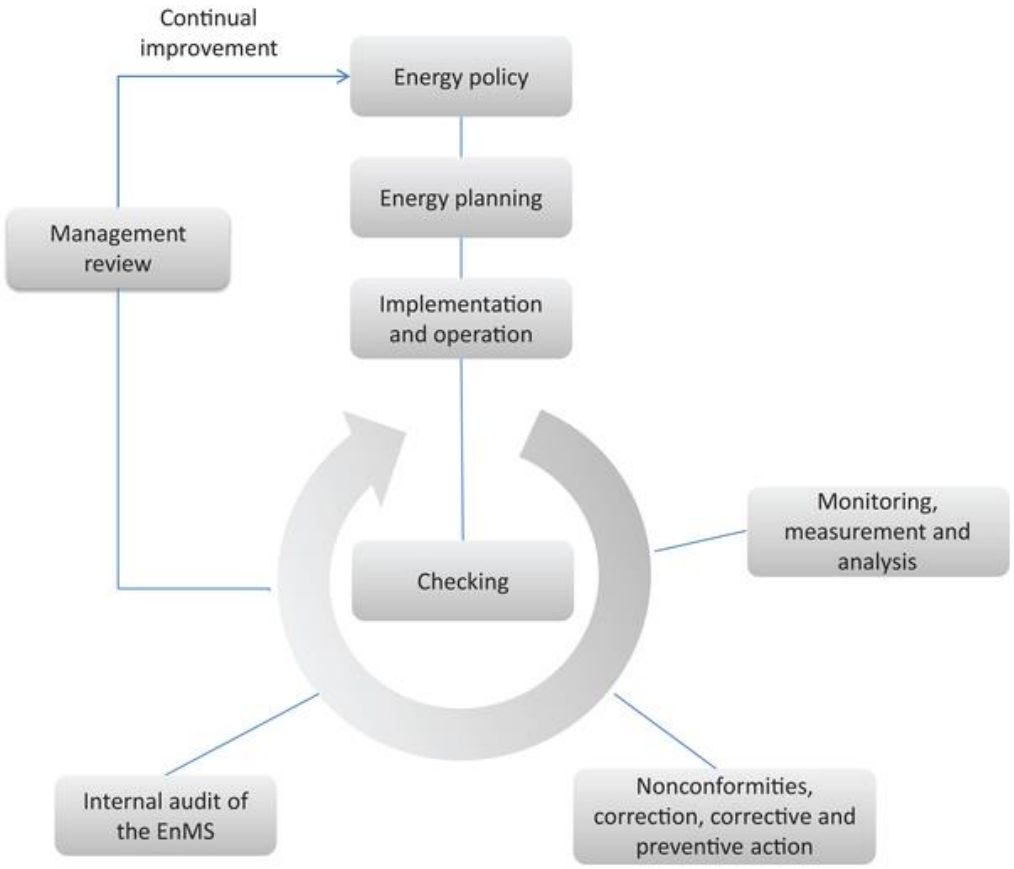
Also ISO 50002 which arises from the Energy Management Systems normative - ISO 50001 - gives guidance for the execution of energy audits comprising a detailed analysis of the energy performance of organizations, equipment, systems or processes. It is based on appropriate measurement and observation of energy use, energy efficiency and consumption. Energy audits are planned and conducted as part of the identification and prioritization of opportunities to improve energy performance, reduce energy waste and obtain related environmental benefits. An energy audit can support an energy review and can facilitate monitoring, measurement and analysis as described in ISO 50001, or it can be used independently. The energy audit process is presented as a simple chronological sequence, but this does not preclude repeated iterations of certain steps.

5.3.4.3 Building Energy Management Systems (BEMS)

Energy management systems are systematic processes for continually improving energy performance. The implementation of an energy management system should present itself as an important tool for public authorities to put into practice as a way to continuously monitor and improve their energy processes and fine tune their energy performance. The EU Energy Efficiency Directive has defined energy management system as a "set of interrelated or interacting elements of a plan which sets an energy efficiency objective and a strategy to achieve that objective". It can be applied to any organisation but is regarded particularly beneficial for energy intensive processes. Unlike a sole energy audit, an energy management system is a process of continuous improvement which requires organisations to continue seeking out new opportunities for energy savings in all areas of their activity.

The implementation of an energy management system requires an organization of any kind to follow a series of pre-defined steps, which typically include establishing an energy policy, assigning responsibilities within the organization, identifying main energy users, setting measurable goals and targets, implementing actions to meet these goals, checking for success of actions, and a continuous review of the system. Similarly to other management systems like the ISO 9001 (Figure 1), the principle of Plan, Do, Check, Act also applies with the continuous improvement as a main driver for the evolution of such system.

Figure 1. Energy Management System model for ISO 50001



Some tools that may be implemented within an energy management system are Building Energy Management Systems, that may come in helpful for energy managers to better visualize the buildings' energy flows and act upon the information being served.

Building energy management systems (BEMS) are computer-based control systems generally applied to the control of systems such as heating, ventilation, and air-conditioning (HVAC). BEMS use software to control energy-consuming equipment or the full buildings' energy consumption, and can monitor and report on the buildings' performance, allow for dedicated controls and energy sub-metering by the individualization of energy flows by energy carrier and the type of use or equipment.

BEMS are available for quite some time now, especially in energy-intensive buildings, where a fine monitoring of the energy flows is of a greater importance.

BEMS are generally composed by:

- Controllers, sensors (temperature, humidity, luminance and presence sensors) and actuators (valves, switches and similar) for different types of parameters distributed in various zones of the buildings;
- HVAC central system with local controllers for each area or room in the building (zoning) and central computer assisted control;
- Central control hardware and software (with general control, monitoring functions) Monitoring through energy consumption measurement devices.

With the advent of the smartphone and the massification of personal computers all over the world, being connected to the internet has passed from a work related need to an almost basic need. This has allowed for the development of the "smart" ecosystem, especially within the residential market. With the roll-out of smart meters, an increasing development of smart grid projects, a growing Demand Response market and the access to fast internet, has potentiated the development of the Home Energy Management Systems.

Some of the Home Energy Management Systems include:

- Energy Portals: Informatics based application that delivers usually imperceptible energy consumption information to energy managers or final energy consumers in a more user friendly way.
- In-Home Displays: Simple interfaces that provide immediate energy use feedback for the consumer, also having the ability to send pricing signals. These devices are connected to the home energy network via a traditional meter and communicate with other devices via a home area network.
- Load Monitors: Give basic energy consumption information (eventually a calculation of costs) of an energy consumption device. Load monitors are connected between the power outlet and the actual device.
- Smart Appliances – Usually white goods appliances that are communication enabled with possible bi-directional communication between the user and energy utilities. This communication platform can be used for functionalities like demand side flexibility.
- Smart Thermostats – Have the same main functionality as traditional thermostats but with the added features of enhanced allowed programming, self-learning algorithms of the consumption patterns and intuitive interfaces with an easy user experience.
- Smart Lights and Smart Plugs – Devices that incorporate normal lighting and normal plug features with embedded technology that allow for automatic and remote control. These devices are provided with sensors that detect environmental light or occupancy and act upon prompts defined by the user.
- Smart Hubs – Devices that aggregate several connected devices within the smart home environment. Smart hubs have the main objective to integrate the functionalities of all these devices and communicated with all in a concerted way, within a home network.

The most important feature of Building/Home management systems is probably the ease of access of information that is being delivered to the final energy consumer or the energy managers within organizations, giving them an actual tool to act upon this information and potentiate energy savings in the long run. The "JRC Science for Policy Report: Energy Feedback Systems: Evaluation of Meta-studies on energy savings through feedback" ([39]) has focused on the potential energy savings arising from energy feedback being given to residential energy consumers. In general, the study has found that effective feedback, other than the traditional energy bill can realistically reduce households' energy consumption up to 10%, especially when it is tailored to the householder, presented clearly and engagingly, accompanied by advice for reducing energy consumptions, delivered regularly and with high frequency through enhanced billing or in the presence of In Home Devices, web based, interactive and digital.

5.3.4.4 Office appliances

Energy savings in office appliances are possible through the selection of energy-efficient products. Only an assessment of the systems and the needs can determine which measures are both applicable and profitable. This could be done by a qualified energy expert with IT experience. The assessment conclusions should include hints for procurement of the equipment, via purchase or leasing. The definition of energy-efficiency measures in IT in the early planning stage can result in a significant reduction of loads for air conditioning and UPS, and thus, can optimise the efficiency for both investments and operation costs. Additionally the duplex printing and paper saving in general are important measures for saving energy for paper production, as well as reducing operation costs. The following tables (**Table 15,**

(39) https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/energy-feedback-systems-evaluation-meta-studies-energy-savings-through-feedback

Table 16, Table 17) show the potentially significant energy savings measures which might be applicable to your IT landscape. In each table the measures are presented, beginning with those that have a large potential impact and are the easiest to implement.

Table 15. Step 1: Selection of energy efficient product – Examples

Description of measure	Saving potential
Centralised multi-function devices replacing separate single-function devices save energy, but only if the multi-function is used	Up to 50 %
Centralised printer (and multi-function devices) replacing personal printers save energy, when well dimensioned for the application	Up to 50 %

Table 16. Step 2: Selection of energy-efficient devices in a defined product group – Examples

Description of measure	Saving potential
The specific appliance dimension for the realistic application is the most relevant factor for energy efficiency	Not quantified
Use of Energy-Star criteria as a minimum criterion for call for tender will prevent the purchase of inefficient devices	0 – 30 % compared to state of the art
Make sure that the power management is part of the specification in the call for tender and that it is configured by installation of the new appliances	Up to 30 %

Table 17. Step 3: Check power management and user-specific saving potentials – Examples

Description of measure	Saving potential
The power management should be initiated in all devices	Up to 30 %
Screensavers do not save energy and thus, should be replaced by a quick start of standby/sleep mode	Up to 30 %
Use of a switchable multi-way connector can avoid power consumption in off-mode for a set of office equipment for night and absence	Up to 20 %
To switch off monitors and printers during breaks and meetings reduce energy consumption in stand-by mode	Up to 15 %

The label ENERGY STAR ([40]), available for energy-efficient office equipment, covers a wide range of products from simple scanners to complete desktop home computer systems. The requirements and specifications of a product to be labelled can be found at www.eu-energystar.org. A product-comparison tool is available that allows the user to select the most energy-efficient equipment.

(40) Further information available at www.eu-energystar.org

The EU Ecolabel Product Catalogue ([41]) covers a wide range of product groups, namely Personal, Notebook and Tablet Computers and makes sure that the products constant in the catalogue are of high energy efficiency, are designed to have a longer lifetime, less hazardous substances and are designed to be easier to repair, upgrade and recycle in comparison with regular devices in the market.

(41) http://ec.europa.eu/ecat/

6 Infrastructure lighting

Local authorities can establish specifications for outdoor lighting and infrastructure lighting including standards for lighting fixtures and requirements for light levels.

6.1 Traffic Lights

The availability of compact LED packages on the market boosts the replacement of incandescent lamps in traffic lights with more energy-efficient and durable LED ([42]) ones. This action yields a significant reduction of energy consumption. A LED array is composed by many LED unities. The main advantages of LED traffic lights are:

- The light emitted is brighter than the incandescent lamps, which make LED traffic lights more visible in adverse conditions.
- A LED's lifespan is 100 000 hours (about 10 times more than incandescent bulbs). This implies a significant reduction of maintenance costs.
- The energy consumption reduction is higher than 50 % with respect to incandescent bulbs.

Box 14. LED Traffic lights: Verona, Italy

The action consists in a complete replacement of the incandescent lanterns of traffic lights with LED lanterns, in order to reduce the maintenance costs, the electricity consumption and, hence, carbon emissions. The energy and economic savings amount to 75 - 80% for electricity consumption (Electricity savings 1036 MWh / year) and the carbon emissions avoided to 513 tCO_2 / year.

In particular, the number of lanterns is 1885, with 80 W lamps and an average daily operation of 21 hours, for a total estimated consumption of 613.2kWh/year per lantern. The overall consumption of the incandescent lanterns at present is 1155882 kWh / year (1885 x 613.2). Assuming a total replacement with LED lamps that show an average power of 8.3 W and a total consumption of 119.9 MWh / year, the saving achievable is 1035.98 MWh /year (1155.88 - 119.9). Moreover, since the costs of LED lanterns have drastically decreased in the recent years, the payback time is short (two / three years) thanks to energy savings of about 80%.

The overall replacement will be carried out by 2020. The action brings several co-benefits: a reduction of maintenance costs and consumables, improved brightness even in critical atmospheric conditions and road safety.

http://www.covenantofmayors.eu/about/covenant-community/signatories/key-actions.html?scity_id=1843

6.2 Public lighting

Public lighting is an essential municipal service. It offers significant potential for energy efficiency ([43]), in particular through the replacement of old lamps with more efficient ones, such as low pressure, high pressure lamps or LED. Over the years the efficiency of lamps has improved significantly. The high-pressure mercury lamp is the most frequent in public lighting. It has been used since 1960s and is extremely energy in-efficient. High-pressure sodium and Metal Halide lamps are very energy efficient ones and commonly used recently.

Replacing lamps is the most effective way to reduce energy consumption. However, some improvements, such as the use of more efficient ballast or adequate control techniques, are also suitable measures to avoid the excess of electricity consumption. In addition, the use of autonomous public solar street lighting systems powered by PV panels with energy storage battery is spreading across cities.

(42) LED – Light Emission Diode
(43) Further information available at www.eu-greenlight.org and www.e-streetlight.com (European project supported by Intelligent Energy Europe)

Luminous efficiency, CRI, duration, regulation or Life Cycle must be included in the set or design parameters for the choice of the most suitable technology. For instance, if a high CRI is required in a public-lighting project, the use of LED technology is recommended. This technology is a suitable solution to reach a good balance between CRI and Luminous efficiency. If CRI is not essential for a given installation, other technologies may be more appropriate. In the following **Table 18**, recommended lamps for public lighting are reported in case of either replacement or new installation.

Table 18. Recommended ended Lamps Direct substitution and new installation

Type of intervention	Original Lamp	Luminous efficiency	Recommended lamp	Luminous efficiency
Direct substitution	High pressure mercury lamps Arc lamps	32-60 lm/W 30-50 lm/W	Standard high pressure sodium lamp	65-150 lm/W
			Metal Halide Lamp	62-120 lm/W
			LED	65-100 lm/W
New Lighting Installation		Less than 60	Low pressure sodium lamp	100-200 lm/W
			Standard high pressure sodium	65-150 lm/W
		More than 60	LED	65-100 lm/W

Arc discharge lamps, such as fluorescent and HID (High Intensity Discharge) sources, require a device to provide the proper voltage to establish the arc and regulating the electric current once the arc is struck**.**

Box 15.

I) Exchange of sodium lamps for LED streetlights: Ostrava, Czech Republic

Ostrava decided to modernise public lighting in the period of 2010 – 2013. The number of lighting points increased as well as the energy performance. In accordance with the Sustainable Energy Action Plan modernization of public lighting system continued, including use of LED technology and renovation of lightning points, which replaced the previously commonly installed lamps. LED lamps with built-in control are used from 2014 with a systematic renovation of lighting points.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

II) Installation of solar street lighting: Gradiška, Bosnia and Herzegovina

Gradiška provided the installation of solar public lighting with PV panels for the production of electricity for 72 street lamps installed in the main street of the city. The power of the mini power plant with PV is 14.5 KW and it produced 18345 MWh/y. The installation takes place by 2020.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

Other measures may be implemented to achieve significant energy reduction:

- Take into consideration the use of the public area (parking, pedestrian, dangerous intersection) in order to provide the appropriate kind of lamp and level of lighting.
- Ballasts: compensate voltage variation in the electrical supply. Since the electronic ballast does not use coils and electromagnetic fields, it can work more efficiently than a magnetic one. These devices allow a better power and light intensity control on the lamps. The energy consumption reduction caused by electronic ballasts has been

estimated around 7% ([44]). In addition, LED technology not only reduces the energy consumption, but also allows an accurate regulation depending on the needs.

- Electronic photo-switches can contribute to the electricity savings in public lighting by reducing night burning hours (turning on later and turning off earlier).
- A tele management system enables the lighting system to automatically react to external parameters like traffic density, remaining daylight level, road constructions, accidents or weather circumstances. Even if a tele management system does not reduce the energy consumption in lighting by itself, it can reduce traffic congestion or detect abnormalities. Tele management systems can be used to monitor failed lamps and report their location. Maintenance expenses can be reduced by considering the remaining life of nearby lamps that might be replaced during the same service call. Finally, data collected by the tele management system that tracks the hours of illumination for each lamp can be used to claim warranty replacement, establish unbiased products and supplier selection criteria, and validate energy bills.

(44) E-street project www.e-streetlight.com. Supported by Intelligent Energy Europe

7 Urban and Land Use planning

7.1 Embedding Climate Change in land use planning

There are many site-specific strategies that local authorities may adopt to face Climate Change and to reduce carbon emissions of cities. Land use and transport interaction, green infrastructures and local energy production are some of the main fields where urban planning may have a role to address Climate Change at local level. Furthermore, there is growing evidence and consensus that when local authorities act on these issues, there is a suite of economic, environmental and social 'co-benefits' which can fundamentally improve the liveability, competitiveness and resilience of cities. As a consequence, Climate Change mitigation became a key pillar (alongside traditional economic, social and environmental aspects) in decision-making in cities.

Strategic planning decisions impact cities both in the way they function and in the behaviours of the urban community. For this reason, these decisions need to be carefully and holistically considered, by taking into account the complex interdependencies among fields and potential trade-offs due to the implementation of different measures. Furthermore, sustainable urban planning is most effective when policy instruments are bundled and coordinated towards a common vision and strategy. When local policies are integrated within a regional framework (i.e. urban clusters), the definition of how and where to build a new development provides resource efficiencies for the constituent cities. This type of approach can build economies of scale and offer opportunities to establish efficient public transport networks, shared infrastructure investment and overall improved use of capital.

Box 16. The Greater Paris Region: Paris, France

The Greater Paris Region has effectively linked sub-centres with synchronized bus and rail services. Upgrades to the tramway and Metro systems in the city and the regional commuter rail lines linking the city to suburban and local rural areas has created an efficient and user-friendly regional network.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

The following sections reference the key aspects for both existing and new developments to be taken into account in urban planning oriented to improve the energy efficiency and sustainability of cities. Despite being treated separately, all these aspects are deeply interrelated.

7.1.1 Urban Form and Layout

GHG emissions at urban level are deeply influenced by the layout of neighbourhoods. In particular the key issues that influence carbon emissions are urban density and efficient urban mobility. New urban developments give the opportunity to apply and test existing best practices implemented, in the whole or in part, worldwide to create sustainable urban environments. On the contrary, the case of existing areas, "heritage" cities, is extremely more challenging and onerous. Urban form, land use and characteristics of the building stock are strategic issues in improving energy performance.

7.1.1.1 Mixed-use development and sprawl containment

Sprawl represents one of the key aspects where the correlation that lies between energy and urban layout appears. Compact cities and the promotion of mixed-use developments an reduce mobility demand within cities and create more sociable, equitable and economical urban environments.

Urban density and limiting sprawl can have significant benefits in terms of reducing the overall environmental impact of cities. In terms of GHG abatement, dense cities offer reduced travel distances and, hence, increase the feasibility for public transport and active travels; provide improved opportunities for district energy; and preserve

surroundings, green and rural areas, which may also potentially provide carbon sequestration. Policies aimed at requiring minimum values for density (by unit or floor area) and promoting green belt ([45]) can encourage low carbon developments with appropriate layouts when considered in context with other strategies for public and green areas (proper densities, mixed use, accessibility and other strategies).

Mixed-use Development is a common approach to urban growth, especially in areas of higher urban density. There is significant evidence and consensus that creating high residential densities co-located with high commercial (employment) densities can lead to reduced commuting and mobility demand. This type of development needs to be considered closely with the public transport strategies and infrastructure to ensure that developments do not become isolated or difficult to service.

Box 17. Urban density in Helsinki, Finland

Within the 2013 city plan, Helsinki aims at increasing the urban density in order to support an ecologically efficient urban structure, with more appealing and organised public transport that allow city residents' commuting and, therefore, minimising carbon emissions due to traffic. The densification of the urban structure requires stressing quality instead of quantity, by providing connected green spaces and city parks of high functional quality.

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Urban plan - the new Helsinki city plan Vision 2050. City Planning Department of Helsinki 2013

7.1.2 Transport and land use

The integration of land use and transport planning is one of the key elements of a long term strategy aiming at energy efficient districts. Moreover other options are available to improve the energy performance of urban developments.

Transit Oriented Development (TOD) is a planning strategy which aims at producing low carbon development, by considering public transport and transit stations as priorities. The development of housing, employment, activity sites and public services are placed around existing or new stations served by frequent and efficient service. TODs are characterised by medium to high densities, compact urban forms and mixed use. In this framework, both corridor and nodal approaches to development are considered with the goal of moving citizens as efficiently as possible. The main features of TODs are:

- rapid and frequent transit service
- high accessibility
- mixed use
- high quality public spaces and streets
- pedestrian and cycle routes
- medium- to high-density development within 800 metres of the transit station

As a consequence, as well as optimising the infrastructure requirements for public and active travel, this type of development often provides other community benefits (i.e. creating mixed-use 'hubs').

(45) Green belt application needs to be carefully managed as it can result in the outward migration of development (i.e. outside the green belt).

Box 18. Transit Oriented Development Copenhagen, Denmark

Copenhagen has demonstrated successful applications of TOD and has benefitted significantly from this approach. The city has among the lowest private vehicle ridership per capita in Europe and has also benefited from substantial improvements to air quality and quality of life indices. Local policies and the expansion of the rail service contributed to this result.

TOD principles have been maintained since Copenhagen's 1947 Finger Plan. As a result of the plan, urban development has focused on decentralised concentration close to urban rail stations. Ørestad New Town is an important example of TOD, it is a planned urban development half a century after the five original corridors designated in the 1947 Finger Plan. Ørestad is a mixed use community, with green areas, and high accessibility. It was planned to be a sustainable development with the metro line at its core together with good bicycle lanes and a deliberately low and expensive car parking provision designed to minimise the use of private car transport.

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Knowles, R. (2012). Transit Oriented Development in Copenhagen, Denmark: from the Finger Plan to Ørestad, Journal of Transport Geography, 22: 251-261

Limiting vehicle infrastructure can reduce and control private vehicle travels and encourage the use of public transport. Similar measures to reduce the provision of parking spaces impose congestion charges and assign low speed zones can have similar impacts. See chapter 0 [Urban Transport] for more details on these options.

Box 19. Congestion charge in London: London, United Kingdom

London has employed congestion charges in central London to reduce congestion, improve air quality and reduce GHG emissions from transport. Proceeds from the charges are subsequently reinvested to finance public transport, further enhancing the impact of the initiative.

https://tfl.gov.uk/

Providing infrastructure for active travel to encourage cycling and walking as alternative forms of commuting and travel can significantly reduce vehicular traffic. Conversion of inner-city areas and peripheral neighbourhoods to pedestrian zones has far-reaching effects in terms of reduced car-related accidents, improved air quality (especially in central areas), and socio-economic benefit for local retail and public transport ridership.

Box 20. Active travel in Barcelona: Barcelona, Spain

Barcelona is developing a 'Superblocks' approach by redesigning the city's streets to limit traffic and increase green and recreational spaces. The basis of the initiative is to bundle the existing city blocks and create spaces reserved for cycling/walking, only retaining vehicular traffic on perimeter roads. Each *Superille* (superblock) combines 12 city blocks to maximize public space and shape small neighbourhoods around which traffic flows, while inside spaces are repurposed to public-pedestrian friendly areas.

http://ajuntament.barcelona.cat/superilles/es/

7.1.3 Green areas and heat island

The heat island effect (see Part IIIb - 2.7 and glossary) is the phenomenon whereby atmospheric and surface temperatures are higher in urban areas than in the surrounding rural areas (typically by 1-3°C in larger cities) ([46]). The issue is a result of the combination of low surface albedo (i.e. low reflectivity) of urban surfaces combined with high building density which can limit air circulation. This not only creates health problems and discomfort for urban citizens during extreme weather, but also increases the electricity demand for cooling buildings (by approximately 2-4% per 1°C). There is also a negative impact on air quality. The heat island effect is best mitigated by carefully considering the configuration of (especially high-rise) buildings and green spaces and by creating more reflective, high albedo (i.e. light) surfaces.

(46) United States Environmental Protection Agency

Urban green space provides also carbon sequestration. However, it is generally marginal in the context of overall urban GHG emissions. Parks, greenways, green roofs and community gardens have other indirect benefits in terms of Climate Change mitigation, for example reducing the heat island effect (and therefore cooling demand) and encouraging active travel. Green spaces can also have significant benefits in terms of air quality and human health and climate adaptation/resilience (i.e. reducing storm water run-off and the urban heat island effect)([47]).

Box 21.

I) Cooling routes in Athens, Greece

Athens is implementing a suite of projects ranging from the application of cool materials, increasing green areas, increasing shaded areas and promoting "cooling routes" to alleviate the impact of heat waves for the city's residents while also mitigating the heat island effect.

http://www.c40.org/networks/cool_cities

II) Observatori del Canvi Climàtic and Bio Oficina de València: València, Spain

Valencia provided two interpretation permanent centres on Climate Change, the "observatori del canvi climàtic" and "bio_oficina", that host educational and training exhibitions directed towards young and general public. The two buildings host talks, conferences, roundtables, workshops and other participative activities aimed to arise public concerns and co-responsibilities towards Climate Change.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

7.1.4 Energy production

Planning urban form to enable renewable, low carbon and smart energy can offer significant benefits in terms of reducing emissions, but also improving access to sustainable and secure energy supply and potential to reduce fuel poverty.

Heat mapping exercises can help determine where energy/heat surpluses and demands are and to create robust energy strategies. This can be further linked to plans for electric vehicle infrastructure or energy storage plans. Some cities have created municipal utilities to own, regulate and sell the energy produced, contributing to local authority revenue and local employment.

7.1.5 Strategies for new developments: Urban regeneration and Eco districts

One mechanism to reduce urban sprawl, while revitalizing brownfield sites and local economies is through urban regeneration initiatives. Former industrial or other economically redundant sites can be repurposed to make best use of available land without increasing the urban footprint on green land. Typically, there is a premium to pay to demolish, remediate and reconstruct brownfield sites (especially former industrial sites); however, this can have a positive impact on localised economies and for revitalising neighbourhoods.

(47) DG CLIMA Project Adaptation Strategies of European Cities (EU Cities Adapt); http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change

Box 22. Urban regeneration in Heidelberg, Germany

The Bahnstadt development is located on a former industrial brownfield site in a central city district of Heidelberg. An integral part of the overall planning is an energy conception comprising three central areas:

- reduction in the energy need,

- efficient energy provision and

- process-accompanying implementation.

The EGH (Heidelberg Development Agency) was the institution responsible for the development of the major part of Bahnstadt:

- All of Bahnstadt is to be built to passive house standards. The local authority of Heidelberg provides promotional funds for passive houses.

- Heat supply for Bahnstadt to be provided through district heating which, in the medium term, will be generated from renewable energy, among others through deep geothermics and biomass thermal power plants.

The local authority of Heidelberg and EGH develop an image of Bahnstadt as an energy-efficient, future-oriented city district and implement an advisory service for owners and builders.

An electricity-saving concept will be developed for Bahnstadt that particularly takes into account the constructional optimization as to heat protection in the summer.

Moreover, several sustainable measures are included in the project in order to achieve zero-emissions. Besides passive standard of buildings, green roofs, non-motorized transportation and significant green space are in place.

Numerous co-benefits (economic, environmental, health, social) are provided.

Climate Protection Commitment Heidelberg (2010)

Available at: https://www.heidelberg.de/,Len/908607.html

7.1.6 'Eco Districts'

District level approaches to resource efficiency are growing in application, especially in urban-regeneration of brownfield sites (particularly industrial). Large scale development sites offer the opportunity to create mixed-use districts which can adhere to all the latest approaches to urban sustainability. Developments are typically financed by public-private partnership and are focussed on using holistic approaches to create sustainable districts: efficient use of resources; vibrant communities; prosperity; liveability, health; equity, ecological enhancement. Usually "Eco districts" (see also glossary):

- include buildings with low energy consumption (materials, orientation, insulation, ventilation);
- are based on renewable energy (solar, wind, biomass, geothermal) to meet the energy needs.
- consider waste and water management,
- are transit oriented, pedestrian and cyclist friendly
- have active communities.

Box 23.

I) Eco District in Malmö, Sweden

An Eco District has been developed in the Western Harbour district of Malmö. The Western Harbour redevelopment consists of various different projects. The first – Bo01 – was launched in 2001. The last is due for completion after 2030. The eco district has been developed from the conversion of an industrial wasteland setting into a world class example for sustainable living. The aim is that it achieves 100 % local renewable energy. The environmental focus areas are:

- Waste management

- Biodiversity in the dense city

- Mobility management

- Cleaning the soil

A wind turbine has been installed to provide most of the electricity demand while geothermal heat pumps are utilised for heating and cooling. Walking and cycling infrastructure is prioritised and there is a series of sustainable urban drainage systems to manage water runoff. Green roofs and green spaces have also been created to enhance the ecology of the site significantly.

www.special-eu.org/ and www.malmo.se/sustainablecity

II) The Hammarby Sjöstad district in Stockholm, Sweden

This mixed-use development is the result of the conversion of a former brownfield area into a sustainable neighbourhood. There is a strong focus on environmentally sensitive solutions:

-Sustainable public transportation is offered with electric trains, biogas powered buses and commuter boats. Biking, walking and car-pooling are also supported means.

-Residents are offered recycling stations and food waste collection for biogas production.

-All apartments are connected to the district heating system and the household waste supplies fuel for the district heating plant.

For the success of this district, integrating the environmental program into the planning process and ensuring the inclusion of all stakeholders were key components in getting technical solutions in place.

www.ecodistricts.org

7.2 Implementing Effective Sustainable Urban Planning

The preparation of a SECAP offers the opportunity for local authorities to bring together several departments and services and to redefine their approach to urban planning. For example, creating stronger connections between transport, planning, infrastructure, energy and economic development departments can foster a more cohesive approach to master-planning and urban form, which can further trickle down to intelligent application of localised infrastructure. To deliver climate mitigation policies, this multi-disciplinary approach, paired with financial resourcing and political will should be aligned with the goal of reducing GHG emissions. As discussed, engagement between the local authority, private sector and academia, in a so-called 'Triple helix' approach, can provide added confidence to urban and land use planning decisions. In this context, the necessity of a linkage between planning instruments developed at local level (such as masterplans and land-use regulations, energy plans, building codes, urban mobility plans) and SECAPs arises in order to achieve sustainable and low carbon communities towards the 2030 targets.

To fund relevant policy and infrastructure, traditional forms of financing for urban development can be used, such as municipal revenue, central government investment, public-private partnerships and various forms of borrowing. Increasingly innovative means of raising municipal funds to deliver Climate Change mitigation are continually being developed. For example, municipal green bonds, congestion charges, raising parking charges, levies etc. have all been successfully deployed at a sub-national scale.

Regardless of the source of financing, the business case for projects should be assessed not only in the context of Climate Change, but also considering all the other potential economic, environmental and social benefits.

In summary, local authority should look at establishing the following measures to create more sustainable, low carbon urban areas:

- a multi-level, multi-departmental governance structure which empowers cities to coordinate effective urban transformations, including political will at the highest level;
- formalised institutional arrangements that ensure Climate Change mitigation is a key aspect in the decision making alongside other (more traditional) urban priorities; and,
- sufficient and diverse sources of finance (including incentives/disincentives) to support mitigation policies and actions.

Box 24. QUICK TIPS

Introduce energy and Climate Change criteria in planning (land use, urban, mobility planning).

Promote mixed use developments (housing, services and jobs).

Plan to avoid urban sprawl:

- control the expansion of built areas;
- develop and revitalize old (deprived) industrial areas;
- position new development areas within the reach of existing public transport lines;
- avoid 'out-of-town' shopping centres.

Plan car free or low car use areas by closing areas to traffic or introducing congestion charge schemes and provide more active transport infrastructure.

Identify opportunities to increase and improve green spaces.

8 Urban transport

8.1 Urban transport: trends, drivers and policy options for local authorities

Transport plays a key role in delivering on the Paris Agreement, the Sustainable Development Goals and the New Urban Agenda. While providing essential services to society and economy, transport is also an important part of the economy and it is at the core of a number of major sustainability challenges, in particular Climate Change, air quality, safety, energy security and efficiency in the use of resources. This part of the guidelines summarises key actions to decarbonise urban transport and to promote low-carbon solutions to contribute to sustainable cities, opportunities for synergies of sustainable development and Climate Change objectives and governance and institutional issues affecting the implementation of measures.

There are various levers where local authorities can shape the energy consumption and the sustainability of urban transport systems through infrastructure, service and policy decisions. In the following, key areas for local policy and planning interventions holistically focused on the urban transport system are reported. These address transport planning, transport activity, the modal structure, the energy intensity and the fuels and energy carriers. **Table 19** summarises actions and benefits of four general actions for low carbon mobility. The first two lines comprise actions that have influence on the transport demands by reducing the need of mobility. On the contrary, the second two lines regard vehicles and their efficiency, on which actions have no influence on the demand side.

Table 19. Summary of sustainable urban mobility actions and potential benefits

Low-carbon urban mobility actions	**Emission reduction potential**	**Co-benefits and synergies**
Activity and flows (reduction and management: short distances, compact cities and mixed use)	Potential to reduce energy consumption by 10 to 30%	Reduced travel times; improved air quality, public health, safety and access
Structure (shift to more energy efficient modes)	Potential for energy efficiency increases varies greatly, but for example Bus Rapid Transit (BRT) systems can deliver up to 30% reductions at a cost of $1-27 M/km	Reduced urban congestion and increased accessibility
Intensity (vehicle fuel efficiency)	Efficiency improvement of 40-60% by 2030 feasible at low or negative costs	Improved energy security, productivity and affordability
Fuel (switch to electricity, hydrogen, CNG, biofuels and other fuels)	Changing the structure of the energy consumption, but not necessarily overall demand.	Diversification of the fuels used contributes to climate, air quality and/or energy security objectives

8.2 Urban mobility solutions

This section explores key strategies for sustainable urban mobility, including integrated urban planning, public transport, walking, cycling, pricing measures, urban logistics, intelligent transport systems and options to boost electric mobility.

Local authorities have an important role in shaping the energy efficiency of urban transport. There are a large number of possible interventions that local authorities can

initiate in their jurisdiction to positively influence travel behaviour, vehicle choice and use. Local authorities have a key role to play in shaping urban form and planning local transport infrastructures. With integrated urban planning and the ability to regulate, fund and often even operate public transport services a local authority can shape the modal structure of its transport system substantially. These policies have further good implications on energy security, on the reinforcement of social and economy cohesion, on the improvement of the quality of life and on the reduction of externalities. A number of policies that manages the energy efficiency of the transport sector are driven at national (e.g. vehicle and fuel tax) or European level (e.g. fuel efficiency regulation). However, several policies that have a similar effect on the choice and use of means of transportation are applicable at local level, such as road and parking pricing or access limitations. Three widely recognized strategies for the reduction of energy consumption in transport are AVOID, oriented to limit or avoid the demand; SHIFT, a transformation towards low impact transport models, and IMPROVE, the advancement in the technical and technological characteristics of vehicles. **Table 20** provides an overview of good practices classified according to the type of strategy (avoid, shift and improve) showing also potential benefits in other fields.

Table 20. Examples for energy efficiency measures, their CO_2 emission reduction potential, and contribution to other sustainable development objectives

Strategy	Good practice cities/projects	CO_2 emission reduction	Sustainable development benefits (and risks for trade-offs)		
			Economic	Social	Environmental
Avoid					
Road user charging	Road user charge in Stockholm, London, Gothenburg	Example London: 25% CO_2 reduction	Travel time reductions	Social costs : reduction: €144 million / year	Funds can be re-invested in e.g. public transport
Shift					
Bus Rapid Transit (BRT)	Trans Milenio Bogotá	Reduction of carbon dioxide emission by 200.000 tons (in 3 years)	Rationalised bus system, 32% commuting times reduction, Increases employment	Access for disabled and poor, 90% lower accidents in BRT corridors	Air quality improvements
Non-motorised Transport (NMT)	Walking and Cycling in Copenhagen: Cycle-friendly city	Overall GHG emission reductions not quantified	Faster transport, Green jobs (650 full time in Copenhagen)	Increased physical activity, Reduced health impacts: 5.51 DDK/km (annually €268 million), reduced road accidents	Zero air pollutants, Less noise

Strategy	Good practice cities/projects	CO_2 emission reduction	Sustainable development benefits (and risks for trade-offs)		
			Economic	Social	Environmental
Improve					
Fuel switch options for public vehicle fleets	Public Transport fuels switch from e.g. hybrid/electric bus	Medium to high potential for CO_2 savings		Emission reduction, reduce congestion delays	CO_2 emission reduction potential depends on the electricity mix. SO_2, NO_x emissions may be reduced significantly if switch to hybrid/electric.

Within the framework of sustainable transport planning, a package of complementary measures is required to actively manage travel demand and improve transport energy efficiency. This includes improvements of the public transport system as a reliable and affordable alternative to the car and measures targeting the efficiency of the vehicle fleet. This chapter will explore some of these measures and in doing so will focus primarily on measures that can be implemented at the local level.

Vital to the success of sustainable urban transport concepts is a mix of measures that improves the efficiency of the vehicle fleet, reduce travel distances via integrated land-use planning and provide modal alternatives to the private vehicle. Whereas the vehicles fleet policies fall only partially in the jurisdiction of city councils, the land-use planning and modal efficiency are key areas of responsibility for local authorities.

8.2.1 Integrated urban planning

Integrated land-use planning focuses on higher densities, mixed use and the integration of public transport and non-motorised transport infrastructure ([48]). Combined, these factors can reduce travel distances, can enhance the role of non-motorised modes and can improve accessibility and efficiency of public transport. Smart land-use planning only takes effect over longer time scales, but impacts are lasting. Local authorities can largely influence future travel patterns.

Thereby, land-use planning decisions of today can ease the traffic management task in the future. Cities can limit the increase in car use with mixed use developments that play an important role in improving the efficiency of the transport system, by reducing the need to move. The integration of land use and transport is, indeed, a strategy that improves the connectivity and the accessibility, providing a better mobility service and making closer people and places. As part of this, cities may want to consider integrating fares, infrastructure and operations for integrated public transport planning, and create easy connections with non-motorised transport. Cities that have applied this successfully, such as Copenhagen and Freiburg show that by properly integrating public transport planning with wider urban planning and non-motorised infrastructure, urban mobility is considered to be more convenient, efficient and provides better access to services, jobs, education and social activities.

8.2.2 Sustainable Urban Mobility Planning (SUMP)

Sustainable Urban Mobility Plans (SUMP) can be strategic planning documents that guide the integration of all transport modes and work towards a sustainable transport system

(48) Banister D. (2011). "Cities, mobility and climate change". Journal of transport geography, 19, 1538-1546

within a city. The development of a SUMP includes a number of steps from the identification of the main transport issues, in a city, to the development of a joint vision and the identification of specific measures and a process to implement actions. The European Commission provides detailed guidelines, addressed to cities in the development process ([49]). A vital component of the process of developing a SUMP is the involvement of stakeholders and the active participation of the public.

8.2.3 Urban Access Regulation

8.2.3.1 Low Emission Zones

Restricting access to certain areas of a city, normally the city centre, can have a direct effect on local air quality noise pollutions and traffic safety in this area. The effect on greenhouse gas emissions depends on the design and complexity of the scheme and the provision and integration of modal alternatives. Access restrictions schemes are applied in many cities in Europe in different forms and generally aim to restrict access to city districts or specific traffic hotspots in the city. The main objectives are to reduce congestion and pressures on parking spaces, to improve safety, and to decrease noise and harmful emissions. Basic access restriction schemes are easy to adopt, but require enforcement efforts to operate in the intended way.

Box 25. Planning for sustainable transport solutions

The SUMP guidelines developed under EU funded projects set out a strategic planning process for local authorities, fostering the balanced development and integration of all transport modes while encouraging a shift towards more sustainable modes. A SUMP aims at solving urban transport problems and contribute to reaching local and higher-level objectives for environmental, social and economic development. A Sustainable Urban Mobility Plan can help reveal the real challenges that a city faces and explain how conditions will change if the city remains on its present course. It can help ensuring that transport proposals are based on a sound understanding of the existing transport system. The process of preparing a SUMP can also help a diverse group of stakeholders rally around a common vision and agree on packages of mobility measures to improve the transport system in their city. A successful SUMP can provide a feasible and powerful strategy to tackle urban mobility challenges. Developing a SUMP is an innovative, integrated planning process requiring intensive cooperation, knowledge-exchange and consultation between planners, politicians, institutions, and local and regional organisations and citizens. Traditional mobility planning follows an approach known as "predict-and-provide." Even though there is an increasing awareness of the importance for more sustainable solutions around the globe, infrastructure development still dominantly follows the trend of increasing individual motorisation. Today, transport planning increasingly recognises that transport trends are far from inevitable—the infrastructural investment choices that a local authority makes have a profound impact on the travel behaviour of its residents.

SUMP Guidelines: http://www.eltis.org/guidelines/sump-guidelines

There are different types of access restriction schemes, including those that control access at specific points (e.g. when crossing a bridge), cordons or areas (e.g. around a specific location), which may differentiate further between different types of vehicles or times of the day. While these schemes can be very effective in managing congestion, noise and air pollution, they may have unintended consequences, e.g. banning higher polluting, but potentially more fuel efficient diesel cars from entering the city, which may induce travel by redirecting to longer routes or encourage the shift to a less efficient petrol powered car. Hence, access restrictions should be implemented in combination with other measures that minimise trade-offs.

8.2.3.2 Urban Road Tolls/congestion charges

One very effective option to improve traffic flows and reduce overall travel demand by avoiding and shifting traffic to more sustainable transport modes is congestion charging,

(49) http://eltis.org/content/sump-process

which is an urban road pricing scheme for peak hours. Congestion charging lies at the intersection of traffic management and travel demand management, as information gained from real-time traffic information systems could be used to improve the pricing mechanisms of congestion charging by introducing real-time variable pricing systems, which can encourage more efficient travel behaviour.

Congestion charging systems have been operating in Singapore for several decades and were implemented more recently in London and Stockholm. As early as 1975, the road pricing was implemented in Singapore to manage the choked streets of the rapidly growing city. First, an Area License System was established, which required a permit to enter Singapore's central area. The city entry charge boosted public transport patronage almost immediately after its introduction and led to a 45% reduction in traffic, road site accidents decreased by 25% and average travel speeds increased from about 20 km/h to over 30 km/h (OECD & ECMT 2007). The system resulted in a public transport share of over 60% in daily traffic, an increase of nearly 20% (SOLUTIONS 2016). The success of the system in improving infrastructure capacity, safety and air quality and reducing travel demand, fuel use and greenhouse gas emissions inspired the congestion charge systems in London and Stockholm and provided the basis for several feasibility studies for similar schemes for cities around the world ([50]).

Box 26. Gothenburg, Sweden

Despite being a mid-sized city Gothenburg in Sweden decided to introduce a congestion charging system in January 2013, which has already shown to be effective in reducing traffic by over 10% during the charging hours and a similar increase in public transport ridership. The case of Gothenburg shows that these types of schemes are not only applicable for large cities, such as London and Singapore, but also for mid-sized cites.

The congestion tax applies when drivers enter or exit the congestion tax area and varies depending on the time of the day, from 0 during the night, on weekends and holiday to 22 SEK (around 2.30 Euro).

http://urbanaccessregulations.eu

8.2.3.3 Public transport infrastructure, operation and vehicles

A reliable and affordable public transport system is a key element of a sustainable urban transport concept. While providing a similar level of mobility, public transport only requires a fraction of energy and space compared to the private car. Public transport not only contributes to lower energy consumption and emissions it also reduces congestion, which improves traffic flows and reduces travel times. Moreover, provision of new infrastructures has the potential for revamping outdated and sectorial planning practices, towards a comprehensive approach of strategic and sustainable planning ([51]). As public transport is typically more than twice as energy-efficient per passenger kilometres as individual motorised transport, enhancing the share of public transport in urban passenger transport yields the potential to mitigate rising energy consumption and emissions. Thus, it contributes to the objective of reducing congestion and at the same time is part of the wider concept of sustainable urban transport. Vital elements to shift transport demand from individual motorised transport to public transport are investments in capacity and reliability and physical integration with walking and cycling and park & ride facilities. Reliability is an important factor for modal choice. The predictability of travel times with metro (MRT), light rail (LRT) and/or bus rapid transit (BRT) compared to a journey in the private car may provide enough incentives to shift from individual to public transport. Public transport systems generally require substantial public

(50) Prud'homme & Bocarejo (2005). The London congestion charge: a tentative economic appraisal, Transport Policy, 2005, vol. 12, issue 3, 279-287

(51) La Greca P., Martinico F. (2018) "Shaping the Sustainable Urban Mobility. The Catania Case Study". In: Papa R. Fistola R. Gargiulo C., Smart Planning: Sustainability and Mobility in the Age of Change. GREEN ENERGY AND TECHNOLOGY, Basel:Springer International Publishing

investments and the operation often requires continued subsidies. Linking public transport investments with road user charging and parking pricing schemes can help to reduce the pressure on public funds and at the same time create disincentives to use the private car and encourage the use of public transport. **Table 21** shows some of public transport measures.

Table 21. Selected measures for public transport

Public transport measures	**Good practice cities/projects**
Light Rail Systems (LRT)	Light rail or trams are rail systems that operate on urban roads either sharing the street with other road users or operating on a segregated part of the road. Trams are powered electrically and have a high level of service quality in terms of frequency, speed and reliability. *Examples:* http://www.uitp.org/news/knowledge-brief-LRT
Bus Rapid Transit (BRT) systems	Bus Rapid Transit (BRT) systems are high-performance bus systems on urban corridors with a high demand for public transport. BRT systems mimic rail systems with an efficient, high capacity bus-based scheme, which often is cheaper and faster to implement. BRT systems can particularly address public transport challenges if rail based systems are not feasible. *Examples*: http://www.uemi.net/toolkit.html
Trolleybus systems	Trolleybuses are buses that run on electricity provided by overhead wires, giving them similar characteristics to rail modes, such as metro and light rail systems, but normally cheaper to construct and often with a greater operational flexibility. Examples: https://www.trolleymotion.eu/
Battery electric and hybrid public transport vehicles	Electric and hybrid buses are being tested and operated in several European, Asian and American cities incl. BEVs (battery or blade electric vehicles), PHEVs (parallel hybrid electric vehicles) and CHEVs (complex hybrid electric vehicles). *Examples:* http://www.eliptic-project.eu/thematic-pillars
Integrated fare systems	London's Oystercard, Bremen's *Mobility pass,* the Netherland's smart card are some of the numerous examples of integrated ticketing systems that combine the services of different transport providers in one payment system, which is linked through smart cards and/or apps. Examples: http://civitas.eu/collective-transport/ticketing
Bus priority lane	Warsaw introduced a bus priority lane in the city centre stretching 7 km in each direction. The bus lane covers the city's main three-lane artery roads and serves three lanes in both directions. As result the average speed of buses in both directions has increased by 19% faster to the east city edge and 30% faster to city centre, with an average of 26 km/h in both directions, from an average 10 km/h before the bus lane was implemented. *Examples:* http://civitas.eu/content/bus-priority-measures

8.2.4 Car sharing

Owning a car is recognized as increasingly uneconomical, considering the initial costs of buying a vehicle, insurance, registration, vehicle tax, parking space and maintenance. Care sharing schemes are becoming increasingly popular in particular in central areas of cities. Among the various providers of car-sharing schemes there are free floating and stationary systems. Free-floating schemes such as car2go, Multicity and DriveNow allow for their users to park the car anywhere within a designated zone and facilitate the pick-up through GPS-assisted smartphone apps.

Users of stationary car sharing systems such as Cambio and Zipcar return the vehicle to designated parking areas, reservation and payments are normally also handled through

apps. Charges can be based on time and/or kilometres driven and usually cover all costs including fuel. Most of the free-floating car sharing providers focuses on larger cities and, even there, focuses on the most densely populated areas. This may lead to a more competitive approach than to a complementarity with public transport. Many mid-sized cities work with providers of stationary sharing schemes, which often have a higher rate of replacing privately owned vehicles.

Box 27. Car sharing in Bremen, Germany

In 2003, Bremen introduced on-street stations designed to create seamless links between public transport and bike and car-sharing, connected with an app and smartcard system. The city of Bremen estimates that every car-sharing vehicle that is part of this system replaces between 8-10 privately owned cars. While providing access to a car the system gradually reduces vehicle usage and this behavioural change results in reduced greenhouse gas emissions and increased use of public transport and active modes. It also reduces the need for on-street parking and expensive underground parking, freeing up public and recreational space, widening sidewalks and improving bike lanes.

http://eclink.org/en/projects/103/

8.2.5 Parking management

Similar to road user charging, parking management and pricing can help discouraging the use of a privately owned car and raise revenue to fund public transport, walking and cycling infrastructure and improve public spaces. Parking management schemes lead to a reduction in the number of cars entering the city, which can reduce congestion and can encourage the use of public and non-motorised transport. The parking pricing structure and the level of enforcement are important aspects to consider. A structured fee that differentiates between different zones of a city or times depending on the demand is one aspect that needs strong enforcement to be meaningful. Coordination of parking pricing and zoning among relevant local authorities is another vital aspect. Parking management can be a powerful tool for local authorities to manage car use and to raise revenue. Parking management also includes time restrictions and a control of the number of available parking spaces.

Parking time restriction for non-residents, e.g., to two hours, is a proven tool to reduce commuting by car without affecting accessibility to urban shops. In fact, in many cases shops and other local businesses become more accessible when public space is freed up by a reduced number of parking spots.

Box 28. Parking management in Bologna, Italy

The city of Bologna introduces a differentiated parking fee system that is based on the environmental characteristics of vehicles. The wider parking management strategy includes an extension of on-street parking payment areas in the city centre from 30,500 to 45,000 spaces, and an extension of the time frame during which parking fees apply beyond 20:00. Specific high demand areas are planned to be extended and paid parking permissions for residents for the second car per family are also foreseen.

More examples: http://civitas.eu/content/pricing-and-monitoring-policies-parking

8.2.6 Supporting Walking and Cycling

Non-motorised modes, i.e. cycling and walking, can take a substantial share of the urban transport sector, in particular on short distances. As a consequence, soft mobility contributes in the reduction of emissions, energy consumption and congestion. Walking and cycling are suitable for urban transport as in cities the majority of trips covers short distance (below 5 km). The fundamental advantage of non-motorised modes is that they are low cost compared to other transport options, not only for the individuals, but also for public authorities. Moreover, cycling and walking leads to further benefits, such as health benefits for the cyclists or pedestrians, environmental and economic benefits resulting from zero emissions and energy consumption While taking up a noticeable

share of the transport task, walking and cycling infrastructure consumes less space than roads, yet this kind of infrastructure is often neglected in transport planning. The provision and maintenance of infrastructure for pedestrians and cyclists is crucial to make these modes more attractive and, hence, an alternative to private motorised transport.

Frequently, citizens are discouraged from cycling because of safety issues. However, not only infrastructure must be safe, it must be perceived to be safe by the users. Separate crossing signals, cycle lanes, well-marked lanes and crossing, and buffers between road and lane can reduce the risk of accidents. Well maintained routes, free from litter and with appropriate lighting increase the feeling of safety. Moreover, beyond these measures, creating a cycle friendly environment may boost the cycle use. In this perspective, users may consider cycling convenient (e.g. networks should be more advantageous in terms of directness than roads, covered and safe cycle parking should be provided); the routes must be accessible and integrated with the transit network; the routes and surroundings should be attractive, with pleasant settings, and linked to well-designed public spaces, allowing users to stop, chat and rest in a pleasant environment.

These measures may be applied in case of both existing and new infrastructure for pedestrians and cyclists. However, cycling policies are successful when developed as part of an integrated transport policy for all modes of transport, which may be also reinforced by other policies such as land use policies, urban development policies and socio-economic policies (see also chapter 7).

Box 29. Walking and Cycling in Helsinki, Finland

The city of Helsinki created a pathway for pedestrians and cyclists called Baana that leads from the Western Harbour area to Kamppi and the Töölö Bay and is built on a former railway line. Baana is 1.3 km long and on average 15 m wide (it is 34 m at its widest). The pedestrian and bicycle lanes run side by side and are marked with different colours: the bicycle lane is paved with reddish-brown asphalt and the pedestrian lane with black asphalt. In addition to the end points, bicycle access to Baana is allowed by four evenly spaced ramps and pedestrian access by several staircases from streets. There are also accessible entrances at both ends and in the middle of the course.

More examples: http://www.uemi.net/toolkit.html

Finally, numerous cities around the world have implemented the bike sharing scheme as a supporting sustainable mobility strategy. The sharing of bicycle fleet is a service that makes bicycles available for shared use on short terms, allowing users to use bicycles on an "as-needed" basis without the costs and responsibilities of bike ownership and enabling them to pick up and return bicycles to different stations. IT and advanced technology are key elements of the system, which allows users to locate, reserve and access bicycles.

As a consequence, with technology development, in the last years, bike sharing systems are advancing in sophistication. The scheme targets daily mobility that is integrated in public transport and provides a low-carbon solution to the "last mile" problem[52], which indicates the short distance between home and public transit. Bike sharing provides a solution also to urban journeys within city centres for commuters and people who live in suburbs and drive to work. Moreover, usually first minutes of each use are free to incentivise the use of the system. The scheme is used also in a touristic framework and in college and work campuses.

(52) S. Shaheen, S. Guzman, and H. Zhang. 2010. Bikesharing in Europe, the Americas, and Asia: Past, present, and future. Transportation Research Record

Box 30. Establishment of bike sharing system: Strovolos, Cyprus

The bike sharing system has been the most ambitious project related with urban mobility within the Greater Lefkosia area. The local authority has established DEPL (Inter-municipal Bike Company of Lefkosia), which aims to change the behaviour of citizens through sustainable mobility and reduce the traffic via an automated 3rd generation bike sharing system which is similar to the ones used widely in major cities across the world. The bike sharing system has been implemented to complement the development of existing bike lanes within the Lefkosia area and it will also integrate with the new bike lanes that are currently under construction. In the Lefkosia Greater Area were installed 100 bikes in 5 stations were installed: in the city of Aglantzia 50 bikes in 5 stations, in the city of Strovolos 80 bikes in 8 stations, in Dali 20 bikes in 3 stations, in Agios Dometios 20 bikes in 2 stations, in Latsia 15 bikes in 2 stations and in Engomi 30 bikes in 3 stations. The system is integrated between all of the participating cities and each user can use and return a bike at any station.

http://www.covenantofmayors.eu/plans-and-actions/good-practices.html

8.2.7 Supporting the up-take of clean vehicles

Local authorities have a number of options to encourage the purchase and use of electric vehicles, which can start with an active dialogue with stakeholders, such as electricity suppliers, car-park operators and where applicable vehicle manufacturers and continues with concrete actions. For example introducing reduced or free parking for EVs (as in Oslo, Norway), exemption from road user charges or city tolls (e.g. London, UK), allowing access to high-occupancy vehicle lane, and giving priority to electric vehicles in municipal and car sharing fleets.

Box 31. LIVE platform, Barcelona, Spain

Barcelona aims to promote electric vehicles in close cooperation with the private sector. As part of this effort the city established the LIVE platform - a public- private partnership to coordinate, monitor and communicate e-mobility activities in Barcelona and the surrounding area. The LIVE platform supports policies and projects to promote e-mobility and supports new start-ups offering EV products and services in the city. It also provides subsidies for charging infrastructure (€2,000 per plug for on-street stations and €1,000 for off-street stations) and works with private stakeholders to install infrastructure in hotels or shopping centres. The city of Barcelona also provides tax deductions and free parking for all-electric vehicles.

More examples: http://www.uemi.net/toolkit.html

8.2.8 Registration management

A managed approach to vehicle registrations can help limiting the amount of cars in a city by differentiating registration fees for vehicles e.g. according to their CO_2 emissions or engine size. This can guide purchasing behaviour and can encourage people to opt for cleaner vehicles or more sustainable modes such as public transport and non-motorised modes. This approach is not common in European cities, but has be implemented very successfully in several cities in Asia, e.g. Singapore and Shanghai. Vital to this approach is that the authority to register vehicles lies with the local authority.

8.3 Implementing urban mobility solutions

The transport sector is unique in its complexity with regard to the number and diversity of its users and the various types of mobility solutions. Accessibility and mobility are vital components of city life and its economy. Moreover, addressing urban mobility in an integrated way can make the essential difference to the success and the liveability of a city. If applied in combination, sustainable transport interventions can be mutually reinforcing and create synergies between policy objectives. **Table 22** reports the combination of potential measures.

Table 22. Measures combination and complementarities

Examples for urban mobility measures	Complementarity of measures
Compact city design and integrated planning	The planning of compact and mixed use areas enables to reduce the length of trips and therefore, o modal alternatives and accessibility are provided.
Provision of public transport, walking and cycling infrastructure and services	Reliable and affordable public transits in a compact city allow reducing the car dependence for daily activities. Moreover, with a high-quality environment, also walking and cycling modes expand.
Road User Charging, parking pricing, access restrictions, registration restrictions and number plate auctions, eco-driving schemes, urban logistics	Complementary measures at the local level help managing travel demand and can generate funds that can be re-distributed to fund low-carbon transport modes

8.4 Sustainable sources for Transport

Vegetable oil methyl esters (biodiesel) can be used for transport applications, either in pure form or blended with fossil diesel. Use in blends below 7% does not require any modification of the engine. Pure vegetable oils can also be used but engines have to be adapted. Ethanol can be used in gasoline engines either at low blends (up to 10%), in high blends in Flexible Fuel Vehicles or in pure form in adapted engines. Ethanol can also be processed into ETBE (ethyl tertio butyl ether) and blended in gasoline. Biomethane can also be used by vehicles equipped for natural gas. Advanced biofuels from wood, lignocelluloses and waste, such a biomass to liquid (BTL), Dimethyl ether (DME) or ethanol are subject to intense R&D efforts.

9 Local energy generation

Local energy generation and distribution systems are an important area of intervention within the Covenant of Mayors that concerns effective action at the local level within the competence of the local authority ([53]). Local authorities usually control or have influence over the local energy supply system as the owner or a partner in the local energy utilities, which can effectively enhance the opportunities by which renewable energy sources can be effectively integrated to support CO_2 mitigation targets.

This chapter aims at providing an overview of the key municipal policies and strategies to promote local energy generation, ranging from decentralised renewable energy in buildings to centralised options for promoting integrated and sustainable energy systems at the urban level ([54]). Well-rounded policy support from a synthesis of urban climate governance options, including those that relate to municipal self-governing, governing by provision, governing by regulation and planning, and governing through enabling ([55]) is required to transform the local energy structure. In turn, such policies have a crucial role in demonstrating, guiding and influencing key measures for achieving emission reductions through efficient electricity and local heat/cold production.

The sections in this chapter provide a collection of best practices on local energy generation based on the Covenant of Mayors Signatories experiences ([56]) and the literature, especially those that are connected to best practices in signatories.

The chapter is organized into two sections according to best practices and key measures:

- Municipal policies to support sustainable local energy generation:

There is a wide range of policies to promote the utilization of renewable energy sources for both decentralized and centralized local energy generation. These policies should be structured in complementary ways whenever possible, such as combining financial incentives for decentralized energy generation with awareness and capacity building support. Policies should also be complemented by a close cooperation among the different actors to ensure an effective outlook towards the implementation of well-rounded policy support for local energy generation.

- Key measures for a transition to sustainable local energy generation:

A holistic understanding of the key measures and technological options that are available at the local level is required to support the design and implementation of policies to promote local energy generation. For this reason, key measures are described with the aim of providing guidance towards potential application areas. Insight from signatories that have already undertaken the technological options is summarized to underline the rapid transition that is taking place at the local level based on the promotion of local energy generation with renewable energy.

Over 80 exemplary best practices are overviewed across the technology areas of photovoltaics, solar thermal, wind energy, hydroelectric power, bioenergy, geothermal energy, combined heat and power (CHP), district heating and/or cooling (DH/C), smart grids, as well as energy generation from waste and wastewater based on the Covenant of Mayors Signatories' experiences ([56]). These best practices are associated with the urban climate governance options that have been put into action. The best practices exemplify that support for local energy generation can be effectively triggered by local policies.

(53)Kona A., Melica G., Bertoldi P., Rivas Calvete S., Koffi B., Iancu A., Zancanella P., Janssens-Maenhout G. Dallemand J.F., (2017). Covenant of Mayors in Figures: 8-year Assessment, JRC Science for Policy Report.
(54)IRENA (2016). Renewable energy in cities. International Renewable Energy Agency (IRENA). Abu Dhabi, *http://www.irena.org/publications/2016/Oct/Renewable-Energy-in-Cities*
(55)Kern K., Alber G., (2009). Governing Climate Change in Cities: Modes of Urban Climate Governance in Multi-level Systems, In: The International Conference on Competitive Cities and Climate Change, Milan, Italy, 9 - 10 October, 2009, *Paris: OECD, pp.* 171 – 196
(56) https://www.covenantofmayors.eu/plans-and-actions/good-practices.html

9.1 Municipal policies for local energy generation

In this section examples of policies and best practices are described according to the four modes of governance defined in Chapter 2 namely *municipal self-governing*, *governing through enabling, governing through provision,* and *regulation and planning*. As evident by subsequent discussions, a successful implementation of measures with widespread impact requires well-rounded support from multiple modes acting in combination to local energy generation.

Municipal self-governing

- Management of the local authority's estate to increase local energy generation: The local authority requires renewable energy generation to provide for a high share of the building energy needs in the design of new public buildings and the retrofit of existing public buildings. Town halls with innovative solar energy façades and schools that are powered by photovoltaic panels may be given as initial examples. When possible, the local authority can also require DH/C grids in public buildings areas, including through contract to connect municipal buildings to the district heating and/or cooling network.
- Renewable energy demonstration projects in public facilities: Public buildings provide important opportunities as demonstration sites for renewable energy technologies. Local authorities can publicly test and show the success of renewable energy measures that are implemented in public buildings. Moreover, priority may be also given to less wide-spread testing technologies, such as low-power absorption, chillers and microcogeneration. It is important that the results of the pilot installations (positive and negative) are shared with the stakeholders. The pilot projects can also attract the interest of private stakeholders upon which similar projects can be replicated across the city. Additional opportunities include the use of biogas from wastewater treatment facilities in a cogeneration plant or in public vehicles fleet driven by biogas/natural gas.
- Public procurement: In addition to the mobilization of public resources for renewable energy projects, municipal purchases of certified green electricity can increase the share of electricity consumption from renewable sources, going beyond national schemes. Public procurement can also be used to prescribe a share of renewable supply in the case of service contracts to public facilities. One of the prerequisites for the use of public procurement as a strategic tool to increase local energy generation in municipality-owned assets is the identification of appropriate public buildings and facilities. Public facilities that typically have high energy intensity profiles include swimming pools, sports facilities, and office buildings as well as hospitals or retirement homes. Inefficient heating plants and boilers at these sites can be replaced by cogeneration, trigeneration, renewable energy installations or a combination of both according to the energy demand profile for heating and cooling. Actions at these sites can also have a high replication potential across the private sectors, such as the food industry and hotels, among others. For this reason, a strong communication policy is essential to share the results with the private sector.

Box 32. Possible Actions with High Replication Potential

Substitution of the old heating and cooling plants by trigeneration installations to provide the base demand of heat and cold throughout the year in municipal buildings

Substitution of a public swimming pool's old heating plant by an installation of a combined solar thermal and biomass system, financed through an ESCO scheme.

Municipal enabling

- Public-private partnerships: Cooperation between local authority, local investors, and local citizens are deemed to be vital factors of success for realizing the transition to 100% renewable energy systems ([57]). The leadership of local authorities usually have a crucial role in forging partnerships and pooling resources across the public and private sectors. Examples include public-private partnerships for anaerobic digestion of biowaste for CHP-based district heating and the co-financing of public energy upgrading between local and regional authorities and private investors. Especially in the bioenergy sector, the supply of urban biowaste can depend on citizen awareness and motivation to put aside organic waste for separate collection. For this reason, it is also important to motivate citizens in partaking in waste management strategies to enable the use of organic waste to produce biogas.
- Awareness raising and training activities: Examples of training material may be found on European projects' web-pages ([58]). Promotional campaigns, such as solar energy campaigns, can be effectively combined with supporting tools, including the provision of a solar atlas and solar land registry.

Box 33 Tools in Support of Awareness Building for Renewable Energy

I) Berlin Solar Atlas

Integrated in the Berlin Economic Atlas, the Solar Atlas shows the solar potential of each building in the city in clear, sharp images in both 2D and 3D. Property owners and investors can use the Atlas to determine whether a building's roof is suitable for a solar installation and whether the investment will pay off. The Atlas provides key information at a glance on such matters as the potential power output, reductions in CO_2 emissions, and estimated investment costs.

http://www.businesslocationcenter.de/en/berlin-economic-atlas/the-project/project-examples/solar-atlas

II) Paris Solar Land Registry, France

Launched in the summer of 2013 as part of the European project POLIS, the first French solar land registry provides information on the roofs that may receive a photovoltaic or solar thermal system, taking into account the parameters of building construction, such as geometry, orientation and angle tilt roof, as well as incidence shadows.

http://www.eumayors.eu/en/

III) Vlaams-Brabant Climate Map, Belgium

The climate map of the Vlaams-Brabant Province includes over 1,192 local climate and energy initiatives and projects in the areas of mobility, building, agriculture, energy production and consumption. It is an interactive map that enables local authorities and local stakeholders (e.g. companies, citizen groups, schools, etc.) to include their actions in a user-friendly way. Renewable energy producers can use the map to calculate their contribution to the CO_2 reduction efforts of the province.

http://www.eumayors.eu/en/

- Community cooperatives for local energy projects: Community cooperatives for local energy projects can enable citizens to have collective ownership and management of such projects, including those based on renewable energy generation ([59]). At the same time, community cooperatives require a certain level of citizen engagement and empowerment. For this reason, awareness building activities can be used to mitigate perceptions of risk of renewable energy cooperatives that can hinder the profitability of such initiatives as well as their contribution to energy transition objectives. In this case,

(57) Young, J. and Brans, M., (2017). Analysis of factors affecting a shift in a local energy system towards 100% renewable energy community, *Journal of Cleaner Production* 169, pp. 117-124
(58) Energy Efficiency Training of Trainers (EETT)
https://ec.europa.eu/energy/intelligent/projects/en/projects/eett
(59) https://transitionnetwork.org/

awareness building in support of local energy generation can also be used to satisfy needs to empower community participation and buy-in in such initiatives ([60]).

Box 34. Solar Systems Integration Manual in Lisbon, Portugal

Historic buildings are exempted within the Portuguese national legislation on buildings energy performance for the obligation on installing solar thermal systems in residential buildings. Although one can easily understand the importance of preserving the national patrimony, this exemption is often misunderstood by investors and property developers that heritage buildings should not comply with the actual requirements for energy efficiency and comfort in residential buildings. As a consequence, these districts are abandoned and left derelict, a common situation in several European countries. To overcome this trend it is important to upgrade residential historical buildings to modern standards, including the possibility of integrating solar technologies.

In the Baixa Pombalina's urban regeneration plan, Lisboa E-Nova , in cooperation with the Local authority of Lisbon and IGESPAR (the entity responsible for the management of the national archaeological and architectural heritage), promotes the programme 'Solar Systems Integration Potential in the Lisbon Baixa Pombalina Area'. The project outcomes will be incorporated in the area's urban regeneration plan to promote the integration of solar systems during refurbishment while following cultural heritage requirements. To complement this potential assessment, there will be an Integration Manual, to be developed according to existing market solutions on solar systems and to the relevant criteria for integrating such systems in historical buildings. The solutions identified can be adopted also in other protected historical areas across Europe.

Source: Fernandes, J. Solar Thermal Systems in Lisbon Historical Baixa Pombalina, Lisboa E -Nova

Governing through provision

- Direct energy infrastructure investments: The utilization of renewable energy sources in the urban built environment may be limited due to insufficiencies in the energy infrastructure. In this case, direct investments at the local level are needed, including those for modernizing and expanding DH/C networks. In combination with regulatory means of governance, local authorities can further require that connections to the DH/C network are compulsory for buildings located in related zones. In the case of municipally owned utilities, minimum quotas for renewable energy sources or co-generation can be set. Otherwise, local authorities can involve utility companies in new projects for local energy generation to take advantage of their experience, facilitate greater access to the grid and reach a larger share of individual consumers. Public housing further provides a venue to promote the integrated use of renewable energy sources, including solar thermal, solar PV, biomass and micro-cogeneration. This entails adapting the design of public housing to the requirements of these options.
- Incentives and grants to local energy generation: Local authorities can issue municipal green bonds and create funds for renewable energy deployment. The provision of financial opportunities such as these can overcome market failures and address economic barriers for the widespread deployment of related technologies. In addition, local authorities can provide subsidies for connections to the district heating network as well as those that may involve the use of any low temperature heating systems that can reduce the operating temperature of the network to increase its efficiency ([61]).
- Subsidies for local electricity and thermal energy production based on CHP plants as well as the provision of financing for demonstration projects on smart grids can also accelerate progress towards CO_2 mitigation targets based on local energy generation.

Regulation and planning

(60) Herbes, C., Brummer, V., Rognli, J., Blazejewski, S., Gerick, N., (2017). Responding to policy change: New business models for renewable energy cooperatives – Barriers perceived by cooperatives' members, *Energy Policy* 109, pp. 82-95

(61) Verda, V., Caccina, M., Kona, A., (2016). Thermoeconomic cost assessment in future district heating networks, *Energy* 117 (2) pp. 485-491

- Ordinances on the mandatory use of renewable energy: Solar Thermal Ordinances (STOs) represent one of the most prevalent forms of mandatory regulations for renewable energy. STOs are legal provisions making the installation of solar thermal systems in buildings mandatory. The obligation mainly applies to new buildings and those undergoing major refurbishment. The owner must then install a solar thermal system meeting legal requirements. Most of the existing STOs are connected to national or regional energy laws and implemented through the municipal building codes. A growing number of European local authorities, regions and countries has adopted such obligations ([62]). In addition, local authorities can require mandatory installations of photovoltaic systems among other renewable energy technologies.
- Ordinances on the mandatory use of renewable energy: Regulatory measures can further require households and private companies to purchase green electricity through obligations on local energy suppliers. Alternatively, consider establishing a joint framework agreement to purchase green electricity.
- Review and revise urban planning regulation to consider the necessary infrastructures required for the development of the DH/C.
- Adapt the administrative procedures to shorten the time required to obtain permits, and reduce local taxes when energy efficiency improvements or renewable energy sources are included in the proposals. Declare these projects as "Public Interest" and apply them advantageous administrative conditions when compared to non-energy efficient projects. Administrative procedures should be clear, transparent and quick enough to facilitate the development of DH/C projects to alleviate any barriers and uncertainty.
- Contact networks of other local authorities or European/national/regional local authorities and produce a common proposal of new regulation for the promotion of distributed energy generation addressed to the relevant public authorities.
- Set up rules to clarify the roles and responsibilities of all actors who are involved in selling and buying energy, especially in cases where experience and regulations may be previously lacking, including those for new DH/C networks. Check that duties and responsibilities are clearly identified and that each actor is aware of them. In the energy-selling sector, make sure that measurements of energy are in accordance with recognised standards, e.g. International Performance Measurement and Verification Protocol (IPMVP). Transparency is a key aspect from the point of view of consumers and investors. "Rules of the game" should be in force as soon as possible. Convoke all stakeholders to obtain their views and understand their interests and concerns.
- Strategic energy planning to support local energy generation: in addition to setting regulations, strategic energy planning tools and decisions provide a means for local authorities to evaluate and enforce decisions to promote local energy generation. Box 35 exemplifies instances in which strategic energy planning would be necessary to promote the generation and utilization of local energy resources, including those of residual heat from the industry, data centres, and wastewater treatment plants. Local maps with information on heat demand densities and the locations and magnitudes of residual heat from industry and power generation can largely facilitate this process ([63]).
- In addition, land use planning should be considered for large-scale solar plants and wind turbines. These aspects call for integrated urban planning processes to support local energy generation decisions as the basis for additional action, such as:
- Establish an integrated urban planning process to promote renewable energy generation deployment. Identify possible sites to install local energy generation installations, such as those for solar, wind, small hydro and biogas, ensuing the availability and compatibility of space to achieve projects. If needed, provide public space to install local energy

(62) Solar Thermal Ordinances = Making a commitment to local sustainable energy *http://www.estif.org/fileadmin/estif/content/projects/prosto/downloads/prosto%20brochure.pdf*
(63) Pan-European Thermal Atlas (PETA 4.2) *http://www.heatroadmap.eu/maps.php*

generation installations. Some European local authorities offer rooftops of public buildings to private companies for rent to produce energy by means of photovoltaic collectors ([64]). The contract duration is established beforehand and the objective is to exploit large unused spaces to promote renewable energy.

- Establish integrated urban planning processes, including those to promote DH/C networks and cogeneration plants. Develop appropriate mapping tools of thermal energy demand from buildings based on reliable data from utilities.

Box 35. Planning for Local Energy Generation and Utilization

Evaluate geothermal energy potential considering legal and technical barriers of ground perforation and the environmental effect on the underground water layer.

With regard to the use of biomass, make a technical and economical evaluation of the potential of the biomass harvested in public spaces, companies and citizens' properties, the potential impacts of biomass combustion on air quality and health should be also evaluated.

Consider the integration of residual heat into the district and cooling network, including sources of residual heat from the industry, data centres, wastewater treatment plants, and waste incinerators.

9.2 Key measures for transition to sustainable local energy systems

Policy measures give direction to increasing the valorisation of local opportunities in the context of local characteristics and available measures. This section is intended to provide a collection of key measures to promote the uptake of renewable sources and integrated urban energy systems. The options for the transition to sustainable local energy generation systems range from decentralised renewable energy options to centralised solutions, such as cogeneration and district heating and/or cooling networks.

Europe has the ambition to be the world number one in renewable energy ([65]). To fulfil this objective, the next generation of renewable technologies must be developed and the energy that is produced from renewable sources must be integrated into the energy system in an efficient and cost-effective manner. In this context, there is increasing interest in the decentralisation of the energy supply with more local ownership. Local energy supply options can take the form of district energy systems, local power generation utilities, and energy services companies (ESCo). Local authorities can be in whole or partial owners of these utilities and promote community partnership.

Decentralised renewable energy technologies offer the possibility to produce energy with a much lower impact on the environment when compared to conventional energy technologies. Distributed electricity generation allows to reduce electricity transport and distribution losses and to use micro-cogeneration technologies while increasing the penetration of low-scale renewable energy technologies. The electricity grid must be able to distribute this energy to the final consumers when the resources are available, and rapidly adapt the demand, or cover the energy that is required using more adaptable technologies when the former are not available, such as hydropower or biomass.

Centralised options include cogeneration power plants and DH/C networks. Cogeneration (or CHP – Combined Heat and Power) and DH/C networks offer an efficient way of producing electric power and thermal energy for cities. Cost-effective policies that maximise efficiency benefits should focus on measures targeting areas with high heating and cooling densities. In addition, DH/C provides a proven solution for the efficient use of multiple renewable energy sources on a large scale, including biomass, geothermal, and

(64) Guide for local and regional governments "Save the Energy, save the climate, save money" (2008). CEMR Climate Alliance, Energie Cités
http://www.ccre.org/img/uploads/piecesjointe/filename/sustainable_energy_en.pdf
(65) Energy Union Research, Innovation and Competitiveness Priority, No1 in Renewable Energy
https://setis.ec.europa.eu/low-carbon-technologies/no1-renewables

solar thermal energy resources, and recuperates the residual heat from electricity production, fuel and biofuel-refining, waste incineration, and industrial processes. The Heat Roadmap Europe Pan-European Thermal Atlas (PETA) maps the magnitude and localities of such opportunities, including urban biowaste, surplus heat from thermal generation with the main activity of electricity generation, and various industries ([66]). Opportunities for the utilization of bioenergy resources, solar thermal district heating, and geothermal heat are also emphasized within the common mapping platform.

Table 23 summarizes the key measures to promote local energy generation by renewable energy source or technology. The relevant modes of urban climate governance that are involved are marked to showcase the integrated approach that is needed for supporting particular renewable energy solutions. Examples for the policy measures are based on compilations from the Covenant of Mayors Signatories available at https://www.covenantofmayors.eu/plans-and-actions/good-practices.html

Table 23. Policy measures to promote local energy generation by renewable energy source

Area of intervention	Policy measure
Local electricity generation: Photovoltaics	Municipal financing and ownership of PV pilot plants on public buildings (rooftop PV and building-integrated PV systems)
	PV installations on the roofs of bus sheds (968 kW in Mantova, IT) or parking lots
	Construction of a PV park on ground of municipal property at a former landfill site (994 kW in Torrile, IT; Évora, PT)
	Concession of surface rights and renting of rooftop areas in public buildings for PV
	PV installations in public buildings based on collaboration with the ESCo and third-party financing for PV systems in school buildings
	Public-private partnership for Photovoltaic Solar Park (24.2 MW in Coruche, Portugal)
	Energy supplier obligations for PV systems Mandate for PV system installations equal to a given share of the total installed power in the city
	LAs bonus for photovoltaic and solar thermal installation on citizen's roof
	Interest-free loans for associations or schools for PV panel installations (Bree, BE)
	PV systems that supply electric vehicle charging stations (135 kW in Poole, UK)
	Awareness building and supporting tools Solar land registry for roof-top photovoltaic or solar thermal installations (Paris, FR) Solar chart for identifying preferable areas for solar energy technologies (Lisbon, PT) Solar roof cataster (Bremen, DE; Fürstenfeldbruck, DE; Hanover, DE; Barcelona, ES and others)
	Real time electricity generation data on PV systems of the City Council (Málaga, ES) and visual consoles on CO2 reductions

(66) Pan-European Thermal Atlas (PETA 4.2) *http://www.heatroadmap.eu/maps.php*

Area of intervention	Policy measure
Local electricity generation: Photovoltaics	Public awareness to reach annual targets for PV in the private buildings
	Awareness building and supporting tools Solar land registry for roof-top photovoltaic or solar thermal installations (Paris, FR) Solar chart for identifying preferable areas for solar energy technologies (Lisbon, PT) Solar roof cataster (Bremen, DE; Fürstenfeldbruck, DE; Hanover, DE; Barcelona, ES and others)
	Real time electricity generation data on PV systems of the City Council (Málaga, ES) and visual consoles on CO2 reductions
	Public awareness to reach annual targets for PV in the private buildings
	City supported photovoltaic campaign One million square metres of solar modules by 2020 (Hanover, DE)
	Land use planning for utility-scale photovoltaic plants in the city
Local heat generation: Solar thermal	Solar collectors on rooftops of municipal buildings, swimming pool facility, sport buildings and schools (including flat-plate and parabolic solar collector installations) Replacement of electrical heaters and boilers in public buildings
	Ordinance for installing solar collectors Solar collectors in all buildings in the health care sector (Zagreb, HR) Solar thermal systems in 100% of schools that include south-facing facades and terraces (Loures, PT)
	Purchasing groups to allow widespread diffusion of solar thermal technology
	Targets to increase the area of solar thermal in the city
Local electricity generation: Wind energy	Wind and solar farm with citizen cooperation (Nijmegen, NL)
	Installation of wind power farms Promotion of locally owned wind turbines (Ringkøbing-Skjern, DK) Public procurement of municipal wind turbines (4 x 3.3 MW in Eskilstuna, SE that is 40 % of the municipal electricity load) Co-ownership of wind-power plants (municipal company in Lund, SE)
	Attraction of companies that want to generate electricity from wind energy Prioritized case handling and licencing of wind turbines
	Land use planning for wind turbines
Local electricity generation: Hydroelectric power	Mini-hydro plants on municipal waterworks Ronchi Valsugana, IT
	Attraction of investment to realize an in-stream tidal hydro power plant (10 MW)
	Run-of-river hydroelectric plants Produces the amount of electricity needed for public buildings and public lighting loads (Roman, RO)
	Hydroelectric power plant construction (Manerbio, IT; Mazzin, IT; Rosà, IT)

Area of intervention	Policy measure
Bioenergy	Biogas cogeneration plant for electricity and thermal energy provision based on anaerobic digestion (Annicco, IT)
	Biogas cogeneration based on zootechnical wastewater and silage cereals
	Biogas driven district heating network
	New anaerobic digestion plant in public waste recovery and treatment company
	Public-private partnership between the local authority and waste management utility for anaerobic digestion of biowaste for CHP-based district heating (Este, IT)
	Recovery of methane gas from landfills to produce electricity based on gas engines 120 wells degassing biogas capture and network piping (Málaga, ES)
	Biomass based district heating network and/or biomass boilers for replacing diesel boilers (local wood chips < 60 km from sustainable management of forests): 6 MW in Banja Luka, BH
	Consortium for a cogeneration plant based on biomass certified as sustainable (waste produced locally or from local consortium companies (Bagnolo San Vito, IT)
	Installation of wood chip boilers in the CHP plant for carbon neutral district heating Fuel switching in Liepāja, LT and other signatories
	Collection and recycling of used cooking oil for biodiesel production (Loures, PT)
Geothermal energy	Construction of a geothermal power plant
	Low enthalpy geothermal heating for municipal residential building
Renewable energy (other)	City Council grants and subsidies for renewable energy (PV, solar thermal, biomass, ground source heat pumps) Subsidy per square meter of solar thermal collector area (Bonn, DE) Grants for solar collector and heat pump installations (Alken, BE) Subsidy to renewable heat sources in residential buildings (Gdynia, PL)
	Clean technology funds for renewables
	Promotion of distributed energy generation based on Urban Building Regulations and simplified building authorization procedures
	Public buildings that are self-sufficient based on on-site renewable energy Self-sufficient town hall based on bioenergy and PV (Baradili, IT)
	Demonstrations of net or nearly zero energy building with renewable energy Net zero energy schools (Göteborg) Viikki Environment House as nearly zero energy office (Helsinki, FI) Pilot public school built according to the Nearly Zero Energy (NZE) Standard (Winkelomheide, BE) Co-financing of a near zero energy school building with local and national funds (Scuola Pascoli)

Area of intervention	Policy measure
Renewable energy (other) *(suite)*	Public buildings with bioclimatic design principles and renewable energy utilization Public social building complex Energy renovation of public buildings including solar thermal collectors (Karlovac, HR) Daycare centre with solar and geothermal energy (Kozani, GR)
	Brownfield urban development with renewables and sustainable districts Transformation of former port and industrial area into a new sustainable district (Ravenna, IT) Sustainable Järva with 10,000 m2 solar cells (Stockholm, SE)
	Co-financing between local and regional authorities for public energy upgrading Co-financing of solar thermal systems on public buildings (Castelnuovo Rangone, IT)
	Purchasing of certified renewable power for public buildings and public lighting Joint framework agreement for purchasing 100% green electricity (Province of Limburg, Netherlands)
	Onshore Power Supply with high-voltage for docking ships in the port (Gothenburg)
	Awareness building actions Experimental sessions on renewable energy for students Training campaigns organized by the local energy utility/agency

Source: Compiled from good practices of Covenant of Mayors ([56])

The above grouping of the best practices by renewable energy source or technology is also indicated by options for local electricity generation or heat generation as relevant. In other cases, processes for local energy generation for power and heat/cold are combined and/or relate to central district energy infrastructure. For these cases, **Table 24** provides a similar compilation for CHP plants, DH/C systems, and smart grids. Similarly, modes of urban climate governance that are involved in the measures showcase the integrated approach that is needed to support local energy generation solutions.

Table 24. Policy measures to promote CHP, district energy/cooling systems and smart grids

Area of intervention	Policy measure
Combined heat and power	Cogeneration plant for municipal buildings
	Biomass-based combined heat and power plant to support the district heating system (Jönköping, Sweden 340 GWh_t 130 GWh_e)
	Modernization of the cogeneration plant with fuel flexibility for waste and bioenergy (Västerås, SE)
	Investment of the public utility company in a new cogeneration plant with both district heating and cooling infrastructure Bioenergy based plant with co-location of PV panels on the roof of the plant (Fürstenfeldbruck, DE)
	Subsidies for CHP electricity production
District heating/ cooling plant	Large scale solar thermal solutions in district heating systems (Marstal District Heating in Aeroe, Denmark)
	Flue-gas heat recovery to increase efficiency of heat production (Riga, LV)
District heating/ cooling network	Contract to connect municipal buildings and schools to the district heating network Commitment to invest 10% of the contract sum to energy retrofitting and maintenance (Milan, IT)
	Integrated heating systems between public buildings (Vittorio Veneto, Italy)
	Initiative to increase the purchased volume of energy from the district heating network Subsidies and/or obligations for connection to district heating
	Modernization and rehabilitation of district heating and/or cooling networks Remote monitoring of pipelines and insulation to reduce heat losses (30% to 12% in Bielsko-Biala, PL)
	Installation of thermal energy distributors and thermostatic radiator valves in the district heating network (Rijeka, HR)
	Connection of low energy houses to a low-temperature district heating network (Västerås, SE)
	Connection of buildings and industries to the district cooling network Energy efficient data center with PV on the server hall roof (Växjö, SE)
	Utilization of residual heat from urban wastewater (Aachen, Germany)
	Utilization of industrial waste heat Recovery of waste heat from the local steel industry (Finspång, SE) Substitution of the use of natural gas based on the use of waste heat from a pulp mill (Judenburg, AT)
	Cooperation to establish noise barriers for road and rail traffic equipped with solar energy collectors to support the local district heating system (Lerum, Sweden)
	Cooperation with the local energy utility to establish a district heating network
	Interconnection of district heating networks and extension of distribution piping
	Urban energy planning to increase the connection of buildings to the district heating network (Kristianstad, SE)
	Increase in the share of renewable energy sources in the district heating network (from 40% to 75% in Ringsted, DK)
Smart grids	Cooperation with the district network operator for demand side management Monitoring and response to peak load in public buildings towards a future smart grid (Glasgow, UK)
	Financing of pilot projects on smart grids and allocation of local demonstration sites (local, regional, national, and EU funds)

In addition to the energy sector, opportunities for local energy generation exist within the water and waste sector. A cross-sectoral perspective that is not limited to only one sector is therefore necessary. **Table 25** complements this aspect based on a compilation of policy interventions for measures involving waste management, wastewater treatment plants, and water management. The relevant modes of urban climate governance emphasize the integrated approach that is needed also in these areas of intervention.

Table 25. Policy measures for waste and water management including wastewater treatment

Area of intervention	Policy measure
Waste management	Separate waste collection to increase the recycling of municipal solid waste and the use of organic waste for biogas production
	Use of green waste for the production of compost and pellets (Lakatamia, CY)
	Utilization of organic waste for composting rather than waste-to-energy incineration
Wastewater treatment plants	Self-sufficient wastewater facility based on methane driven combined heat and power plant (Neumarkt in der Oberpfalz, DE)
Water management	Integration of renewable sources for supplying power to pumping tapwater
	Reduction in electricity usage for pumping based on reductions in water losses in the drinking-water distribution network Seixal, PT; Bilbao, PT
	Information system for energy and water use in the public sector (Voznesensk, UA)

Source: Compiled from good practices in Covenant of Mayors ([56])

9.2.1 Renewable energy in buildings

Renewable energy will play a major role in tackling Climate Change and can provide an affordable and secure source of energy, including in the building stock. Renewable energy is cheaper now than ever due to technological developments, mass production and market competition. In the case of photovoltaic (PV) electricity generation, the technology has reached or on the verge of matching household electricity prices for grid-parity in certain contexts ([67]). Key measures for the deployment of decentralised renewable energy in buildings consist of photovoltaic electricity generation, solar thermal systems, biomass systems, and geothermal heat pumps.

Developments are further driven by legislation on nearly zero-energy targets that require buildings to produce nearly as much energy as used on an annual basis, which is possible based on the integration of distributed energy generation from renewable energy sources in buildings ([68]). In Europe, all new buildings are required to satisfy nearly zero-energy performances by the end of 2020 while all new public buildings shall be nearly zero-energy by the year 2018 ([69]). Both targets affect the building stock at the local level.

(67) Haas, R., Lettner, G., Auer, H., Duic, N., (2013). The looming revolution: How photovoltaics will change electricity markets in Europe fundamentally, *Energy* 57, pp. 38-43
(68) Nearly zero-energy buildings, *https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings/nearly-zero-energy-buildings*
(69) Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings, *http://data.europa.eu/eli/dir/2010/31/oj*

9.2.1.1 Solar thermal systems

Solar thermal systems convert sunlight directly into heat and make this heat available for various applications. Solar thermal energy, together with biomass and geothermal energy can be a major source of heating and cooling in Europe. Currently, solar thermal applications are mainly used for domestic hot water (DHW) and space heating in single and multi-family homes although large-scale uses of solar thermal systems are increasing. Heating DHW during the summer is one of the easiest and therefore cheapest ways of using solar thermal energy. In addition, solar thermal heat can be used to drive a thermal cooling machine and can be used as an energy source for cooling ([70]).

A relevant contribution of solar energy to space heating requires an increase of the solar fraction per building, which is the share of solar energy on the overall heat demand for DHW and space heating. In central Europe, combi-systems for DHW and space heating already achieve high market shares. Combi systems for DHW and space heating have a size of typically 10 to 15 m^2 of collector area and can provide a solar fraction of about 25 %, depending on the size, efficiency of the building, and on-site climate conditions.

In Central and North Europe, the level of solar radiation is much lower in winter than in summer time. A solar fraction close to 100% thus requires the shift of a significant amount of solar heat generated during the summer to the heating season and the installation of a very large seasonal storage water tank. Based on improved insulation standards for buildings and improved solar heating technology, a solar fraction of about 60% was developed as a good compromise of high solar fraction at acceptable storage volume in the case of Solar-Active-Houses. In Central Europe, a typical single family house needs a collector area of 30 to 40 m^2 and water storage tank of 5 to 10 m^3 ([71]).

In addition to solar thermal systems, photovoltaic/thermal (PV/T) systems are an option for the utilization of solar energy to produce both electricity and thermal energy. Typical electrical conversion efficiencies are found to vary from 10% to 20% while those for thermal efficiencies range around 50% or more so that it is possible for PV/T systems to reach higher efficiencies ([72]). The comparison of building integrated PV/T systems with building integrated PV (BIPV) systems indicated similar results ([73]). The use of phase change materials (PCM) can further increase performances. The area that would be needed for PV/T systems to satisfy similar energy loads in buildings across localities with different solar radiation values were also compared for 10 European cities ([74]).

The JRC has created a database ([75]) that contains solar radiation data all over Europe. These data may be used by the designers for the evaluation of the necessary collector's surface by using, for example, an f-chart or direct simulation model. The database is focused on the calculation of photovoltaic installations, but data linked to the solar radiation may also be used for solar thermal installations designs.

9.2.1.1 Bioenergy for bioheat and/or bioelectricity in buildings

Currently, the use of bioenergy for heating as bioheat in the residential, services, and industry sectors exceeds the use of bioenergy in the power and transport sectors as bioelectricity and biofuels ([76]). In the case of biomass, sustainably harvested biomass is

(70) European Technology Platform on Renewable Heating and Cooling, Strategic Research Priorities for Solar Thermal Technology, *http://www.rhc-platform.org/fileadmin/Publications/Solar_thermal_SRP.pdf*
(71) Solar-Activehouse, *http://www.activehouse.info/cases/solar-activehouse/*
(72) Al-Waelia, A., Sopiana, K., Kazem, H., Chaichan, M., (2017). Photovoltaic/Thermal (PV/T) systems: Status and future prospects, *Renewable and Sustainable Energy Reviews* 77, pp. 109–130
(73) Agrawal B, Tiwari GN., (2010). Life cycle cost assessment of building integrated PV thermal (BIPVT) systems. *Energy and Buildings* 42, pp. 1472–1481
(74) Ramos, A., Chatzopoulou, M., Guarracino, I., Freeman, J. and Markides, C., (2017). Hybrid Photovoltaic-thermal Solar Systems for Combined Heating, Cooling and Power Provision in the Urban Environment, *Energy Conversion and Management* 150, pp. 838-850
(75) Photovoltaic Geographical Information System, *http://re.jrc.ec.europa.eu/pvg_tools/en/tools.html*
(76) Bioenergy insight – Bioheat, Biopower, Biofuel, *http://www.aebiom.org/bioenergy-insight-bioheat-biopower-biofuel/*

considered a renewable resource. However, while the carbon stored in the biomass itself may be CO_2 or greenhouse gas neutral, the cropping and harvesting (fertilisers, tractors, pesticide production) and processing to the final fuel may consume an important amount of energy and result in considerable CO_2 releases, as well as N_2O emissions from the field. Therefore, it is imperative to take adequate measures to make sure that biomass, used as a source of energy, is harvested in a sustainable manner and used in the most efficient manner possible, including in systems for both bioheat and bioelectricity.

Biomass is considered as a renewable and carbon-neutral energy source when the territorial approach is used for the CO_2 accounting. If the Life Cycle Analysis (LCA) approach is chosen for the CO_2 emissions inventory, the emission factor for biomass will be higher than zero so that differences between both methodologies in the case of biomass may be very important. Following the criteria established in the 2009/28/EC Directive ([77]) on the "Promotion of the Use of Energy from Renewable Energy Sources," biofuels will be considered as renewable if they fulfil specific sustainability criteria.

Biomass systems are available on the market from 2 kW onwards. During a building refurbishment, fossil fuel boilers (in particular coal) can be replaced by biomass systems. The heat distribution installation and radiators are the ones used with the previous installation. A biomass storage room must be foreseen for the accumulation of pellets or wood chips. The performance of the combustion and the quality of the biomass are critical to avoid the emissions of particles into the atmosphere and the system must be adapted to the type of biomass that is to be used. Related best practices include the use of biomass in boilers for replacing diesel boilers and in CHP based DH/C networks.

9.2.1.2 Heat pumps and geothermal heat pumps in buildings

Heat pumps ([78]) combine high energy conversion with the capability of utilising aerothermal, geothermal or hydrothermal heat at useful temperature levels. Heat that is extracted from the environment by a heat pump (ambient heat) is considered renewable as long as a minimum Seasonal Performance Factor (SPF) for the unit is met ([79]). Heat pumps present a versatile energy technology that can provide both heating and cooling in a great variety of building contexts and applications, which can be combined with smart technologies and storage. Heat pumps can also provide for flexibility in the electricity system and contribute to the management of the variability of heating and cooling demand. For these reason, heat pumps have the potential to become a mainstream technology in the heating and cooling sector, including at the building level.

Heat pumps are composed by two heat exchangers. In winter the heat exchanger located outdoors will absorb heat from the environmental air. The heat is transferred to the indoor exchanger to heat the building. In summer the role of each part is inverted. The outdoor unit must transfer heat in summer and absorb it in winter so that a heat pump's performance is highly influenced by the outdoor temperature. In winter (summer), the heat pump's performance will decrease according lower (higher) temperatures. Since the performance of heat pumps depends on both the indoor and the outdoor temperatures, it is convenient to reduce the difference between them as much as possible to increase performance. Accordingly, in the winter season, an increase of temperature in the heat pump's cold side (outside) will improve the performance of the cycle. The same reasoning can easily be applied to the hot (outside) side in summer.

In addition, a possible solution to increase typical performance values is to use ground water as a source of heat in winter and source of cold in summer. This can be done due to the fact that, at a certain depth, the ground temperature does not suffer significant fluctuations throughout the year. Generally, the coefficient of performance (COP) or

(77) Directive 2009/28/EC Art 17, Sustainability Criteria for Biofuels and Bioliquids *http://data.europa.eu/eli/dir/2009/28/oj*
(78) Further information available at http://www.egec.org and http://*www.groundmed.eu*
(79) Directive 2009/28/EC Annex VII, Accounting of energy from heat pumps *http://data.europa.eu/eli/dir/2009/28/oj*

energy efficiency ratio (EER) values can be improved by 50%. Seasonal Performance Indicators can be improved by 25% ([80]) with respect to an air-water cycle. This leads to the conclusion that the electricity consumption in this case could be 25% lower than the case of an air-water conventional heat pump.

The heat transfer process between the Ground Heat Exchanger (GHE) and surrounding soil is dependent on local conditions such as the local climatic and hydro-geological conditions, the thermal properties of soil, soil temperature distribution, GHE features, depth, diameter and spacing of boreholes, shank spacing, materials and diameter of the pipe, fluid type, temperature, velocity inside the pipe, thermal conductivity of backfill and finally the operation conditions, such as the cooling and heating load and heat pump system control strategy. Geothermal energy systems can be used with forced-air and hydronic heating systems while also designed and installed to provide "passive" heating and/or cooling. Passive heating and/or cooling provide cooling by pumping cool/hot water or antifreeze through the system without using a heat pump to assist the process.

9.2.2 Local electricity production

Local electricity production can be supported by photovoltaic electricity generation, wind power, hydroelectric plants and mini-hydro, as well as the power output of cogeneration. These options are overviewed based on technical aspects to guide policy support and the key measures that are being used to promote these options based on best practices.

9.2.2.1 Photovoltaic electricity generation (PV)

Photovoltaic modules permit the conversion of solar radiation to electricity by using solar cells. The majority of photovoltaic modules are used to generate power connected to an electricity grid while there is also a smaller market for off-grid power, particularly in remote areas and developing countries. The integration of renewable energies in cities, in particular building integrated photovoltaics (BIPV), represents significant opportunities in combination with increased energy efficiency ([81]). The integration of solar modules has been improved by manufacturers. In addition to roofs and bricks, modules are integrated to external building walls, semi-transparent façades, skylights, and shading systems ([82]).

A European solar radiation database was developed using a solar radiation model and climatic data integrated within the Photovoltaic Geographic Information System (PVGIS). PVGIS is a web application for the estimation of the performance of photovoltaic (PV) systems in Europe and Africa, as well as a large part of Asia, which has become widely used by the PV community. The online interface to the PVGIS database lets the user estimate the long-term energy performance of different types of PV systems ([83]). The database, with a resolution of 1 km x 1 km, consists of monthly and yearly averages of global irradiation and related climatic parameters, representing the period 1981–1990. The database has been used to analyse regional and national differences of solar energy resource and to assess the PV potential in the 25 European Union member states and 5 candidate countries. The lifespan of PV modules can reach about 25 years, after which material recovery may be an option to improve security of critical raw materials ([84]).

Table 26 reports the average PV output per country in EU+EEA. The values in the last column are the yearly energy output in kWh per kWp installed. The calculation is an average of the period 2007-2016. South of 60N the calculation was made with modules

(80) Geotrainet Project Webpage, http://www.geotrainet.eu
(81) IRENA (2016). Renewable energy in cities. International Renewable Energy Agency (IRENA). Abu Dhabi, *http://www.irena.org/publications/2016/Oct/Renewable-Energy-in-Cities*
(82) Building integrated photovoltaics. A new design opportunity for architects, *http://www.aie.eu/files/RES%20TF/BIPV_web.pdf*
(83) Huld T., Müller R., Gambardella A., 2012. A new solar radiation database for estimating PV performance in Europe and Africa. Solar Energy, 86, 1803-1815
(84) Latunussa C, Mancini L, Blengini G, Ardente F, Pennington D. (2016). Analysis of material recovery from photovoltaic panels. EUR 27797. Luxembourg (Luxembourg): Publications Office of the European Union; doi:10.2788/786252

inclined 20deg. south-facing, while north of 60N the inclination angle is 40deg. Country averages are made over the whole area of the country.

The calculation of electricity generation potential by contemporary PV technology is a basic step in analysing scenarios for the future energy supply and for a rational implementation of legal and financial frameworks to support the developing industrial production of PV.

Policy measures include municipal financing and ownership of PV pilot plants on public buildings, concession of surface rights and renting of rooftop areas in public buildings, PV installations on the roofs of bus sheds, and the construction of a PV park on municipal property at a former landfill site.

Table 26. Country average yearly energy output in kWh per kWp installed

Country	PV output, kWh/kWp per year	Country	PV output, kWh/kWp per year
Austria	1,008	Latvia	877
Belgium	958	Lithuania	893
Bulgaria	1,229	Luxembourg	971
Croatia	1,197	Malta	1,633
Cyprus	1,690	Netherlands	939
Czech Republic	989	Norway	833
Denmark	911	Poland	959
Estonia	854	Portugal	1,492
Finland	826	Romania	1,150
France	1,142	Slovakia	1,051
Germany	961	Slovenia	1,099
Greece	1,407	Spain	1,479
Hungary	1,150	Sweden	863
Iceland	856	Switzerland	1,015
Ireland	850	United Kingdom	848
Italy	1,305		

Policy measures further include PV installations in public buildings and third-party financing for PV systems in school buildings, public-private partnerships for Photovoltaic Solar Parks, energy supplier obligations for PV systems, the provision of a bonus from local authority for photovoltaic installations on citizen's roof, interest-free loans for associations or schools for PV installations, PV systems that supply electric vehicle charging stations, solar land registry for PV installations, real time electricity generation data on PV systems of the City Council, and supported PV campaigns. The campaign of Hanover, Germany, for 1 million square metres of solar modules by 2020, are given in Box 36.

Box 36. Solar Energy Campaign, Hannover, Germany

The city of Hannover started a solar campaign, which was launched to significantly increase the share of renewable energies in the city. The goal is to install one million square metres of solar modules by 2020. This is quite a challenge because it means increasing the area seventeen fold. A solar atlas was published on the internet. All home owners will be able to look and see whether their homes within the city's boundaries are suitable for a solar system. Investors can also draw on further support offerings free solar checks or the support of a photovoltaic pilot financed by the proKlima fund. The project is co-financed by Intelligent Energy Europe (IEE) in the frame of the Leadership for Energy Action and Planning (LEAP) project.

http://www.eumayors.eu/about/covenant-community/signatories/key-actions.html?scity_id=1610

9.2.2.2 Wind Power

Similar to PV systems, the use of electricity that is generated based on wind power systems displaces the electricity demand that would have otherwise been supplied by the local utility. Since no emissions are associated with the operation of wind turbines, the emission reductions from this mitigation measure are equivalent to the emissions that would have been produced had electricity been supplied by the local utility.

For this reasons, local authorities such as Eskilstuna in Sweden are mobilizing resources to enable the use of a greater share of electricity from wind turbines in the local energy mix (see Box 37). Other policy measures in support of wind power include wind farms with citizen cooperation, promotion of locally owned wind turbines, public procurement of municipal wind turbines, co-ownership of wind-power plants, attraction of companies to generate electricity from wind energy, prioritized case handling and licencing of wind turbines, and land use planning for wind energy among other measures.

Box 37. Municipal Wind Turbines: Eskilstuna, Sweden

The city of Eskilstuna has ordered 4 x 3.3 MW wind turbines, which would be directly owned by the local authority. One more turbine is optional. The turbines were installed in 2015 in Sollefteå in the north of Sweden. The order is the biggest public procurement of wind turbines in Sweden so far. The power production will match the local authority's own electricity consumption and the energy production of the windmills is expected to be around 37,500 MWh per year, which covers about 40% of the local authority's own electricity consumption on an annual basis.

9.2.2.3 Hydroelectric plants and mini-hydro

Hydropower represents an essential example of the energy-water nexus in which the availability of water resources based on rainfall affects the amount of energy production. Different types of hydroelectric plants have different capacities, including run-of-the-river hydro plants that do not require a dam, or if so, only a very small one. While large-scale hydropower technology is one of the most mature renewable energy technologies, research is ongoing to better adapt turbines and facilities to the head flow to optimize the techno-economic performance of small hydropower applications ([85]). Best practices that involve hydropower technologies include those to attract or allocate investment (Box 38).

Box 38. Investments in Local Hydro Power Projects

I) In-Stream Hydro Power Plan: Bremen, Germany

Getting investors interested in the new project to replace the old hydropower facility took years but finally could be achieved. The hydro power plant in Bremen is now Europe's largest in-stream tidal hydro power plant (10 MW) based on water plunges between 2-6 meters. Around 10% of the budget was spent for fish protection measures.

http://www.eumayors.eu/about/covenant-community/signatories/key-actions.html?scity_id=1603

(85) Manzano-Agugliaro, F., Taher, M., Zapata-Sierra, A., Juaidi, A., Montoya, F., (2017). An overview of research and energy evolution for small hydropower in Europe, *Renewable and Sustainable Energy Reviews* 75, pp. 476-489

II) Run-of-River Hydropower Plant: Roman, Romania

The project focused on the achievement of a new capacity for the production of electricity in the city of Roman and surrounding areas, for recovering renewable hydroelectricity by placing a hydropower plant on the Moldova River. Through the plant, Roman City produces its own electrical energy required to public lighting and buildings belonging to the local authority, becoming the first local administration in Romania that owns and produce electrical energy using a hydropower.

http://www.empowering-project.eu/wp-content/uploads/SV%20ROMAN/02_Roman%20SEAP.pdf

9.2.2.4 Bioenergy for electricity generation (biomass, biogas)

Combustion followed by a steam cycle is the main technology for utilizing biomass for electricity generation. Newer technological alternatives include the use of biomass in organic Rankine cycle (ORC) plants and gasification systems. Biomass is used as the main fuel but can also be co-combusted with coal or peat. Biogas from anaerobic digestion is mainly used on-site for co-generation applications while biogas can also be upgraded into biomethane towards injection into the existing natural gas grid.

Best practices for the use of bioenergy for electricity generation include biogas cogeneration based on anaerobic digestion, anaerobic digestion in the public waste recovery and treatment company, biogas cogeneration based on zootechnical wastewater and silage cereals, and biogas driven district heating networks. Other best practices include public-private partnerships between the local authority and waste management utility for anaerobic digestion of biowaste for CHP-based district heating, the recovery of methane gas from landfills to produce electricity based on gas engines, and consortiums for cogeneration plants driven by sustainable certified biomass based on waste produced locally or from local consortium companies.

9.2.3 Local heat/cold production

Local production of heat and/or cold is an important component of enabling local energy demands to be met with sources of energy supply that may involve lower levels of energy quality (exergy) as an alternative to the combustion of fossil fuels. Below, the developments for local thermal energy production are given under the headings of large solar thermal systems, thermal energy storage, and district heating and/or cooling. The advantages of district energy networks in smart energy systems are also underlined.

9.2.3.1 Large solar thermal systems

Large solar thermal systems have experienced a strong growth over recent years. Large scale solar thermal process can heat applications for industrial and agricultural processes. Solar district heating systems with and without large seasonal heat storages are relevant for district energy systems. For example, the Marstal District Heating in Aeroe, Denmark provides a large scale solar thermal solution for district heating systems.

Large solar heating systems can also be integrated into an existing district heating system in which heat is supplied by a cogeneration plant ([86]). Collective systems that are used in multi-family homes, hospitals, hotels and retirement homes are other options ([87]). Such installations can be well-suited for ESCO schemes due to the positive effect of profitability and the effect of economies of scale ([88]).

(86) Winterscheid, C., Dalenback, J., Holler, S. (2017). Integration of solar thermal systems in existing district heating systems, *Energy* 137, pp.579-585
(87) SOLARGE Project Good Practice Database (Enlarging Solar Thermal Systems in Multi-Family-Houses, Hotels, Public and Social Buildings in Europe), *http://www.solarge.org/index.php?id=2*
(88) Large scale solar thermal systems in ESCo models, *http://www.buildup.eu/en/learn/tools/large-scale-solar-thermal-systems-esco-models-energy-service-companies*

9.2.3.2 Thermal energy storage (TES)

Thermal energy storage (TES) addresses the key bottleneck against the widespread and integrated use of renewable energy sources, since the renewable supply does not always coincide with demand for heating or cooling. Numerous technologies in sensible, latent or thermochemical form can time shift renewable energy supply to periods of greatest demand, each of them characterised by different specifications and specific advantages.

9.2.3.3 District Heating and Cooling (DHC)

District heating ([89]) and/or cooling ([90]) (DH/C) consists of using a centralised plant to provide thermal energy for external customers. The energy input may be supplied by fossil fuels or a biomass boiler, solar thermal collectors, a heat pump, cooling systems (thermally driven or compression chillers) or from a CHP plant. A combination of the mentioned technologies is also possible and may even be advisable depending on the technologies, the fuel used and other technical issues. The characteristics of the market and demand in the heating and cooling sectors place DH/C as a viable technological option ([91]).

District energy infrastructure that is based on cogeneration enables the integration of the power and thermal energy sectors so that energy can be supplied to urban energy systems more efficiently. The multiple benefits of district energy systems involve up to a 50% lower primary energy usage, related reductions in greenhouse gas emissions, and increased opportunities to integrate renewable energy sources into the heating and cooling sector ([92]). Urban energy infrastructure that benefits from the use of district energy systems can simultaneously contribute to reducing energy imports and provide a means to make use of residual heat sources and/or sources of free cooling, such as those provided by seawater, river, lake or aquifer water using a heat exchanger. The district heating and cooling capacity in 45 cities that are identified as champions in this field has exceeded over 36 GW and 6 GW, respectively, with about 12,000 km of district energy networks ([93]). In addition, district energy infrastructure can provide an opportunity for demand response and balancing in the power system when there is excess variable electricity production from renewable energy sources. For example, electricity generation from wind or solar energy can be used in large-scale heat pumps in support of the district energy infrastructure or even power-to-gas options in times of oversupply ([94]).

Energy efficiency benefits and advantages of DH/C are based on high SPF (Seasonal Performance Factor) due to an intensive operation of the installation, introduction of highly efficient equipment, proper insulation of the distribution network, and on efficient operation and maintenance. For example, the seasonal performance that is defined as the total amount of supplied heat over the total primary energy consumption can be improved from 0.62 for individual heat pumps to 0.85 for district heating heat pumps. Absorption chiller seasonal performance can be improved from 0.54 for an individual absorption chiller and boiler to 0.61 for the same type of installation in a district heating network ([95]). Since each installation operates under different conditions, detailed engineering studies are necessary to evaluate the percentage of distribution losses in the network and overall efficiency. In addition, the use of environmentally-friendly energy resources, such as biomass or solar energy, will determine any CO_2 emission reductions.

(89) SOLARGE project database contain good examples of large solar district heating. Most of them are located in Denmark and Sweden. *http://www.solarge.org/index.php?id=2*
(90) ECOHEATCOOL project *www.euroheat.org*. Supported by Intelligent Energy Europe / Danish Board for District Heating *www.dbdh.dk*
(91) ECOHEATCOOL: European Heating and Cooling Market Study, *https://www.euroheat.org/our-projects/ecoheatcool-european-heating-cooling-market-study/*
(92) UNEP (2015) District Energy in Cities - Unlocking the Potential of Energy Efficiency and Renewable Energy, *http://staging.unep.org/energy/portals/50177/DE_Executive%20Summary_lowres_double.pdf*
(93) Ibid.
(94) Ibid.
(95) Y. Shimoda et al. (2008). Verification of energy efficiency of district heating and cooling system by simulation considering design and operation parameters, *Building and Environment* 43, pp.569-577

District energy networks thus enable a powerful solution for cities by enabling the connection of multiple thermal energy users through a piping network to environmentally optimum energy sources, such as CHP, industrial waste heat, and renewable energy sources (RES) ([96]). The energy and exergy savings benefit of such options in comparison to alternative heating technologies depends on the annual energy request, the population density, and the efficiency of heat production ([97]). Since district energy networks can better exploit existing local energy sources, such as surplus heat from electricity production and industry, the need for new thermal (condensing) capacities are effectively reduced. Similarly, District Heating (DH) can offer synergies between energy efficiency, renewable and CO_2 mitigation by serving as hubs to utilize residual heat that otherwise would be wasted. DH can provide significant contributions to the reduction of both CO_2 emissions and particulate matter leading to air pollution while increasing energy security.

The decarbonisation of DH/C networks requires the integration of much higher shares of RES and waste heat, the reduction of the end-user connection costs and the development of low-temperature heating networks. For example, cases that involve renewable energy options can be found to provide significant cost advantages among cases for district heating systems ([98]). In Sweden, the current focus for district heating systems is given to be renewable heat, heat recycling and their combination ([99]). Synergies between waste-to-energy processes and district heating/cooling could also provide a secure, renewable, and in some cases, more affordable energy in displacing fossil fuels. DH/C networks can offer flexibility to the energy system by cheaply enabling the storage of thermal energy.

District Cooling (DC) can make usage of alternatives to conventional electricity cooling from a compression chiller. The resources can be natural cooling from deep sea, lakes, rivers or aquifers, conversion of surplus heat from industry, CHP, waste incineration with absorption chillers or residual cooling from re-gasification of LNG. District cooling systems can greatly contribute to avoiding electricity peak loads during summer. Table **27** compares different DC components based on the supply and distribution structure.

Table 27. Components in different district cooling systems ([100])

Type of District Cooling (DC)	Components in Each Type of District Cooling Design				
	Supply	Distribution	Extra Steps in the Hybrid System		Units in the Building
Conventional DC	Large-scale heat pumps/chillers	Cold pipes	-	-	Substations for cold
Natural Cooling	Natural cooling, usually from the sea or a river	Cold pipes	-	-	Substations for cold
Hybrid Cooling	Heat	Heat pipes	Central absorption heat pumps	Cold pipes	Substations for cold
Sorption Cooling (SCH)	Heat	Heat pipes	-	-	Individual sorption heat pumps

(96) IEA (2008) IEA Implementing Agreement on District Heating and Cooling, Including the Combined Heat and Power ANNEX VIII
(97) Verda, V., Guelpa, E., Kona, A., Lo Russo, S., (2012). Reduction of primary energy needs in urban areas trough optimal planning of district heating and heat pump installations, *Energy* 48 (1), pp. 40-46.
(98) Mikulandrić, R., Krajačić, G., Duić, N., Khavin, G., Lund, H., Vad Mathiesen, B. and Østergaard, P., 2015. Performance analysis of a Hybrid District Heating System: A Case Study of a Small Town in Croatia, *Journal of Sustainable Development of Energy, Water and Environment Systems*, Vol. 3, No. 3, pp 282-302
(99) Werner S. (2017). District heating and cooling in Sweden, Energy 126 pp. 419-429
(100) AREA, 2014. Guidelines How to approach District Cooling http://area-eur.be/sites/default/files/2016-05/Guidelines%20District%20Cooling%20140131.pdf

Large-scale district cooling systems can radically reduce the specific capacity costs (€/kW) that have to be invested when compared to individual systems per household. The investment reduction is due to the avoidance of redundant investments and variances in customer's peak load across time (simultaneity factor). Cities with district cooling are estimated to have a 40% reduction in total installed cooling capacity ([101]).

Best practices from the signatories include contract to connect municipal buildings and schools to the DH network, integrated heating systems between public buildings, initiative to increase the purchased volume of energy from the DH network, including subsidies and/or obligations for connection to DH networks, modernization and rehabilitation of DH/C networks, remote monitoring of pipelines and insulation to reduce heat losses, and installation of thermal energy distributors and thermostatic radiator valves in the DH network. The connection of low energy houses to a low-temperature DH network in Västerås, Sweden is also a promising solution.

The following box provides the best practices of Helsinki in realizing an integrated district heating and cooling system to achieve its climate obligations.

Box 39. Integrated District Heating and Cooling, Helsinki, Finland

In a country where temperatures are below 10°C for half of the year, heating buildings is a crucial basic utility. As a result, Finland has been leading in cogeneration of heat and power (also known as combined heat and power - CHP) since a long time. In Helsinki, some 93% of the buildings are connected to district heating. What may be more surprising is that the local authority has also been seriously investing in cooling solutions for its districts since a few years' time. District cooling is now a clearly growing business in Helsinki, already covering a volume of buildings of 11.5 million m^3.

Ten years ago, the local authority started a pioneering project called "Helen-IT", which aims at cooling data centres and recovering the heat produced in this process by piping it into the district heating network, to heat buildings and provide them with hot water. This way the heat produced by the computer hall is recycled and not wasted warming up the air outside.

When the operation started, it was based on the estimation that cooling demand would grow rapidly in Helsinki despite the northern climate. The objective was to provide reliable, economical and eco-efficient cooling solutions for all types of property owners. In 2010, some 250 large buildings in the city centre were using the system, most of them being private companies.

In 2015 district cooling in Helsinki is estimated to save about 60,000 tonnes of CO_2 emissions. But the advantages of "Helen-IT" are not limited to the energy savings. The solution is also totally silent and unobtrusive, as the district cooling equipment installed in the clients' premises takes up much less space than traditional cooling devices. If all the computer halls in Finland operated on this principle, up to 500 MWh of energy could be saved every day. At the same time, a medium-sized city's worth of buildings could be heated.

Currently there are three district cooling production methods in Helsinki, each of them adapted to the season of the year:

The absorption technique is used in the summer time when the sea water is too warm for free cooling. District cooling is produced by using thermal energy that would otherwise be lost in energy generation.

The heat pump system is used to recover thermal energy obtained from district cooling. The heat is transferred to the district heating network for heating buildings and domestic hot water.

The free cooling method produces district cooling from cold sea water between November and May, when the water temperature is below 8°C.

Pajunen, J., Integrated district heating and cooling helps Helsinki to achieve its climate obligations,

http://www.covenantofmayors.eu/IMG/pdf/Helsinki_Case_Study_Covenant_Mayors_1_.pdf

(101) Possibilities with More District Cooling in Europe, ECOHEATCOOL Work Package 5, *https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/ecoheatcool_more_district_cooling_in_europe.pdf*

Among other best practices, Box 40 provides the example of the district of Kirchhellen in the city of Bottrop, Germany that achieved energy self-sufficiency based on a mix of renewable energy solutions, including wind, photovoltaics, biogas, and geothermal energy, and a district heating network. Other best practices include cooperation with the local energy utility to establish a district energy network, the connection of buildings and industries to the DC network, utilization of residual heat from urban wastewater, interconnection of district heating networks and extension of distribution piping, as well as an emphasis in urban energy planning to increase the connection of buildings to the district heating network in Kristianstad, Sweden. The utilization of industrial waste heat among the signatories includes those from the local steel industry (Finspång, Sweden) and the substitution of the use of natural gas through the use of waste heat from a pulp mill (Judenburg, Austria). Targets to increase RES shares in district networks are put forth, including in Ringsted, Denmark.

Box 40. Energy Self-Sufficiency, Bottrop, Germany

Kirchhellen is the first district of the city of Bottrop with the aim of energetic self-sufficiency.

In 2009, only 4 % of the city's renewable energy consumption was produced in the district of Kirchhellen. Today, Kirchhellen produces as much energy as consumed by its' households - all from renewable sources, such as wind power, photovoltaics, biogas, and geothermal energy. To reach this aim, the local authority was able to build upon already existing structures of renewable energy production as well as on their established governance structures. Three additional wind power plants as well as the installation of a district heating network based on renewables contribute to the aim of self-sufficiency.

Furthermore, the integration of a large-scale geothermal project in domestic construction as well as plans for a zero-emission industrial area complements the integrated approach. In addition, the project "Heat Production from Effluents" contains the creation of an energy map to analyse the heat potential in effluents as well as possible heat recipients. Through the additional analysis of determining factors, such as yearly effluent temperature, or dry weather discharge, three pilot projects have been identified:

a) Heat from sewage system,

b) Heat from purification plant,

c) Direct usage of effluent heat.

Pilot project a) has been implemented in cooperation with the Hochschule Ruhr West which is using heat from effluents from a nearby sewer for their new building, the Energy Campus Lab. The usage of thermal energy from heat effluents contributes to the aim of the Hochschule to avoid emissions in the operation of the building.

http://www.eumayors.eu/about/covenant-community/signatories/key-actions.html?scity_id=4407

Box 41 involves the best practice of the District Heating Manual of London, which emphasizes the direction of the industry towards "fourth generation" district heating networks that is initiating to be applied in districts. In comparison to previous generations, developments towards "fourth generation" district heating networks (4GDH) addresses the integration of sectors in the energy system based on smart electricity, thermal and gas grids ([102]).

In smart energy systems, smart electricity grids involve generators, consumers, and those that function in both domains as prosumers to provide a sustainable, economic, and secure supply of electricity. Smart thermal grids act as an interface between centralized as well as decentralized production units and all connected facilities to satisfy heating and/or cooling demands. This includes low-temperature district heating networks that have low supply temperatures. The operation of the distribution network at lower supply temperatures reduces transfer losses and improves grid efficiency.

(102) Lund H., Werner S., Wiltshire R., Svendsen S., Thorsen J.E., Hvelplund F., Mathiesen B. V., (2014). 4th Generation District Heating (4GDH) Integrating smart thermal grids into future sustainable energy systems, *Energy* 68, 1-11

Box 41. District Heating Manual for London, United Kingdom

London has prepared a District Heating Manual to support the urban planning process to expand and modernize the district heating network. The main steps are put forth as:

- Mapping energy demands in the area, considering ownership and control of these demands;

- Mapping energy supplies in the area, including local heat and fuel sources;

- Mapping existing and planned district heating schemes;

- Mapping new development in the area;

- Identifying suitable locations for energy centre (s);

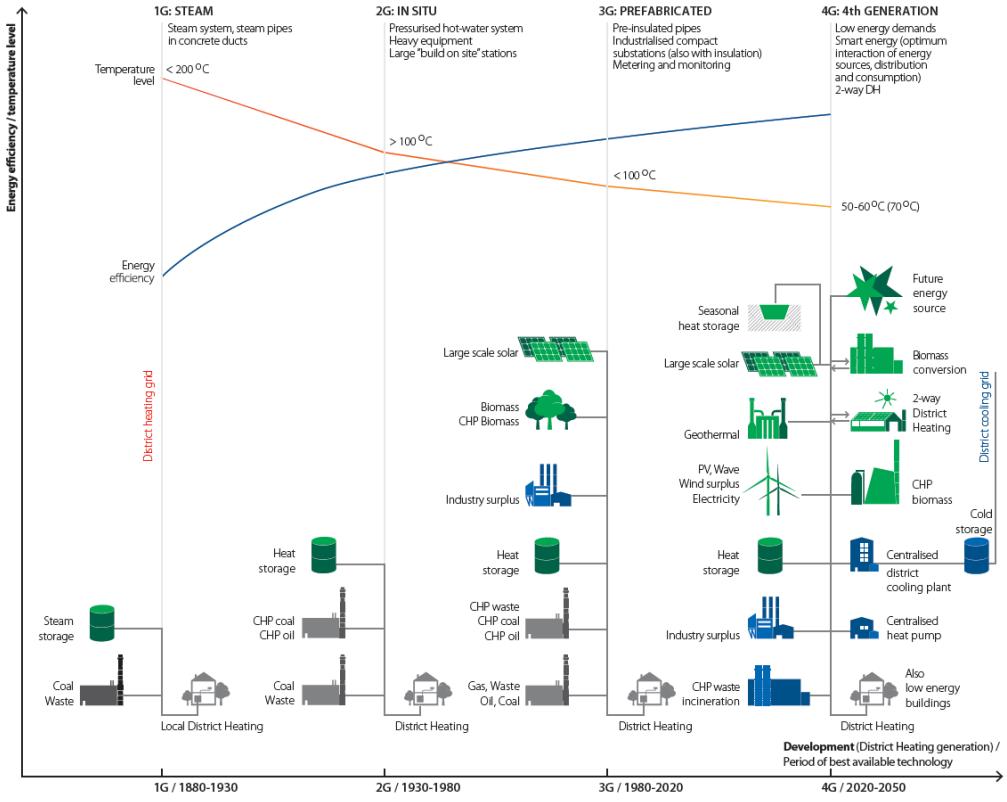
- Identifying routes for potential district heating networks.

In the same Manual, the direction of the industry towards "fourth generation" district heating networks (4GDH) is acknowledged.

Greater London Authority, (2013). District Heating Manual for London

Figure 2 compares the four generation of district heating developments based on energy supply, energy efficiency, and temperature level.

Figure 2. District heating generations by supply, efficiency, and temperature level



Source: Lund, H., Werner, S., Wiltshire, R., Svendsen, S., Thorsen, J. E., Hvelplund, F., Mathiesen, B.V.(102)

In addition, two-way district heating involves the possibility that residual sources of heat can be shared in the network, including residual heat from data centres ([103]). Smart gas grids address the need for gas supplies and storage, which also have an important role in

(103) Two-way district heating creates a heat trading market for the customer https://www.euroheat.org/news/two-way-district-heating-creates-heat-trading-market-customer/

contributing to the above grids and vice versa ([104]). **Table 28** summarizes the progression of heat production and integration with the electricity supply towards 4GDH networks.

In such a cross-sectoral approach, there remains an important role for energy savings so that the increased penetration of variable renewable energy technologies is integrated in an optimal way. For this reason, the promotion, planning, cost, and operation of smart energy systems must be supported by a sufficient institutional framework, including analytical tools based on geographical information systems (GIS) and tariff policy ([102]).

Table 28. Generations of Production and System Integration in District Heating Networks

Generations	**1st Generation**	**2nd Generation**	**3rd Generation**	**4th Generation**
Label	Steam	In situ	Prefabricated	4GDH
Period of best available technology	1880-1930	1930-1980	1980-2020	2020-2050
Heat production	Coal steam boilers and some CHP plants	Coal and oil based CHP and some heat-only boilers	Large-scale CHP, distributed CHP, biomass and waste, or fossil fuel boilers	Low-temperature heat recycling and renewable sources
Integration with electricity supply	CHP as heat source	CHP as heat source	CHP as heat source, and some large electric boilers and heat pumps in countries with temporary electricity surpluses. Some very few CHP plants on spot market as exception	CHP systems integrated with heat pumps and operated on regulating and reserve power markets as well as spot markets

Source: Lund, H., Werner, S., Wiltshire, R., Svendsen, S., Thorsen, J. E., Hvelplund, F., Mathiesen, B.V.([102])

Different energy sources that are involved in various generations of DH networks, including those in 4GDH, can have different advantages and disadvantages. For this reason, it is important that the design of such systems take into account aspects of availability and possible environmental impacts as summarized in the table below. **Table 29** compares the advantages and disadvantages of various energy sources.

(104) Mathiesen B.V., Lund H., Connolly D., Wenzel H., Østergaard P.A., Möller B., Nielsen S., Ridjan I., Karnøe P., Sperling K., Hvelplund F.K., (2015). Smart Energy Systems for coherent 100% renewable energy and transport solutions, Applied Energy 145, 139–154

Table 29. Comparison of the advantages and disadvantages of energy sources

Source	Description	Advantages	Disadvantages
Geothermal or ground source heat pumps ([105])	Built in locations above large geothermal sources, typically those with naturally occurring hot springs, geysers or aquifers	Provides year around low cost heating and cooling using district energy technology	Geologically limited and usually only efficient in moderate temperature zones
Biomass ([106])	Often using wood or energy crop based material to provide heat	Renewable resource that has strong advantages in a sustainable energy future	Low availability in many places in Europe
Waste Incineration ([107])	Combustion of urban waste to provide heating to nearby buildings	Utilization of heat generated from burning waste	Potential health effects from emissions when improperly managed
Waste heat ([108])	Industrial and commercial process waste heat is used	Provides excess heat to nearby buildings and is able to offset some of the normal district heating fuel costs	Usually cannot provide sole source heating, but can be coupled with an existing DH system
Fossil fuels ([109])	Burning of coal, oil and natural gas to provide heat	Processes and infrastructure often already in place, reducing fuel transport costs	Large source of greenhouse gas emissions, non-renewable energy source
Solar thermal ([110])	Using sunlight and solar collectors to provide high temperature water for heating and cooling purposes	Passive and active systems with the option to also provide cooling during warmer seasons using absorption chillers.	Geographic assessments as well as proper planning are necessary; variations in peak demand may significantly influence performance

Source: Lake A., Rezaie B., Beyerlein S. ([111])

A systematic approach for synthesizing options for more sustainable heating and cooling supply has been put forth by the EU-funded Stratego Enhanced Heating & Cooling Plans

(105) Thorsteinsson H.H., Tester J.W., (2010). Barriers and enablers to geothermal district heating system development in the United States. *Energy Policy* 38 (2), 803-13
(106) Ericsson K., Nilsson L. J., (2006). Assessment of the potential biomass supply in Europe using a resource-focused approach. *Biomass Bioenergy* 30(1), 1-15
(107) Cordioli M., Vincenzi S., De Leo G., (2013). Effects of heat recovery for district heating on waste incineration health impact: a simulation study in Northern Italy. *Science of the Total Environ* 444, 369-80
(108) Ivner J., Broberg Viklund S., (2015). Effect of the use of industrial excess heat in district heating on greenhouse gas emissions: a systems perspective. *Resource Conservation and Recycling* 100, 81-7
(109) Su D., Zhang Q., Wang G., Li H., (2015). Market analysis of natural gas for district heating in China. *Energy Procedia* 75, 2713-7
(110) Urbaneck T., Oppelt T., Platzer B., Frey H., Uhlig U., Göschel T., Zimmermann D., Rabe D., (2015). Solar district heating in East Germany – transformation in a cogeneration dominated city. *Energy Procedia* 70, 587-94
(111) Lake A., Rezaie B., Beyerlein S., (2017). Review of district heating and cooling systems for a sustainable future, *Renewable and Sustainable Energy Reviews* 67, 417-425

project ([112]). The approach involves five steps that are oriented to guiding local authorities in overcoming challenges in drafting heating/cooling plans based on local opportunities and assessments involving stakeholder engagement as summarized in **Table 30 and Table 31**.

Table 30. Five step approach to support local authorities to draft heating/cooling plans

Steps	**Challenges**	**Lessons Learned**
Mapping local heating and cooling demand supply - Mapping the heating and cooling infrastructure - Mapping the energy saving potential - Mapping the excess heat potential - Mapping the renewable heat potential	Mapping of cooling demand, energy saving potential and diffuse renewable heat sources	Simple maps already can provide inspiration for projects
Identification of areas of priority for intervention - Adding heat savings - Comparing heat network solutions - Comparing individual heating solutions - Integrating more excess and renewable heat - Integrating more renewable electricity in the heating sector - Heat roadmap	Assessment of costs and benefits	The list of categories gives good guidance to define projects
Business models for local partners	Developing business models to the level of investment grade plans	Business models put the end-consumer at the heart of the projects
Involvement of local stakeholders	Involvement of a wider range of stakeholders	An early involvement of a wider range of stakeholders smoothens the path for the implementation of the projects
Input to local heating / cooling action plans	Reaching the level of a strategic heating / cooling action plan	A strategic master plan at local level puts single projects into a wider context

Source: Based on Stratego Enhanced Heating & Cooling Plans ([112])

(112) Stratego Enhanced Heating & Cooling Plans (2016). Insights from drafting local heating cooling action plans. Summary Report on WP 3: National plan - local action: supporting local authorities, p. 5

Table 31. Consideration for the identification of areas of priority for intervention

Projects to consider	Areas of priority to look for
Reduce heating and cooling demand at end-consumers	• Areas with a higher specific heat or cooling demand than average • Areas with buildings with a poor energy label • Areas suffering from energy poverty

Improve and expand existing heating and cooling networks or build new ones in areas with a substantial heating and cooling density	• Areas where there is currently a district heating or cooling grid (DH/C grid)
	• Areas currently without a heating or cooling grid but close to an existing DHC grid and with a high enough heat or cooling density or with a cluster of large heat or cooling customers
	• Areas with a high enough heat density:
	  ○ DH grid high feasible: > 300 TJ/km²
	  ○ Current DH grid feasible: 100-300 TJ/km²
	  ○ 4th gen. DH grid feasible: 30 – 100 TJ/km²
	• Clusters of large heat consumers
	• Clusters of large cooling consumers

Look for more sustainable individual heating and cooling solutions in areas with a limited heating and cooling density	• Areas where roofs are suited to install solar water boilers • Areas where there is enough free land around the building to install heat pumps • Areas with a supply of biomass sources
Tap excess heat from thermal power stations, waste-to-energy installation, energy-intensive industry, etc.	Installations that can supply excess heat and that are nearby potential heating (eventually cooling) consumers
Tap renewable heating and cooling sources (geothermal, bio-energy, solar thermal)	• Areas where large solar hot water boilers can be installed • Areas where large heat pumps can be installed • Areas with favorable geologic conditions to install (deep) geothermal wells • Related to the previous point: water purification stations or large sewers nearby potential heating (eventually cooling) consumers from which heat can be extracted • Areas with a supply of biomass resources

Improving conversion of fossil fuels to heat or cooling	• Areas with a gas grid or where a gas grid can be expanded and where existing, currently less efficient, boilers can be replaced by
	  ○ Cogeneration units
	  ○ Condensing boilers

Source: Stratego Enhanced Heating & Cooling Plans ([113])

Exergy principles can also guide local authorities in structuring an optimized energy supply structure ([114]). Exergy is the part of an energy flow that can be transformed into

(113) Stratego Enhanced Heating & Cooling Plans (2016). Insights from drafting local heating cooling action plans. Summary Report on WP 3: National plan - local action: supporting local authorities, p. 41-42
(114) IEA EBC Annex 64 LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles https://www.annex64.org/

any other form of useful energy ([115]) and is a measure of the potential of a given amount of energy to perform useful work. Different energy supply systems can be considered to satisfy energy demands in more efficient ways based on the exergy levels on the supply and demand sides. There are multiple opportunities to satisfy low-exergy demands for space heating and cooling as well as domestic hot water with energy resources other than those that represent high exergy resources capable of being combusted and producing electricity. Even in the case of renewable energy, an exergy based approach can promote a more efficient energy supply structure since renewable energy sources also need to be allocated to matching exergy demands whenever possible. **Table 32** provides practical advice through a comparison of technological options that represent a mismatch between a high exergy resource and a low-exergy demand (left column) and a technological option that represents a better exergy match (right column). At the local level, the Canton of Geneva has required the application of an exergy concept from buildings and city projects, particularly to increase heating and cooling efficiencies based on various technological options ([116]). The use of exergy principles can also be applied to direct districts towards net-zero targets ([117]).

Table 32. Comparison of Options with and without Exergy Matches

Options without exergy matches (mismatch)	**Options with better exergy matches**
Electric heaters, natural gas boilers or combustion of renewable energy resources (biomass) to satisfy space heating demands in buildings	Utilization of high energy resources in CHP-based district heating networks – Including biomass/biogas Utilization of lower exergy resources in district heating/cooling networks – Solar energy – Geothermal energy – Seawater heat pumps – Residual heat: Industrial processes; Wastewater; Data centers Use of solar collectors and/or PV-thermal panels in buildings

9.2.4 CHP – Combined heat and power generation

A cogeneration or CHP plant is an energy production installation that simultaneously generates thermal energy and electrical and/or mechanical energy from a single input of fuel ([118]). Combined heat and power generation represents about 11.22% of the gross electricity generation in member states ([119]). The necessity to "substantially increase the uptake of high efficiency cogeneration, district heating and cooling" to reinforce an efficient energy supply has an immediate impact for urban energy systems ([120]).

(115) Torío, H. Schmidt, D. (2011). Low Exergy Systems for High-Performance Buildings and Communities IEA ECBCS Annex 49 Final Report, https://www.annex49.info/download/Annex49_guidebook.pdf
(116) Favrat, D., Marechal, F., Epelly, O., (2008). The challenge of introducing an exergy indicator in a local law on energy, *Energy*, 33, pp.130-136
(117) Kılkış, Ş., (2014). Energy System analysis of a Pilot Net-zero Exergy District, *Energy Conversion and Management* 87, pp 1077-1092
(118) Directive 2004/8/EC of the European Parliament and of The Council of 11 February 2004 on the Promotion of Cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC, http://data.europa.eu/eli/dir/2004/8/oj
(119) Eurostat, Combined heat and power generation
http://ec.europa.eu/eurostat/web/products-datasets/-/tsdcc350
(120) Communication from the Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions, Energy 2020 A strategy for competitive, sustainable and secure energy, COM(2010) 639 final

Signatories have implemented measures towards high-efficiency cogeneration power plants in close collaboration with local utilities for sustainable energy systems ([121]).

CHP plants are usually very close to the electricity consumer, thereby avoiding network losses during transmission and distribution to the end-users. CHP plants can be part of distributed generation schemes in which several smaller CHP plants produce energy being consumed nearby. Cogenerated heat may also be used to produce cold through absorption refrigeration chillers. Other types of thermally driven chillers are commercially available although their market presence is more limited than that of absorption chillers.

Plants that simultaneously produce electricity, heat and cooling are known as trigeneration ([122]) plants. A part of the trigeneration units offer significant relief to electricity networks during the hot summer months. Cooling loads are transferred from electricity to gas networks. This increases the stability of the electricity networks, especially in Southern European countries that undergo significant peaks in summer ([123]).

CHP leads to a reduction of fuel consumption at least 10 % when compared to conventional electricity and separate heat production ([124]). The reduction of atmospheric pollution follows the same proportion. The power range and efficiencies of CHP technologies are summarized in **Table 33.** CHP may be based on gas turbines, reciprocating engines, Stirling engines, or fuel cells. The electricity produced in the process is consumed by the users of the grid and the useful thermal energy may be used in industrial processes, space heating or in a chiller for the production of cold water.

Table 33. Power Range and Efficiencies of Cogeneration Technologies

Technology	Power range	Electric Efficiency	Global efficiency
Gas turbine with heat recovery	500 kWe - >100 MWe	32 – 45%	65 – 90%
Reciprocating engine	20 kWe -15 MWe	32 – 45%	65 – 90%
Micro gas turbines	30 - 250 kWe	25 – 32%	75 – 85%
Stirling engines	1 - 100 kWe	12 – 20%	60 – 80%
Fuel cells	1 kWe - 1 MWe	30 – 65%	80 – 90%

Source: COGEN Challenge Project([125])

Small-scale heat and power installations can play an important role in the energy efficiency improvement in public, residential and commercial buildings, including hotels, swimming pools, hospitals and multi residential dwellings. As compact systems, they are convenient to install. The dimensioning of the micro-cogeneration installation will depend on the heat loads. Combined electrical and thermal efficiency varies between 80% and well above 90%. Similar to electrical efficiency, unit capital costs per kW_{el} depend on the electrical capacity of the system. A significant decline of capital costs due to scale effects are observed particularly as systems reach the 10 kW_{el} range ([126]). CO_2 emissions of natural gas driven micro-cogeneration systems are in the range 300-400 g/kWh.

(121) Kona et al. Covenant of Mayors in Figures: 8-year Assessment
(122) POLYSMART - Polygeneration with advanced small and medium scale thermally driven air-conditioning and refrigeration technology, http://www.cordis.europa.eu/project/rcn/85634_en.html
(123) CAMELIA - Concerted Action Multigeneration Energy systems with Locally Integrated Applications, http://cordis.europa.eu/project/rcn/87901_en.html
(124) Methodology for Determining the Efficiency of Cogeneration Process (Annex II). Directive 2012/27/EU of the European Parliament and of the Council, http://data.europa.eu/eli/dir/2012/27/oj
(125) http://www.cogeneurope.eu/challenge/
(126) Pehnt, M., Cames, M., Fischer, C., Praetorius, B., Schneider, L., Schumacher, K., Voss, J., (2006). Micro cogeneration: towards decentralized energy systems. Springer-Verlag Berlin Heidelberg

Box 42. Cogeneration Plant and Roof-Top PV, Fürstenfeldbruck, Germany

In 2014, the public utility company of Fürstenfeldbruck, Germany (Stadtwerke Fürstenfeldbruck GmbH) added a new cogeneration plant at "Energiezentale West". Correspondingly, they extended their district heating infrastructure. The plant not only supplies households with almost CO_2-free heat, but also provides district heating and cooling to several large companies. The roof of the plant is home to photovoltaic collectors.

www.energieatlas.bayern.de

9.2.5 Waste and water management

Local waste management strategies are particularly crucial for enabling the minimization of the amount of waste generated through waste prevention, the diversion of waste from landfills through recycling, reuse, and composting, and the utilization of environmentally-conscience waste-to-energy options ([127]). Water management also has a direct impact on energy usage at the local level through the electricity that is used for the preparation of tap water and its pumping through pressurized water distribution systems to reach end-users. Minimizing water leakages in the water distribution system and reducing water usage through conservation can thus reduce the level of energy usage for water services. In addition, the selection of water supply reservoirs in proximity to the city, which can reduce extraction and transport costs, can be directly affected by the effectiveness of water management practices at the local level. Especially in cases where desalination may be required for water supply, including those in islands, the integration of renewable energy sources can support the energy loads of the energy intensive infrastructure ([128]).

In the aspect of wastewater treatment, opportunities for local energy generation involve the combustion of digester gas or its use for cogeneration as well as the extraction of residual heat from wastewater based on heat exchangers and heat pumps. The integration of renewable energy, such as solar and geothermal energy to assist in covering the energy requirements of the wastewater treatment plant, is another option. Cases in which wastewater treatment plants (WWTPs) have reached energy self-sufficiency based on the utilization of such options take place among the best practices. At the same time, the heat generation potential in WWTPs often exceeds the amount that is required on-site, which provides opportunities to satisfy other local heat demands in the vicinity, including those of buildings and industries ([129]). In the context of the energy system as a whole, WWTPs can offer opportunities for demand response, particularly in the sludge processing equipment, thereby assisting in any power load levelling ([130]).

9.2.5.1 Utilization of biogas resources at the local level

Biogas is a naturally occurring by-product of the decomposition of organic waste in sanitary landfills or from sewage and residual waters. It is produced during the degradation of the organic portion of waste. Biogas essentially contains methane (CH_4), which is a highly combustible gas. Therefore, biogas is a valuable energy resource that has wide range of uses for biogas for heating, electricity, and transport fuel ([131]). Biogas can be used as in a gas turbine or a reciprocating engine, as a supplementary or primary fuel to increase the production of electric power, as a pipeline quality gas and vehicle fuel, or even as a supply of heat and CO_2 for nearby greenhouses and various industrial processes. Biogas is mostly produced based on sewage sludge while production from

(127) Waste Framework Directive 2008/98/EC, *http://ec.europa.eu/environment/waste/framework/*
(128) Duić, N., Krajačić, G., Graça Carvalho, M., (2008). RenewIslands methodology for sustainable energy and resource planning for islands, *Renewable and Sustainable Energy Reviews* 12(4), pp. 1032-1062
(129) Kollmann, R., Neugebauer, G., Kretschmer, F., Truger, B., Kindermann, H., Stoeglehner, G., Ertl, T., Narodoslawsky, M., (2017). Renewable energy from wastewater - Practical aspects of integrating a wastewater treatment plant into local energy supply concepts, *Journal of Cleaner Production* 155 (1), pp. 119-129
(130) Aghajanzadeh, A., Wray, C. and McKane, A., (2015). Opportunities for Automated Demand Response in California Wastewater Treatment Facilities, Berkeley National Laboratory, Berkeley, California, USA
(131) Achinas, S., Achinas, V., Euverink, G., (2017). A Technological Overview of Biogas Production from Biowaste, *Engineering* 3 (3), pp. 299-307

landfill, food-processing residues and wet manure are expected to increase ([132]). In contrast, methane is a greenhouse gas (GHG) with a global warming potential (GWP) that is 21 times higher than CO_2. The use of methane content that would otherwise be released without being utilized as an energy source is a valid climate mitigation option.

Local policies can promote low-carbon waste practices and the recovery of its energy content when appropriate either as biogas or incineration. Through municipal initiatives or private–public partnerships, waste-to-energy can be promoted as a potential source for heat and electricity, including possible interventions is wastewater treatment plants (Box 43). The use of biogas as an energy source has a role in upholding circular economy principles in which outputs are streamlined to provide inputs for other systems ([133]).

Box 43. Biogas Options from Waste and Wastewater

- Organic waste streams used in bioenergy gasification or composted

- Landfill gas capture

- Upgrading of biogas to biomethane for distribution via the exiting natural gas grids

- Methane recovery from the wastewater for reuse

- Integration of low enthalpy geothermal sources for the digestion of the sewage sludge in the wastewater systems in the process of producing biogas.

Best practices in the signatories involve separate waste collection to increase the recycling of municipal solid waste and the use of organic waste for biogas production, the use of green waste for the production of compost and pellets, and a self-sufficient wastewater facility based on a biogas driven CHP plant in Neumarkt in der Oberpfalz, Denmark. Detailed best practices involving a biomethane chain to obtain bioelectricity, bioheat and biofuel in Wielopole, Poland are given in Box 44 and summarized in Figure 3.

Box 44. Bioelectricity, Bioheat and Biofuel Opportunities: Wielopole, Poland

The BIOMASTER project has helped Biogazownie Małopolskie in Wielopole, Poland to generate heat and power from manure and agricultural waste, attracting investors for its long term bioenergy ambitions. Bioelectricity has been sold to the local power network and bioheat is used for the heating needs of farms. Opportunities for biomethane and compressed natural gas (CNG) processing for transport fuel is also being undertaken ([134]).

The BIOMASTER project exploited the potential of biomethane production and use for transport in a "waste-to-wheel" partnership, bringing the key components of the biomethane chain into a joint initiative to stimulate investments, remove non-technological barriers and mobilize action for uptake. The project also addressed the available distribution modes and the legal, organisational and financial barriers, focusing on the ambition of enabling biomethane grid injection.

Biomethane as an Alternative Source for Transport and Energy Renaissance (BIOMASTER), https://ec.europa.eu/energy/intelligent/projects/en/projects/biomaster

Box 45 provides another best practice from Helsingborg, Sweden in which the municipal waste treatment company produces biogas as well as biofuel through biogas upgrading.

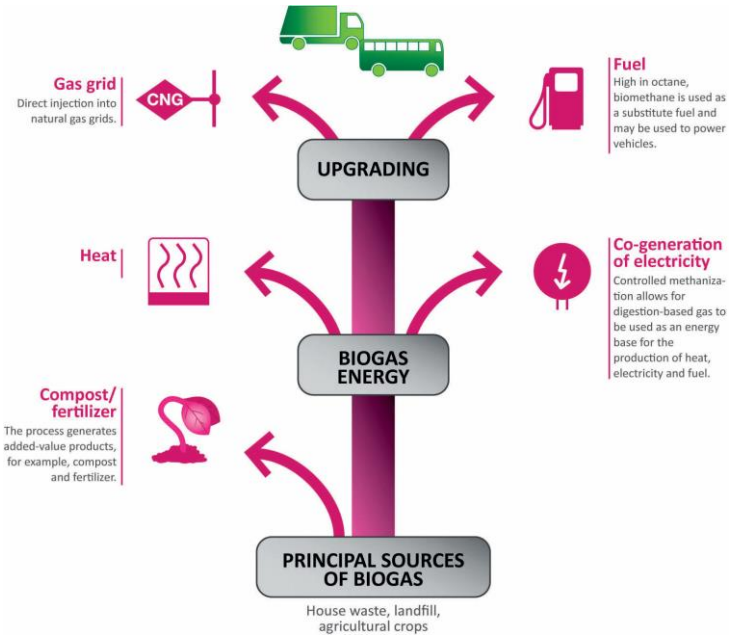
(132) European Environmental Agency, (2006). How much bioenergy can Europe produce without harming the environment? Copenhagen: EEA, *https://www.eea.europa.eu/publications/eea_report_2006_7*
(133) Achinas, S., Achinas, V., Euverink, G., Technological Overview.
(134) Good practice in energy efficiency, Proposal for a Directive of the European Parliament and of the Council amending Directive 2012/27/EU on Energy Efficiency.

Box 45. Doubled Biogas Production: Helsingborg, Sweden

The municipal waste treatment company started their biogas production in 1996. Since then, several improvements and extensions have been made. In 2014, the latest addition to the plant was taken into service. The capacity for biogas production had then been doubled ending up at 80 GWh. The biogas is upgraded and used as motor fuel. The digestion residue is used as biofertiliser and is transported by pipelines to the farmers.

http://www.covenantofmayors.eu/about/covenant-community/signatories/key-actions.html?scity_id=4878

Figure 3. Biomethane Chain Involving Compost, Cogeneration and Upgrading ([135])



9.2.5.2 Landfill biogas recovery

Waste disposal in landfills can generate environmental problems, such as water pollution, unpleasant odours, explosion and combustion, asphyxiation, vegetation damage, and greenhouse gas emissions ([136]). Landfill gas is generated under both aerobic and anaerobic conditions. Aerobic conditions occur immediately after waste disposal due to entrapped atmospheric air. The initial aerobic phase produces a gas mostly composed of CO_2. Since oxygen is rapidly depleted, a long-term degradation continues under anaerobic conditions, thus producing a gas with a significant energy value that is typically 55% CH_4 and 45% CO_2 with traces of certain volatile organic compounds (VOC) ([137]).

Practices for sustainable landfilling can monitor such indicators as leachate composition, methane production, landfill settlement and in situ waste temperature ([138]). Emissions are relatively greater in operating landfills than in closed landfills due to the time of decay and degradation of the landfilled waste ([139]). The economic viability of utilizing landfill gas for local energy generation depends on the methane content of the available

(135) Ibid.
(136) The information given may not be relevant for countries where landfills are no longer allowed.
(137) IEA Bioenergy – Task 37 Energy from Biogas and Landfill Gas, Methane emissions in biogas plants - Measurement, calculation and evaluation, *http://www.iea-biogas.net/files/member-upload/DRAFT_Methane%20Emissions.pdf*
(138) van Vossen, W., (2010). Sustainable landfilling in The Netherlands: Developments, Methodologies and Experiences, Österr Wasser- und Abfallw 62: pp.141-148, *https://doi.org/10.1007/s00506-010-0201-6*
(139) Lou, X., Nair, J., (2009). The impact of landfilling and composting on greenhouse gas emissions – A review, *Bioresource Technology* 100, pp. 3792-3798

gas, local energy prices, and the selected equipment based on the engine and turbine ([140]).

Globally, landfills are estimated to account for 8% of anthropogenic CH_4 emissions as an important source of anthropogenic CH_4 emissions. As mitigation options, Directive 1999/31/EC states in Annex I that "Landfill gas shall be collected from all landfills receiving biodegradable waste and the landfill gas must be treated and used. If the gas collected cannot be used to produce energy, it must be flared" ([141]). Similarly, the Environmental Protection Agency (EPA) of the US presents a method for calculating GHG emissions associated with three different landfill management systems ([142]). These are landfills that do not capture landfill gas, those that recover methane and flare it, and those that recover methane and combust it for cogeneration. A conservative value for the percentage of methane that is chemically or biologically oxidized is 10 % for landfills with low permeability cover while the default efficiency of methane capture systems is 75 %.

9.2.5.3 Renewable energy in wastewater treatment plants

Another possibility to produce biogas is through the installation of a biodigester in sewage and residual waters facility. The residual waters are conducted to the sewage plant where the organic matter is removed from the wastewater. Organic matter then decays in a biodigester in which the biogas is produced through an anaerobic process. Around 40 % to 60 % of the organic matter is transformed in biogas with a methane content of around 50% to 70 % ([143]). The biodigester can also be fed by vegetable or animal wastes. Modern plants can be designed to reduce odours to a minimum extent. Biogas plants may be designed to fulfil the prerequisites for approval by the food industry to use the bio-fertilizer in agriculture.

Other best practices include the integration of renewable sources for supplying power to pumping tap water, including photovoltaic electricity generation, while reducing electricity usage for pumping based on reductions in water losses in the tap water distribution network and an information system for energy and water use in the public sector.

(140) Zamorano, M., Pérez, J., Pavés, I., Ridao, A., (2007). Study of the energy potential of the biogas produced by an urban waste landfill in Southern Spain. *Renewable and Sustainable Energy Reviews* 11, pp. 909-922

(141) Council Directive 1999/31/EC of 26 April 1999 on the Landfill of Waste *http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31999L0031*

(142) US EPA, (2006). Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, Section 6.

(143) Bruno, J., Ortega-López, V., Coronas, A, (2009). Integration of absorption cooling systems into micro gas turbine trigeneration systems using biogas: Case study of a sewage treatment plant, *Applied Energy* 86, pp.837-847

Additional Resources

International Energy Agency (IEA)

IEA's Programme of Research, Development, and Demonstration on District Heating and Cooling, including the integration of Combined Heat and Power.

http://www.iea-dhc.org/index.html

ECOHEATCOOL Project

The overall purpose of this project is to communicate the potential of district heating and cooling to offer higher energy efficiency and higher security of supply with the benefit of lower carbon dioxide emissions.

www.ecoheatcool.org

Euroheat & Power

Euroheat & Power is an association uniting the combined heat and power, district heating and cooling sector throughout Europe and beyond, with members from over thirty countries.

www.euroheat.org

COGEN EUROPE

COGEN Europe is the European association representing the cogeneration sector. It aims at promoting the benefits and wider use of cogeneration in the EU and wider Europe.

https://www.cogeneurope.eu/

ELEP Project

ELEP (European Local Electricity Production) is a European Project that offers technical and policies information, tools and best practices on local electricity generation.

https://ec.europa.eu/energy/intelligent/projects/en/projects/elep

Heat Roadmap Europe

Heat Roadmap Europe is a project funded under the European Union's Horizon 2020 programme with the aim of a low-carbon heating and cooling strategy for Europe.

http://www.heatroadmap.eu/

Pan-European Thermal Atlas

The atlas contains mappings of residual heat from industry and renewable energy opportunities for about 90% of the EU's total heat market.

http://www.heatroadmap.eu/maps.php

http://www.heatroadmap.eu/peta.php

ST-ESCOs Project

ST-ESCOs (Solar Thermal Energy Services Companies) offers technical and economical software tools aimed at studying the feasibility of ST-ESCO projects, guiding information and best practices examples.

http://www.cres.gr/st-escos/

PV GIS

PV-GIS is a web-based solar radiation database for the calculation of PV potential in Europe, Africa and Asia

http://re.jrc.ec.europa.eu/pvgis/

PART 3 B:
Existing policies and initiatives
and good practices for adaptation to Climate Change

10 EU commitment to adaptation

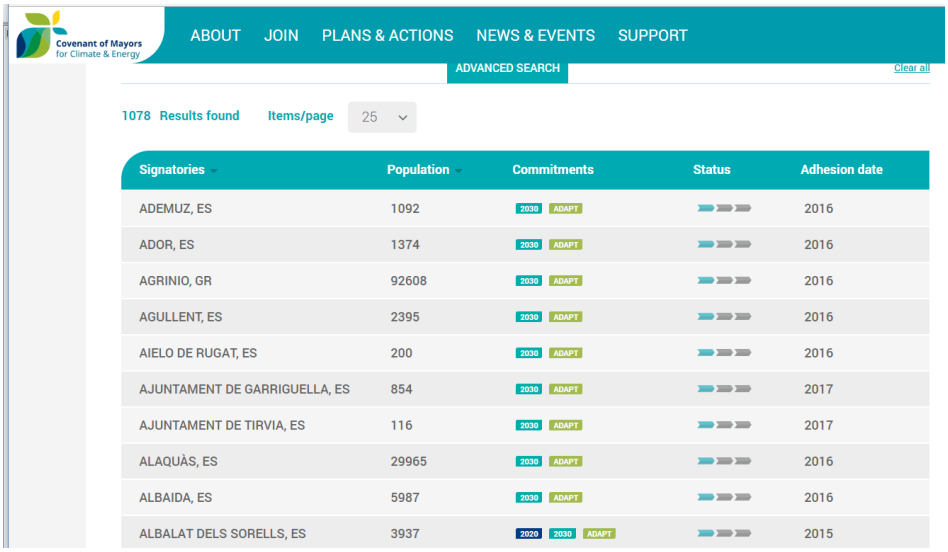
10.1 Climate change adaptation in the EU

Adapting to Climate Change is a relatively new topic for most cities across Europe. Increasing their resilience to Climate Change impacts is therefore an urgent challenge ([144]). To tackle this issue, the EU 2013 Climate Change Adaptation Strategy, establishes a framework and mechanisms for taking lead towards the preparedness for current and future climate impacts. Concretely, Action 3 of the EU Adaptation Strategy ([145]) was dedicated to urban issues (see Annex 1). 25 EU Member States have also adopted national adaptation strategies (NAS) where urban-related issues are covered under sectoral strategies. In addition, different initiatives – such as the EU Covenant of Mayors or the EEA's Climate-ADAPT portal – have been developed to support city adaptation processes and increase awareness among local authorities.

10.2 The Adaption Pillar of the Covenant of Mayors initiative

The adaptation pillar was first introduced through Mayors Adapt, launched in 2014 by the European Commission (DG Climate Action) as a parallel initiative to the Covenant of Mayors. Mayors Adapt was an EU-wide movement of cities committed to adaptation. In 2015, the European Commission merged the two initiatives into the Covenant of Mayors for Climate and Energy in an effort to promote an integrated approach to climate and energy action. From 2015 onwards, adaptation and therefore the Mayors Adapt initiative is entirely integrated into Covenant of Mayors for Climate and Energy. According to the Covenant website ([146]), more than 1,000 local authorities (signatories) are committed to adaptation.

Figure 4. List of Covenant signatories committed to adaptation



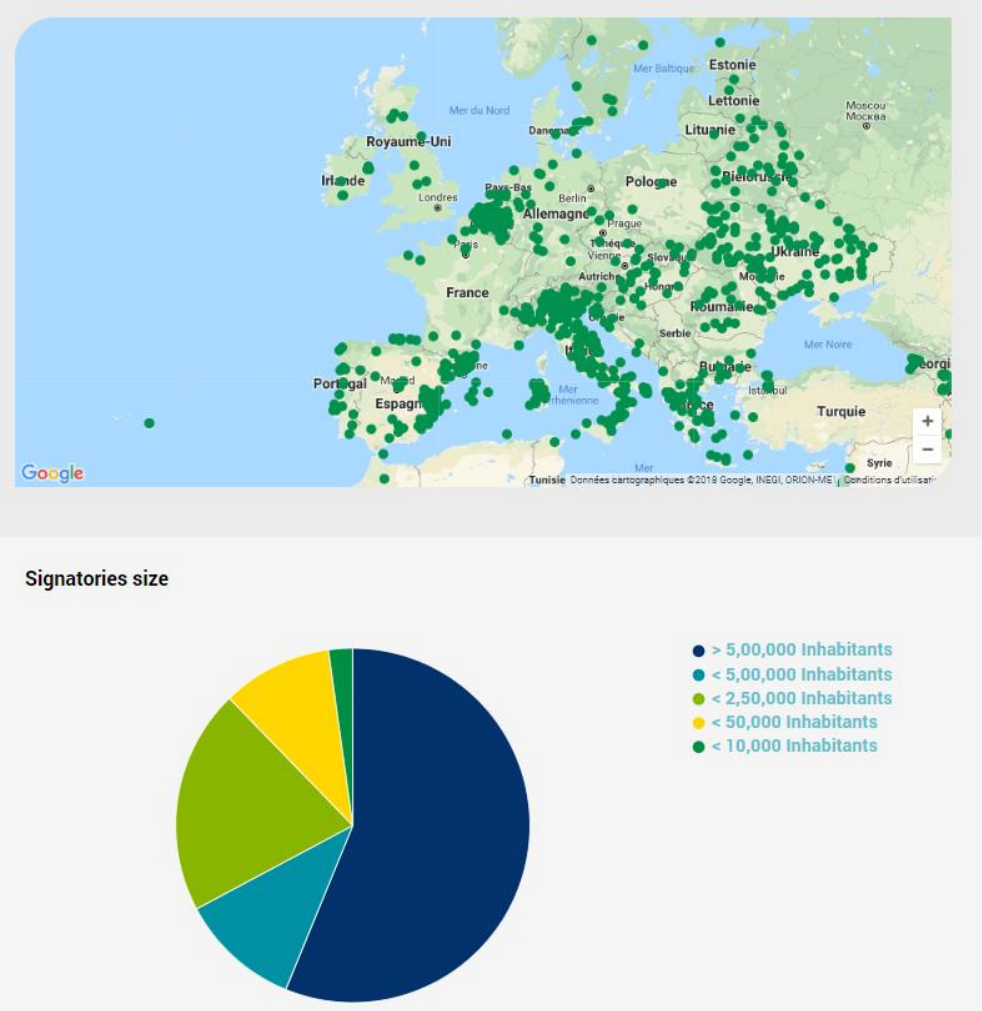
Source: Covenant of Mayors for Climate and Energy website, June 2018 ([147])

(144) UCCRN, 2011. Climate change and Cities: First Assessment report ARC3. Urban Climate Change Research Network. Cambridge press, pp.28
(145) European Commission, 2013. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS: An EU Strategy on adaptation to climate change. COM (2013) 0216 final, Brussels, 16.04.2013
(146) The "origins and development" page on the Covenant website: https://www.covenantofmayors.eu/about/covenant-initiative/origins-and-development.html
(147) https://www.covenantofmayors.eu/about/covenant-community/signatories.html

Local authorities committed to both mitigation (2020 and/or 2030 target) and adaptation. The status points out the phase of the process: 1. Signature; 2. Submission of adaptation strategy; 3. Monitoring results in June 2018.

By joining the initiative, signatories commit to voluntarily developing a comprehensive local adaptation strategy or integrating adaptation into on-going development plans, as well as to reporting their progress every second year. COR (2016) points out that small- and medium-size cities are the majority of Covenant of Mayors signatories, reflecting a more pressing need for support and resources than bigger cities ([148]) (Figure 5).

Figure 5. Signatories size and location



Source:https://www.covenantofmayors.eu/about/covenant-initiative/covenant-in-figures.html

(148) Revi, A., D.E. Satterthwaite, F. Aragón-Durand, J. Corfee-Morlot, R.B.R. Kiunsi, M. Pelling, D.C. Roberts, and W. Solecki, 2014. Chapter 8: Urban areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 535-612

Even though an upward trend in cities' willingness to increase their resilience to Climate Change is observed, many barriers still remain to local adaptation — especially in smaller cities ([149]), such as the lack of:

- budget and difficulties to access funding tailored to adaptation;
- multi-level/multi-stakeholder governance;
- political commitment;
- legal framework enabling adaptation;
- data about risk and vulnerability at local level;
- good-practice exchange.

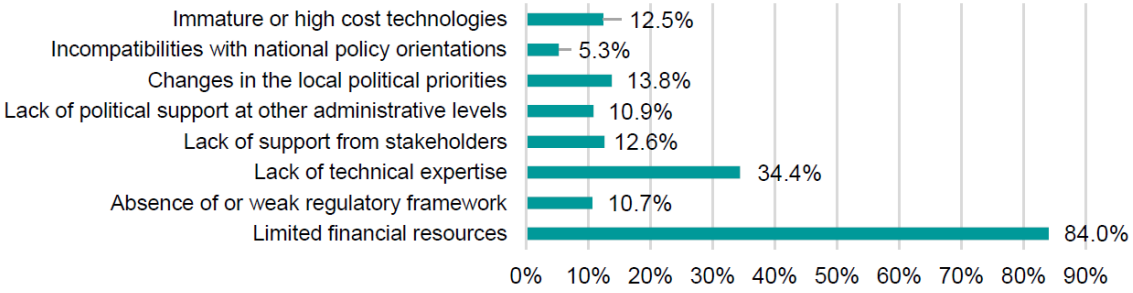
Another obstacle to adaptation to Climate Change is to break the "silo-thinking" and move towards a more cross-cutting approach; this demands a change in the way local authorities usually address urban development. Such horizontal governance crossing different sectoral strategies is a new issue for most cities, which still struggle to understand local impacts of Climate Change and define clear accountability across different local authority' departments and stakeholders.

An analysis of the main knowledge gaps ([150]) was conducted by the Mayors Adapt team in the first semester 2015 through literature review, online survey and more in-depth interviews. It pointed out that the initiative offered a great possibility for exchange of information, objectives, approaches and good practices between cities; even though they reported that they often have a limited capacity to make full use of this opportunity. Most of them said that limited cooperation between government levels was still a barrier to adaptation, as well as lack of funding. Moreover, the lack of knowledge on potential economic costs and social impacts and the limited knowledge on potential impacts on essential services (e.g. energy, water, food supply…) were also highlighted among others as main difficulties.

Similarly, the outcomes reported in the Covenant of Mayors Needs Assessment report ([151]), conducted in the first semester 2017, confirm the fields for which local authorities encounter much difficulty in developing and implementing the action plans. In this process, local authorities were asked to select the two main barriers they face in developing/implementing a mitigation or adaptation plan, among a range of options. Limited financial sources and lack of technical expertise were the barriers that were most frequently selected by local authorities, with respectively 84 % and 34.4 % of respondents selecting those options (Figure 6).

(149) COR, 2016. Regional and local adaptation in the EU since the adaption of the EU Adaptation Strategy in 2013. Report by European Committee of the Regions, pp. 114.
COR, 2017. Towards a new EU climate change adaptation strategy – taking an integrated approach. OPINION by European Committee of the Regions, ENVE VI/015, pp.11. Plenary session, 8-9 February 2017
(150) https://www.covenantofmayors.eu/IMG/pdf/MA_KnowledgeBaseStrat_ExecSummaryFinal.pdf
(151) European Covenant of Mayors needs assessment report Covenant community's needs for SE(C)AP design and implementation August 2017. http://www.eumayors.eu/news-and-events/news/1522-the-european-covenant-of-mayors-needs-assessment-report-is-now-available.html
See the "origins and development" page on the Covenant website:
https://www.covenantofmayors.eu/about/covenant-initiative/origins-and-development.html

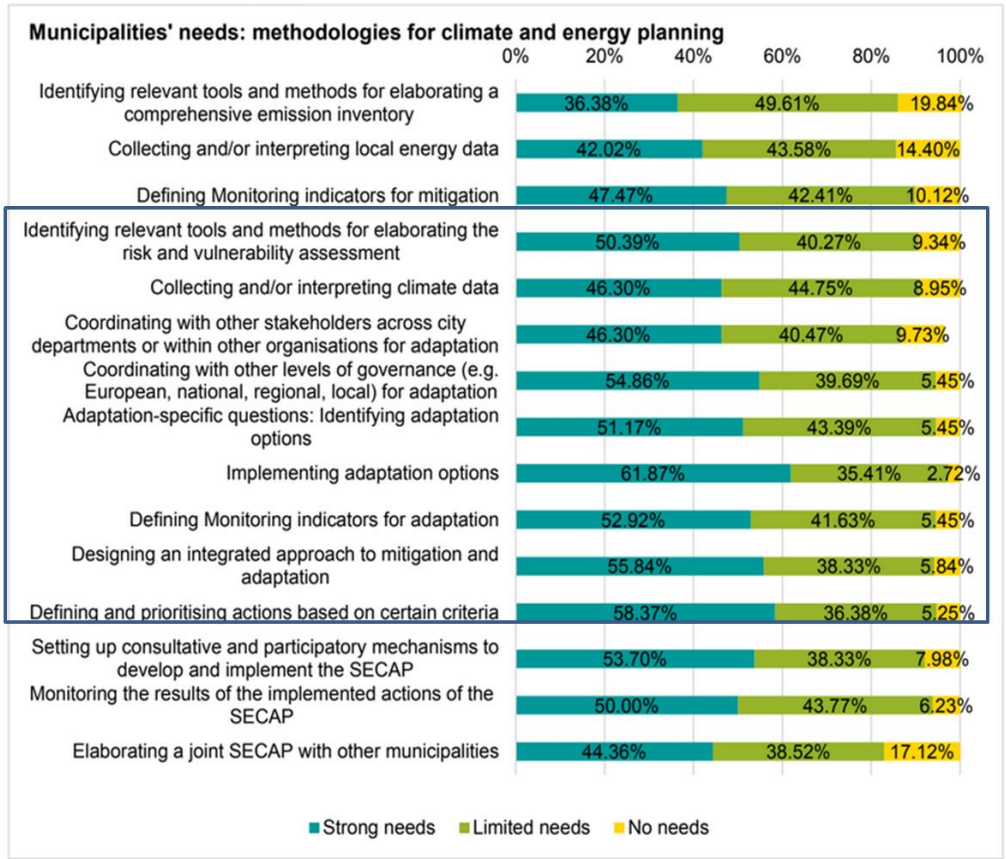
Figure 6. Barriers faced by local authorities



Source: European Covenant of Mayors Needs Assessment Report ([151])

The needs' assessment survey ([151]) showed also that out of the Covenant 3 pillars, climate adaptation is where cities need most support (45.14 %). Cities, whose national government demonstrated weak engagement to adaptation, indicated that the lack of appropriate legislative and regulatory frameworks hindered action ([149]). Even though some local authorities recognized the need for technical support, e.g., vulnerability and risk assessment and selecting adaptation options, they also argued that this support should be provided locally (Figure 7).

Figure 7. Results of the survey conducted by CoMO in 2017 on the Covenant signatories' main needs when developing and implementing their SE(C)AP



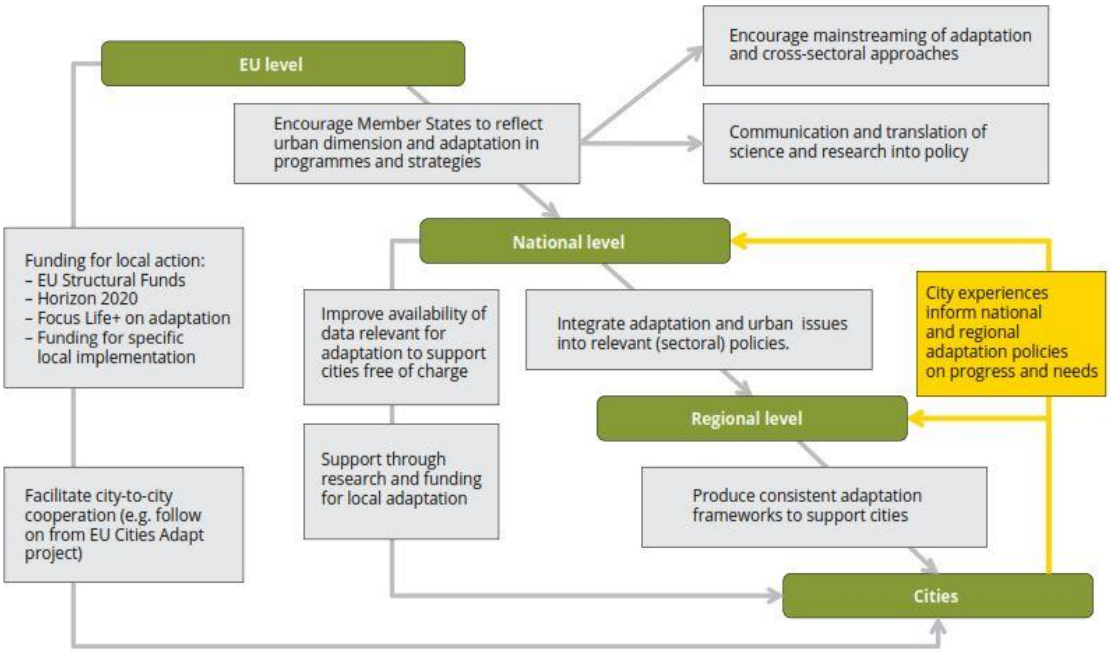
Source: European Covenant of Mayors Needs Assessment Report ([151]).

11 Multi-level governance of urban adaptation action

Cities do not act alone; they are supported by hundreds of provinces, regions and key national authorities – making the Covenant of Mayors initiative one of the most emblematic drivers of multi-governance in Europe. (Look also at CTCs ([162])).

Whilst local authorities stand on the frontline, taking concrete measures to reduce the vulnerability of their territories to the various Climate Change impacts, their regional and national governments as well as the EU institutions set up the policy and legislative frameworks. Multi-level coordination therefore plays an important role in facilitating or constraining local adaptation ([152]), and more broadly help ensuring greater policy coherence but also coordinated and complementary action between the different levels of government. Urban adaptation is a shared competence between local and regional authorities and should be defined according to a city´s peculiarities and needs. The complexity of jurisdictional and economic large-scale national and EU frameworks may be unable to capture site-specific context demands for increasing urban resilience, often distant from local realities, and frequently comes in the form of top-down approach only partially accepted or understood by local actors. Therefore, the definition and implementation of urban adaptation requires local, regional, national and EU approaches to work together; the stakeholders and citizens need to get involved actively. Figure 8 shows local, regional, national and European contributions to urban adaptation, and the potential links and feedbacks within a vertical coordination framework.

Figure 8. Vertical coordination through multi-level governance



Source: EEA, 2016

11.1 EU level

European level coordination is required to foster the development of EU legislative tools (e.g. laws, regulations and directives) and funding programmes that help guiding local, regional and national footsteps towards adaptation. The role of the EU is to ([153]):

(152) EEA, 2012. Urban adaptation to climate change in Europe. Challenges and opportunities for cities together with supportive national and European policies. European Environmental Agency report No 2/2012
(153) Ricardo AEA, 2013. Adaptation strategies for European Cities. Final Report for DG Clima, pp.148

- Provide funding for adaptation and technical support to local authorities to access the funds and comply with the requirements;
- Develop regional, national and EU legislation/guidelines for adaptation, e.g. through the EU Strategy on adaptation to Climate Change;
- Produce, gather and share information needed to develop an adaptation strategy and exchange good-practice examples;
- Define an EU common set of methods and indicators to assess the performance of adaptation projects and monitor the evolution of vulnerabilities and risk;
- Support the creation of adaptation transnational networks on an EU scale.

Given the crosscutting dimension of Climate Change impacts and their transboundary causes, adaptation must be clearly included into different European policy areas (**Table 34**) to ensure better coherence across sectors and different spatial levels, and effective implementation of the numerous EU regulations and initiatives concerning cities ([159]). Moreover, the EU level may help to fill policy/legislative gaps existing at national levels: in some Member States, adaptation has been mainstreamed into spatial planning (e.g., Latvia), in others, adaptation has little support from the national level - local or regional governments tend to retain considerable authority in adaptation related issues (e.g., Italy and Sweden). A common EU framework to guide mainstreaming adaptation into national policies would ensure coherence and consistency across EU Member States. A lack of adaptation targets at national level (and legal obligations) also represents an obstacle to the political engagement of local authorities in adaptation. **Table 34** identifies a number of areas of European policy as particularly relevant for adaptation ([152];[154]).

(154) Gonzalez, Y., Gomes, G. and Barbosa, P., 2017. A database for identifying EU climate change adaptation policies. European Commission JRC technical report, pp.32.

Table 34. EU policy sectors (and legislative tools) relevant to adaptation

Policy sector	Integration of Climate Change adaptation	Importance for urban adaptation
Regional and Cohesion policy	— Structural Funds: 20% EU budget allocated to climate related expenditures (Europe 2020) including "promoting Climate Change adaptation and risk prevention". — EU Urban Agenda	Highly relevant for urban adaptation: possibility of funding through the European Structural and Investment Funds (ESIF), especially the European Regional Development Funds (ERDF) Highly relevant for urban adaptation: a more coherent and effective implementation of EU regulations and initiatives concerning cities through Partnerships, including Climate Adaptation ([155])
Environment	— Directive 2014/52/EC of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EC on the assessment of the effects of certain public and private projects on the environment (EIA); — Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora; — COM (2013) 249 final Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on Green Infrastructure (GI) — Enhancing Europe's Natural Capital; — COM (2011) 244 final — Our life insurance, our natural capital: and EU biodiversity strategy to 2020.	EIA directives: relevant to urban adaptation to better understand local vulnerabilities that could act in synergy with Climate Change. Natural habitats and Green Infrastructures in and around cities deliver important services for adaptation (low regret measures)
Agriculture and rural development	— Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 169/2005.	Relevant to urban adaptation in regional approaches (e.g., river basin management for water supply to cities)

(155) Climate Adaptation partnership is expected to be launched after summer 2017.

Policy sector	Integration of Climate Change adaptation	Importance for urban adaptation
Transport and energy	—Eurocodes: ISO TC 268: Sustainable development in communities and cities;	Relevant for urban adaptation: this standard integrates Climate Change into infrastructure standards, fostering smartness and resilience in cities (ISO TC 268 covers energy, transport, water, waste, IT infrastructures).
Industry/private sector	No integration of adaptation — climate related issue are addressed only through the Emission Directive (IED)	Potentially relevant to urban adaptation: private sector investment in climate-proof business and infrastructures represent an alternative resource for city adaptation
Social/Employment	EU Urban Agenda — Partnership for urban poverty & Partnerships for jobs and skills in the local economy	Highly relevant to urban adaptation: the partnerships aim at increasing the inclusion of poor communities and at regenerating deprived neighbourhoods, and at promoting local economic activity, thus reducing socioeconomic vulnerability and strengthening social cohesion in cities.
Health	EU Health 2020: recognizes the Climate Change impacts on health and the need for integrating health issues in all Climate Change mitigation and adaptation strategies (WHO, 2012) ([156]); —COM (2013) 213 final Green paper on the insurance of natural and man-made disasters.	Highly relevant for urban adaptation: Cities host the majority of EU population and most impacts on health will be concentrated here.

(156) WHO, 2012. The new European policy for health –Health 2020. World Health Organization, regional office for Europe. Draft 2, pp.174

Policy sector	Integration of Climate Change adaptation	Importance for urban adaptation
Water	— Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks; — Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy; — COM(2007) 414 final. Communication from the Commission to the European Parliament and the Council— Addressing the challenge of water scarcity and droughts in the European Union; — COM(2012) 673 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — A Blueprint to Safeguard Europe's Water Resources.	Flood directive: relevant for regional and urban adaptation (multi-level governance). Water scarcity and drought directive/communication: relevant for regional and urban adaptation (multi-level governance).
Research	Horizon 2020 programme.	Highly relevant for urban adaptation: H2020 funds projects that aim at creating and sharing knowledge about Climate Change impacts and risks (and increasing uptake of main outcome by local authorities).

Source: JRC own elaboration

11.2 National level

Member States should provide the legal basis and standards for adaptation and organise knowledge transfer to cities in-country. The lack of national adaptation strategies and targets for adaptation represent a barrier to local actions, reducing awareness among local authorities and their responsibility for developing local strategies.

25 EU Member States have adopted a national adaptation strategy (NAS) and 15 have developed a national adaptation plan (NAP) ([157]). Most of them are structured according to policy sectors and, although cities are not being explicitly addressed, urban-related issues are covered under sectoral strategies ([158]). A few countries, such as Austria, dedicate a specific chapter of the NAP to adaptation needs in cities, providing recommendations, targets and actors for adaptation actions. Other countries do not explicitly address urban issues in their NAP.

In some cases, the top-down steering from national government can hinder local adaptation since its policy level is too far from site-specific contexts and their needs. For this reason, NAPs are better at coordinating across sectors (horizontally) than between levels of government (vertically) ([159]).

Including adaptation at local level in existing national legal frameworks is necessary to mainstream adaptation to Climate Change into on-going activities (e.g. spatial planning, infrastructure development, among others), facilitating access to financial resources from other policy sectors (**Table 35**). In Denmark, for example, the NAP enables and obliges local authorities to include Climate Change adaptation issues directly into municipal development plans. An agreement between national government and local authorities increased municipal investments into adaptation for wastewater collection and treatment; moreover, the water utility authority charged the investment cost in adaptation measures on water users.

Table 35. Local adaptation in national adaptation strategies or sectoral plans

Integration of urban adaptation in national policies	Countries
Urban issues included in a specific part of the national adaptation strategy	Austria, Italy, Slovakia, United Kingdom
Urban issues mainstreamed throughout the national adaptation strategy	Bulgaria, Denmark, France, Turkey
Urban issues mainstreamed thematically into:	
- building and construction	Finland, Spain, Turkey
- spatial planning	Czech Republic, Finland, Germany, Portugal, Spain, Switzerland, Turkey
- health	Belgium, Czech Republic, Finland, Germany, Portugal, Spain, Switzerland
- transport	Belgium, Czech Republic, Finland, Portugal, Spain
- disaster risk management	Czech Republic, Portugal, Turkey
- water management	Netherlands, Portugal, Turkey

Source: Breil and Swart, 2015 ([158])

National funding and research programmes for adaptation set up at the national level are mainly targeted to filling knowledge gaps and capacity building at local level, promoting pilot actions in selected cities. The scarcity of budgetary resources for adaptation can limit the replication and extension of the research to the other cities on the country.

A recent survey conducted among the signatories of Mayors Adapt initiative ([149]) pointed out that, for some of them, adaptation has already been recognized as a priority by local authorities, while at the national level there was still a lack of support for local action.

(157) https://www.eea.europa.eu/airs/2017/environment-and-health/climate-change-adaptation-strategies
(158) Breil, M. and Swart, R., 2015.National action supporting urban adaptation in EEA Member States. Eionet Report ETC/CCA 2015/3, pp.45
(159) EEA, 2016. Urban adaptation to climate change in Europe 2016. Transforming cities in a changing climate. European Environmental Agency report, No 12/2016, pp. 140

11.3 Regional level

Climate change impacts have a regional scale in several sectors such as water management, flood control, and transport and mobility, among others which are calling for an effective collaboration between local authorities and regional offices (e.g., river basin agency, Civil Protection). Clear legal regional frameworks could facilitate governance across local authorities and sectors. In addition, reinforcing the cooperation between Covenant of Mayors and Regions Adapt ([160]) in the most pressing issues for local authorities, such as infrastructure planning (**Table 36**), could be a good starting point in order to:

i) test and improve the multi-level governance framework for climate action (adaptation & mitigation) in Europe;

ii) promote the CoM platform in all cities located within signatory regions;

iii) create a common regional/local monitoring and reporting system.

Table 36. Examples of climate challenges and strategies for regional adaptation in energy and transport key—areas (infrastructure sector) in Lombardy. Lombardy is one of the four signatories of the Region Adapt initiative

8. Energetic sector: decrease in hydroelectric production capacity	- Promote information and awareness-raising campaigns for saving energy; - Create more incentives and promote greener building and planting trees to save energy in residential areas; - Enhance sensitivity studies concerning the effects of new climate conditions in the renewable energy sectors, to identify local weakness and opportunities (e.g. possible expansion in solar energy suitability).
9. Transports and mobility: impacts on transport infrastructure	- Strengthen the existing monitoring and risk analysis plans to identify main vulnerabilities and priorities for transportation infrastructure; - Promote the adoption of transport infrastructure that can resist meteorological extremes (thermally stable materials, draining asphalt); - Combine adaptation efforts with the promotion of the use of low emission transportation facilities; - Review and update if necessary the authorisation processes and normative bases of transport infrastructure planning, considering future climate changes

Source: Lombardy Foundation for the Environment, 2014

Even though the EU Adaptation Strategy recognized the importance of regions in advancing climate adaptation, especially in flood, water resource, coastal management and mountain areas ([149]), to date, regional coordination has played a limited role in promoting local adaptation ([149]) and a greater involvement is required ([161]) In some countries (e.g. Italy), regional authorities are responsible for urban planning legislation.

(160) The *RegionsAdapt* initiative is a global framework to inspire, support and report efforts on climate change adaptation at the subnational level. http://www.nrg4sd.org/climate-change/regionsadapt/
(161) COR (2017). Towards a new EU climate change adaptation strategy – taking an integrated approach. OPINION by European Committee of the Regions, ENVE VI/015, pp.11. Plenary session, 8-9 February 2017

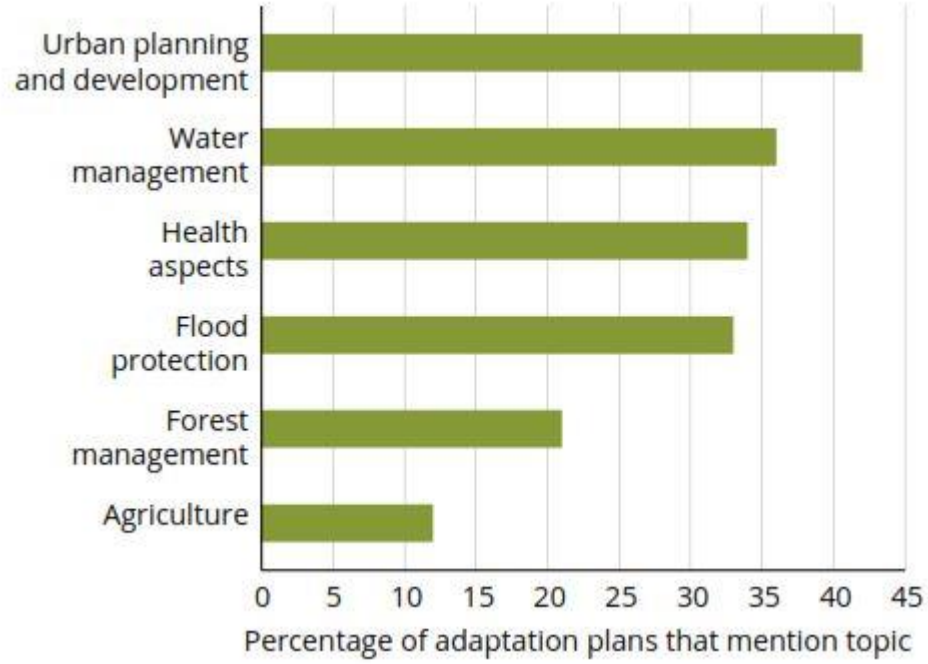
The cooperation between the regional and the local level, and in particular the Covenant coordinators are playing a crucial role for enhancing adaptation.

The Covenant Coordinators may commit to support signatories within their geographical scope by means of providing technical and/or financial support to develop and implement Sustainable Energy and Climate Action Plans, as well as networking activities (additional detailed information can be consulted here: https://www.covenantofmayors.eu/join/join-as-a-coordinator.html) ([162]).

11.4 City level

Local authorities are responsible for in-situ implementation of adaptation measures. In Europe, there are very different examples of how this happens in practice. Some cities have specific adaptation policies; others integrate adaptation into existing sectoral strategies. Mainstreaming adaptation into urban planning and development, water management or health aspects, are common ways to promote adaptation through existing governance mechanisms and budgets (Figure 9).

Figure 9. Most common adaptation issues addressed by cities ([163])



However, there are not enough studies about the cross-sectoral nature of Climate Change impacts and their cascading effects on interconnected urban services and infrastructures ([164]), calling for a more collaborative cooperation among local authority's departments, local universities, key stakeholders and citizens. The need to integrate disaster risk reduction and Climate Change adaptation is being increasingly recognized through a strict collaboration between the Civil Protection and Disaster Assistance offices ([165]), in order to achieve improved planning outcomes at city level ([166]).

(162) https://www.covenantofmayors.eu/about/covenant-community/coordinators.html
(163) Reckien, D., Flacke, J., Heidrich, O., Olazabal, M., Foley, A., Hamann, J., Orru, H., Salvia, M., de Gragorio Hurtado, S., Geneletti, D., Prietrapertosa, F., 2014. Climate change response in Europe: what´s the reality? Analysis of adaptation and mitigation from 200 urban areas in 11 countries. Climate Change, 122, I 1-2, pp.331-340
(164) C40, 2017. Infrastructure interdependencies and climate risk report, pp.56
(165) See for example the Connective Cities platform: https://www.connective-cities.net/en/
(166) Neumann, S., Crick, F., Harman, B. Schuch, G. and Choy, D.L., 2015. Maximizing synergies between disaster risk reduction and climate change adaptation: potential enablers for improved planning outcomes. Environmental science and policy, 50, pp.46-61

Engaging traditional policy sectors in Climate Change adaptation to define an integrated approach to mitigate climate risks across multiple infrastructure and services still demands a huge effort. Institutional structures in cities tend to exist and work in separate silos, with limited interest in Climate Change related issues, often competing for scarce funds, and setting sector-specific policy agendas. Local authorities should put in place institutional mechanisms to help clarify roles and responsibilities, including possible enablers and leaders, to maximise synergies between sectors (e.g. knowledge and data sharing), implement more holistic measures to address climate risks, and avoid policy trade-offs and subsequent maladaptation.

To date, there is still not much evidence about good practices in systematically engaging local communities and private sector initiatives into urban adaptation planning ([167]). Exchanging knowledge and data (qualitative and quantitative), increasing awareness, transferring good practices, and using private resources for investments in adaptation measures, are potential benefits of participatory processes. Engaging with environmental, socioeconomic, and financial stakeholders and citizens in urban development is the key to securing its acceptance and, therefore, the success of any Climate Change adaptation strategy.

11.5 State of play in the EU: national versus local adaptation strategies

Heidrich et al. (2016) ([169]) and Reckien et al. ([163]) studied the influences of the EU, national, and regional levels of governance on the development of local Climate Change strategies or plans ([168]) of 200 European cities from 11 countries. The survey demonstrated that the way cities engage in climate policy and the role of higher levels of government in local action remain largely unclear. The lack of EU guidance and national frameworks explains the current sparseness of cities considering adaptation in their development plans. The results highlighted that only 56 cities have adaptation plans (23% of sample), whilst 130 cities (64%) have a mitigation commitment showing that mitigation is more advanced than adaptation across Europe (**Table 37**).

Table 37. National climate targets and policies, and cities with mitigation and adaptation strategies across 11 countries ([169])

UA cities		EU target[a] 2005–2020 of GHG	Change of GHG[b] 1990–2011	National mitigation Policy[c]	Cities with mitigation strategy	National adaptation policy[d]	Cities with adaptation strategy	CoM of UA cities	CoM cities in country
Country	N	%	%	Year	N	Year	N	N	N
Austria	5	−16	+16.3	2001	3	2012	0	0	14
Belgium	7	−15	−16.4	2008	3	2010	0	4	65
Estonia	2	+11	−47.3	2004	1	–	0	1	3
Finland	4	−16	−23.2	2008	3	2005	2	4	7
France	35	−14	−16.7	2011	15	2011	8	18	151
Germany	40	−14	−23.8	2000	32	2008	13	17	66
Ireland	4	−20	+2.3	2000	2	2012	0	2	9
Italy	32	−13	−9.6	2002	18	–	1	17	2582
Netherlands	15	−16	−8.0	2007	12	2007	3	7	20
Spain	26	−10	+21.9	2007	13	2006	5	17	1323
UK	30	−16	−28.6	2008	28	2008	24	13	44
Total	200				130		56	100	4871

The steps that lead to adaptation plans in European cities differ substantially between countries, and it is not possible to define a common prototypal pattern on how they commit to adaptation. We use the list of countries sampled by Heidrich et al. ([169]) as a

(167) Archer, D., Almansi, F., DiGregorio, M., Robrìerts, D., Sharma, D., Syam, D., 2014. Moving towards inclusive urban adaptation approaches to integrating community-based adaptation to climate change at city and national scale. Climate and Development, vol. 6 (4), pp. 345-356
Chu, E., Angulovski, I., Carmin J., 2016. Inclusive approaches to urban climate adaptation planning and implementation in the Global South. Climate Policy, vol.16 (3), pp. 372-392
(168) The survey considered only plans and policies officially adopted, published or in development by cities.
(169) Heidrich, O., Reckien, D., Olazabal, M., Foley, A., Salvia, M., da Gragorio Hurtado, S., Orru, H., Flacke, J., Geneletti, D., Prietrapertosa, F. Hamann, J., Tiwary, A., Feliu, E., Dawson, R.J., 2016. National climate policies across Europe and their impacts on cities strategies. Journal of environmental management, 168, pp. 36-45

starting point to propose some representative examples of the adaptation policies across Europe.

In **Austria**, the National Adaptation Strategy (NAS) ([170]) was adopted by the Federal government in 2012. It provides information about the state of play in the country on adaptation, gives some examples of good practices, and points out future challenges. The NAS is divided into two parts: 1) the strategic framework, addressing fundamental issues and general context; 2) the action Plan, focusing on the vulnerability of the respective areas for action and presenting concrete recommendations for adaptation. Even though adaptation at local level is explicitly cited in the NAS, the focus of climate planning in Austria seems to be centred at the national level. The NAS strategies cover 14 sectors: agriculture, forestry, water resources and water management, tourism, energy, construction and housing, protection from natural hazards, disaster risk management, health, ecosystems/biodiversity, transportation infrastructure, spatial planning, business/industry, and cities (with a focus on green and open spaces).

Belgium adopted a National Adaptation Strategy (NAS) in 2010 which describes the main Climate Change impacts, the existing responses, a roadmap to a future National Adaptation Plan, and several policy guidelines to strengthen cooperation between different entities on adaptations. The focus of climate planning is centred at the regional (Flanders, Wallonia and Brussels) and federal levels. For example, in 2013, Flanders adopted the Flemish Climate Policy Plan, which includes a section on adaptation (Flemish Adaptation Plan, VAP). The VAP defines the responsibilities of regional departments for action in their policy domain and assumes the cost of the selected measures. Local adaptation policy is still in an incipient phase. The Federal contribution to the National Adaptation Plan was adopted in 2016, identifying the federal cross-sector adaptation actions, namely: i) increase knowledge about Climate Change impacts and risk through capacity-building; ii) anticipate and mitigate risks to maximize the potential benefits of Climate Change ([171]).The National Adaptation Plan was adopted in 2017 and describes national measures for the next few years, covering the period 2017-2020.

Bulgaria ([172]) is currently developing its national adaptation strategy and a complementary national adaptation plan, through a project undertaken with the advisory support of the World Bank. The strategy (foreseen to be finalised in 2018) is underpinned by climate adaptation assessments in nine sectors of interest and by a study on the macro-economic implications of climate change. A Strategy on Adaptation to Climate Change for Sofia Municipality has been developed under the EU funded project "Transitioning towards Urban Resilience and Sustainability "TURAS". Also, two Bulgarian cities (Burgas and Smolyan) have committed to adaptation under the Covenant of Mayors for Climate and Energy. Since no NAS has been adopted yet, a monitoring and reporting framework does not exist to this date.

Croatia's National Adaptation Strategy (NAS) ([172]) is being developed and is due to be completed and prepared for adoption. A parallel National Adaptation Plan (NAP) will also be developed, covering a five-year period. Recognized vulnerable sectors are the following: hydrology and water resources, agriculture, forestry, biological diversity and natural inland ecosystems, biological diversity and marine ecosystems, urban and coastal areas, tourism, and human health. No reports on adaptation at the central or sectorial level have been published since the NAS and NAP are yet to be adopted. No monitoring system has yet been developed to monitor implementation of adaptation actions.

Cyprus ([172]) adopted a new National Adaptation Strategy in 2017. A National Adaptation Action Plan had already been published in 2014 and was incorporated into the NAS, so the NAS and NAP are now presented as one document. Vulnerable sectors that have been identified comprise water, agriculture, soil resources, fisheries and aquaculture, forestry,

(170)
(171)
(172) Additional information available via climate-ADAPT

biodiversity, public health, tourism, coastal zones, energy and infrastructure. A Monitoring Strategy has been developed to complement the NAS, in which a Monitoring Team was suggested. Monitoring reports are scheduled every year from 2017 to 2019 but nothing has been published so far.

The **Czech Republic** adopted its Strategy on Adaptation to Climate Change (NAS) in 2015. The National Action Plan on Adaptation to Climate Change was developed on the basis of this Strategy and adopted in 2017. The following priority sectors were included in the strategy: forest management, agriculture, water regime in landscape and water management, urban landscape, biodiversity and ecosystem services, health, tourism, transportation, industry and energy, emergencies and protection of the population and environment. The monitoring and reporting system is being developed. The default status of indicators, for monitoring the NAS, is defined and the whole monitoring system is aimed to be operational shortly.

The **Danish** ([172]) National Adaptation Strategy was adopted in 2008. Fourteen sectors of priority are identified: construction and housing, coasts and ports, transport, water, agriculture, forestry, fisheries, energy, tourism, nature, health, emergency preparedness, insurance, and spatial planning. An action plan for a climate-proof Denmark was launched in 2012, based on the notion that a responsible climate policy includes both working in the short and the long term. To date, there is seemingly no overall monitoring and evaluation mechanism of climate change adaptation, nor are there clear reports publishing progress on adaptation in different sectors.

The government of **Estonia** is responsible for climate planning and implementation at regional and local level. The Development Plan for Climate Change Adaptation until 2030 ([173]), involves 8 key sectors: health, land use planning, natural environment, bio-economy, infrastructures, energy, economy, society, awareness and cooperation. The document plans adaptation action at local, regional and national levels, ensuring a better coherence between sectors and governance steps. Even though a few cities independently managed adaptation by assessing risks of flood and storms and defying potential measures to cope with, there are not examples of urban adaptation plans linked to national guidance. National Strategy on climate change adaptation was adopted in 2017.

Finland was a front-runner in Europe in adapting a National Adaptation Strategy (2005), and the implementation of climate policy is the responsibility of several institutions at national, regional and local levels. Most Finish cities have already assessed their Climate Change risks and defined an adaptation plan. This is a good example of the importance of having clear national guidance to promote coherent local action on the territory.

In **France,** the National Adaptation Strategy was adopted in 2006 and the National Adaptation Plan (PNACC) in 2011, covering 20 thematic areas: cross-cutting actions, health, water, biodiversity, natural hazards, agriculture, forests, fisheries and aquaculture, energy and industry, transport infrastructures, urban planning and the built environment, tourism, information, education and training, research, funding and insurance, coastlines, mountains, European and international actions, and governance. The integration of adaptation into sectorial policies is part of the NAP's specific actions and measures, the monitoring scheme looks at a qualitative assessment of the status of implementation of the 230 measures in the different sectors. In 2015 the final evaluation of the NAP concluded that around 80% of the actions and 75% of the measures in the NAP have been achieved. The Plan Climat presented in July 2017 announced a revision of the NAP (2e PNACC) and a report summarizing findings from a comprehensive national consultation process was published in early 2018. The national government also plays an important role in guiding urban climate action through legal frameworks, such as the National Climate Plan (2004) or the "lois Grenelle" (law 2010-788 of 12 July 2010), which

(173)http://www.envir.ee/sites/default/files/climate_change_adaptation_development_plan_until_2030_summary_0.pdf

encourages regions and cities to develop a territorial climate-energy plan (PCETs) to define mitigation and adaptation action. Local authorities can register their PCETs on a voluntary basis in a national observatory managed by the French Environment and Energy Agency. Despite the legal obligation, only 8 cities (22% of French sample) have adopted an adaptation strategy, which is often in the early draft stage. Strategic guidelines for risk management and adaptation strategies are prepared at regional level within larger spatial units as part of the Regional Climate, Air and Energy Schemes; the national government is responsible for compliance control. Beyond these plans, a number of cities have started assessing climate risks independently (e.g. heat waves) and have mainstreamed adaptation into local urban planning instruments. Therefore, it is not possible to point out a clear influence of national policy on local action.

Germany adopted a National Adaptation Strategy (NAS) in 2008 and an Adaptation Action Plan in 2011 ([174]). The latter has been developed around four pillars: i) creation and dissemination of knowledge; ii) creation of frameworks by Federal Government; iii) definition of accountability and responsibilities of Federal Government; iv) definition of international responsibilities. The revision of Federal Regional Planning act included adaptation in the principles of spatial planning. National and federal governments are responsible for Climate Change policies and their role does not seem to have had a great influence at local level: only 13 cities (33% of the German sample) have an adaptation plan, and only 12 cities have an integrated mitigation and adaptation approach. This could be due in part to the fact that infrastructure refurbishment and development are the responsibility of Federal Government. Climate change policy is the responsibility of the federal and state governments. To increase cities´ commitments to adaptation, local authorities are supported by the expanded opportunities to obtain funding under the National Climate Protection Initiative, and by several initiatives to develop local decision-making tools ([175]).

Greece ([172]) published its National Adaptation Strategy in 2016. Work is ongoing to develop regional adaptation action plans, but no specific national, sub-national or sectorial adaptation plans have been adopted so far. A National Adaptation Plan will be developed once all regional plans have been developed. The vulnerability assessment of the major sectors in Greece focuses at natural ecosystems and biodiversity, agriculture and food security, forest ecosystems, fisheries and aquaculture, water resources coastal zones, tourism, human health care, energy, and transport. To date, there is no monitoring of the integration of climate change in sectorial policies, nor is there a framework that assesses adaptation actions that are being implemented.

In **Hungary** the first National Climate Change Strategy (NCCS I) from 2008 included a chapter on adaptation and was implemented by a National Climate Change Programme for 2009-2010. A revised strategy (NCCS II) was submitted in May 2017 to the Hungarian Parliament for adoption that would include a National Adaptation Strategy. The current NCCS contains projections and incentives concerning adaptation in the following sectors: natural environment, health, water management, agriculture, crop and livestock management, forest management, regional development, human/built environment. NCCS II would add to the list regional development, urban planning, green infrastructure, critical infrastructure and tourism. Currently there is no system in place for monitoring mainstreaming of adaptation into specific sectorial policies, or assessing adaptation actions that are being implemented.

The **Irish** Department of Communication, Environment and Climate action has been building the National Adaptation Framework (NAF) ([176]) upon the substantial work already carried out under the existing National Climate Change Adaptation Framework

(174)
(175) See for example the Urban Strategies to Combat Climate Change (www.stadtklimalotse.net)
(176)http://www.dccae.gov.ie/en-ie/climate-action/topics/adapting-to-climate-change/national-adaptation-framework/Pages/default.aspx(177)http://www.minambiente.it/sites/default/files/archivio/allegati/clima/strategia_adattamentoCC.pdf

(NCCAF, 2012), and it will deliver the draft version by the end of 2017. The NAF will set out Ireland´s first statutory strategy for the application of adaptation measures in different Government sectors, pointing out risks and potential opportunities of Climate Change at regional level. It has been designed according to EU and international best practices. The current framework (2012) requires the development and implementation of sectoral and local adaptation plans, using the document as general guidance about the policy to be pursued. The framework does not identify specific adaptation measures or projects in relation to sectors, which will be developed with regional and local authorities. Adaptation plans are prepared regionally with national guidance; urban adaptation is still a new topic for local authorities and many cities are still developing their Climate Change strategies.

In **Italy**, the Ministry of Environment is responsible for the implementation of the National Adaptation Strategy (NAS) ([177]), which provides guidance for regional and local adaptation actions. The survey showed that only 1 of 35 cities sampled has an adaptation strategy, which in part is due to the lack of guidelines from national and regional levels and to the delay of the Italian government in developing its NAS ([159]). Nonetheless, there are some interesting examples of front-runners in this field, at regional (e.g., region of Lombardy within the Region Adapt initiative) and local (e.g., cities of Bologna, Ancona, Padua) levels. Bologna developed the Bologna Local Urban Environmental Adaptation Plan for a Resilient City (BlueAp), financed by the LIFE+ programme, by taking into account the potential impacts of Climate Change and the role of key stakeholders in increasing resilience. The selected adaptation measures will be included in existing urban planning instruments, such as the structural plan (PSC) or the building code (RUE). According to another survey conducted in 38 Italian cities before the definition of the NAS ([178]), about two thirds of them had adopted measures to cope with extreme weather events and their consequences. It is a clear indication that cities were able to independently manage adaptation issues, even in the absence of a national guidance; some of them (Padua) developed adaptation plans thanks to their involvement in EU funded projects. According to the Covenant of Mayors for Climate and Energy website, Italy hosts by far the largest number of cities that signed the initiatives (see **Error! eference source not found.**) demonstrating the engagement of local authorities with climate related issues and a need for technical and economic support to develop their adaptation strategy.

Latvia ([172]) is expected to finalise its National Adaptation Strategy (NAS) to climate change, including an Action Plan up to 2030 in 2018. Climate change risk an vulnerability assessments, cost-benefit and cost-effectiveness assessments for adaptation measures were developed in 2017 for the most vulnerable sectors, which include biodiversity and ecosystem services, forestry and agriculture, tourism and landscape planning, health and welfare, building and infrastructure planning, civil protection and emergency planning. The draft NAS includes an adaptation monitoring, reporting and evaluation system with 32 adaptation indicators and 38 climate change parameters.

Lithuania adopted a 'Strategy for National Climate management Policy 2013-2050' in 2012. An Interinstitutional Action Plan on the implementation of the goals and objectives of this Strategy was adopted for the period of 2013-2020. The following priority sectors have been identified: energy, transport, industry, agriculture, landscape, spatial planning, ecosystems and biodiversity, fisheries and aquaculture sector, forestry, tourism, groundwater resources, and waste management. Every two years, the Government of the Republic of Lithuania prepares a report on the implementation of the Strategy. The outcomes of the monitoring, reporting and evaluation scheme will feed into further development of the Action Plan and the update of the Strategy.

(177)http://www.minambiente.it/sites/default/files/archivio/allegati/clima/strategia_adattamentoCC.pdf
(178)Giordano, F., Rizzitiello, F., Ndong, C. and Scaramella, A., 2014,'Adattamento ai Cambiamenti Climatici nelle Città Italiane: Risultati del Questionario ISPRA', in: Focus sulle città e la sfida dei cambiamenti climatici, ISPRA — Istituto Superiore per la Protezione e la Ricerca Ambientale, Rome, Italy

Luxembourg's Council of Ministers adopted a National Adaptation Strategy on Climate Change in 2011, prioritising four sectors: biodiversity, water, agriculture and forestry. Currently a new, more comprehensive adaptation strategy is being elaborated. It will list concrete measures mostly in those areas that are the most impacted by higher and erratic rainfalls as well as by river flow regimes: drinking water, agriculture, viticulture, biodiversity, energy, buildings and infrastructure, navigation, health, tourism and other domains. No National Adaptation Plan has been adopted, nor has a Monitoring and Reporting Framework been developed.

In **Malta**, the current Maltese National Adaptation Strategy was adopted in 2012. The 2015 Climate Action Act formalises the requirement to maintain a strategy that is reviewed and updated at least every four years. Several sectorial action plans are available, covering the most vulnerable sectors, which are water resources, infrastructure and land use, natural ecosystems, agriculture and fisheries, health, civil protection immigration and vulnerable groups, and finally tourism. Monitoring of adaptation measures is done through the screening of Malta's National Environment Policy under the sections related to climate change, while monitoring on the strategy implementation is done by the sectorial focal persons on the Inter-Ministerial Committee on Climate Change. Malta has initiated the process of developing a national Low Carbon Development Strategy (LCDS) which, given, the particular specificities of the country and in view of being a vulnerable island in the Mediterranean, will also incorporate the National Adaptation Strategy.

The Netherlands has a National Climate Agenda: "resilient, prosperous and green" ([179]), which outlines a climate strategy focused on assembling a broad-based coalition to address climate related issues (theme 1) and adopt an integrated approach based on adaptation (theme 2) and mitigation (theme 3) measures. Local authorities are responsible for urbanization policies and development plans, while regions only act to define the balance between green and built environments. The national Delta Programme handles strategic adaptation planning related to rising sea level, water supply and quality issues. This national initiative can hinder the interest of local authorities in developing urban adaptation plans, as demonstrated by the fact that only Rotterdam has a detailed adaptation plan.

The 'Polish National Strategy for Adaptation to Climate Change by 2020 with the perspective by 2030' was adopted by the **Polish** government in 2013([172]). Risk assessments have covered the following sectors: agriculture, forestry, biodiversity, human health, water, coastal areas, mountain areas, transport, energy, built environment, and spatial/urban planning. Many other strategic documents, at national, regional and local levels, highlight the importance of climate change adaptation in Poland (e.g. the Strategy for Responsible Growth, the National Environmental Policy 2018 – 2030, and Energy Security and Environment – perspective up to 2020). On a subnational level, a prominent ongoing initiative will develop action plans for 44 cities above 100 000 inhabitants. The NAS 2020, alongside the strategic objectives, sets out a number of relevant monitoring indicators, but no systematic framework has been developed and monitoring of the strategy, although foreseen, has not been undertaken yet. Monitoring and evaluation of NAS 2020 was commenced in 2017 and a comprehensive monitoring system for adaption policy is currently being developed in connection with work on the National Environment Policy 2018 – 2030. The monitoring and evaluation system is anticipated to be adopted by the end of 2018 or early 2019.

In **Portugal**, a First National Adaptation Strategy (ENAAC) was adopted in 2010 (2010-2015) and revised in 2015 (ENAAC 2020 for 2015-2020). There is a significant shift towards the development of Local Adaptation Strategies, with the project ClimAdaPT. Local having led to 27 local adaptation strategies. A National Adaptation Action Plan (NAP) is currently under development based on the selection of actions foreseen in the

(179)

biannual activity planning from some sectors and transversal areas. Nine priority sectors have been identified: agriculture, biodiversity, economy, energy, forests, health, safety of people and assets, transport and communications, and coastal areas/sea. Presently the monitoring has been guaranteed for reporting purposes through ENAAC's Coordination Group. A more formal procedure is addressed in ENAAC 2020 in order to establish a monitoring and review system for the overall adaptation process, particularly with close collaboration with sectorial groups following a mainstreaming approach.

In 2016, **Romania** adopted its 2016-2030 National climate change and low carbon growth strategy and an associated 2016-2020 National action plan on climate change – each of them with distinct adaptation components. The sectors covered are: agriculture and rural development, water resources, infrastructure and urban planning, transportation, industry, energy, tourism, forestry, biodiversity, education, insurance, public health and emergency response services. Reports on the implementation of the NAS/NAP have so far not been published. Apart from the regular implementation progress report on the action plan, which is to be provided according to the strategic environmental assessment permit, no specific monitoring framework has been provisioned. Romanian cities signed up for the more ambitious 2030 Covenant of Mayors, for objectives covering both mitigation and adaptation.

Slovakia adopted its National Adaptation Strategy (NAS) in 2014. An update is foreseen in 2018. To date, no specific national adaptation plan (NAP) has been adopted, though some adaptation actions are included into existing sectorial strategies and plans for water management, agriculture and forestry. Some adaptation plans have been also adopted on a local level. Regardless of which, the NAS proposes a set of adaptation measures in the following sectors: geological environment, water management, biodiversity, urban environment, health, agriculture, forest management, transport, energy, tourism, and disaster risk management. Progress on the NAS is periodically reviewed, and the Government adopted a progress report in 2016, containing a mostly qualitative assessment of undertaken adaptation efforts. A more detailed Monitoring and Reporting Framework has yet to be developed. Adaptation measures with positive impacts on public health are considered to be a top priority.

Slovenia ([172]) has a National Adaptation Strategy in place, developed through its Strategic Framework for Climate Change Adaptation. Adopted in 2016, the Framework provides a long-term vision and strategic guidelines for adaptation-related activities. Slovenia is currently in the process of developing a National Action Plan (NAP) based on a comprehensive national Climate Change Vulnerability Assessment. Sectors that have devoted most attention to climate change adaptation action are water management (and associated risks of flood and drought), agriculture and forestry. No monitoring and reporting framework is operational to date.

Even though the 3rd Work Programme (2013) of the **Spanish** National Plan for Adaptation to Climate Change (2006) pointed out the importance of adaptation at local level, only a few cities in Spain included adaptation in their climate strategies (19% of Spanish sample), and only Zaragoza developed a strategy exclusively for adaptation. The National Plan provides the guidelines, but the high level of decentralization and devolution to the 17 regional governments gives regional and local authorities most of the responsibilities for Climate Change policies, water basin management, spatial planning, and others, demanding tight coordination between these two levels of governance. The province of Barcelona and its council support smaller cities in their climate strategies, work in close cooperation with the Catalonian government as well as with the metropolitan region of Barcelona, and foster experience exchange and the optimization of existing resource use ([159]). The national guidance does not seem to play an active role in promoting adaptation.

The **Swedish** policy for adapting to climate change is laid out in the 2008 bill 'An Integrated Climate and Energy Policy' ([172]). Adaptation policy efforts are supported by a range of strategic documents and action plans that are implemented at national, regional and local levels. Several government agencies/national authorities have developed action

plans of their own. The sectors that are pointed out in the Swedish strategies are related to critical societal functions: biodiversity and ecosystem services, fresh water supply, health, infrastructure, rural businesses, technical supply systems, and urban areas. An assessment report on the Swedish climate change adaptation strategy and the actions being taken since 2007 was completed in 2015, and Sweden expects to adopt a National Adaptation Strategy in 2018. Since 2009, the administrative boards of the regions (County Administrative Boards) are responsible for climate adaptation at regional level and supporting the adaptation work of municipalities. All 21 regions have undertaken climate impact studies and adopted regional action plans. While some monitoring is currently undertaken on a regional level, a national system for evaluation and monitoring is currently being developed.

In **United Kingdom** (UK) the Climate Change Act ([180]) puts in place a policy framework to promote adaptation in the UK. It consists of: i) a 5-year climate risk assessment for UK key sectors; ii) the National Adaptation Programme, which defines the national strategy for addressing the main climate risks; iii) the UK Adaptation Reporting Power, which enables the Secretary of State to require public service organizations to produce reports on what they are doing to adapt. The Climate Change Act has proven to be an effective framework for soliciting local authorities to establish policies to adapt to and mitigate Climate Change. This has resulted in the highest level of integration of adaptation into planning processes, with 24 cities (80 % of UK sample) having an adaptation strategy.

Table 38 points out that European cities show very different degrees of commitment to adaptation, and varying means of integrating their strategies into wider national or regional frameworks. The causal relationship between higher levels of governance and local action is often unclear, and it is not possible to define a common pattern for European countries. In most cases, national adaptation strategies act as a guide for regional and local adaptation. Legal obligations and requirements have proven to be an effective stimulus for adaptation in the UK, but this is not observed in France. In some countries, rules and standards at national or regional levels could limit local action by transferring climate risk management (e.g., floods) to the higher levels, or by disabling local adaptation measures (conflicting policies). It is noteworthy that front-runner countries, such as Finland, have higher shares of cities committed to adaptation, if compared with States that only recently adopted a national strategy. On the other hand—among the later ones—Italy hosts many cities that developed their own adaptation strategy independently; Italy also shows the largest number of signatories in the Covenant of Mayors for Climate and Energy initiative committing to mitigation and adaptation targets. In Spain, regional authorities have much more influence on local climate action that the national government.

Cities have demonstrated, in many cases, a proactive role in implementing their own climate strategy to address local vulnerabilities, such as exposure to floods (Italy), storms (Estonia) or heat waves (France). They have delivered detailed adaptation strategies without the support of higher levels of governance; the smaller and mid-size cities often have to be supported by EU funding or by city-network technical assistance.

This confused and diversified panorama of adaptation patterns across EU countries reinforces the need, and highlights the difficulty, of developing and adopting a common European framework for Member States able to integrate adaptation and different interests and peculiarities across local, regional and national scales.

Table 38. National, regional and local policies and initiatives targeted to adaptation. Information has been largely based on Heidrich et al. (2016) ([169]) and Reckien et al. (2014) ([163])

Country	Existing policies	Considerations

(180) https://www.theccc.org.uk/tackling-climate-change/preparing-for-climate-change/uk-adaptation-policy/

Austria	National Adaptation Strategy	NAS covers 14 sectors, including cities. Climate Planning is centred at national level. Rare examples of adaptation at local level
Belgium	National Adaptation Strategy; regional adaptation plans	Adaptation centred at Federal and regional levels. Local adaptation policy is still in an incipient phase
Estonia	Development Plan for Climate Change Adaptation until 2030	Adaptation planning centred at national level.
Finland	National Adaptation Strategy (front-runner in EU); many cities adopted an adaptation strategy	National guidance influence and enable local adaptation.
France	National Climate Plan and Grenelle law (national); the Regional Climate, Air and Energy Schemes; some cities independently managed adaptation (e.g. heat wave plans)	Despite the strong guiding role and the legal obligations, national framework does not automatically trigger local adaptation.
Germany	National Adaptation Strategy and National Adaptation Plan; National Climate Protection Initiative	Climate change policies and planning are responsibilities of Federal and State government; adaptation is partially implemented on German territory even though national/federal frameworks recognized the importance of local action.
Ireland	National Climate Change Adaptation Framework and NAF	Adaptation policies are developed regionally with national guidance. Urban adaptation is still a novel for most local authorities
Italy	National Adaptation Strategy; regional adaptation plans; city adaptation plans	There are many front-runner initiatives at regional level (e.g., Lombardy in the EU Region Adapt) and city level (e.g., Bologna) that developed adaptation strategies before the adoption of NAS.
The Netherlands	National Climate Agenda: "resilient, prosperous and green"; Delta Programme; few urban adaptation plans.	Only Rotterdam has a detailed adaptation strategy. Some important issues, such as flood control, are addressed at national level, which can hinder local action.

Country	Existing policies	Considerations
Spain	National Plan for Adaptation to Climate Change; some cities have adaptation strategy	High level of decentralization and devolution to regions and provinces. Adaptation is still a new issue for most cities, which are developing their climate plans in close collaboration with regional authorities
United Kingdom	Climate Act (National Adaptation Programme; UK adaptation Reporting Power)	Legal obligations and effective monitoring/reporting encouraging cities to develop local adaptation strategies. Adaptation is highly integrated into urban development plans

Source: JRC elaboration.

11.6 Recommendations

Table 39 summarizes the main recommendations emerging from the previous chapters for improving multi-level governance of local adaptation action.

Table 39. Recommended measures to improve multi-level governance, according to the main gaps emerging in the previous chapters

Actor	Recommended Measures
EU level	Define a coherent framework to help mainstream adaptation into national and regional policies, helping to optimize possibilities of synergies with other policy areas and exploiting co-funding opportunities. A common EU framework of vertical governance could help reduce differences among MS in terms of their commitments to adaptation, and bring together the numerous uncoordinated initiatives across Europe
	Ensure that local adaptation policies can be tackled by all cities, including cities in the less developed economies of EU (mainstreaming adaptation into Cohesion Policy)
	Develop a common reporting system for national, regional and urban projects on adaptation to Climate Change by defining the list of indicators, criteria and standards for reporting and assessment, among others
	Further explore the possibility of leveraging private sector investments within cities (especially for infrastructure development)
	Provide capacity building and training for national, regional and local authorities to improve their understanding of Climate Change impacts and their commitment to adaptation. Enhancing technical skills of local authorities may increase their capacity to access different funding opportunities at international, EU, national and regional levels.

Actor	Recommended Measures
National level	Establish clear coordinating procedures between national and subnational governments (vertical governance) and coherent national legal frameworks in order to enable local adaptation actions
	Include the spatial aspect of Climate Change impacts (e.g., according to administrative units) in national strategies (usually shaped according to policy sectors)
	Use national budgets to support local adaptation and provide technical support to access EU funds and other financing mechanisms
	Establish national communication programmes on Climate Change and support national data sharing and good-practice exchange on adaptation issues
	Include a dedicated chapter about urban issues in the NAP/NAS, defining adaptation targets, local responsibilities and funding targeted to adaptation
	Improve mainstreaming adaptation into country sectoral strategies (e.g., health, transport, water management, among others), in order to optimize synergies and explore further funding opportunities (horizontal governance across sectors)
Regional level	Define a regional legal framework to coordinate inter-municipal adaptation strategies
	Support smaller cities to develop their adaptation strategies through capacity building, regional data sharing and participatory processes with a broad range of local and regional stakeholders from public and private sectors thus pooling capacities and resources
	Foster cooperation between Mayors Adapt and Region Adapt, in order to provide a common monitoring and reporting system on adaptation
City level	Define a horizontal governance to foster inter-agency and cross-sector collaboration on adaptation, define accountability and leaderships, avoiding policy trade-offs and spill-over effects, and improve use of resources
	Create a local/regional platform (or/and communication channels) to share knowledge and data about Climate Change impacts and vulnerabilities across different sectors, with higher resolution available (downscale to local context)
	Foster participatory processes with local communities (especially the most affected and vulnerable by Climate Change impacts) and private sector actors increasing their engagement in decision-making processes and data/knowledge exchange

11.7 Key adaptation measures for climate hazards

Climate change will increase the frequency and intensity of extreme weather and climate events in different regions of the world; hence, more extensive damages and losses from weather-related disaster are expected. There are, at least, nine types of climate hazards that could potentially affect negatively societies, its economies and the environment: extreme heat, extreme cold, extreme precipitation, floods, sea level rise, droughts, storms, landslides, and forest fires (however, other hazards may also be listed, such as vector-borne diseases).

These hazards may be considered as a climatic risk only if something of value is at stake, such as demographic, financial, infrastructure, cultural and heritage assets, among others. The gravity of risks depends on the vulnerability of the impacted system and its adaptive capacity. For example, whilst urban inhabitants may be all equally exposed to extreme heat, those inhabitants living in poorly isolated buildings would be more vulnerable than those living in bioclimatic houses.

The exposed/vulnerable sectors - such as buildings, transport, energy, water, waste, agriculture and forestry, biodiversity, health, among others - may be possibly impacted with different levels of severity (low, medium, high) and over different time periods (e.g.: short-term, medium-term, long-term).

Whilst mitigation climate action is meant to reduce greenhouse gas emissions and, therefore, oriented to reduce global warming and hence the potential climatic hazards, adaptation action is focused on improving the resilience of the systems at stake through target investments in infrastructure development, planning, monitoring and early warning system, awareness and education, amongst other. The following boxes present several examples of successful adaptation actions, accompanied by a table summarising examples found in the literature (see also Annex 2).

Providing ventilation corridors and green spaces helps to lower the temperature and, hence, to deal with **heat waves**.

Box 46. Green spaces and urban corridors in Stuttgart, Germany

Due to Urban Heat Island effect, the inner city is 0.9 degrees Celsius hotter than its surroundings – an effect that is likely to increase in the future. In order to reduce the average temperatures and help dilute airborne pollutants and smog, ventilation corridors have been provided.

Ventilation corridors are basically areas without buildings. The open corridors allow for the inflow of cooler air from surrounding areas to the inner city.

The positive effects of the 'cooling corridors' have led to implementation of this strategy in the local Land Use Plan. At this moment green areas cover more than 60 percent of the Stuttgart's surface area and 39% of the total area of the city is protected through landscape and nature conservation laws.

http://climate-adapt.eea.europa.eu/metadata/case-studies/stuttgart-combating-the-heat-island-effect-and-poor-air-quality-with-green-ventilation-corridors

On the contrary, a **cold wave** is a rapid fall in temperature that for example may lead to ice formation on road infrastructure which reduces the road safety by increasing the number of crashes.

Box 47. Fixed in-road Anti-icing Spray Systems in Minnesota, US

To reduce ice formation on road infrastructure a control computer with specific software has been connected to temperature values. The control computer continuously polls the environmental sensors to gather data used to predict or detect the presence of black ice or snow. When predetermined threshold values are met, the computer automatically activates flashing beacons on bridge approach ramps to alert motorists, checks the chemical delivery system for leaks, and initiates one of 13 spray programs. Each program activates different valves, in various spray sequences, at different spray frequencies based upon prevailing environmental conditions. An average spray cycle dispenses 34 gallons (128.7 litres) of potassium acetate (i.e., 12 gallons or 45.4 litres per lane mile) over ten minutes. At the end of each winter season the anti-icing system is inspected and reconfigured to spray water instead of potassium acetate. Over the summer, the system is manually activated on a monthly basis to ensure proper operation of the pump and delivery. The system is re-inspected in the fall before being configured for anti-icing during winter operations. In the first year of operation the automated anti-icing treatment strategy significantly improved roadway safety through a 68-percent decline in winter crashes. Mobility enhancements resulted from reduced traffic congestion associated with such crashes. Installing the bridge anti-icing system also improved performance by lowering material costs and enhancing winter maintenance operations throughout the district.

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Floods can be produced from many sources caused by multiple mechanisms. Climate change is expected to significantly impact on extreme precipitation events frequency and magnitude and on temperature (important for snowmelt). Moreover, human modifications of the basin areas, land use change and anthropological pressure on the rivers are consistently impacting on the retention and drainage capacity of the catchment areas which may lead to an increase of surface runoff ([181]). Between 1998 and 2009, Europe suffered over 213 major damaging floods. Severe floods in 2005 further reinforced the need for concerted action. In order to integrate the measures into new and existing developments in the flood prone areas, spatial planning approaches have been used, especially when a holistic, risk-based approach is taken. Spatial planning is not only useful in developing flood risk management plans, but also to facilitate communication between stakeholders, enhance participation and reduce conflicts and improve the urban environment.

Box 48.
I) Flood defence solutions for the Scheldt Quays in Antwerp, Belgium

The aim of the project is to protect population and assets from sea level rising combining also urban renovation. Antwerp stands before the largest renovation project the Scheldt Quays have ever been subjected to, combining flood defence solutions with the renewal of public space and the restoration of the historic quay wall. The first projects have been initiated and the complete Master Plan will probably be realised in 2030. The flooding sensitivity has been reduced from 1/70 years (beginning Sigma plan) up to 1/4,000 years in 2030 (at the end of the renovation). The action implementation costs are about 44 million €.

https://www.covenantofmayors.eu/about/covenant-community/signatories/action-plan.html?scity_id=1586

(181) https://climate-adapt.eea.europa.eu/metadata/adaptation-options/adaptation-of-flood-management-plans/#websites

II) Lower Danube green corridor, Bulgaria, Romania, Ukraine and Moldova

In recent years (e.g. 2005 and 2006), severe floods occurred along the Lower Danube River. Even more frequent flooding is anticipated with Climate Change. A large part – about 80% - of Danube's wetlands has been lost in the past century because of human intervention. The construction of dikes reduced the size of the river's floodplains considerably. In addition, large parts of the Danube are experiencing river bed erosion due to gravel extraction, dredging and dams, contributing to a lowering of water tables on adjacent agricultural lands. In the "Lower Danube Green Corridor Agreement" it was agreed by the governments of Bulgaria, Romania, Moldova and Ukraine to restore 2,236 km^2 of floodplain to form a 9,000 km^2 Lower Danube Green Corridor. Once restored, these lands will be of similar scale as the area inundated in the 2005 and 2006 floods. As of 2012, 600 km^2 of floodplain has been restored or is undergoing restoration; and enhancing flood protection and local peoples' livelihoods through the strengthening of ecosystem services and nature conservation. The goal of this action is to protect and restore wetlands along the river and reconnect the river to its natural flooding areas, reducing the risks of major flooding in areas with human settlements and offering benefits both for local economies – e.g. through fisheries, tourism – and for the ecosystems along the river. Most flood plain restorations have been achieved by removing sections of dykes. During the 2013 flood in the Danube along the lower Danube there was no flooding, although the water level was above average. The flood peak decreased downstream of the Iron Gates dam, which was also due to the dam's operations. The action implementation costs are about 183 million euros.

https://climate-adapt.eea.europa.eu/metadata/case-studies/lower-danube-green-corridor-floodplain-restoration-for-flood-protection/#challenges_anchor

Drought has been a recurrent feature of the European climate. From 2006–2010, on average 15 % of the EU territory and 17 % of the EU population have been affected by meteorological droughts each year. The severity and frequency of meteorological and hydrological droughts have increased in parts of Europe, in particular in south-western and central Europe. Droughts have severe consequences for Europe's citizens and most economic sectors, including agriculture, energy production, industry and public water supply. Measures aimed at reducing water demand and increasing public awareness are decisive in advancing resilience to future droughts and water scarcity associated with Climate Change ([182]).

Box 49. Drought and water scarcity in Zaragoza, Spain

Zaragoza stands on a semi-arid region with an average annual precipitation of only 314 mm, with water shortage and drought being a problem (e.g. early 1990's droughts). In the future, the number of consecutive dry days is projected to increase significantly in southern Europe, in particular in summer, thus possibly exacerbating the problem of water scarcity in this region. With the aim of reducing water demand and the leakage from the distribution networks, awareness campaigns and economic incentives were set up for behavioural change. Water restrictions and consumption cuts and leakages from the city's aging water supply pipeline were reduced. A progressive reduction of water consumption was obtained: from 180 l per capita per day (lpcd) in 1980, through 136 lpcd in 2000, to just under 100 lpcd in 2010. In terms of the overall water savings, the city exceeded its own target: in 2009 total water consumption was 59.9 Mm^3. Thus, 15 years after the start of the campaign, the city achieved a reduction of water consumption by almost 30 %, despite a 12 % population increase in the same time. The approximate cost of the awareness campaigns between 2002 - 2010 was around 2.5 million euros.

https://climate-adapt.eea.europa.eu/metadata/case-studies/zaragoza-combining-awareness-raising-and-financial-measures-to-enhance-water-efficiency

Fire risk depends on many factors, including climatic conditions, vegetation, forest management practices and other socio-economic factors. Climate change projections suggest substantial warming and increases in the number of droughts, heat waves and dry spells across most of the Mediterranean area and more generally in southern Europe. These projected changes would increase the length and severity of the fire season, the

(182) https://www.eea.europa.eu/

area at risk and the probability of large fires ([182]). Actions such as reforestation and tree planting can prevent fires.

Box 50. Forest Fires, Cascais, Portugal

Forest Fires are very common in Portugal and in this city. In the future, increasing temperatures and decreasing precipitations can increase the fire danger conditions. To reduce the fire hazard conditions and prevent the occurrence of forest fires, Cascais considered as key measures planting and reforestation actions to prevent the spread of invasive species and reduce fire hazard and implementing fire hazards plans. These measures are ongoing and the approximate investment costs between 2016-2030 should be around 6.8 million euro.

https://www.covenantofmayors.eu/about/covenant-community/signatories/action-plan.html?scity_id=1869

Landslides are a major hazard in most mountainous and hilly regions as well as in steep river banks and coastlines. Their impact depends largely on their size and speed, the elements at risk in their path and the vulnerability of these elements. Every year landslides cause fatalities and result in large damage to infrastructure and property. Landslides occur in many different geological and environmental settings across Europe, population expansion into landslide-prone areas is raising landslide risk in Europe. In addition, an increase of landslides associated to extreme rainfall events is expected in the future due to Climate Change ([183]).

Box 51. Multi-Hazard approach to early warning system in Sogn og Fjordane, Norway

Sogn og Fjordane is a coastal, mountainous region of Norway that boasts hundreds of thousands of tourist visits annually. Several communities in Sogn og Fjordane are facing numerous hazards such as flooding, avalanches, rock slides and other extreme weather events that might be exacerbated by Climate Change. Great distances between peripheral communities and not accessible transport and communication infrastructure can make accessibility inadequate, thus making communities more vulnerable to extreme weather events. The potential for an effective, reliable and cost-efficient early warning system that has a multi-hazard approach and makes use of location and population-based communication technologies, such as mobile phones and social media has been explored. In order to establish a cost-effective and sustainable early warning system, multi-hazard approach is a prerequisite, to share the costs among different scopes. The system and operational activities must be established within a framework that considers the warning needs of all undesirable events and hazards and the requirements of various end-users. The system is based on already available modern technology and infrastructure, and anchored to existing legislative and institutional frameworks. This project demonstrated how an existing county-encompassing organization could be used to issue the population warning. As this organization is closely coordinated with the police whilst being an inter-municipal organization, it is suited for the issuing of both non-emergency and emergency warnings with a multi-hazard approach. Moreover, it has been investigated how modern technology can help reduce the negative consequences of weather related hazards in current and Climate Change conditions, thus also helping to prevent the loss of lives. The action implementation costs are about 105.000 euros.

https://climate-adapt.eea.europa.eu/metadata/case-studies/multi-hazard-approach-to-early-warning-system-in-sogn-og-fjordane-norway

(183) https://esdac.jrc.ec.europa.eu/themes/landslides

12 Final considerations

Cities are home to more than 70 % of the European population, host important infrastructure and financial assets, and are the centres of technological innovation and private sector initiatives that guarantee the economic activity of Europe. Cities will have to play a leading role in addressing Climate Change impacts, including the potential consequences for numerous high value assets. This leadership role should be recognized by the higher levels of governments. A city is embedded in a wider legal framework, and a robust multi-level governance of climate related issues is needed to tackle Climate Change challenges in a coherent and cost-effective way. Cooperation across different spatial scales demands clear accountability among the main actors: Europe, Member States, regions and cities. European and national levels have to support adaptation by:

- i) providing transparent legislative frameworks to mainstream adaptation into sectoral strategies, developing programmes targeted at Climate Change adaptation, or guiding local authorities across the numerous existing uncoordinated EU initiatives;
- ii) raising awareness, sharing knowledge, and ensuring effective uptake of main research outcomes by local authorities, including by facilitating region-to-city and city-to-city cooperation;
- iii) guaranteeing appropriate funding, including provision of technical support to access the existing funds, and helping to define new business models for adaptation (by assessing which options and directions make economic sense) (See Part III).

Moreover, cities cannot fulfil their Climate Change leadership potential without an internal transformation. That implies a new horizontal cooperation among local stakeholders, including public sector (e.g., municipal agencies, universities), private sector (e.g., urban service and utility providers, investors) and citizen networks. Creating an "enabling environment" for adaptation is a key-issue at the local level and demands a deep change in the way local authorities deal with climate related issues. Local decision-makers often focus on immediate benefits of a measure that fits into their political agenda, whilst adaptation is known to have long-term benefits; local authority's departments usually work in separate silos to comply with the agenda of a specific policy area, instead of promoting a holistic and integrated approach that could mainstream adaptation into urban sectoral strategies, maximizing resource use and co-benefits. Adaptation (and mitigation) should be a core element in urban planning and design in order to increase the urban capacity for coping with Climate Change impacts in the long term, independently of any electoral timeframe.

A clear multi-level framework should guarantee that local authorities could connect city priorities and strategies with national and federal legislation and programmes to match actions and obtain the financial and technical support they need to implement climate action in their territory. European cities show very different degrees of commitment to adaptation, and varying means of integrating their strategies into wider national or regional frameworks. The causal relationship between higher levels of governance and local action is often unclear, and it is not possible to define a common pattern for European countries. It is reasonable to say that stronger national guidance and legal obligations, including monitoring and reporting, would contribute to triggering adaptation in European cities - following the example of UK and Finland. Fast-track access to financing mechanisms for local authorities committed to adaptation would be an important incentive to go ahead with the implementation of effective climate action, overcoming the scarcity of resources (and the difficulty of accessing them) which still represents one of the main obstacles to local adaptation. Mitigation is more advanced than adaptation in almost all cities in Europe; effective communication of robust scientific evidence of climate risks in site specific contexts (and the expected costs of inaction) will guarantee the uptake of the main research outcomes by local authorities, contributing to the creation of an "enabling environment" for adaptation strategies at local level.

Part 3 C:
Financing Sustainable Energy and Climate Action Plans

13 The role of local authorities in financing

The successful implementation of Sustainable Energy Action Plans (SECAPs) requires sufficient financial resources. It is, therefore, necessary to identify available resources, schemes and financial mechanisms. Local authorities (LAs) play a key role in this framework, since they drive the low carbon transition of their cities and, therefore, must take into account the financial resources when joining the Sustainable Energy Action Plans program. Successful SECAP actions will reduce the long-term energy costs of the local authority, the inhabitants, companies, and in general all stakeholders. When considering the costs of SECAP actions, local authorities should also take into account their co-benefits. These not only regard health, quality of life, employment and local attractiveness, but also economic aspects (such as the return on the investments).

Energy-efficiency financing decisions must be compatible with public budgeting rules. For example, the cash generated by energy-efficiency improvements and reductions in the energy bill may lead to a reduction of financial resources in the following budgeting period. This is due to the fact that most often EE projects are financed via capital expenditure budgets, where energy bills are paid from operational budgets. The local authority should allocate the necessary resources in the annual budgets and make firm commitments for the years to come. As local authorities' resources are scarce, there will always be competition for available financial funding. Therefore, efforts should be continuously made to find alternative sources of resources. Regarding multi-annual commitment, different political parties should give their approval by consensus in order to avoid disruption in the development of the SECAP when a new administration is elected. Local authorities may be induced to opt for energy-efficiency projects with short paybacks. However, this approach will not capture the majority of potential savings available through energy retrofits. Instead, it is recommended that all profitable options are included and, in particular, those that yield a rate of return higher than the interest rate of the investment capital. This approach will translate into greater savings over the long term. Quick paybacks on investments mean too often that organisations do not pay attention to "life-cycle costing". Payback time shall be compared with the lifespan of the goods to be financed. For instance, a 15 years payback time cannot be considered long when it comes to building with a lifespan of 50-60 years.

The recently published opinion "Towards a new EU Climate Change adaptation strategy—taking an integrated approach" by the European Committee of the Regions ([161]) (COR, 2017) pointed out that accessing to EU funding supporting Climate Change action is still the main challenge faced by cities and regions in implementing an adaptation strategy. The first steps of most urban adaptation plans are usually supported by external funding or private donor organizations in the form of research projects. Most of these funds are tailored to specific project goals (e.g., Vulnerability Risk Assessments) and run out after the project completion date, representing a constraint to the progressive implementation of adaptation strategies and their long-term objectives ([184]).This calls for EU support to local authorities in accessing funds at international, EU, national and regional levels. With a clear guidance, local authorities should leverage private sector investments and channel them to urban adaptation, promoting public-private synergies and guaranteeing secure financing.

Numerous barriers impede the development and implementation of sustainable actions in cities. In the following chapter these are illustrated along with ways LAs can address these issues and eventually secure the appropriate source of funding throughout implementation.

(184) Ricardo AEA, 2013b. State of Play –Impacts vulnerability and adaptation in European cities. Appendix 7 to Adaptation strategies for European Cities - Final Report for DG Clima. pp.70

14 Challenges for local authorities

Local authorities may face a number of challenges when considering the implementation of urban sustainable projects that has an impact on the environment, the climate, the citizens and the city itself.

The main obstacles for Local and Regional Authorities when dealing with climate finance mechanisms might arise in terms of:

1. Lack of awareness about climate finance options: Local Authorities lack knowledge of all the options of financing schemes available. There are existing initiatives that try to tackle this problem such as 'one-stop shops', which provide comprehensive information about the different financing options available for energy efficiency (EE) in the EU, the opportunities to set up innovative financial instruments at the local level and offer technical and financial expertise on how to access and manage such sources. Another fact is that LRAs usually rely on public funds and are unaware of other financing tools such as blending facilities, revolving funds and green bonds. The identification of the most suitable instrument is quite difficult for investments that are already in action while new financing opportunities can possibly arise. In this case, sometimes already in action investments are not labelled as such in order to be supported by funding mechanisms from various sources and levels of government.
2. Insufficient administrative capacity and technical knowledge: the preparation of applications and securing financing can be challenging. There are practical issues in this point such as the fact that the applications for centrally-managed EU funds should be prepared in English and this may require collaborations with organizations from other Member states. The partnerships and the preparation of applications in a different language create time constraints and require a lot of human effort. Unfortunately smaller LRAs do not always have sufficient human resources and skills to prepare such applications. Hence, insufficient administrative capacity is one of the most significant obstacles in accessing climate finance at local level. It has been suggested to LRAs to require expertise in-house as raising public engagement and communications.
3. Budgetary and regulatory constraints: as mentioned before, the funds should be sufficient and available to invest. For instance, the preparation of applications for the EU funds or other financing instruments might require the hiring of new personnel or external consultants which could be really costly especially for smaller LRAs. Additionally, LRAs usually do not take into consideration the expenses that may occur at the last-minute since they plan their financial needs in advance many years ago the actual finalization of the project.
4. Creating bankable projects: A bankable project is a clearly documented economically viable project. Building a bankable project starts with sorting out the pieces that make a project economically attractive. Initially, it is required to examine the project's key components, make sure that each aspect is properly assessed and that the plan to effectively manage that aspect is clearly presented. Each component carries a risk factor, and each risk factor carries a price tag. An effective ESCO or financial consulting expert knows how to assess each part of a financial project. When a financing project is studied by a bank, the objective is to know the level of risk through an assessment procedure. A technical energy audit is not enough for this purpose. Other aspects such as the engineering skills (of an ESCO or the municipal energy agency for instance) or the level of commitment of each part are crucial to making this project attractive for the bank. For instance, some general requirements may be that the technology is well-proven, well

adapted to the region and to produce an Internal Interest Rate greater than 10 % ([185]).

5. Political constraints: LRAs may face political constraints before accessing climate finance. There is always the hesitation that due to restricted funds, it might not be the proper prioritization of needs. This can result in Member states not incentivising and sponsoring EU funds for climate action.
6. Challenges in meeting the requirements of EU or international funds: an issue that often arises is the fact that the thematic nature of financing instruments and the eligibility criteria are usually too prescriptive. This might end up in preventing the realization of synergies between different types of climate action such as the combination of energy efficiency, renewable energy and sustainable mobility ([186]).

There are four main phases of energy efficiency project financing, namely: 1) Project Development; 2) Tender Requirement; 3) Obligations guarantees; 4) Financing; and it is highly recommended the local authority should be able to provide them:

1. Project Development: the local authority should be able to provide or to obtain: Sufficient energy consumption data and street lighting maps; to have sufficient Capital for the upfront development costs, to have staff resources specifically allocated to the project; to have a Long-term commitment and stability.
2. Tender Requirement: it is recommended the local authority should have the know-how of tender procedures, taking national, EU and/or non-EU tender requirements into account; it should have the design knowledge and the technical know-how required; it should have a thorough knowledge of the procurement process linked to energy performance and financing solution.
3. Obligations guarantees: it is highly recommended the local authority should have a high quality guarantee provided by the ESCO/EPC or O&M (Operations & Maintenance) company; it should be able to overcome the obligations under the (existing) O&M structure; it should have a certain degree of savings assurance that should outweigh the perception of risk.
4. Financing: it is highly recommended the local authority should have: sufficient capital available to invest; the project should have a positive financial and sustainable rating; the local authority should have no regulatory constraints, should be in a positive financial situation and should be able to deal with legal requirements; should have no limits to increase its debt capacity level.

(185) Further information on financing http://sefi.unep.org/fileadmin/media/sefi/docs/publications/pfm_EE.pdf

(186) Rossi, L., Gancheva, M. and O'Brien, S. (2017). *Financing climate action: opportunities and challenges for local and regional authorities*. [online] Brussels: European Union. Available at: https://corclimate-adapt.eea.europa.eu/en/documentation/studies/Documents/Financingmetadata/publications/financing-climate-action-opportunities-and-challenges-for-local-and-regional-authorities/cor_2017_financing-climate-action-opportunities-and-challenges-for-lras.pdf

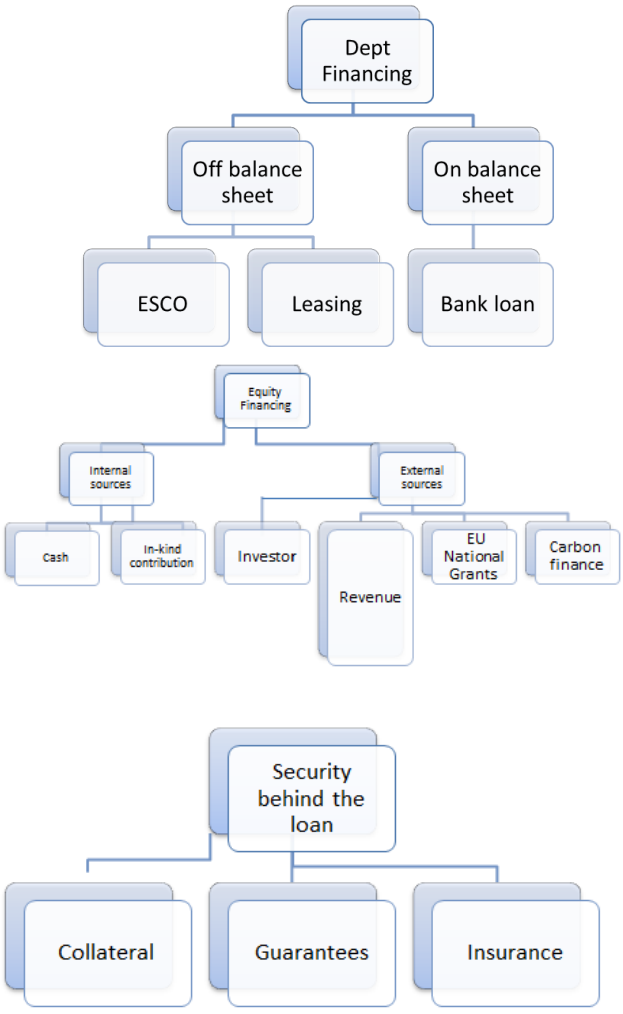
15 Finance mechanisms

Governments can help close the financing gaps, catalyse private investment and accelerate energy efficiency market uptake via financial and non-financial interventions. Given that the large majority of EE technologies are commercially competitive, public financing should pave the way for private financing, rather than substitute it.

There is a wide range of finance mechanisms used by public funds to support energy efficiency. The most common are grants, soft loans, tax incentives, and contracting schemes (e.g. ESCO), as well as some other instruments such as guarantees, venture capital and equity investments, mezzanine finance ([187]) (Figure 10).

Since different EE technologies and different types of organisations require distinct types of finance depending on their particular stage of development, financial instruments are needed along the entire finance continuum from technology/venture/project development to construction and commercial operation.

Figure 10. Capital Structure: Financing Energy Efficiency



Source: Bertoldi, P. (2009). Financing Energy Efficiency ([188])

(187) Bertoldi, P. and Rezessy, S. (2010). Financing energy efficiency: forging the link between financing and project implementation. [online] Ispra: Joint Research Centre of the European Commission. Available at: http://www.konvencijazupanov.eu/IMG/pdf/Financing_energy_efficiency.pdf

(188) Bertoldi, P. (2009). *Financing Energy Efficiency*. Available at: *http://www.kombeg.org.rs/Slike/CeTranIRazvojTehnologija/2011/2011%20Decembar/prezentacije/Paolo_Bertoldi.pdf*

15.1 Financing mechanisms for local energy projects

This section describes the most common financing mechanisms used by local authorities to finance their investments mainly in renewable energy sources and energy efficiency. However, other specific programmes such as European funding are also available.

15.1.1 Grant programs

Investment grants or interest rate subsidies are often provided by governments to support the upfront cost of energy efficiency projects that may entail too high investment costs and long amortisation periods. Investment subsidies increase the financial rate of return on investment, increasing investors' demand for investment. In addition, investment subsidies improve cash flow and thus increase investors' access to debt finance ([187]).

15.1.2 Public grants

Public grant programmes are used in all MS – though to a different extent – in order to support EE projects that contribute to energy and social policies and meet other public policy goals.

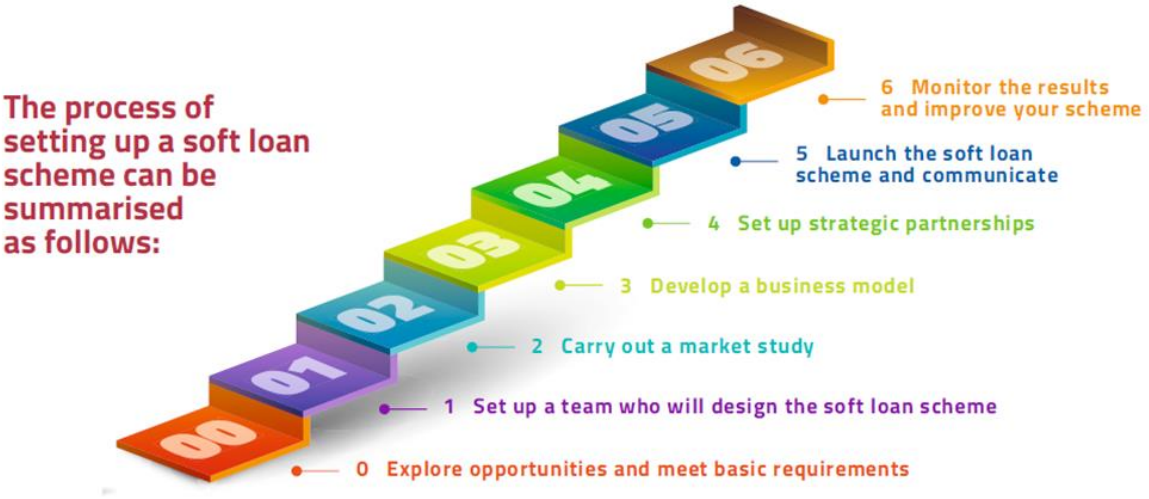
The advantage of public grant programmes is that subsidies can be an important factor in raising the general awareness and trust in EE projects, along with the fact that subsidy level provided is sufficient to attract the building owners. On the contrary, the great disadvantage is that in times of squeezed budgets across the EU, it is often difficult to put aside the necessary budget for subsidies to realise the policy goals. This often places subsidy programs in a stop-and-start operational mode, which may actually delay project implementation encouraging potential project proponents to wait for better grant conditions or for the next funding call. In addition, the share of free riders – beneficiaries that would have implemented their economically sound projects even without the subsidy – is rarely monitored, which makes it difficult to realistically evaluate the effectiveness of a subsidy program. Therefore, comprehensive program packages are needed where public grant programmes interact with other financing schemes deployed by public and commercial FIs in order to increase the investment volume ([187]).

15.1.3 Soft loans

Soft loan schemes which offer below market rates and longer payback periods, and loan guarantees, which provides buffer by first losses of non-payment, are mechanisms whereby public funding facilitates/triggers investments in EPC. They give long-term financial coverage to help bridge the pre-commercialisation financing gap for EE projects by direct subsidies on interest payments, by risk premiums (e.g. an IFI or a state can guarantee a certain amount of loans), or by capital gains to a revolving fund. They are commonly used for energy efficiency measures. Loan conditions include:

- extended payback periods,
- low or zero interest rates,
- short-term interest deferral periods, and/or
- inclusion of payback grace periods ([187]).
- **Figure 11** shows the process of setting up a soft loan.

Figure 11. The process of setting up a soft loan



Source: Cicmanova et al. (2017) ([189])

15.1.4 Third party financing schemes

Perhaps the easiest way for local authorities to undertake comprehensive building energy retrofits is to allow someone else to provide the capital and to take the financial risk. With these alternative methods of financing, high financing costs may be expected to reflect the fact that the debt is registered on someone else's balance-sheet. However, the interest rate is only one factor among many that should be considered in determining the suitability of a project-financing vehicle ([187]).

15.1.5 Leasing

The common way of the market of dealing with the barrier of initial cost is the leasing. Leasing is a way of obtaining the right to use an asset (rather than the possession of this asset). In many markets finance leasing can be used for EE equipment, even when the equipment lacks collateral value. Leasing companies, often bank subsidiaries, have experience with vendor finance programs and other forms of equipment finance that are analogous to EE.

There are two major types of leases: capital and operating. The former usually concerns shorter term leases, the latter transfer the risk to the lessee. Capital leases are instalment purchases of equipment. In a capital lease, the lessee owns and depreciates the equipment and may benefit from associated tax benefits. A capital asset and associated liability appears on the balance sheet. In operating leases the owner of the asset owns the equipment and essentially rents it to the lessee for a fixed monthly fee. This is an off-balance sheet financing source. It shifts the risk from the lessee to the lessor, but tends to be more expensive for the lessee ([190]).The period of contract is shorter than the life of the equipment and the lessor (investor) pays all maintenance and servicing costs.

(189) Cicmanova, J., Turner, I., van Liefland, S., Kaiser, M. and Ethuin, P. (2017). Infinite Solutions Guidebook: Financing the energy renovation of residential buildings through soft loans and third-party investment schemes. [ebook] Brussels: Energy Cities. Available at: http://www.energy-cities.eu/spip.php?page=infinitesolutions_en

(190) www.leaseurope.org/ is an association of car leasing European Companies

Leasing is the most common form of equipment manufacturers' vendor financing, which is often applied in the case of CHP equipment. Leasing is often done as part of a special purpose vehicle (SPV) ([191]).

15.1.6 Energy Services Companies

Energy Services Companies (ESCO) usually finance the energy-saving projects without any up-front investment costs for the local authority. The investment costs are recovered and a profit is made from the energy savings achieved during the contract period. The contract guarantees a certain amount of energy savings for the local authority, and provides the possibility for the local authority to avoid facing investments in an unknown field. Once the contract has expired, the city owns a more efficient building or new energy plant which will imply less energy costs.

Often, the ESCO offers a performance guarantee which can be shaped in several forms. The guarantee can revolve around the actual flow of energy savings from a retrofit project. Alternatively, the guarantee can stipulate that the energy savings will be sufficient to repay monthly debt service costs. The key benefit to the building owner is the removal of project non-performance risk, while keeping the operating costs at an affordable level.

Energy Performance Contracting (EPC) is a contractual arrangement between a beneficiary and an Energy Service Company (ESCO) about energy efficiency improvements or renewables installations. Normally an ESCO implements the measures and offers the know-how and monitoring during the whole term of the contract. Essentially the ESCO will not receive its payment unless the project delivers energy savings/production as expected ([192]).

Financing is arranged so that the energy savings cover the cost of the contractor's services and the investment cost of the new and more energy efficient equipment. The repayment options are negotiable ([193]). Measurements and verification of the energy and savings produced are critical for all the parts involved in the project. Therefore, a protocol aimed at working with common terms and methods to evaluate performance of efficiency projects for buyers, sellers and financiers will be essential. The International Performance Measurement and Verification Protocol (IPMVP) is an international set of standardised procedures for the measurement and verification (M&V) of savings in Energy-Efficiency projects (also in water efficiency). This protocol is widely accepted and adapted ([194]).

ESCO financing structures can employ project finance type of limited recourse debt, usually with additional collateral or credit support needed. There are numerous techniques for securing EE equipment and project loans to end-users, including preferred drawing rights and special escrow accounts, reserve funds, security interest in equipment and project, recourse to equipment vendor, collections via utility bills or property taxes, extra collateral from the borrower, guarantees and credit enhancement programs ([195]).

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(191) Bertoldi, P. and Economidou, M. (2014). Financing building energy renovations. [online] Luxembourg: Publications Office of the European Union. Available at: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC89892/final%20report%20on%20financing%20ee%20in%20buildings.pdf

(192) Bertoldi, P. and Rezessy, S. (2005). ENERGY SERVICE COMPANIES IN EUROPE. [online] Luxembourg. Available at: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC31067/ESCO%20report%20final%20revised%20v2.pdf

(193)http://re.jrc.ec.europa.eu/energyefficiency/
http://www.worldenergy.org/documents/esco_synthesis.pdf
http://www.ieadsm.org/ViewTask.aspx?ID=16&Task=16&Sort=0#ancPublications3

(194) www.ipmvp.org

(195) www.eceee.org/EEES/public_sector/PROSTappendix8.pdf

15.1.7 ESCO Intracting Model or Public Internal Performance Commitments

Besides the large private ESCO sector, a public ESCO sector called "Intracting model", or Public Internal Performance Commitments (PICO), has mainly been used in Germany. In the PICO model a department in the public administration acts as a unit similar to an ESCO in function for another department. The ESCO department organises, finances and implements energy-efficiency improvements mostly through a fund made up of municipal money, and using existing know-how. This allows larger cost savings and implementation of less profitable projects, which would be ignored by a private ESCO ([196]). However, these projects lack the energy savings guarantee, because there are no sanction mechanisms within a single organisation (even though PICO includes saving targets). This can result in lower effectiveness of the investments, but this scheme may increase the activity for energy savings ([195]).

15.1.7.1 Internal Contracting

Strengths of internal contracting are reported in the following scheme ([197])

Internal vs. external contracting:

- Faster implementation of projects
- No profit mark-up
- No cherry-picking
- Supplementary or Part-financing possible
- Facilitated monitoring

Tackling structural barriers:

- Overcoming administrative constraints
- Overcoming fixed budgets
- Avoiding conflicts of interest

Strategic aspects:

- Internal Contracting linked to a revolving fund enables multiple investments for energy savings
- The revolving fund can concentrate all monetary allocations for improvements of energy efficiency, the use of renewable energy and combatting Climate Change
- Internal Contracting strengthens cross-linked and integrated thinking for holistic views on all aspects of energy use – investments in energy and cost savings.

(196) Irrek et al. 2005 – PICOlight project is a project supported by the European Commission through the programme SAVE. More information on http://www.iclei-europe.org/?picolight
(197) Schäfer, N. and Schilken, P. (2017). Infinite Solutions Guidebook: Financing the energy renovation of public buildings through Internal Contracting. [ebook] Brussels: Energy Cities.
Available at: http://www.energy-cities.eu/IMG/pdf/guidebook_intracting_web.pdf

Box 52. Internal contracting in Stuttgart, Sweden

The internal contracting was set up in 1995 under the direction of the Stuttgart Environmental Agency with the specific aim of establishing pre-financing for measures to conserve energy and water more rapidly, as well as implementing the measures themselves. The costs saved through these measures flow back to the Environmental Agency from the energy cost budgets of the individual departments and locally-owned utilities until the investments have been paid off. After this, the funds then become available again. Since the concept was launched, more than 220 measures have been implemented and 8.1 million Euro invested. Both small (improvements to control technology) and large-scale (building of wood-pellet heating systems) projects have been implemented. The average period of return on invested capital is 7 years. Annual savings meanwhile amount to over 1.2 million Euro, which represents some 32,000 m^3 of water, 15,000 MWh of heat energy and 2,000 MWh of electricity. In addition to an increase in energy efficiency, city-internal contracting has also allowed the construction of systems for the use of renewable energy sources (27% of investments).

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Solutions for Change - How local governments are making a difference in climate protection (Climate Alliance 2008)

15.1.8 Public-Private Partnerships

Cooperation between the local authority, local investors, and local citizens are deemed to be vital factors of success for realizing the transition to 100% renewable energy systems ([198]). The leadership of local authorities usually have a crucial role in forging partnerships and pooling resources across the public and private sectors. As an enabler, local authorities have the capacity to steer policies in support of niche innovations that are new to the market as well as technologies that offer multiple social benefits, including through the establishment of public-private partnerships for local energy generation. Examples include public-private partnerships for anaerobic digestion of bio-waste for CHP-based district heating and the co-financing of public energy upgrading between local and regional authorities and private investors. Especially in the bioenergy sector, the supply of urban bio-waste can depend on citizen awareness and motivation to put aside organic waste for separate collection. For this reason, it is also important to motivate citizens in partaking in waste management strategies to enable the use of organic waste to produce biogas ([199]). In this case the local authority uses a concession scheme under certain obligations. For instance, public administration promotes the construction of a zero-emission swimming pool, or a district heating and cooling installation, by allowing a private company to run it revolving the profits on the initial investment. This kind of contract should be flexible in order to allow the private company to extend the contract in case of unexpected payback delays. Moreover, a frequent due diligence is also recommended in order to follow up the evolution of incomes ([200]).

(198) Young, J. and Brans, M. (2017). Analysis of factors affecting a shift in a local energy system towards 100% renewable energy community. Journal of Cleaner Production, 169, pp.117-124
(199) How to develop a Sustainable Energy and Climate Action Plan 2018
(200) Successful worldwide Public-Private Partnerships example can be found in the document "Public-Private Partnerships: Local Initiatives 2007" on www.theclimategroup.org/assets/resources/ppp_booklet.pdf

Box 53. Successful examples of PPPS

Bioenergy system – Enköping, Sweden

This is a typical example of a successful private–public partnership which grew from small scale operations to medium scale decentralized production system. Concerns by the Enköping about energy security and the need for local energy supplies saw the construction of small scale wood chip boilers in 1979. The growing concern of Climate Change resulted in the introduction of a number of policies to support bioenergy development including subsidies and a carbon tax in the 1990s, which played a pivotal role in the commissioning of Enköping's biofuels only medium scale CHP plant in 1994. About 40 % of total investment costs were subsidised by the Swedish Government. The plant had a capacity of 45 MW of heat and 24 MW of electricity. The Enköping local authority formed a company which managed the plant in collaboration with another local private energy company. Feedstock was supplied through the services of a national forestry association, Naturbränsle. The expansion of the system demanded more feedstock, which prompted research on the potential of local production of salix plantations. This resulted in the involvement of the Swedish University of Farmers within 20 km radius of the CHP plant were mobilized to produce salix. This was to reduce transportation costs and fuel use within the project. The project was linked to the water treatment plant to provide sludge for fertiliser (in addition to ash remaining from the burning of wood in the CHP plant) and waste water irrigation for the production of salix.

Bioenergy system - Italy

The agro-energy chain concerns the realization of a plant for energy recovery of vineyards pruning residues and it is divided into different phases: harvesting and storage by round baler, chipping cylindrical bales to obtain bio-chips, whose size is consistent with the biomass boiler, chemical-physical characterization of biochips and energy conversion phase be 0.4 MWth moving grate biomass chips boiler, designed for woodchips. In order to create a consistent supply chain it is necessary to stipulate supply contracts among local farmers and public authority.

Bioenergy system - Greece

The distributed land covers an area of 200ha in total and is divided in four zones. The types of crops used for the biomass production are basically pomegranate, cherry trees, vineyards, tobacco, rice, sunflower, cotton, hard wheat, maize, oat, barley, rye and olives. The residues such as pruning, straw and sarmenta as well are used for the production of biomass. The total production of biomass for the four zones is calculated to be 188,540 tonnes while the heat production of this biomass is calculated to be 2,784,060 GJ and the electricity production 618,680 GJ correspondingly.

Biogas Heat - Este, Italy

This is an example of bio-waste treatment and the gained biogas incineration. In this case the heat was utilised for the city's District Heating grid. The biogas and DH facilities were realised in several different phases and were organised through a public private partnership. Currently, the peak load is 14 MW but there are plans for further extensions. The next planned step is to increase the capacity by 4,5 MW with funding from the European Local Energy Assistance (ELENA). In the subsequent extension, district cooling (in the form of absorption chiller units) will be added to enhance the system even further. By 2020, District heating from biogas was supposed to decrease CO_2-emissions by 30 %.

Electricity production, Spain

The biogas plant Landia has been operational since October 2012, using manure and maize silage as feedstock. The plant had an annual heat production of 7 GWh and received a feed-in tariff (FiT) for its electricity.

Several options were assessed but the operator decided to use the ORC. It had to be evaluated whether the ORC installation would be used for additional electricity production or to replace existing production, as the plant had a fixed agreement with the Croatian energy market operator. As generating additional electricity would have led to a new agreement with lower FiTs, the choice was made to use the ORC electricity as replacement for a part of the existing production. This way the biogas demand and therefore the feedstock demand could be decreased substantially.

Biogas, Denmark

Biogas and heat markets in Denmark are very advanced. Currently, most of the heat from biogas is used either for drying and heating (small plants) or District Heating (centralised plants). However, the government wants to increase biogas production tenfold, so additional solutions need to be developed. As Denmark also had a well-developed gas grid and green transport is one of the challenges of the future, the cases decided to utilise biogas for injection into the natural gas grid and for transport. For both cases upgrading was necessary. Also, the actors were totally different to the ones involved in the other cases and the framework conditions needed substantial adjustments.

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Public Private Partnerships for RES Agro-energy districts (2015) [ebook]

Available at:

https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/rurale.evolution_publishable_final_report_en.pdf

Wagner, I. (2014). Development of sustainable heat markets for biogas plants in Europe. [online] Brussels. Available at: http://www.biogasheat.org/

15.1.9 Energy cooperatives

Energy cooperatives ([201]) play an important role for consumers who want to take action but are not confident or interested in acting alone. By becoming members of an energy cooperative, consumers can overcome such inhibitions and become members of a local community taking energy-related actions.

Different types of energy cooperatives exist. Some operate their own generation assets (such as wind or solar parks). Others can act as aggregators or intermediaries, ensuring optimal operation and management of their members' generation installations (such as roof-top PVs on houses). Yet others can act as financial actors, pooling their members' resources and investing them in larger-scale generation or helping to fund low-carbon renovation/construction works in public facilities. In all cases they have important advantages not only for their members but also for local energy systems. They contribute to decarbonising electricity generation, they involve citizens who can easily understand and, hence, play a role in the energy market and help the energy transition. They can also potentially reduce energy bills or bring revenues to the shareholders. Energy cooperatives can therefore support local plans to reduce GHG emissions and implement sustainable energy measures within the CoM framework ([202],[203]).

Moreover, in combination with energy cooperatives, a crowd-funding platform ([204]) pools resources of different actors, utilizing most of the time an internet-based platform.

(201) Covenantofmayors.eu (2018). Fact-sheet Citizen cooperative [online] Available at http://www.covenantofmayors.eu/support/funding.html#guide_25
(202) Covenantofmayors.eu. (2018). Newsletter Covenant of Mayors. [online] Available at: http://www.covenantofmayors.eu/New-deal-for-consumers-How-can.html
(203) CITYnvest.eu (2017). Cooperatives and local authorities [video]. Available at http://citynvest.eu/content/citynvest-cooperative-model
(204) Covenantofmayors.eu (2018). Factsheet crowd-funding [online]. Available at: http://www.covenantofmayors.eu/support/funding.html#guide_26

Box 54. Limburg Climate Fund, Limburg, Belgium

An example of energy cooperative is the Province of Limburg in Belgium, an active Covenant Territorial Coordinator (CTC) which aims at becoming carbon neutral by 2020 and it is convinced of the importance of diversifying funding opportunities. In 2013 two investment cooperatives were in place in the Province of Limburg. The "Limburg Climate Fund" that invests in climate-friendly local projects ensuring an annual dividend that is 1% higher than the yield on a savings account to all Limburgers that participate in the fund. And the "Limburg Windt", a public company where the 44 LAs of the Province are shareholders that has invested in 90 wind turbines that provide all households of the Province with clean energy. Another example of a successful community cooperative and citizens' engagement is the cooperative of Melpignano. A cooperative community company that aims to promote, develop and implement a widespread network of photovoltaics systems on public and private buildings of the city. The peculiarity of this iniziative that makes Melpignano the first experiment of its kind in Italy, is that citizens adhere to the cooperative promoted by the local authority and thus become, as members users, owners of photovoltaic systems that will be realized for equipping homes and businesses of energy from renewable sources.

http://www.coopcomunitamelpignano.it/

15.2 Debt financing

Debt financing refers to the acquisition of funds by borrowing: a lender provides capital to borrower for a defined purpose over a fixed period of time. Debt options include corporate or project loans under recourse or limited recourse structures, leasing arrangements and full or limited guarantees. Debt financing can include options whereby loans convert to some amount of equity ownership if the project is successful, to increase lenders' rate of return. General corporate capital market activities include sourcing bank debt for general corporate purposes or issuing bonds.

The most common energy efficiency (EE) financial product is a loan directly to the energy end-user (owner of the premises) or to a project developer (e.g. an ESCO) – this is known as third-party financing. A basic loan is the simplest form of debt: it is an agreement to lend a principal sum for a fixed period of time, to be repaid by a certain date and – in commercial loans – with an interest calculated as percentage of the principal sum per year and other transaction costs (e.g. administration fees). Most CFIs offer term lending for plants and equipment, while some have leasing units and structured finance and project finance capacities and thus may already be doing lending similar to that required for EE projects ([187]).

Financing with recourse implies that the company stands behind the project or venture and the related debt and the financiers have to recognise the company's assets in the event of default. The debt holder then reports the loan on its balance sheet as liability – hence the terms corporate financing or 'on balance sheet' financing. Businesses are often willing to use recourse finance only for core business activity business and not for projects in auxiliary activities, such as energy efficiency.

ESCO financing structures can employ project finance type of limited recourse debt, usually with additional collateral or credit support needed.

In EE project financing above a certain threshold there are two common models of third-party financing. One is direct lending to the end-user (with or without an ESCO performance guarantee) and another is lending to the ESCO. When the end-user is the borrower, then end-user credit risks are separated from project performance and project technical risks: the FI assumes the end-user credit risk, while all technical and performance matters are addressed between the ESCO and the end-user. The loan is on the balance sheet of the end-user. Loan financing can be combined with savings guarantees from the contractor.

When the ESCO borrows, it effectively packages together financing with turnkey project implementation and services agreement. In this case the financier has to evaluate not only the end-user credit risk, but also project economics, project engineering and

technical performance, ESCO financials and equity contribution, ESCO management and performance track record, and all project contracts including the Energy Services Agreement. The loan is on the balance sheet of the ESCO and the ESCO is exposed to the end-user credit risk.

Quality of collateral is judged by the value of the asset being pledged and the consistency of that value over time, as well as the ease with which it can be liquidated including the cost to reposition the asset and general market demand for the asset category.

There are numerous techniques for securing EE equipment and project loans to end-users, including preferred drawing rights and special escrow accounts, reserve funds, security interest in equipment and project, recourse to equipment vendor, collections via utility bills or property taxes, extra collateral from the borrower, guarantees and credit enhancement programs ([187]).

Further debt instruments include syndicated loans - granted to companies that wish to borrow more money than a single lender is prepared to lend in a single loan with a syndicate of banks each lending a portion of the principal sum – and bonds, which are debt securities issued by companies or governments with a fixed lifetime and entitling the holder to the repayment of the principal plus interest (repaid at the end or in regular instalments during the lifetime of the bond).

15.2.1 Bonds

A bond is a debt security, in which the authorized issuer owes the holders a debt and, depending on the terms of the bond, is obliged to pay interest (coupon) and/or to repay the principal at a later date, termed maturity. Thus the issuer is the borrower (debtor), the holder is the lender (creditor), and the coupon is the interest.

An example of bond financing relevant to energy efficiency is issuing municipal bonds in procuring funding for municipal energy efficiency. The city of Varna in Bulgaria issued municipal bonds to obtain financing for an EE project involving retrofit and modernization of the city's street lighting. The bonds raised 3 million Euro, and the simple payback of the project was 2 years and 9 months. The local authority collected relatively high volumes of financing by issuing general obligation bonds at 9%. Repayment of the bonds was done in three equal portions during a three year period, primarily as revenue bond emission through the savings. Six other cities participated in issuing bonds to raise funding for their projects.

15.2.2 Forfeiting

An innovative financing option is forfeiting, which is a form of transfer of future receivables from one party (cessionary – an ESCO) to another (buyer – a FI). The original creditor (the ESCO) cedes his claims and the new creditor (the FI) gains the right to claim future receivables from the debtor (the client). The ESCO sells future receivables to an FI in return for a discounted one-time payment. A cession of future receivables is not a stand-alone financing option, but can serve as additional collateral for the FI.

With forfeiting the ESCO originates transaction as extended trade payments and sells long-term receivables to a bank which assumes the credit risk.

In a forfeiting transaction the ESCO or equipment vendor assigns - via an Assignment Agreement - future receivables (e.g. the end-user payments) from an Energy Service Agreement to a lender together with pledge of assets. The end-user pays directly to the bank; the payments are used to amortise the ESCO debt. If an ESCO is involved, the end user, the ESCO and the lender also sign a "Notice and Acknowledgment of Assignment" where the end user acknowledges the terms of the Assignment Agreement and further agrees not to set-off any future claims. Under an Energy Services Agreement the ESCO provides performance guarantee, while the end user pays fixed monthly payment to amortize the investment. All the technology installed is pledged to ESCO. ESCO performs

maintenance of the system and the end user pays fixed monthly payment for this service under a separate Maintenance Agreement ([187]).

15.2.3 Risk transfer and risk sharing tools

Debt financing for EE projects will almost always require some form of guarantee mechanism. In some rare cases the project developer – i.e. a large and well-established ESCO or a large end-user – as a company may have a sufficiently strong balance sheet (supported by equity) and strong income statements from other business activities that can be used against the loan. Even in this case end-users may prefer to tie their balance sheets with financing core business activities only.

International risk management obligations require commercial banks and leasing companies to demand assets as collateral for loans that are often not available to sustainable energy ventures.

Factoring is a similar form of cession of a bundle of receivables of goods and service deliveries with a short-term payment target and/or the cession of single invoices. Factoring mainly transfers the collection of payments and in the case of non-recourse also of financial risks to a specialized FI. Factoring is not applicable for long-term contract durations.

This is why guarantee programs – or any form of publically backed guarantees – are crucial to ensure that end-users and ESCOs are able to access affordable debt financing.

Risks are an inherent feature of financial transactions; thus guarantees can be applied in all phases of the finance continuum to improve access to and the terms of financial products that would be under-supplied without guarantees. The product in need of guarantee can be risk capital (equity or mezzanine finance, bank credits, bonds or security issues or letters of credit). Guarantees for bank credits are the most common form related to EE financing.

Development Financial Institutions (DFIs) are capable of assuming risk and mobilising substantial public or donor funds. Because EE projects are usually too small for DFIs to finance directly, DFIs can support local CFIs to provide EE financing via the provision of tools such as

- credit lines for on-lending to EE projects,
- mezzanine debt facilities,
- guarantees and risk sharing facility programs, and
- supporting technical assistance.

Development Financial Institutions can be multilateral banks (e.g. the World Bank, IFC, EBRD, etc.) or national development banks (public banks, such as the KfW) or even sub-national development banks.

15.2.4 Solutions provided by guarantees

Risk sharing mechanisms – such as partial risk guarantees – provide collateral from external partners for part of the debt of projects. Partial risk guarantees can boast EE financing when domestic financial systems do not face liquidity constraints, but financial intermediaries are reluctant to lend to EE projects because of high perceived risks.

Guarantees can help bridge the gap between the perceived credit risks, as reflected in credit underwriting practices, and actual credit risks, thus assisting beneficiaries in providing them access to finance, reducing their cost of capital, and expanding loan tenor or grace periods to match project cash flows. Guarantees thus can address the credit risk barrier common in many EE market segments and make local FIs more comfortable with the risk.

Partial-risk loan guarantee programs have shown some success in recent years in jumpstarting energy efficiency financing programs through local FIs (see the Commercial Energy Efficiency Finance program of the IFC). They can act to extend the loan repayment period and decrease the interest level, thus improving projects' cash flow and viability. They can also increase debt-to-equity ratios, enhancing returns to developers.

Publicly backed guarantees and insurance schemes can use risk mitigation to steer the flow of private funds towards EE projects, thus leveraging private financing at times of squeezed budgets across the EU. Publicly backed guarantee schemes have been used in project finance and asset finance.

In project finance, publicly backed guarantees can support the implementation of large-scale projects with above-average project risks, accelerate investment in infrastructure and solve specific debt and equity finance problems in small scale project finance.

In asset finance publicly backed guarantees enable aggregation and standardisation of small-scale EE loans to end-users, as well as the financing of EE investments by ESCOs and low-income households. In asset finance guarantees can help bring down bank costs of transactions in dealing with mass requests for end-user finance.

Portfolio guarantees can assume part of the financial risk of the ESCO related to revenue streams: because ESCOs or other energy service providers rely strongly on debt financing, they need precisely budgeted and timed revenue money flows in order to service their debt. Delays or defaults in payments on the side of their clients may have serious impacts on the servicing of debts of the ESCO itself. Yet, guarantee funds cannot be used as a stand-alone solution and are not appropriate for all market situations: for instance, they are of no or limited use where the main financing challenge is bank liquidity. In markets where financial institutions have sufficient liquidity, but low appetite for risk, guarantees should be examined as a mechanism within a larger program ([187]).

Partial credit guarantee schemes are not an effective instrument to attract a CFI loan to a project, when the investors' equity is insufficient to comply with the minimum equity requirement for eligibility. A complementary instrument is needed in this case, such as subordinated debt or equity, which can substitute for and reduce the amount of senior debt and close an existing equity gap. To mobilize EE investment where there is lack of EE lending experience and limited FI knowledge of EE, there is a need of not only support via credit enhancement financial products, but of technical assistance for financial product development and marketing and aggregating the market (project pipeline) as well ([187]).

15.2.5 Solutions provided by other debt financing instruments

Funding for municipal energy efficiency via municipal bonds can be arranged by local authorities of bigger cities with potentials to attract the attention of investors. Issuing municipal bonds requires lengthy and expensive preparatory work that consists of analysing and forecasting the local authority’s financial resources, and launching a procedure for obtaining a credit rating from an international credit agency. The local authority also needs to define bond emission parameters and prepare an Investment Memorandum.

The downside to bond financing for municipal energy efficiency is that benefits from the project accrue over time, usually 5-10 years, while repayment of principal on the bonds has to occur simultaneously at maturity. This can create cash-flow issues for the local authorities if bonds’ maturity date is not correlated to the financial savings from the energy efficiency project. Bond financing is beneficial when the revenue from bond issuance is eligible for tax breaks or tax exemptions.

Forfeiting is a suitable opportunity for immediate flow of cash for financing an EE project.

The development of forfeiting can be advantageous if the cash flow can serve as main collateral. A pre-condition for forfeiting is the legal rightfulness of the receivables – e.g. the ESCO has to perform the energy performance contract and deliver the savings

guaranteed. Generally the ceded receivables must be from investment, goods or service deliveries with a mid-term duration of 6 months to 5 years or longer, which is applicable to future receivables. Forfeiting is expected to be economically advantageous if the client's creditworthiness is better than this of the ESCO or if the project cash flow could serve as main collateral. From the ESCO perspective it is desirable that the FI assumes certain risks, such as the financial performance risk of the client. In this context non-recourse means that the FI waives the right to resort back to the ESCO, provided that the ESCO has fulfilled the contractual obligation including the savings guarantee of the EPC. The transaction costs of setting a forfeiting contract – not a standard financing product to date – may be high ([187]).

15.3 Equity financing

Equity financing refers to the acquisition of funds by issuing shares of common or preferred stock in anticipation of income from dividends and capital gain as the value of stock rises. It also sometimes refers to the acquisition of equity in private unlisted companies or start-up companies. Equity is the residual claim or interest of the most junior class of investors in an asset, after all liabilities are paid.

Ownership equity includes preferred stock; share capital, common stock; capital surplus; stock options; retained earnings; treasure stock, etc. other creditors are paid. Ownership equity is also known as risk capital or liable capital. The equity held by private individuals is often held via mutual funds or other forms of pooled investment vehicles: unless the sponsor is a large company, this equity is typically supplied by private equity funds.

Equity financing can come from professional venture capitalists. Venture capital (VC) is a specific sub-segment of private equity investment, which entails investing in start-up companies with strong growth potential; private equity entails investment in the expansion and growth of any company that is not listed on a public stock exchange. VC investors obtain equity shares in the companies that provide EE goods or services and generally play a significant role in the management and technical aspects of the company. VC investments in technology innovation must also meet investment exit expectations. Without clear exit paths, typically through re-sale or initial public offerings (IPOs), VC investors cannot easily commit to the deal, even when they are convinced of the investment potential ([187]).

Private equity is essential for growing businesses that want to expand their activities, as well as for large-scale project developers. Several public agencies and funds have developed finance mechanisms that provide equity investment opportunities for sustainable energy businesses and projects, often leveraging large amounts of investment from other private financing sources.

With respect to energy efficiency businesses, equity investment can take the form of an ESCO issuing additional shares in the company's common ownership. The issuance of shares gives the investor a right to any proceeds that may result from a distribution of dividends to the owners or cash proceeds from any sales of the assets of the company after the satisfaction of any outstanding liabilities.

While private equity funds are not very typical in energy efficiency, an example of equity fund in the field of sustainable energy is the Marguerite Fund. This is a pan-European infrastructure fund for long-term institutional investors to finance the implementation of strategic European policy objectives and projects in the transport, energy, climate and renewables sectors.

The Marguerite Fund provides equity to energy and infrastructure projects with a focus on green field investments which are not sufficiently served by other investment funds. The expected total fund size is 1.5 billion Euros in total equity. The core sponsors – which now count public long-term investors from almost all the largest EU member states (France, Italy, Germany, Spain and Poland) – plan to obtain a Fund in the order of 750 million Euro of which each core sponsor has committed to investing 100 million Euros. In

order to reach the 1.5 billion Euro target, the Fund needs to attract private investors, which should provide a key contribution in the context of subsequent closings of the Fund. In addition, the presence of private investors will promote an innovative form of public-private partnership dedicated to long-term investment in infrastructure sectors. The Fund will have a target life time of not less than 20 years with a target investment period of four years from the final closing. The EU is working to give a direct investment of 80 million Euro from the budget of the trans-European network projects under the TEN Regulation. The Marguerite fund is set up as a closed-end investment company established as a regulated SICAV-FIS under Luxembourgish law. Marguerite will provide equity or quasi equity to companies that own or operate infrastructure in the sectors of transport (in particular TEN-T), energy (in particular TEN-E), and renewable energies, including sustainable energy production, clean transport infrastructure, energy distribution and systems for hybrid transport, geothermal, biomass, biogas, hydro, waste-to energy projects. The fund is intended to be fully invested in four years. It will focus on asset creation. The investors in the fund and other long-term credit institutions intend to establish a debt co-financing initiative of up to 5 billion Euros, providing a source of long-term debt for the projects that the Marguerite Fund invests in ([187]).

15.3.1 Equity financing in energy efficiency: summary of limitation and success factors

As already indicated, private equity is essential for growing businesses to expand their activities. As the industry grows and financiers become more familiar with EE, equity will play an increasing role. Equity leverages debt investment and is crucial for industry growth. ESCOs require equity for capital-intensive EE projects, where costs of large transactions affect negatively debt investment options and profitability. ESCOs can use their equity for collateral for large loans, but the equity is not made available to be put back on the books until revenue comes in through savings or service payments and loans are repaid in full. Thus, equity funds can assist EE businesses, such as ESCOs, in generating sufficient capital to support early development costs. By separating the risk of the project from the risk of the ESCO as a venture, equity provides the ESCO with cash position on its books and improves its balance sheet by improving cash flow after debt payments. In some mature ESCO markets the private sector is investing equity in ESCO ventures. While equity investments put ESCOs in better cash position, this may become an expensive solution because of giving up some control.

15.3.2 Subordinated Debt financing (mezzanine finance)

Subordinated debt financing, sometimes called Mezzanine Financing, is capital that sits midway between senior debt and equity and has features of both kinds of financing. Subordination refers to the order or priority of repayments: subordinated debt is structured so that it is repaid from project revenues after all operating costs and senior debt service has been paid. There are much fewer sources of Subordinated Debt than there are of senior debt or equity, so it is often considered to be specialty financing.

Subordinated debt is substantially more risky than senior debt since it is generally subordinate to senior debt in terms of collateral rights and rights to cash flow. Subordinated debt financing is generally made available directly from insurance companies, subordinated debt funds, or finance companies. Alternatively, it is raised with public offerings of high-yield bonds to institutional investors. These funds are loaned based on the amount and predictability of cash flow exceeding that required to service senior debt. Because subordinated debt usually has little collateral protection, the lending institution may be granted stock options to own equity of the outstanding stock.

Subordinated debt funds can be undertaken in partnership with senior lenders. Alternatively, a subordinated credit facility can be provided to the Commercial Financial Institution which acts as senior lender; the senior lender then on-lends to the project, blending together the subordinated debt together with its senior debt provided from its own resources. That implies that in the meantime ESCOs may not be able to pursue new

business development or project expansion because they will not qualify for financing. The borrower sees one single loan, but the senior lender applies loan payments to repay the senior debt component on a priority basis. Furthermore, concessional funds could be blended with Development Financial Institution funds, and provided on a "first loss" basis, thereby improving the Development Financial Institution's risk position on the subordinated loan facility. The concessional funder would be supporting and leveraging the subordinated debt which in turn supports and leverages the senior debt. This concept has been applied by the EU's Patient Capital initiative. This funding can also be combined with TA funding that can assist the sub-debt fund and/or its partner senior lenders to market and prepare projects for investment, including aggregated investment programmes ([187]).

15.3.3 Subordinated debt financing and energy efficiency: summary of limitations and success factors

For sustainable energy project developers, subordinated debt financing is cheaper than what would be available on the equity market, does not usually involve sacrificing any control of the company and can allow companies to raise sufficient capital to meet the debt-equity requirements of senior lenders. Subordinated debt is considered as a complementary or alternative solution to portfolio guarantees. It can substitute or reduce the amount of senior debt. This will improve the loan-to-value ratio and the debt service coverage ratio for the senior lender, thereby reducing risk and strengthening the project's financial structure from the senior lender's viewpoint.

Subordinated debt instruments can be extended out for 6-12 years, providing a more 'patient' capital investment option. They have proven to be most successful when operating in mid- to well-developed capital markets where equity and debt instruments are well established. Given that subordinated debt finance can be regarded as a hybrid of debt and equity, it can improve a company's credit rating and put it in a better position to acquire further debt and equity investment. Because of the high return requirements, mezzanine finance instruments mostly address companies with stable cash flows and high growth expectations ([187]).

15.4 Project financing

It is the cash-flow related funding and refers to transactions whereby the project is financed largely based on its own merits. Project finance is long-term financing based upon the projected cash flows of the project rather than the balance sheets of the project sponsors. The financing is typically secured by all of the project assets, including the revenue-producing contracts. Project lenders are given a lien on all of these assets, and are able to assume control of a project if the project company has difficulties complying with the loan terms ([187]).

In project finance, financiers have recourse to the project's cash flow and assets or additional collateral as securitisation. When making a secured loan, banks evaluate both the quality of the borrower and the collateral. Because smaller companies may not have sufficient internally generated cash flow or the debt capacity to borrow easily for general corporate purposes, they often turn to secured debt by offering collateral such as inventory and receivables or property, plant, equipment, or sometimes a bank letter of credit. Pledging collateral may allow such companies to obtain bank loans when they would not normally qualify for unsecured loans. The collateral is used to reduce a bank's loss in the event of a default on the loan ([187]). Unlike conventional debt financing that relies on an individual company's credit-worthiness, project financing relies on a project's cash flow expectations and spreads the risk between the different actors. Third-party financing can be sought by an end-user engaging in financing the project directly, or by an ESCO or similar entity that executes the project. Projects initiated by ESCOs are largely project-financed and off the balance sheet of the company. Importantly, project finance is often based upon a complex financial structure where project debt and equity are used to finance a project, rather than the balance sheets of project sponsors.

Usually, a project financing structure involves a number of equity investors, as well as a syndicate of banks that provide loans to the operation. The loans are most commonly non-recourse loans, which are secured by the project assets and paid entirely from project cash flow, rather than from the general assets or creditworthiness of the project sponsors, a decision in part supported by financial modelling.

The ratio of debt to equity is much higher in project finance than in 'on balance sheet' corporate financing: as indicated, a project with 70- 80% debt and 20-30% equity is common in project financing. Compared to on balance sheet finance, banks will usually be willing to extend the length of the project finance loans to almost 15 years because they have much more control over the project. Another particularity of project financing is that it transfers the risk away from the financiers and spreads it amongst the different actors. Through contracting and because risk is divided between the different sponsors of the project, project financing ensures that there are different outcomes in case of non-payment ([187]).

A Special Purpose Vehicle (SPV) – also referred to as Special Purpose Entity – is a firm or other legal entity established to perform some narrowly-defined or temporary purpose, which facilitates off-balance sheet financing of projects. SPVs are used in a variety of transactions, including securitizations, project finance, and leasing. An SPV can take various legal forms, including corporations or partnerships. A standard approach is to form a SPV and place assets and liabilities on its balance sheet. The investors (a.k.a. sponsoring firms) accomplish the purpose for which an SPV has been set up – for example implementing a large EE project – without having to carry any of the associated assets or liabilities on its own balance sheet ([187]).

15.4.1 Project financing: summary of limitations and success factors

Because a typical project finance structure includes a wide array of contracts between the different actors that transfers the risk and allows an adequate risk coverage and division, project financing is associated with large transaction costs and intricacies that imply a very high threshold investment price, typically above 10 million Euro.

EE finance marketing will prosper where lenders can make credit decisions on the basis of free cash flow and ability to pay and also include a prudent portion, e.g., 70%, of estimated energy cost savings in these calculations. Many Development Financial Institutions finance programs offering guarantees emphasize this point: to assist the partner FIs to create secure transactions while requiring less extra collateral from borrowers, and instead, underwrite the loans based on the project's benefit stream and the borrower's ability to pay.

Off-balance sheet financing is attractive from a risk management standpoint. When assets and liabilities are moved from one balance sheet to another, the risks associated with those assets and liabilities go with them. Off-balance sheet financing also affords considerable flexibility in financing. Most importantly from the standpoint of EE project financing, an SPV does not utilize the sponsoring firm's credit lines or other financing channels. An SPV is presented to financiers as a stand-alone entity with its own risk-reward characteristics. It can issue its own debt or establish its own lines of credit. Often, a sponsoring firm overcapitalizes an SPV or supplies it with credit enhancement. In this circumstance, the SPV may have a higher credit rating than the sponsoring firm, and it will achieve a lower cost of funding. Cogeneration projects are often implemented by ESCOs and frequently structured through an SPV setup by investors. The sponsor establishes a SPV with the objective to own and operate a cogeneration system. Assets of the company are represented by the co-generator facilities, and investment return is assured by two revenue streams: one is heat sales to end-user companies (approx. 10-20%) and the other is electricity sales to the grid (approx. 80-90%), sometimes based on a preferential CHP feed-in tariff. Borrower is the SPV ([187]).

15.5 Other financing mechanisms: developing EE financial products and creating demand for EE finance

This section reviews other financing mechanisms and supporting tools that may be applied in energy efficiency venture or project financing. Due to the fact that equipment finance increases the vendor's sales and profits, the equipment vendor has an interest in supporting the financing. This can be in the form of direct recourse, limited or partial recourse, or repurchase or remarketing of equipment in default and repossession events. Utilities can be important partners or originators for EE equipment loan financing. If the utility can perform collections of finance payments via energy bills, the credit structure of the loans will be enhanced.

15.5.1 Vendor financing (equipment supplier/vendor credit)

In order to support their marketing efforts, many general equipment manufacturers have established either captive or third-party vendor financing relationships. Vendor financing helps the manufacturer sell its product by facilitating financing of a customer's purchase. Vendor financing occurs when a financier provides a vendor with capital to enable them to offer "point of sale" financing for their equipment. Under a vendor financing scheme there are two types of arrangements: one between the vendor and the financier; and the other between the vendor and the customer. The former defines the terms that can be offered to the customer such as rates, length of term and necessary documentation. The vendor/customer agreement defines the repayment terms of the loan. For energy efficient equipment these agreements can be structured such as that the customer payments are lower than the value of energy savings associated with the new equipment. If vendor financing is done by a third party, that party has typically done the work necessary to become comfortable with the technical aspects of the product as well as its collateral value.

An example of vendor financing was the OTP Bank-Tivi street lighting program in Hungary. IFC has a Guarantee Facility Agreement (GFA) with OTP supporting loans to small and medium-size cities to acquire Turnkey Street lighting system retrofits. A vendor finance program was successfully implemented with Tivi, a company specialising in municipal street lighting. The OTP facility provided financing on a series of Tivi projects, using a fixed payment energy services agreement vendor finance structure.

15.5.2 Energy Efficient Mortgage

An energy mortgage is a mortgage that credits a home's energy efficiency in the home loan. For an energy efficient home, for example, it could mean giving the home buyer the ability to buy a higher quality home because of the lower monthly costs of heating and cooling the home. For homes in which the energy efficiency can be improved, this concept allows the money saved in monthly utility bills to finance energy improvements. There are two types of energy mortgages:

- Energy Improvement Mortgage (EIM) - finances the energy upgrades of an existing home in the mortgage loan using monthly energy savings.
- Energy Efficient Mortgage (EEM) - uses the energy savings from a new energy efficient home to increase the home buying power of consumers and capitalizes the energy savings in the appraisal.

Essentially, an EEM is a reduced rate mortgage that credits the energy efficiency of the building in the mortgage itself. To get an EEM a borrower typically has to have energy rating conducted before financing is approved. This verifies to the lender that the building is energy efficient. In the United States EEMs are typically used to purchase a new home that is already energy efficient, such as Energy Star qualified one.

An EIM is used to purchase existing homes that will have an energy efficiency improvement made. EIMs allow borrowers to include the cost of energy efficiency improvement in the mortgage without increasing the down payment. EIMs allow

borrowers to use the money saved in utility bills to finance energy improvements. In the US both EEMs and EIMs require a home energy rating (building certification) to provide the lender with the estimated monthly energy savings and the value of the energy efficiency measures.

Box 55. Eco-mortgage in France

As an example of EIM in the EU, in 2009 France introduced eco-mortgage to undertake energy conservation works, which can be used in tandem with tax credits that are also available for home energy conservation. The mortgages l'éco prêt à taux zéro (éco PTZ) are available for a sum of up to 30,000 Euro, subject to a limit of 300 Euro/m² of the property. They are only available on a property constructed between 1948 and 1990. Repayment of the mortgage is over a period of 10 years, although in some cases the repayment period can be extended to 15 years. The mortgages are offered without a test of resources and are not subject to maximum income limits. The type of works envisaged by the regulations includes wall insulation, double and secondary glazing, new entrance doors, and replacement energy efficient space and water heating systems. The works will need to meet a minimum level of performance as set out in the regulations. The loans are available through the main French banks.

15.5.3 On-bill financing

Integrating loan payments with energy bills and allowing utilities to cut off energy supply to defaulting customers has the potential to both lower collection costs and enhance credit quality of the financing scheme, thereby lowering financing costs. Payment via utility bill reduces risk of credit default and lowers collection risk.

Energy regulators may disapprove and distrust the addition of loan repayments into utility bills, preferring to keep the utility/customer contractual relationship implicit in utility billing simple and straightforward, and resisting, in particular, provisions allowing customer disconnection due to loan repayment default.

Energy suppliers collect the repayment of a loan through energy bills. It leverages the relationship, which exists between a utility and its customer in order to facilitate access to funding for sustainable energy investments ([187]).

15.6 Alternative financing schemes

Development Financial Institutions – often in cooperation with national governments – provide framework facilities that extend credit lines to local financial intermediaries for on-lending to private enterprises for investments in energy efficiency in certain sectors. Credit lines may be combined with a grant component targeting end-borrower investment grants and administration fees for participating banks.

15.6.1 Pooled procurement

Pooled procurement refers to procurement by public or by private entities joining forces in procuring energy efficient products or services related to improving the energy performance of new and renovated buildings, purchasing energy efficient office equipment and more efficient vehicles.

15.6.2 Export credit agencies

Export credit agencies (ECAs) are private or quasi-governmental institutions that act as intermediaries between national governments and exporters to issue export financing. They can provide credits (financial support) or credit insurance and guarantees or both, depending on the mandate they are given by respective governments. ECAs can also offer credit or cover on their own account; this does not differ from normal banking activities. Vendors and buyers can take advantage of export credits and guarantees supplied by the export credit agencies to sell or purchase imported equipment.

15.6.3 Carbon finance

Carbon finance refers to the purchase of project-based greenhouse gas emission reductions. The emission reductions are generally purchased through an IFI carbon fund on behalf of a contributor, or by an Annex-I entity regulated under the UNFCCC's Kyoto Protocol. Emissions reductions are purchased within the framework of the Kyoto Protocol's Clean Development Mechanism (CDM) or Joint Implementation (JI).

Carbon funds typically do not lend or grant resources to projects, but rather contract to purchase emission reductions similar to a commercial transaction, paying for them annually or periodically once they have been verified by a third party auditor. The selling of emission reductions and their incorporation into the overall structure of a given transaction - or carbon finance - has been shown to increase the financial viability of projects, by adding an additional revenue stream, which reduces the risks of commercial lending or grant finance. Thus, carbon finance provides a means of leveraging new private and public investment into projects that reduce greenhouse gas emissions. Yet, carbon finance can imply new types of risk, especially in terms of performance on delivery and purchase contracts for credits from emissions-reducing projects.

15.6.4 Taxation

Taxation can be a powerful tool to stimulate energy efficiency by giving incentives to invest in such projects through tax exemptions and through incentive regimes related to e.g. capital gain tax, property tax, VAT and accelerated or free depreciation. Here we only outline specific tax that can stimulate investment in energy efficiency, leaving out general carbon and/or energy taxation.

Tax allowances are used, for instance, in the case of income tax deductions for investments in defined energy efficiency measures (e.g. insulation). They have the effect of a direct grant, but are administered via income tax declarations, without special grant applications. Accelerated depreciation on investments in specified equipment, allows companies investing in energy saving technologies to depreciate it at a faster rate, entailing lower corporate tax. The Dutch Vamil scheme is an example of successful accelerated depreciation on designated equipment placed on a green fiscal list, thus bringing forward allowable costs, which can be used to offset against profits and improve cash flow. France also provides accelerated depreciation for industry.

Another form of tax allowance is the tax credit, whereby in addition to normal rules for tax allowance, a percentage of the investment cost of approved technologies can be used to offset corporate profit taxes. Exemptions of reduced rates of taxation on corporate profits are occasionally given to environmentally friendly activities. Denmark and the Netherlands use tax credits to encourage energy audits; France and Italy have established tax credits as a policy to promote EE. A tax relief offers a reduction in the amount of income tax payable.

A regime of differentiated VAT may function either to encourage or to discourage efficiency improvements. For instance, in some countries VAT on district heating (DH), natural gas and electricity may be reduced, while VAT on efficiency equipment and/or services may not be reduced, which has a negative impact on project economics (e.g. Hungary, Slovakia), while in other cases VAT for environmentally friendly products and goods related to energy savings may be reduced (e.g. Czech Republic). Under certain conditions property tax regimes can demotivate owners from refurbishing their homes – in Sweden the calculation of the property tax is based on five categories, one of which is energy efficiency, so the better the performance of the property, the higher the property tax. In France the tax is calculated on the potential revenue in case the property is rented. On the contrary, in the Czech Republic house owners can get a real estate tax relief for five years if they reconstruct their heating system, switching from solid fuels to gas or RES and in Bulgaria high efficiency residential buildings get a temporary exemption from property tax.

Public funds, while capable of stimulating interest in energy efficiency, should not be the only tool to foster energy efficiency due to their inherently limited size and duration. Government funding often leads to stop-and-start in progress because once funding is depleted, potential participants may hold off in anticipation of renewed funding, creating consumer hesitation. This uncertainty tends to increase the cost of capital due to the hurry in meeting a deadline created by the end of an incentive. This may cause a boom and bust cycle for capital equipment.

Finally, regulatory frameworks can also facilitate the creation of additional cash flows, which improve EE project economics, most notably energy saving obligations and white certificate schemes as implemented and planned in a few MS ([187]).

15.6.5 Cooperatives, Citizen based financing and Crowd funding platforms

A crowd-funding platform pools resources of different actors, utilizing most of the time an internet-based platform. This can happen in combination with energy cooperatives, which are business models based on shared ownership and democratic decision-making procedures ([201]).

15.6.6 Revolving funds

This financial scheme aims at establishing sustainable financing for a set of investment projects. The fund may include loans or grants and have the ambition of becoming self-sustainable after its first capitalisation. The objective is to invest in profitable projects with short payback time, be repaid, and use the same fund to finance new projects. It can be established as a bank account of the owner or as a separate legal entity. The interest rate generally applied in the capitalisation of revolving funds is lower than the market one or even 0%. Grace periods are also frequent for the periodic payment of revolving funds. A revolving fund can complement to an ESCO.

There are several parties in a revolving fund: the owners can be either public or private companies, organisations, institutions or authorities. The operator of the fund can be either its owner or an appointed authority. External donors and financiers provide contributions to the fund in the form of grants, subsidies, loans or other types of repayable contributions. The borrowers can be either the project owners or contractors. According to the conditions of the revolving fund, savings or earnings gained from projects should be paid back to the fund within a fixed period of time, at certain time intervals ([205]).The advantage of revolving funds is that they are less dependent on external investors. If they are operated effectively, revolving fund can contribute to a permanent financing structure for energy efficiency investments, which is separate from political influence. Typical disadvantages for using revolving funds in energy efficiency are that they require substantial upfront investment and also might be cumbersome and expensive to administer. Yet, the later complexity is also inherent to subsidy schemes ([187]).

15.6.7 On-bill financing

Integrating loan payments with energy bills and allowing utilities to cut off energy supply to defaulting customers has the potential to both lower collection costs and enhance credit quality of the financing scheme, thereby lowering financing costs. Payment via utility bill reduces risk of credit default and lowers collection risk.

Energy regulators may disapprove and distrust the addition of loan repayments into utility bills, preferring to keep the utility/customer contractual relationship implicit in

(205) Interactive Funding Guide. Financing Opportunities for Sustainable Energy & Climate Action PlanssActions (2018). [online(2016) [ebook] Brussels: Covenant of Mayors Office. Available at: http://www.covenantofmayors.eu/support/funding.html

utility billing simple and straightforward, and resisting, in particular, provisions allowing customer disconnection due to loan repayment default.

Energy suppliers collect the repayment of a loan through energy bills. It leverages the relationship, which exists between a utility and its customer in order to facilitate access to funding for sustainable energy investments ([187]).

16 EU financing sources

Access to financing is crucial for transforming ambitious Sustainable Energy and Climate Action Plans into projects. This section presents an outline of existing climate finance instruments available to local and regional authorities in the EU. An overview of finance options at the EU and international levels (**Figure 12**) and information on the funding initiatives managed by key financial institutions are provided.

Figure 12. Overview of EU financing opportunities for Climate Change mitigation and adaptation measures

Source: https://www.covenantofmayors.eu/support/funding.html

16.1 Financial schemes

Over half of EU funding is channelled through the European Structural and Investment Funds (ESIF). They are jointly managed by the European Commission and the EU countries. The ESIF represent an important source of funding for Local Administrative units to tackle Climate Change issues. In principle, each part of the ESIF can support Climate Change mitigation and adaptation measures, but some funds concentrate more on mitigation while others focus on adaptation ([186]).

The European Territorial Cooperation objective (ETC, or INTERREG) can support joint climate actions undertaken by local administrative units across different countries. The URBACT III programme aims to support sustainable integrated urban development in cities across Europe by promoting cooperation and knowledge exchange. INTERACT III provides advice on several issues, including on how to use financial instruments under INTERREG. The ERDF also finances the CIVITAS programme and Urban Innovation Actions (UIA). CIVITAS is particularly designed to support sustainable urban mobility in the EU, while UIA supports new solutions for urban challenges that range from integration of migrants to energy transition. Advisory services are available to beneficiaries seeking to access ESIF among these, JASPER, JESSICA and URBIS. Special Support instruments were introduced to improve cooperation between EC and European Investment Bank (EIB) to increase knowledge and skills and support Member States in

an efficient use of the funds. Among these, JASPERS (Joint Assistance to Support Projects in European Regions) and JESSICA (Joint European Support for Sustainable Investment in City Areas). The former is an initiative aimed at improving the quality of investment supported by EU funds (European Regional Development Fund, Cohesion Fund, Connecting Europe Facility and Instrument for Pre-Accession Funds). It is a partnership between the European Commission, the European Investment Bank and the European Bank for Reconstruction and Development. It offers support to authorities and promoters in the preparation and implementation of ESIF projects. With the recent increase in the use of financial instruments under ESIF, a specific advisory service, FI-Compass, is available to Managing Authorities to support them in using FIs. JESSICA is an initiative of the European Commission developed in co-operation with the European Investment Bank (EIB) and the Council of Europe Development Bank (CEB). It supports sustainable urban development and regeneration through financial engineering mechanisms. Urban Projects wishing to receive funding through the JESSICA initiative must comply with the requirements of the ERDF Regulations.

In addition to the ESIF, other EU funds are relevant for local climate finance: LIFE, Horizon 2020 (H2020), the European Fund for Strategic Investments (EFSI) and the European Energy Efficiency Fund (EEEF). LIFE specifically finances environmental and climate projects in the EU. In addition to grants, two financial instruments exist under LIFE and are managed by the European Investment Bank (EIB): the Natural Capital Financing Facility (NCFF), which is tailored to biodiversity and climate adaptation projects, and the Private Finance for Energy Efficiency (PF4EE), which provides finance for energy efficiency programmes of EU Member States.

H2020 supports climate action through research and innovation investments, and has a 35% target for climate expenditure across the fund. As a result, climate action is funded across all parts of the programme, particularly in the 'societal challenges' programmable actions. Local authorities are able to partner with researchers and other stakeholders to access funding under the H2020 programmable actions for research and innovation activities. LAUs may also benefit from the outcomes of H2020 actions ([206], [207]). H2020 also provides grants for PDA ([208]) under Societal Challenge 3 Secure, clean and efficient energy and TA under ELENA (European Local Energy Assistance). This instrument is specifically designed for LAUs to improve the quality and viability of their energy efficiency and renewable energy projects. LAUs can use ELENA for the preparation of studies, calls and 'bankable' projects. ELENA can be combined with future EIB operations, and serve as a first step for EIB financing operations.

The EEEF, promoted by CDP, EIB and Deutsche Bank, provides finance for specifically energy efficiency and renewable energy in the form of Private Public Partnerships (PPP). The EEEF includes a TA facility to support the preparation of sustainable energy programmes.

The EFSI was designed to mobilise private financial resources for investments that are key for EU policy objectives. Economically and technically viable projects that are consistent with the EU policies are eligible for EFSI financing. As climate action is a key priority of the EU, EFSI is an important financing source for Climate Change mitigation measures (e.g. investments in sustainable energy). As part of the Investment Plan that includes the EFSI, the European Commission launched the European Investment Advisory Hub (EIAH), which is managed by the EIB and aims to support project promoters during the project development process through dedicated advice and technical assistance from

(206) http://citynvest.eu/
(207) Piccolo G.E. (ed.) Setting up innovative financing schemes for energy efficiency renovations: a guidance for local authorities. Available at: http://citynvest.eu/sites/default/files/library-documents/CITYnvest%20Step%20by%20Step%20Guidance_CITYnvest%20brochure.pdf
(208) http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/lc-sc3-ee-11-2018-2019-2020.html

experts. The EIAH is intended to help project promoters, including LAUs, in overcoming technical obstacles before and during EFSI financing applications.

16.1.1 European structural and investment funds

Financial Instruments (FIs) transform EU resources under the European Structural and Investment Funds (ESIF) into financial products such as loans, guarantees, equity and other risk-bearing mechanisms. These are then used to support economically viable projects which promote EU policy objectives. FIs aim to put EU funds to good and efficient use, ensuring that grants are complemented by other financial products so that EU funding can be used time and time again in a revolving fashion. FIs can be combined with technical support or guarantee/interest rate subsidies.

The European structural and investment funds include five separate EU funds:

- European Regional Development Fund(ERDF);
- European Social Fund (ESF);
- Cohesion's Fund (CF);
- European agricultural fund for rural development (EAFRD);
- European maritime and fisheries fund (EMFF).

Adaptation is mainstreamed into the European Structural and Investment Funds (ESIF), which contributes to the implementation of EU´s Adaptation Strategy (EC, 2013) across the five mentioned funds.

16.1.1.1 European regional development fund (ERDF)

The European Regional Development Fund (ERDF) aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions. The ERDF supports regional and local development by co-financing investments in R&D and innovation, Climate Change and environment, business support to SMEs, services of common economic interest, telecommunication, energy and transport infrastructures; health, education and social infrastructures and sustainable urban development. Cities are directly targeted by several of the ERDF investment priorities, and SECAPs development and implementation may be supported by the fund.

16.1.1.2 European social fund

The European Social Fund (ESF) supports the transition to new business models and job profiles. The fund supports local, regional and national authorities, workers and employers organizations, NGO's and companies. It focuses on sustainability, quality and mobility of labour, social inclusion tackling poverty and discrimination, education and institutional capacity. Part of the ESF is dedicated to improving education and training systems necessary for the adaptation of skills and qualifications and for the creation of new jobs in sectors related to energy and the environment. The ESF is also used by some Member States to alleviate energy poverty, as a complement to the European Regional Development Fund and the Cohesion Fund for energy efficiency investments in housing. The funding may arise from different kind of sources like grants, guarantees, loans, equity participation and other risk-bearing mechanisms but with possible technical assistance support and seed funding like an indirect funding mechanism.

16.1.1.3 Cohesion fund

Cohesion's Fund beneficiaries are local and regional authorities and depending on the operational programme it focuses on renewable sources and efficiency, low carbon economy, Climate Change adaptation, environment protection and resource efficiency, sustainable transport and institutional capacity. It funds countries where the gross national income (GNI) per inhabitant is less than 90 % of the EU average. In 2014-20, these are Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary,

Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia. There are several types of funding, direct ones such as grants, guarantees, loans, equity participation and other risk-bearing mechanisms, possibly with technical assistance support and some indirect funding tools such as loans, risk capital and seed funding.

16.1.1.4 European agricultural fund for rural development (EAFRD)

European agricultural fund for rural development (EAFRD) focuses on resolving the particular challenges facing rural areas. EAFRD co-finances the rural development through programmes run by national governments. Member States and regions draw up their rural development programmes (RDP) based on the needs of their territories and addressing the following priorities:

- fostering knowledge transfer and innovation in agriculture, forestry and rural areas
- enhancing the viability and competitiveness of all types of agriculture, and promoting innovative farm technologies and sustainable forest management
- promoting food chain organization, animal welfare and risk management in agriculture
- restoring, preserving and enhancing ecosystems related to agriculture and forestry
- promoting resource efficiency and supporting the shift toward a low-carbon and climate-resilient economy in the agriculture, food and forestry sectors
- promoting social inclusion, poverty reduction and economic development in rural areas.

The beneficiaries of the funding are local authorities and administrative bodies social, cultural and educational institutions, NGOs, companies, SMEs and associations while the funding itself might arise from grants, guarantees, loans, (quasi-) equity participation and other risk-bearing mechanisms, possibly with technical assistance support ([209]).

16.1.1.5 European maritime and fisheries fund (EMFF)

The European Maritime and Fisheries Fund (EMFF) is the fund for the EU's maritime and fisheries policies. The fund helps fishermen in the transition to sustainable fishing supports coastal communities in diversifying their economies, it finances projects that create new jobs and improve quality of life along European coasts.

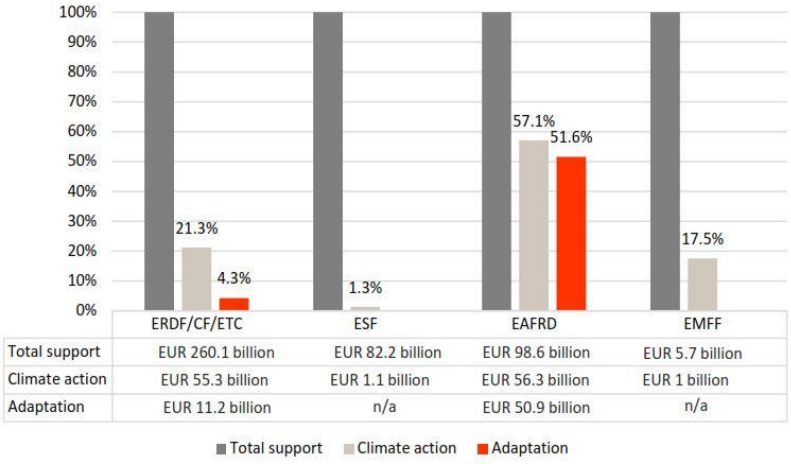
The six priorities of the fund are: environmentally sustainable, resource efficient, competitive fisheries; environmentally sustainable, resource efficient, competitive aquaculture; fostering the implementation of the common fisheries policy; increasing employment and territorial cohesion through the promotion of economic growth and social inclusion in coastal and inland communities depending on fishing; fostering marketing and processing through improved market organisation for fishery and aquaculture products and through improved processing and marketing sectors in particular in Outermost Regions; fostering the implementation of the Integrated Maritime Policy.

The beneficiaries of the funding are local authorities and administrative bodies social, cultural and educational institutions, NGOs, companies, SMEs and associations while the funding itself might arise from grants, guarantees, loans, (quasi-) equity participation and other risk-bearing mechanisms, possibly with technical assistance support ([210]).

(209) Agriculture and rural development - European Commission. (2018). Rural development 2014-2020 - Agriculture and rural development - European Commission. [online] Available at: https://ec.europa.eu/agriculture/rural-development-2014-2020_en
(210) European Commission - European Commission. (2018). European structural and investment funds. [online] Available at: https://ec.europa.eu/info/funding-tenders-0/european-structural-and-investment-funds_en

Figure 13 displays the share of ESIF funds. Among the 11 investment priorities supported by ESIF —also known as thematic objectives (TOs)—the 5th one, "promoting Climate Change adaptation, risk prevention and management", is covered by the ERDF/CF (including the European Territorial Cooperation, ETC) and the EAFRD.

Figure 13. Share of ESIF funds for climate-related action (mitigation and adaptation pillars) and adaptation separately



Source: Bertoldi, P. and Rezessy, S. (2005) ([199])

16.1.2 European funding programmes

16.1.2.1 LIFE

The LIFE programme is the EU's funding instrument for the environment and climate action. LIFE funds innovative projects that demonstrate new techniques and methods. The general objective of LIFE is to contribute to the implementation, updating and development of EU environmental policy and legislation by co-financing pilot or demonstration projects with added value. Since its start in 1992, LIFE has been continuously co-funding innovative projects that help address the EU's transition to a low-carbon and climate-resilient economy, strategically underpinning the implementation of the EU strategy on adaptation to Climate Change and demonstrating ways to meet the climate action challenges from now to 2030. LIFE funding can also be supported by two financial instruments, the Natural Capital Finance Facility (NCFF) and Private Financing for Energy Efficiency (PF4EE). Additionally, LIFE projects can provide technical assistance, strengthen capacity building and carry out preparatory work for environmental legislation. Projects are financed under the following categories:

- Traditional projects are best-practice, demonstration, pilot, information, awareness-raising or dissemination projects that cover the following priority areas: Nature & Biodiversity Environment & Resource Efficiency, Environmental Governance & Information, Climate Change Mitigation, Climate Change Adaptation, Climate Governance & Information.
- Preparatory projects address specific needs for the development and implementation of EU environmental or climate policy and legislation.
- Integrated projects are implemented on a larger territorial scale (regional, multi-regional, national or trans-national) than other LIFE projects. Under the sub-programme for Environment, these projects implement plans or strategies required by specific EU environmental legislation - primarily in the areas of nature, water, waste and air. Under the sub-programme for Climate Action, Integrated projects implement climate action plans, strategies or roadmaps required by EU climate legislation - primarily in the areas of Climate Change mitigation and adaptation.

- Technical Assistance projects, under both the sub-programmes for Environment and Climate Action, provide action grants and financial support to help applicants prepare Integrated projects.
- NGO operating grants help develop and implement EU environmental or climate policy, by facilitating dialogue with all stakeholders. European NGOs coordinate and channel the views of national organisations and citizens as input into decision-making processes, participate in preparatory studies, and play an important role in raising awareness.

Of the many issues addressed by LIFE, there is a focus on practices and measures that promote resilient communities, safeguard natural resources, encourage protection of ecosystems and foster adaptive technologies for economic sectors that are vulnerable to Climate Change. LIFE has focused on forest fires and flood prevention measures and the application of the precautionary principle. It also made a particular contribution to the development and elaboration of hydrological and climate models as tools necessary to address water scarcity and droughts. Other projects supported by LIFE developed tools and novel technologies demonstrating realistic Climate Change scenarios for specific sites to enable impact and vulnerability assessments and suggest the most appropriate adaptation measures to protect biodiversity and improve urban and rural resilience ([211]). The fund may be used for supporting signatories, coordinators, supporters, academia for SECAP development, SECAP implementation and hiring of experts.

16.1.2.2 Urban Innovative Actions

The main objective of Urban Innovative Actions (UIA) is to provide urban areas throughout Europe with resources to test innovative solutions to the main urban challenges, and see how these work in practice and respond to the complexity of real life. The programme supports the implementation of pilot projects and puts emphasis on participatory processes involving various stakeholders. The beneficiaries of the program are the local authorities from a population of at least 50 000 inhabitants or association of local authorities if the total sums up to 50,000 (can be cross-border, but territorial contiguity is strongly recommended). The participating countries are the EU 28 member states. The first call of proposals (31/03/2016) focused on the integration of migrants and refugees, the creation of jobs and skills in the local community, the energy transition and the tackling of the urban poverty. Next calls that followed also included actions taken regarding climate adaptation, circular economy, housing, urban mobility, green procurement, digital transition, air quality and nature-based solutions. The project size in terms of money is calculated to be maximum 5 million euros with a co-funding rate of maximum 80%.

16.1.2.3 CIVINET (CIVITAS National Networks) Activity Fund

CIVITAS program aims to cleaner and better transport in cities and the acronym stands for CIty-VITAlity-Sustainability. CIVITAS is an EU initiative for supporting and evaluating the implementation of integrated sustainable and energy efficient urban transport strategies in European cities that should make a real difference to the welfare of the European citizen. The CIVITAS Activity Fund is a programme that supports the take-up of sustainable urban mobility measures in Europe by providing financial assistance for specific activities of the CIVNETS. CIVINET is a group of city networks that promote the CIVITAS approach at a local level, overcoming language and contextual barriers for local authorities and organisations interested in urban sustainable mobility. Members exchange information in their own language working together to engage with the European Union and national governments, about transport policy issues, legislation, regulations, and funding. Each CIVINET City Network works independently, with

(211) ec.europa.eu. (2018). Environment - LIFE : Products. [online]
Available at: http://ec.europa.eu/environment/life/products/factsheets.htm

cooperation through CIVINET to share learning, experiences and spread the city network approach to other countries.

16.1.2.4 URBACT III

URBACT helps cities to develop pragmatic solutions that are new and sustainable and that integrate economic, social and environmental urban topics. URBACT's mission is to enable cities to work together and develop integrated solutions to common urban challenges, by networking, learning from one another's experiences, drawing lessons and identifying good practices to improve urban policies. To respond to the numerous challenges facing cities, local authorities need to continually improve and build knowledge and skills to enable them to develop and implement sustainable integrated policy. URBACT III (2014-2020) has been developed to continue to promote sustainable integrated urban development and contribute to the delivery of the Europe 2020 strategy. The programme is organised around four main objectives:

- Capacity for Policy Delivery: To improve the capacity of cities to manage sustainable urban policies and practices in an integrated and participative way
- Policy Design: To improve the design of sustainable urban policies and practices in cities
- Policy Implementation: To improve the implementation of integrated and sustainable urban strategies and actions in cities
- Building and Sharing Knowledge: To ensure that practitioners and decision makers at all levels have access to knowledge and share know-how on all aspects of sustainable urban development in order to improve urban development policies.

To reach these objectives, URBACT III has developed three types of interventions: transnational exchange, capacity-building and capitalisation and dissemination. The thematic objectives focus on strengthening research, technological development and innovation, supporting the shift towards a low-carbon economy in all sectors, protecting the environment and promoting resource efficiency, promoting employment and supporting labour mobility and last but not least protecting the social inclusion and combating poverty.

The expected impacts of the program are as follows:

- Urban practitioners in cities have increased knowledge and capacity in relation to integrated approaches to sustainable urban development
- Cities have designed integrated strategies and action plans for sustainable urban development
- Cities have improved their performance with regard to the implementation of integrated plans for sustainable urban development
- Practitioners and decision-makers at all levels have increased access to URBACT thematic knowledge on sustainable urban development and make use of it.

16.1.2.5 Territorial Cooperation

European Territorial Cooperation (ETC), better known as Interreg, is one of the two goals of cohesion policy and provides a framework for the implementation of joint actions and policy exchanges between national, regional and local actors from different Member State. Interreg is built around three strands of cooperation: cross-border (Interreg A), transnational (Interreg B) and interregional (Interreg C).

A) Cross-border Cooperation: helps transform regions located on either side of internal or external borders of the European Union into strong economic and social poles. In particular, cross-border actions are encouraged in the fields of entrepreneurship, improving joint management of natural resources, supporting links between urban and rural areas, improving access to transport and communication networks, developing joint

use of infrastructure, administrative cooperation and capacity building, employment, community interaction, culture and social affairs. Cross-border cooperation is essentially about "filling the gaps". It does so through agreed cross-border "analysis and response" strategies, specifically formulated and tailored for each border region.

B) Transnational Cooperation: promotes cooperation among greater European regions, including the ones surrounding sea basins (e.g. Baltic Sea Region, North Sea, Mediterranean and Atlantic Area) or mountain ranges (e.g. Alpine Space) and facilitates coordinated strategic responses to joint challenges like flood management, transport and communication corridors, international business and research linkages, urban development and others. Special attention is given to outermost and island regions (e.g. Indian Ocean, Caribbean Area or Northern Periphery).

C) Interregional Cooperation: provides a framework for the exchange of experiences between local and regional actors from across Europe in order to contribute to the EU's strategies on growth, jobs and sustainable development. In addition, it aims at reducing disparities by matching less experienced regions with more advanced regions in the various policy fields such as innovation, demographic change, energy supply and Climate Change ([212]).

Five programming periods of Interreg have succeeded each other: INTERREG I (1990-1993) - INTERREG II (1994-1999) - INTERREG III (2000-2006) - INTERREG IV (2007-2013) - INTERREG V (2014-2020). For the period 2014-2020 there are 60 cross border programmes, 15 transnational programmes and 4 interregional programmes.

16.1.2.6 Horizon 2020

Horizon 2020 (H2020) is the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020). H2020 aims to achieve smart, sustainable and inclusive economic growth. H2020 is organised in thematic sections each dedicated to a specific challenge. Among these, particularly relevant for local authorities are the so called Societal Challenges (SC).

- SC1: Health, demographic change and wellbeing;
- SC2: Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy;
- SC3: Secure, clean and efficient energy;
- SC4: Smart, green and integrated transport;
- SC5: Climate action, environment, resource efficiency and raw materials;
- SC6: Europe in a changing world - inclusive, innovative and reflective societies;
- SC7: Secure societies - protecting freedom and security of Europe and its citizens.

The Societal Challenge 3 of the Work Programme for 2018-2020 focuses on research, demonstration, innovation and market-uptake actions across different low-carbon energy sectors, notably in the core priorities identified in the Energy Union Strategy: renewable energy; smart energy systems; energy efficiency; and, as an additional priority, Carbon Capture Utilization and Storage. This part of Horizon2020 also includes the Smart Cities and Communities calls. The Societal Challenge 5 Work Programme for 2018-2020 focuses on moving to a greener, more resource efficient and climate-resilient economy in sync with the natural environment, demonstrating a strong commitment to supporting the UN's Sustainable Development Goals (SDGs) and the targets of the COP21 Paris

(212) ReitelJean, B., Peyrony, J., Wassenberg, B. and Rubió, J. (2015) Territorial cooperation in Europe: A historical perspective. [online] Luxembourg: Publications Office of the European Union. Available at: http://ec.europa.eu/regional_policy/sources/information/pdf/.../futurium/en/system/files/ged/interreg_25years_en.pdf

Agreement. This Work Programme is structured around two calls: 'Building a low-carbon, climate resilient future: climate action in support of the Paris Agreement' and 'Greening the economy in line with the SDGs'. The focus area 'Building a low-carbon, climate resilient future' will align R&I investments towards the Climate Change targets of the Paris Agreement. Work related to the circular economy and the focus area on 'Connecting economic and environmental gains – the Circular Economy' will also align R&I towards these targets. The Societal Challenge 4 Work Programme for 2018-2020 focuses on Smart, Green and Integrated Transport. These calls have the overall objective of achieving a European transport system that is resilient, resource efficient, climate- and environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society ([213]).

16.1.3 Project Development Assistance and Funding Advice

Project Development Assistance (PDA) has been set up to support ambitious public authorities – at regional or local level or groupings of those - and public bodies in developing bankable sustainable energy projects. The PDA facilities aim to bridge the gap between sustainable energy plans and real investment through supporting all activities necessary to prepare and mobilise investment into sustainable energy projects. These activities can include feasibility studies, stakeholder and community mobilisation, financial engineering, business plans, technical specifications and procurement procedures.

16.1.3.1 ELENA

A joint initiative by the EIB and the European Commission under the Horizon 2020 programme, the European Local Energy Assistance (ELENA) supports local and regional authorities and other entities acting on their behalf. It provides grants for technical assistance focused on the implementation of energy efficiency, distributed renewable energy and urban transport projects and programmes. The grant can be used to finance costs related to feasibility and market studies, programme structuring, business plans, energy audits and financial structuring, as well as to the preparation of tendering procedures, contractual arrangements and project implementation units. The ELENA facility is led by a team of experts consisting of engineers and economists with extensive experience in the transport and energy sector. Established in 2009, the ELENA facility has awarded around EUR 100 million of EU support triggering an estimated investment of around EUR 4 billion on the ground.

Typically, ELENA supports programmes above EUR 30 million with a 3-year implementation period for energy efficiency and 4-year for urban transport and mobility, and can cover up to 90% of technical assistance/project development costs. Smaller projects can be supported when they are integrated into larger investment programmes. The annual grant budget is currently around EUR 20 million. Projects are evaluated and grants allocated on a first-come-first-served basis. ELENA may co-finance investment programmes in the following fields:

Energy efficiency and distributed renewable energy

- public and private buildings (including social housing), commercial and logistic properties and sites, and street and traffic lighting to support increased energy efficiency
- integration of renewable energy sources (RES) into the built environment – e.g. solar photovoltaic (PV) on roof tops, solar thermal collectors and biomass

(213) Horizon 2020 Work Programme 2018 - 2020. (2017). [ebook] European Commission. Available at: https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-intro_en.pdf

- investments into renovating, extending or building new district heating/cooling networks, including networks based on combined heat and power (CHP), decentralised CHP systems
- local infrastructure including smart grids, information and communication technology
- infrastructure for energy efficiency, energy-efficient urban equipment and link with transport

Urban transport and mobility

- investments to support the use and integration of innovative solutions for alternative fuels in urban mobility
- investments to introduce on a large-scale new, more energy-efficient transport and mobility measures in cities including passenger transport, freight transport.

16.1.3.2 ELENA KfW

ELENA KfW is a financial scheme that supports local and regional authorities and other entities acting on their behalf. The focus areas are energy efficiency in public and private buildings and street lighting, integrated renewable energy sources (RES), energy efficiency, urban transport including freight logistics in cities, local infrastructures for energy efficiency and municipal waste-to-energy projects. KfW-ELENA consists of two elements, ELENA grant from the European Commission for Project Development Services and global loans to local participating financial intermediaries (PFIs) in order to target smaller investments (volume up to EUR 50 million).

16.1.3.3 Horizon 2020 (Call EE22 – PDA)

Horizon2020 Project Development Assistance (PDA) is a technical assistance facility to support building technical, economic and legal expertise needed for project development and leading to the launch of concrete investments. The beneficiaries of the program are local and regional authorities, public bodies, private infrastructure operators, ESCOs and SMEs. The program focuses on areas regarding public and private building stocks, public lighting, district heating and cooling networks, urban transport, energy efficiency in industries and services and investments in RES by hiring of experts / preparation of bankable projects. It supports programs above 7.5 to 50 million euros maximum. Moreover, other funding opportunities can be found in the Horizon2020 Smart Cities & Communities call ([214]).

16.1.3.4 European energy efficiency fund (EEEF)

The European Energy Efficiency Fund has set up a new assistance scheme to support ambitious public beneficiaries in developing bankable sustainable energy investment programmes. These projects shall relate to the energy efficiency sector, small-scale renewable energy and/or urban public transport. The EEEF – Technical Assistance Facility (eeef - TA) supports projects in the sector of energy efficiency and partly small-scale renewable energy. EEEF-TA aims to bridge the gap between sustainable energy plans and real investments by supporting all activities necessary to prepare investments into sustainable energy projects. Eligible applicants: regions, city councils, universities, public hospitals and other public entities located in the Member States of the European Union. EEEF is supporting beneficiaries by allocating consultant services to the planned investment programmes (for example for feasibility studies, energy audits and evaluating the economic viability of investments). It also covers direct staff costs of the beneficiaries and external legal service costs required. Should the investment programme not be

(214) https://ec.europa.eu/inea/en/horizon-2020/smart-cities-communities

funded under EEEF, the reimbursement of services previously paid by EEEF is required ([187]).

16.1.3.5 Joint Assistance to Support Projects in European Regions (JASPERS)

JASPERS assistance advices cities and regions on strategic planning in a wide range of sectors. JASPERS belongs to Special Support instruments and is a technical assistance partnership between the EIB and the European Commission and at the same time an important instrument of the EU Cohesion Policy. JASPERS provides independent expert advice and capacity building support to public authorities and final beneficiaries on how to plan, develop and implement high quality large investment projects to be co-financed by European Structural and Investment Funds (ESIF), as well as programmes and sector strategies that deliver EU policy objectives. It supports projects in many sectors such as roads, air, maritime, public transport, water, solid waste, smart development and energy. JASPERS focuses on large projects with total costs exceeding EUR 50 million for environmental projects and EUR 75 million for transport or other sectors. However, there is flexibility about these thresholds in the case of small countries or where projects serve as pilot actions to establish best practice. JASPERS supports projects in the following 5 areas:

- Energy and solid waste
- Rail, Air and Maritime
- Smart development
- Roads
- Water and wastewater.

It can provide support to Signatories, Coordinators, Supporters for Hiring of experts and preparation of bankable projects.

16.1.3.6 URBIS

URBIS is a new dedicated urban investment advisory platform within the European Investment Advisory Hub (EIAH). URBIS is set up to provide advisory support to urban authorities to facilitate, accelerate and unlock urban investment projects, programmes and platforms. URBIS has been developed in partnership by the European Commission (DG REGIO) and the EIB in the context of the EU One Stop Shop for Cities and in support of the ambitions defined in the EU Urban Agenda. In its initial phase, URBIS will consist of three modules, implemented in parallel:

- Increased awareness raising of existing instruments, programmes, services;
- Tailor-made technical and financial advice to cities, and
- Exploring innovative financing approaches for city investments.

It will thus simplify access to existing advisory programmes and services and also address some of the current gaps in the provision of advisory support. Local authorities wishing to access the service should first submit a request form, describing the proposed assignment, the project, programme or investment platform that it will support and sets out how the assignment will meet the eligibility criteria ([215]).

(215) http://eiah.eib.org/about/initiative-urbis.htm

List of abbreviations and definitions

BEI	Baseline Emission Inventory
BEM	Building Energy Management System
BMS	Building Management Systems
BRT	Bus rapid transit
CDM	Clean Development Mechanism
CEB	Council of Europe Development Bank
CFL	Compact Fluorescent Lamps
CHP	Combined heat and power
COR	Committee of the Regions
CRI	Colour Rendering Index
DHC	District heating and cooling
DHW	Domestic hot water
EEM	Energy efficient mortgage
EE	Energy efficiency
EIM	Energy improvement mortgage
EPBD 2002/91/EC /EPBD recast 2010/31/EU	Energy Performance of Buildings Directive
ESCO	Energy Services Company
ESIF	European Structural and Investment Funds
ETC	European Territorial Cooperation
EU	European Union
FI	Financial Instrument
GFA	Guarantee Facility Agreement
GHG	Greenhouse gas
GIS	Geographic information system
HVAC	Heating, Ventilation and Air Conditioning
ICT	Information and communication technologies
IPMVP	International Performance Measurement and Verification Protocol
JESSICA	Joint European Support for Sustainable Investment in City Areas
JI	Joint Implementation
JP	Joint Procurement
LA	Local Authorities
LCA	Life cycle assessment
LED	Light Emitting Diodes
LRT	Light Rail System
MS	Member State
NAP	National adaptation plan
NAS	National Adaptation Strategy

NZEB	Nearly Zero-Energy Buildings
OECD	Organisation for Economic Co-operation and Development
PPP	Public-private-partnerships
PV	Photovoltaic
RED	Renewable Energy Directive 2009/28/EC
RES	Renewable Energy Systems
RVA	Risk and Vulnerability Assessment
SECAP	Sustainable energy and Climate Action Plan
SUMP	Sustainable Urban Mobility Planning
TES	Thermal energy storage
TOD	Transit Oriented Development
UDF	Urban Development Funds
UNFCCC	United Nations Framework Convention on Climate Change

List of boxes

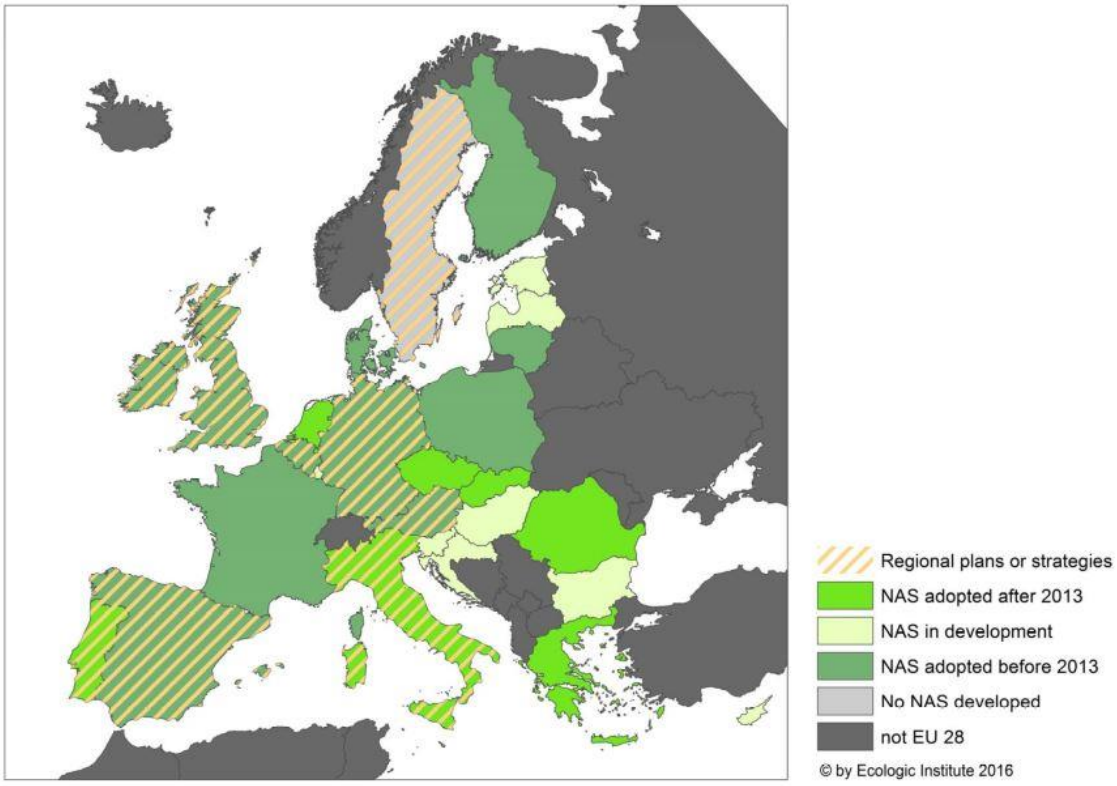
List of figures

List of tables

Annex 1. EU Adaptation Strategy (2013)

The EU Adaptation Strategy ([145]) was adopted in 2013, provides a framework and mechanisms to improve the preparedness of all actors to deal with the current and future Climate Change impacts. Until 2013, only 15 Member States had developed a National Adaptation Strategy. At present 25 MS defined their NAS.

Figure 14. Development of National Adaptation Strategies in EU



Source: COR, 2016.

The EU Adaptation strategy aims at supporting MS by promoting greater coordination and data sharing and by ensuring that adaptation issues are addressed by all relevant EU policies.

EC, (2013) refers to three main priorities and defines a series of actions to fulfil them:

- Priority 1: Promoting Action by Member State.

- Action 1. Encourage all MS to adopt comprehensive adaptation strategies
- Action 2. Provide LIFE funding to support capacity building and step up adaptation action (2013-2020), in vulnerable areas.

Direct reference to urban adaptation: This action points out the need of mainstreaming adaptation into urban planning and building layouts.

- Action 3. Introduce adaptation in the Covenant of Mayors framework.

Direct reference to urban adaptation: the Commission supports adaptation in cities by launching voluntary commitment to adopt local adaptation strategies and awareness raising activities.

- Priority 2: Better informed decision making

- Action 4. Bridge the knowledge gap

Direct reference to urban adaptation: this action points out the need to improve regional and local analyses and risk assessments.

- Action 5. Further develop Climate-ADAPT ([216]) as the "one-stop shop" from adaptation information in Europe.

Direct reference to urban adaptation: the Commission promotes the integration of regional and local portals under a common umbrella to guarantee data sharing and good-practice exchange across different scales.

- Priority 3: Climate-proofing EU action: promoting adaptation in key vulnerable sectors.

- Action 6. Facilitate the climate-proofing of the CAP, the Cohesion Policy and Common Fisheries Policy.
- Action 7. Ensure more resilient infrastructure.
- Action 8. Promote insurance and other financial products for resilient investments and business decision.

Annex 2. Adaptation case studies per type of climate risk

Hazard	Sector impacted	Action	Case study	Source
Extreme heat	Environment & Biodiversity	Green spaces and corridors in urban areas	Barcelona	http://climate-adapt.eea.europa.eu/metadata/case-studies/barcelona-trees-tempering-the-mediterranean-city-climate
			Stuttgart	http://climate-adapt.eea.europa.eu/metadata/case-studies/stuttgart-combating-the-heat-island-effect-and-poor-air-quality-with-green-ventilation-corridors
				CIRCLE-2, 2013
			Antwerp	CoM SECAP of Antwerp
			Bologna	CoM SECAP of Bologna
			Kamen	CIRCLE -2, 2013
	Buildings	White roof, innovative solar shading and bioclimatic design	Madrid	http://climate-adapt.eea.europa.eu/metadata/case-studies/white-roof-innovative-solar-shadings-and-bioclimatic-design-in-madrid
		Green roofs	Copenhagen	CIRCLE -2, 2013
		Green walls	Nijmegen	CIRCLE -2, 2013
		Green roofs subsidy	Ghent	CoM SECAP of Ghent
		More energy efficient building codes and more renewable sources	California	Vine, 2012
		Awareness raising demonstrations and exhibitions	Antwerp	CoM SECAP of Antwerp
		Room acclimatisation with plants	Eferding	CIRCLE -2, 2013

Hazard	Sector impacted	Action	Case study	Source
Extreme heat *(suite)*	Transport	Improve indoor climate conditions in public transportation	Bologna	CoM SECAP of bologna
		Temperature resistant road surface	Stuttgart	SECAP template
	Civil Protection & Emergency	Early heat warning systems and emergency plans	Kassel	http://climate-adapt.eea.europa.eu/metadata/case-studies/heat-hotline-parasol-2013-kassel-region
			Tatabánya	http://climate-adapt.eea.europa.eu/metadata/case-studies/tatabanya-hungary-addressing-the-impacts-of-urban-heat-waves-and-forest-fires-with-alert-measures
				CIRCLE -2, 2013
	Health	Creating and/or repairing fountains for drinking and cooling; Cooling by water spray (fountains); Cooling by wetting streets.	London	http://climate-adapt.eea.europa.eu/metadata/adaptation-options/water-uses-to-cope-with-heat-waves-in-cities
		Web-site information on heatwaves and air quality	Bologna	CoM SECAP of Bologna
Storm	Agriculture & Forestry	Cover crops, minimum tillage (planting in the stubble), furrow pressing, spreading manure on top of the soil and adjusting the crop rotation	Vombsänken	Riksen and De Graaff, 2001
	Water	Storm surge gates	London, Rotterdam, Venice, & St. Petersburg	http://climate-adapt.eea.europa.eu/metadata/adaptation-options/storm-surge-gates-flood-barriers
			Antwerp	CoM SECAP of Antwerp
Extreme cold	Transport	Fixed in-road Anti-icing Spray Systems	Minnesota	U.S. Department of Transport

Sea level rise	Green Infrastructure	Restauration and management of Coastal wetlands	Danube Estuary	http://climate-adapt.eea.europa.eu/metadata/case-studies/lower-danube-green-corridor-floodplain-restoration-for-flood-protection
		Cliff stabilization	East Anglia	http://www.eacg.org.uk/default_smp.asp
		Restauration of dunes and sand spreading	Flanders	http://climate-adapt.eea.europa.eu/metadata/case-studies/implementation-of-the-integrated-master-plan-for-coastal-safety-in-flanders
			Zuid-Holland	https://www.government.nl/latest/news/2011/01/17/province-of-zuid-holland-expands-seawards
	Grey infrastructure	Construction/Improvement of dykes, dams, seawalls, jetties	Scheldt Estuary	http://climate-adapt.eea.europa.eu/metadata/case-studies/an-integrated-plan-incorporating-flood-protection-the-sigma-plan-scheldt-estuary-belgium/#adapt_options_anchor
			New York	
		Floating and mobile barriers	Venice	https://www.mosevenezia.eu/
		Depolderisation (via tidal gate) and coast realignment	Medmerry	https://www.ice.org.uk/knowledge-and-resources/case-studies/managed-realignment-at-medmerry-sussex
		Amphibious and floating housing	Rotterdam	http://www.deltacities.com/cities/rotterdam/climate-change-adaptation
	Civil Protection & Emergency	Modelling, Monitoring, Flood Risk Management Plans (FRMPs)	Scheldt Estuary	http://climate-adapt.eea.europa.eu/metadata/case-studies/an-integrated-plan-incorporating-flood-protection-the-sigma-plan-scheldt-estuary-belgium/#adapt_options_anchor
			Šibenik-Knin County	http://climate-adapt.eea.europa.eu/metadata/case-studies/integrating-climate-change-adaptation-into-coastal-planning-in-sibenik-knin-county-croatia
	Transport	Floated or elevated roads	Nederland	http://www.iiinstitute.nl/sites/default/files/FloatingRoad_343.pdf
	Civil society, education &	Participatory process with local representatives for adaptation	Waitakere City	https://coastadapt.com.au/sites/default/files/information-manual/IM09_community_engagement.pdf

	health	education, planning and action		
		Health care plans including Climate Change concerns as cause of psychological distress	UK	http://climate-adapt.eea.europa.eu/metadata/publications/climate-change-and-mental-health-in-the-uk-impacts-of-changes-in-temperature-precipitation-and-uv
	Water and Wastewater	Water quality monitoring networks	Purba Midnapur	http://medcraveonline.com/MOJES/MOJES-03-00061.pdf
		Hydraulic barriers, desalinisation, aquifer storage and recovery	Santa Cruz and Soquel	http://scwd2desal.org/Page-PreventSWIntrusion.php
	Insurance	Risk-transfer tools	New York	http://www.deltacities.com/cities/new-york-city/climate-change-adaptation
Landslides	Green Infrastructure	Agro-forestry on landslide prone slopes	Rio de Janeiro	http://www.rio.rj.gov.br/dlstatic/10112/4402327/4113195/PROGRAMADEPROTECAOCOMUNITARIA.pdf
			Quito	http://www.100resilientcities.org/wp-content/uploads/2017/10/Quito-Resilience-Strategy-PDF.pdf
	Grey infrastructure	Property rebuilding in safe areas (citizen reallocation)	Salvador	http://www.100resilientcities.org/cities/salvador/
		Soil stabilization: soil nails, reinforced walls and deep drainage systems	Lyme Regis	https://www.newcivilengineer.com/latest/lyme-regis-landslip-stabilisation-coastal-conservation/8658793.article
	Civil Protection & Emergency	Early Warning systems; Disaster management planning	Sogn og Fjordane County	http://climate-adapt.eea.europa.eu/metadata/case-studies/multi-hazard-approach-to-early-warning-system-in-sogn-og-fjordane-norway
		Vulnerability and Risk Assessment (RVA)	Belo Horizonte	http://www.kas.de/wf/doc/kas_47229-1522-4-30.pdf?161128211634
	Civil society, Education & Health	Strengthening community risk management	Medellin	http://www.100resilientcities.org/strategies/medellin/

	Transport	Hazard control and forecasting system	Ancona (FSI railways)	https://www.comune.ancona.gov.it/ankonline/act-life-adapting-to-climate-change-in-time/
			Austrian Railway	http://climate-adapt.eea.europa.eu/metadata/case-studies/building-railway-transport-resilience-to-alpine-hazards-in-austria
Droughts	Water Supply	Establishment of the "regional water association network of Lavant Valley; Early warning system in place providing daily updated data about the drinking water situation (Wolfsberg)	Lavant Valley/Carinthia (AT)	http://climate-adapt.eea.europa.eu/metadata/case-studies/securing-future-water-supply-on-regional-and-local-level-in-the-river-lavant-valley-carinthia
		Develop the water leakage detection program	Lisbon (PT)	http://climate-adapt.eea.europa.eu/metadata/case-studies/private-investment-in-a-leakage-monitoring-program-to-cope-with-water-scarcity-in-lisbon/#adapt_options_anchor
		Awareness-raising campaign to reduce water consumption and implementation of 50 examples of water efficient technologies and practices in parks, gardens, public buildings and industry.	Zaragoza (ES)	http://climate-adapt.eea.europa.eu/metadata/case-studies/zaragoza-combining-awareness-raising-and-financial-measures-to-enhance-water-efficiency
	Agriculture, Forestry and Natural Habitats	Promoting use of more drought-tolerant tree species and establishing more climate-resilient mixed forest stands.	Lavant Valley/Carinthia (AT)	http://climate-adapt.eea.europa.eu/metadata/case-studies/securing-future-water-supply-on-regional-and-local-level-in-the-river-lavant-valley-carinthia
		Water retention measures ("Watermachine" concept): natural area divided into several compartments mutually interconnected. These compartments are periodically filled with water coming from the Elsebeek River, rainfall and the wastewater treatment plant.	Enschede, Hengelo (NL)	http://climate-adapt.eea.europa.eu/metadata/case-studies/the-watermachine-multifunctional-area-for-flood-protection-and-improved-water-quality-kristalbad-enschede
		Improve water retention and reduce water needs; Agroforestry and crop diversification measures	Montemor-o-novo (PT)	http://climate-adapt.eea.europa.eu/metadata/case-studies/autonomous-adaptation-to-droughts-in-an-agro-silvo-pastoral-system-in-alentejo

		Water Retention Landscapes (WRL) for the restoration of the full water cycle by retaining the water in the areas where it falls as rain.	Odemira (PT)	http://climate-adapt.eea.europa.eu/metadata/case-studies/tamera-water-retention-landscape-to-restore-the-water-cycle-and-reduce-vulnerability-to-droughts
	Transport	In case of drought screw pumps are pumping up water lost by the passing from the ship through the lock. In case of an excess of water, mainly in winter, the screws are used as a bypass to get rid of the excessive amount.	Antwerp (B)	http://climate-adapt.eea.europa.eu/metadata/case-studies/new-locks-in-albertkanaal-in-flanders-belgium
	Urban Green Areas	Installation of underground storage tanks under the pavements and the associated water collection and distribution system (Gomeznarro Park) Removal of impervious pavements and their replacement with permeable surfaces, thereby facilitating water drainage and collection; Replacement of the eroded and compacted soil and Re-vegetation of the eroded areas.	Madrid (ES)	http://climate-adapt.eea.europa.eu/metadata/case-studies/the-refurbishment-of-gomeznarro-park-in-madrid-focused-on-storm-water-retention
Forest Fires	Forest and Natural Habitats	Adaptation of fire management plans and Adaptive management of natural habitats	Dorset (UK)	http://climate-adapt.eea.europa.eu/metadata/case-studies/financial-contributions-of-planning-applications-to-prevention-of-heathland-fires-in-dorset-uk
		Awareness campaigns; Monitoring, forecasting and early warning systems	Tatabánya (HU)	http://climate-adapt.eea.europa.eu/metadata/case-studies/tatabanya-hungary-addressing-the-impacts-of-urban-heat-waves-and-forest-fires-with-alert-measures
Flood	Green Infrastructure	Rain gardens and woodlands	Somerset County	https://somersetnewsroom.files.wordpress.com/2014/03/20yearactionplanfull3.pdf
			Trondheim	https://www.ngu.no/en/topic/urban-groundwater

		River restoration and rehabilitation: green corridors, wetlands and floodplains	Lower Danube	http://climate-adapt.eea.europa.eu/metadata/case-studies/lower-danube-green-corridor-floodplain-restoration-for-flood-protection
	Grey infrastructure	Fixed and mobile barriers and safety valves	Prague	http://climate-adapt.eea.europa.eu/metadata/case-studies/realisation-of-flood-protection-measures-for-the-city-of-prague
			London	https://www.gov.uk/guidance/the-thames-barrier
			Nijmegen	http://climate-adapt.eea.europa.eu/metadata/case-studies/room-for-the-river-waal-2013-protecting-the-city-of-nijmegen
		Amphibious and floating housing	Maasbommel	http://climate-adapt.eea.europa.eu/metadata/case-studies/amphibious-housing-in-maasbommel-the-netherlands
	Civil Protection & Emergency	Flood control system, Flood Risk Management Plans (FRMPs)	Prague	http://climate-adapt.eea.europa.eu/metadata/case-studies/realisation-of-flood-protection-measures-for-the-city-of-prague
		Vulnerability and Risk Assessment (VRA)	Belo Horizonte	http://www.kas.de/wf/doc/kas_47229-1522-4-30.pdf?161128211634
	Civil society, Education & Health	Participatory process with local representatives for adaptation education, planning and action	Tiel	http://www.duurzaamrivierenland.nl/documents/WieWatWater.pdf
		Health care plans including Climate Change concerns as cause of psychological distress	UK	http://climate-adapt.eea.europa.eu/metadata/publications/climate-change-and-mental-health-in-the-uk-impacts-of-changes-in-temperature-precipitation-and-uv
	Transport	Critical node hardening and green roof infrastructure	Newcastle	http://eprint.ncl.ac.uk/file_store/production/237503/F42C93B2-11FC-42D9-AADB-D1F7E15967EE.pdf
		Improving drainage standards of railway networks	UK	http://climate-adapt.eea.europa.eu/metadata/case-studies/implementing-climate-change-allowances-in-drainage-standards-across-the-uk-railway-network

Annex 3. Risk Sharing Mechanisms

Alternative financing schemes may implicate the so-called Risk sharing mechanisms. Risk sharing mechanisms can be a solution when a domestic financial system does not face liquidity constraints, but financial intermediaries are reluctant to lend to EE projects because of high perceived risks. Risks are often perceived initially to be high by local banks that are unfamiliar with energy efficiency business concepts or specialized means to mitigate those risks. There are different types of risk sharing mechanisms, such as partial loan guarantees and loan reserve funds.

Guarantees are contracts interlocking three parties. With partial credit guarantees the contracts are between lender and borrower (loan agreement) and between guarantor and lender (guarantee agreement). In partial risk guarantees, the contracts are between guarantor and investor/lender and between guarantor and host country government. Typical guarantee structures include pari passu partial guarantees, subordinated recovery guarantees, portfolio first loss and second loss guarantees and pro rata loss basis, loss reserves acting like first loss guarantees and liquidity support guarantees.

TYPES OF GUARANTEES

Partial parity guarantee programs involve placement of grant funds into a reserve account used to provide partial credit guarantees clearing part of the risks of loan repayment for energy efficiency loans. A parity guarantee means that the guarantor ranks equally with other lenders in recovery of funds; the guarantee is partial because any losses are shared in agreed proportions. The instrument also may provide a useful platform for delivery of a broad package of assistance to financial intermediaries.[3]

Subordinated recovery guarantees imply that the guarantor ranks behind other lenders in recovery of the guarantee funds it paid out in case the borrower defaults on the loan. A subordinated guarantee is more valuable to lenders and they can be expected to lower interest rates etc. more with this provision. A subordination provision can be used when interest rates are extremely high, due to higher perceived risk, for example if a new technology being used ([185]).

Loan loss reserve funds – considered as an alternative to portfolio guarantees – grant funds are deposited with a bank or banks to provide full or partial coverage for a loan portfolio. No guarantor is required. This approach is better suited for smaller, residential loans where individual guarantees would be too costly. The participating banks may provide part of the reserve together with the source of grant funds, with a specified default level above which the bank bears all additional losses. As with guarantees, this approach is best suited for developed and liquid banking sectors where banks are willing to take some risks. Since it is better suited for a portfolio of small, standard loans, it should be accompanied by technical assistance to support preparation of standardized applications and appraisal methods ([185]).

A preferred drawing right agreement or provision is included in the loan documentation whereby the borrower agrees that the lender is paid automatically at a defined payment date each payment period (monthly, quarterly) and this amount is automatically withdrawn from the borrower's primary bank account. A common project finance technique is to establish dedicated reserves for debt service, repair and replacement of equipment or other purposes.

Security interest protects lenders' interest in a way that if a borrower defaults, a security interest in equipment may also allow a lender to deny access to or use of equipment even if it is not repossessed ([185]).

Individual and portfolio guarantees. Depending on the degree of guarantor's involvement in the loan approval process, there are individual guarantees and portfolio guarantees. In an *individual guarantee scheme* the guarantor is heavily involved in each individual transaction, appraising the eligibility of the applicant borrower for the guarantee in parallel with the primary lender's due diligence to establish eligibility for a

loan. A *portfolio guarantee* guarantees all loans by the primary lender to a class of borrowers.

As an example of the application guarantees in EE financing, the Bulgarian Energy Efficiency

Fund (BEEF) offers partial credit guarantees (80% on a parri passu basis and 50% on first loss basis), as well as portfolio guarantees for ESCOs and for the residential sector. The ESCO portfolio guarantee covers up to 5% of defaults of the delayed payments of an ESCO portfolio; with this guarantee an ESCO can get better interest rates on its debt with commercial banks.

Since delays in payments are more probable than default of clients, the BEEF acts as financial buffer to take the shocks. For the residential guarantee BEEF helps the households in a building to develop a good project; a company is then selected to implement the investment. The bank gives the funds to the project developer, but the repayments afterwards come from the individual households. Each household pays proportionately to their built-up area. BEEF guarantees that it will cover the first 5% of defaults within this block (or portfolio of blocks). This product is being developed as a partnership with commercial banks ([185]).

Guarantees by banks. Other examples include guarantee programs provided by development and public banks – for instance KfW in Germany, the Czech Guarantee and Development Bank in the Czech Republic, KredEx in Estonia, BPME and Ademe (the Fogime guarantee scheme) in France and the Bank for Environmental Protection in Poland. The State Support Programme for the Housing Stock Renewal through the Granting of Bank Guarantees for Loans in Slovakia involves granting of bank guarantees for loans, which enable wider utilisation of bank resources in financing of housing stock reconstructions, thus starting faster renewal and ensuring public fund leverage. A number of financing instruments at EU level can be used to implement guarantee schemes.

At national level governments can choose to guarantee loans used in order to implement measures to improve the energy efficiency. For example residential efficiency loan guarantees could work similar to the way some governments guarantee student loans. The government guaranteeing loans for improved energy performance homes would boost energy efficiency because it reduces the risk to the lender, which leads to reduced risk results in lower interest rates and not having a requirement for mortgage insurance ([185]).

Energy Savings Insurance (ESI) is a formal insurance contract between an insurer and either the building owner or third-party provider of energy services. In exchange for a premium, the insurer agrees to pay any shortfall in energy savings below a pre-agreed baseline, less a deductible. Pricing is typically expressed as a percentage of energy savings over the life of the contract, although it is sometimes expressed as a percentage of project cost. The premium is paid once, in the first year of operation. Such policies are non-cancellable, so the owner is guaranteed to have access to the insurance for the originally agreed contract term. Energy saving insurances typically insures annual savings expectations (a "volumetric" approach). Energy-savings insurance can reduce the net cost of energy-saving projects by reducing the interest rates charged by lenders, and by increasing the level of savings through quality control. Unlike guarantee – which is a three-party contract – insurance is a two-party contract between the insurer and the insured; for the insured insurance operates very similarly to risk guarantee.

ESI is widely practiced in Canada and in the US. In Europe the global market of risk transfer is slowly growing up, but insurance products such as ESI are still limited. In the US several insurance companies already offer ESI, which traditionally has been used to guarantee power reductions at retrofitted buildings. State governments have led ESI efforts, with several requiring such insurance from firms that provide energy management services in state-owned facilities.

Annex 4. Eleven cases of financing urban adaptation

1. Financial incentive programme enabling Hamburg's Green Roof Strategy

Adaptation measures financed

- Awareness campaigns to encourage behavioural change
- Economic incentives to build green roofs
- Water-sensitive urban and building design
- Green spaces in cities

Financing sources:

- National, regional and local budgets
- Private investors
- Supporting regulations

Financing types:

- Subsidy for implementation of green roofs
- Financing mechanisms
- A fund managed by a local development and investment bank

Summary

In response to Climate Change, one of Hamburg's objectives is to become greener, both in the city and 'on top of the city'. The goal is to plant a total of 100 hectares of green roof surface in the metropolitan area over the next decade.

An assessment showed that green roof measure is economically more feasible than extending the sewerage infrastructure to cope with an expected amount of storm water in the future.

The Federal State Ministry for Environment and Energy will be providing financial support for the creation of green roofs to the sum of EUR 3 million until the end of 2019. Two thirds of the funding comes from the Ministry and one third is from the Senate Office. The Hamburg Investment and Development Bank (IFB) handle all funding applications and transactions. The approach taken is that financial incentives are available to those that voluntarily install a green roof before 2020. After that date, Hamburg will consider green roofs to be compulsory by law. Until 2020, building owners can receive non-refundable subsidies to cover up to 30-60 % of the installation costs for the 'greening' process.

Main challenge for implementation

A particular challenge was communication regarding the benefits of green roofs. The promotion of the benefits regarding water retention during heavy storm events was one hurdle. Another aspect was addressing the possible 'negative' effect of green roofs attracting animals. On one industrial flat roof, a seagull colony of more than 5 000 individuals established itself, putting off other businesses from installing green roofs. Similarly, green roofs attract insects, which may discourage others from installing them.

Main success factor for implementation

Promotion and communication of the Green Roof Strategy are a top priority. Strong communication persuaded stakeholders of the benefits that outweigh the potential negative aspects. The federal government supported the strategy as a pilot programme within a larger federal programme, providing financial support to employ staff, networking and transfer of knowledge.

2. Combining private investment and an EIB loan to cope with water scarcity in Lisbon

Adaptation measures financed

- Leakage detection system
- Adjustment of water infrastructure to reduce water leakage
- Adaptation of drought and water conservation plans
- Water restrictions and cuts in consumption

Financing sources:

- Private investors
- Financial institution

Financing types:

- Direct private financing and a loan

Financing mechanisms:

- Business case and EIB loan process

Summary

In Lisbon, the water company EPAL (Empresa Portuguesa das Águas Livres) found a way to reduce the volume of water lost as a result of leakages (also known as non-revenue water). The main source of this problem is linked to faults in the pipelines due to ageing infrastructure. To address the water leakages, EPAL decided to develop the monitoring programme WONE through which it can identify water leakages more quickly and locate them more precisely. It used its own budget. The monitoring system allows the comparison of expected water usage data with real-time water usage using tailor-made software. When a discrepancy is found, it alerts the monitoring team, which then identifies the leak by tracing back from the water meter that provided the data. After the location of the leak, leak detection mechanics carry out field-based leak detection and repair the damage.

To finance the infrastructure renewal, EPAL has received loans of almost EUR 2.5 billion from the EIB, at favourable interest rates, since 1993. It used the EIB support to finance water supply extensions and upgrades, waste management measures, sanitation networks and efficiency improvements. The programme has resulted in a reduction of nonrevenue water from 23.5 % in 2005 to around 8.5 % in 2015.

Main challenge for implementation

It can be difficult for cities to take the initiative in developing a water efficiency programme, as the role of the local authority is limited to that of a facilitator and a customer of the water company. To implement a water efficiency programme is primarily an investment decision that needs to be taken by the water company itself.

Main success factor for implementation

Support of the management board of the company, as well as the involvement of network operations, maintenance, customer relations and other key areas of the company, have been proven to be an important success factor. The extreme drought in 2005 led to a higher awareness of the risks involved in droughts. EPAL and the EIB have built a long-term and trusting relationship through the provision of annual progress reports by EPAL to the EIB on new concepts and methodologies, as well as updates on the related national and international programmes.

3. Public–private partnership for a new flood-proof district in Bilbao

Adaptation measures financed

- Opening of a water canal
- Elevation of ground level of buildings
- Establishment of green open spaces
- Provision of storm water tanks

Financing sources:

- Private investors
- Budget of local authority
- Regional budget

Financing types:

- Direct funding for implementing adaptation measures
- Public–private partnership managed by a newly established commission

Summary

In 2012, Bilbao approved a plan for the redevelopment of the Zorrotzaurre area from industrial to residential use. The main stakeholders of the redevelopment project, the land owners of Zorrotzaurre, created a public–private partnership and the Management Commission of Zorrotzaurre to advance the project. The current members of the commission own 65 % of the land in Zorrotzaurre. These are the Regional Basque Government, Bilbao City Council, and the Port Authority of Bilbao and various private entities. The commission supervises the redevelopment plan and members contribute financially in proportion to the share of the land they own. The costs for opening the Deusto canal are budgeted at EUR 20.9 million and Bilbao City Council takes up this spending, having reached an agreement with the Basque government, which will in turn finance the costs of one of the new bridges. The local authority will also pay EUR 5.1 million for a flood protection barrier, including the structural rehabilitation of the river bank and the storm water tanks (EUR 4.74 million). The costs for the elevation of the ground level of buildings and public green spaces (as well as the other redevelopment costs) are met by the public–private partnership.

Main challenge for implementation

The redevelopment is a complex project, which was also affected by the economic downturn. Therefore, instead of carrying out the entire project at once, it was divided into phased development.

Main success factor for implementation

One of the greatest assets to the project is the involvement of a great number of land owners of all sizes gathered together in the public–private partnership.

4. Ghent crowdfunding platform realising Climate Change adaptation projects

Adaptation measures financed

- Urban farming
- Green garden facades

Financing sources:

- Investors
- Local authority
- Budget
- Private

Financing types:

- Direct funding and subsidy for adaptation measures
- Crowdfunding platform and fund for subsidies

Summary

Ghent has developed a crowdfunding platform that allows citizens to propose and finance their ideas for the city.

Today, two projects addressing Climate Change adaptation have been successfully realised with the support of the 'crowdfunding.gent' platform: (1) urban farming for residents of a social housing quarter, and (2) 'edible streets', achieved by covering the facades along the streets with planters. Any citizen of Ghent or person with an idea located in Ghent can submit a project. They need to provide a short description and a funding goal for the project. The project becomes visible on the platform once the platform manager, who is appointed by the local authority, has approved it. The manager checks whether the project proposal meets a set of predefined requirements.

People who provide financial backing for a project are known as 'supporters'. Their minimum donation is EUR 5. The donated amount per idea is viewed as an indicator of community support; only the projects with sufficient community support will become financially viable. 'Crowdfunding.gent' also offers initiators the opportunity to apply for a municipal subsidy for the project. The local authority has provided a total fund of EUR 55,000 per year specifically assigned to the crowdfunding platform. Per project the maximum amount of municipal subsidy that can be obtained is EUR 5,000.

Project initiators need to indicate the request for municipal funding in the original application form. Initiators can choose to apply for 25, 50 or 75 % municipal funding. To be eligible for this subsidy, the predefined amount of co-funding first needs to be raised.

Main challenge for implementation

The use of crowdfunding as a policy instrument implies acceptance of the fact that the exact outcome cannot be controlled.

Main success factor for implementation

The appointment of a policy officer to manage the platform and support from an existing crowdfunding platform developer.

5. Vrijburcht: a privately funded climate-proof collective garden in Amsterdam

Adaptation measures financed

- Climate-proof collective garden
- Rainwater storage tanks
- Water sensitive urban and building design

Financing sources:

- Private investors
- Financial institution

Financing types:

- Direct funding and a loan

Financing mechanisms:

- Collective private commissioning managed by a foundation

Summary

A group of people living in the centre of Amsterdam initiated the Vrijburcht complex project in 2000. The group centred on an architect. Members saw the opportunity to create their own new housing, including working spaces and a theatre. The heart of the complex is the courtyard garden with trees, a vegetable garden, lawns, flowers, benches and a greenhouse. The garden offers residents a cool environment during warmer summers; rain water is stored in underground tanks for irrigation in dry periods, and the unsealed area permits maximum rainwater permeability.

The project is a collective private commissioning initiative. This means that future residents developed the project jointly, including carrying the risks involved in the pre-financing. The future residents organised themselves into a foundation (Vrijburcht Foundation). This organisational set-up has the benefit of giving considerable freedom to future residents, but also asks for strong commitment to the process. All costs, including those of the garden and a rainwater storage facility (EUR 72 500) and the maintenance of the garden (EUR 3,000 EUR annually), are borne by the Vrijburcht Foundation on behalf of (future) residents. There was no subsidy involved. Instead, the Vrijburcht Foundation arranged the option of a personal loan at a favourable interest rate with Rabobank, and arranged procedures for a special mortgage for people with an average regular income (the so-called 'Amsterdamse Midden Hypotheek'). The social housing corporation 'De Key' also provided financial warranty and expertise in return for subsidised rental housing for assisted living for six young people with a light impairment, and their attendants, in the project.

Main challenge for implementation

Initial difficulties in attracting enough participants.

Main success factor for implementation

Building construction/development was a collective process, with the common desire for a building that was sustainable in both social and climate contexts. People in the foundation invested a lot of time and effort in the process. The social housing corporation provided a financial warranty.

6. European funds for flood protection measures in Smolyan

Adaptation measures financed

- Expansion and cleaning of the riverbed
- Reconstruction and upgrading of the existing flood protection walls
- Construction of new flood protection walls

Financing sources:

- EU funds and local authoritiy funds

Financing types:

- Direct funding and co-funding of adaptation-related measures

Financing mechanisms:

- EU ERDF funding mechanism

Summary

In response to flooding damage in Smolyan's Ustovo neighbourhood in 2005, the local authority implemented a number of flood protection measures that presumably have already paid off during the wet year of 2014. The project included widening of river banks, reinforcing existing protection walls and constructing new walls.

The costs of the combined flood protection measures amounted to EUR 477 259. Smolyan provided a small part (5 %) of the total sum from the municipal budget. The majority of funding (85 %) originated from the EU through the ERDF Operational Programme Regional Development 2007-2013 'Support for Small-Scale Measures to Prevent Flooding in Urban Agglomerations'. Municipal experts took care of the implementation. The local authority submitted the project proposal to the Ministry of Regional Development, the managing authority of this programme. When it granted the project, it drafted a contract with the city of Smolyan. In the next phase, an open contracting procedure was started for the construction works. The construction company answered directly to the local authority, who in turn reported to the ministry.

Main challenge for implementation

Illegal buildings on the construction site, including barns and gardens, had to be demolished before work could start.

Main success factor for implementation

Municipal experts had access to all the information required for the project, including preliminary studies and technical designs. The land on which the measures are being implemented is owned by the local authority and it was easy to obtain building permits.

7. Climate bond financing adaptation measures in Paris

Adaptation measures financed

- Green spaces in cities
- Planting 20 000 trees
- Establishing 30 hectares of new parks by 2020

Financing sources:

- Private investors
- Budget of local authority

Financing types:

- Financing of adaptation measures via an investment instrument with returns (climate bond)

Financing mechanisms:

- Climate bond managed by independent financial institutions; implementation of business case

Summary

The Paris Climate Bond was issued in November 2015 to finance projects in climate mitigation and adaptation. The total size of the bond is EUR 300 million, with a running time until May 2031. The bond targets private investors who consider it a secondary advantage to invest in the sustainability of the city of Paris. They will receive a profit rate of 1.75 % per year. Annual reporting ensures transparency, whereby the issuer has to justify the allocation of money to projects complying with the set criteria. Vigeo, a non-financial rating agency, reviews the process and report thereby providing investors with reassurance on the use of their funds.

In a competitive tendering, Paris local authority selected two banks to accompany it in the process as partners. Paris local authority benefited from their expertise in investor expectations and from their network and marketing services. The Finance Management Support Service (SGF) of the city manages the selection of projects to be included in the bond, in full collaboration with the Urban Ecology Agency (AEU) and overseen by Vigeo. The selection process consists of two steps which are taken in accordance with criteria partly brought forward by SGF and partly from those used for socially responsible investments. Twenty per cent of the bond funds have been assigned to adaptation projects. Currently, two projects with a climate adaptation objective are being implemented: planting 20,000 trees in the city and creating 30 hectares of new parks by 2020.

Main challenge for implementation

Ideally the local authority needs expertise in the green market and knowledge of what investors is expect or value.

Main success factor for implementation

The participation of independent advisors, sectoral experts in green bonds and bankers, as well as an independent financial rating agency.

8. Mix of private and public funding to adapt Malmö's new harbour district

Adaptation measures financed

- Green roofs
- Green areas
- Stormwater management measures

Financing sources:

- Private investors
- National and
- EU funds

Financing types:

- Direct financing of adaptation measures

Financing mechanisms:

- Stakeholder partnership
- National and EU funding mechanisms

Summary

The city of Malmö aims to realise climate adaptation measures by integrating them directly in the design of urban development projects, such as the Western Harbour area. Developers provide the private funding to realise these measures and carry out the actual construction of the projects. They engage in a stakeholder partnership process, initiated by the local authority, to ensure that the final realisation of the urban development reflects Malmö's sustainable vision.

The local authority had asked each developer attached to the development area of the Western Harbour, as either a land owner or a buyer, to participate in the stakeholder partnership.

A stakeholder partnership process generally consists of a series of meetings and workshops for which the local authority provides the topics, depending on the envisaged sustainability goals. The initial phase included the design of a quality assurance programme, comprising a set of strict sustainability guidelines co-developed in 'creative dialogue' with the area developers. The local authority initiated the process, but its involvement decreased over time as the stakeholders take over. In the event that the developers need to meet a higher level of environmental standards, the local authority can initiate an application for additional public funding. The Western Harbour project used both national and European funding. The costs to the local authority are limited to the work time spent by policy officers managing the process and the provision of resources to facilitate meetings and workshops.

Main challenge for implementation

In some cases the developers initially had difficulties trusting each other, as they are usually competitors.

Main success factor for implementation

The most essential factor is trust between the partners and time to build it.

9. GAIA — Green Area Inner-city Agreement to finance tree planting in Bologna

Adaptation measures financed

- Green spaces in cities
- Tree planting

Financing sources:

- Private investors
- EU and municipal funds

Financing types:

- Direct funding of measures that offset greenhouse gas emissions and, as a co-benefit, serve adaptation

Financing mechanisms:

- Greenhouse gas emissions compensation scheme, EU LIFE funding mechanism

Summary

The Bologna Adaptation to Climate Change Plan focuses on the development of innovative adaptation measures. These measures were developed as part of the LIFE+ project BLUE AP. One of the successful initiatives from this project is the 'Green Area Inner-city Agreement' (GAIA). GAIA was based on a public–private partnership model to finance tree planting. It uses financial compensation for the carbon footprint of businesses as a main driver for action. The financial compensation is used to purchase plants and maintain trees throughout the city, providing adaptation benefits.

Participation of the town council and local businesses in the GAIA initiative is on a voluntary basis. An easy-to-use form on the project website allows businesses to calculate the quantity of CO2 involved in their processes and services. The business can select one of three types of partnership they would like to purchase to neutralise their carbon footprint, ranging from a minimum of EUR 200 to EUR 4 200 or more. The city of Bologna has developed clear guidelines that detail the various steps in the process and which party is responsible. The local authority identifies the cost components, approves the Protocol of Agreement, takes the initiative to start the planting works and pays the tree suppliers. The local authority also commits to providing a monitoring report every 6 months from the start of the partnership. A guideline has been developed detailing the steps involved, to aid other authorities that wish to implement the partnership in their own cities.

Main challenge for implementation

Three orders of problems had to be solved: the identification of spaces for tree planting within the densely built-up urban area, the definition of legal terms for the public–private partnership and the identification of suitable tree species, which are sufficiently resilient with respect to future climate conditions (not requiring irrigation and resistant to high and low temperatures) and have a low allergenic potential. Scientific research developed by one of the project partners tackled the latter problem and led to new recommendations for the choice of plant species being introduced into the municipal byelaw for urban green areas.

Main success factor for implementation

Interest from companies to compensate for their CO2 emissions voluntarily.

10. Using European Economic Area grants for implementing climate adaptation measures in the city of Bratislava

Adaptation measures financed

- Increase in green infrastructure
- Tree planting
- Green roofs
- Rainwater retention facilities to reduce run-off and for irrigation purposes
- Sustainable drainage systems

Financing sources:

- European Economic Area and Norway grants and municipal funds
- Private investors

Financing types:

- Direct funding and co-funding for adaptation measures, subsidy for small projects

Financing mechanisms:

- European Economic Area and Norway grants mechanism, small project grant scheme

Summary

Bratislava local authority has prepared and approved a strategy on adaptation to Climate Change and is currently preparing an adaptation action plan, which identifies the adaptation measures for the city (with special focus on heat and rainwater management) and cooperation among decision-makers, planners, the private sector and local communities.

To finance the implementation of the planned measures, Bratislava successfully applied for 'European Economic Area grants and Norway grants'. These grants provided in total EUR 2 411 445 funding Bratislava city office and city districts provided the remaining EUR 926 195. They fund the implementation of such measures as the rehabilitation and creation of new parks, squares and streets, increasing green cover and water retention capacities, as well as the implementation of green roofs.

The project also includes a small projects grant scheme to support sustainable drainage systems. A total amount of EUR 50 000 will be made available for small projects up to a maximum of EUR 1 000 per project. Eligible applicants are private home owners, non-governmental organisations and businesses. The grant covers a maximum of 50 % of total costs, and it is expected that these will be used for water reservoirs, rainwater gardens, small green roofs, adjustment of pavements, use of permeable materials, etc. The grant scheme comes with consultancy for applicants and dissemination activities.

Main challenge for implementation

Complex procedures for the implementation of measures in terms of permits and obligations for public works; time consuming public procurement procedures; and archaeological aspects that have to be taken into account in a historical city.

Main success factor for implementation

The local authority's participation in the 'EU Cities Adapt' project of the European Commission 2012-2013 created the necessary awareness and basic information. Following this, Bratislava had carried out a risk assessment and adopted an adaptation strategy. That served as a key success factor for obtaining the European Economic Area grant.

11. The economics of managing heavy rains and stormwater in Copenhagen

Adaptation measures financed

- Stormwater runoff management measures
- Detention areas to store large volume of water

Financing sources:

- Private investors
- Budget of local authority
- Supporting regulations

Financing types:

- Direct funding

Financing mechanisms:

- Water charges managed through municipal budget and private investments

Summary

Following a disastrous flood in 2011, the local authority developed a Cloudburst Management Plan to reduce the impacts of pluvial flooding after heavy rains, which are expected to increase in frequency as a result of Climate Change. The plan builds on a detailed socio-economic assessment to ascertain which combination of cloudburst and stormwater measures can deliver the best results for society as a whole. It has shown that continuing focus on traditional sewerage systems would result in a loss to society. Solutions that combine grey and green measures, including retention areas and natural drainage, would result in a net saving.

The Cloudburst Management Plan operates with a minimum time-frame of 20 years, requiring a prioritisation of individual projects in line with the Copenhagen Climate Adaptation Plan. The plan includes 300 interlinked projects; some are already implemented. The local authority estimates that around 15 projects a year will be carried out in the next 20-30 years.

The city of Copenhagen, the Capital Area Supply Company (HOFOR) and private land owners will share the total costs of around EUR 1.5 billion. Water charges will finance the part of the solutions concerned with water management. The local authority can save money if it coordinates the implementation of the cloudburst and stormwater management with other construction projects. The combined solutions also require private individuals to invest in anti-flood backflow valves and local stormwater drainage.

Main challenge for implementation

The prioritisation of the projects emphasises large-scale projects, which will require cooperation between local authorities and private land owners.

Main success factor for implementation

An economic assessment shows that the costs of damage if nothing is done to adapt the current runoff and sewerage system are higher than those of adaptation measures. In particular, green infrastructure measures make the city safer and more pleasant and attract people and businesses. An amendment of the Danish Water Sector Act in 2012 clarified that water companies can invest in adaptation and use water charges to fund this.

Annex 5. Glossary

This document provides a glossary with some specific but most recurrent terms within the CoM documents and informative materials. The definitions are consistent with the IPCC terminology and with official documents.

Adaptation

The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

Albedo

The fraction of solar radiation reflected by a surface or object, often expressed as a percentage. Snow-covered surfaces have a high albedo, the albedo of soils ranges from high to low, and vegetation covered surfaces and oceans have a low albedo. The Earth's planetary albedo varies mainly through varying cloudiness, snow, ice, leaf area and land cover changes.

Baseline Emission Inventory

The Baseline Emission Inventory (BEI) quantifies the amount of CO2 emitted in the key sectors and other activity sectors in the territory of the Covenant signatory for the baseline year. It allows identifying the principal anthropogenic sources of CO_2 (and other GHGs) emissions and to prioritise the reduction measures accordingly.

Behavioural change

The alteration of human decisions and actions in ways that mitigate/ reduce negative consequences of Climate Change impacts.

Carbon dioxide (CO2)

A naturally occurring gas, also a by-product of burning fossil fuels from fossil carbon deposits, of burning biomass, of land use changes (LUC) and of industrial processes. It is the principal anthropogenic greenhouse gas (GHG) that affects the earth's radiative balance. It is the reference gas against which other GHGs are measured and therefore has a Global Warming Potential (GWP) of 1.

Carbon sequestration

The uptake of carbon containing substances, in particular carbon dioxide (CO_2), in terrestrial or marine reservoirs. Biological sequestration includes direct removal of CO_2 from the atmosphere through land-use change (LUC), afforestation, reforestation, revegetation, carbon storage in landfills, and practices that enhance soil carbon in agriculture (cropland management, grazing land management). In parts of the literature, carbon sequestration is used to refer to Carbon Dioxide Capture and Storage (CCS).

Climate change

Climate change refers to a change in the state of the climate that can be identified by changes in the mean and the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

CO2-equivalent emission

CO2-equivalent emission is a common scale for comparing emissions of different GHGs. It is the amount of carbon dioxide (CO_2) emission that would cause the same integrated radiative forcing, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs. The CO_2-equivalent emission is obtained by multiplying the emission of a GHG by its Global Warming Potential (GWP) for the given time horizon. For a mix of GHGs it is obtained by summing the CO_2-equivalent emissions of each gas.

Co-benefits

The positive effects that a policy or measure aimed at one objective might have on other objectives. Co-benefits are often subject to uncertainty and depend on, among others, local circumstances and implementation practices.

Decarbonisation

The process by which countries or other entities aim to achieve a low-carbon economy, or by which individuals aim to reduce their carbon consumption.

Ecosystem

A functional unit consisting of living organisms, their non-living environment, and the interactions within and between them. The components included in a given ecosystem and its spatial boundaries depend on the purpose for which the ecosystem is defined. Ecosystem boundaries can change over time. Ecosystems are nested within other ecosystems, and their scale can range from very small to the entire biosphere. In the current era, most ecosystems either contain people as key organisms, or are influenced by the effects of human activities in their environment.

Emission factors

The emissions released per unit of activity.

Emissions

(Anthropogenic) Emissions of greenhouse gases (GHGs), aerosols, and precursors of a GHG or aerosol caused by human activities. These activities include the burning of fossil fuels, deforestation, land use changes (LUC), livestock production, fertilization, waste management, and industrial processes. Emissions are usually classified in direct emissions that physically arise from activities within well-defined boundaries and Indirect emissions that are a consequence of the activities within well-defined boundaries.

Exposure

The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Global warming

Global warming refers to the gradual increase in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions.

Global warming potential (GWP)

An index, based on radiative properties of greenhouse gases (GHGs), measuring the radiative forcing following a pulse emission of a unit mass of a given GHG in the present-day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide (CO2). The GWP represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in causing radiative forcing. The Kyoto Protocol is based on GWPs from pulse emissions over a 100-year time frame.

Governance

A comprehensive and inclusive concept of the full range of means for deciding, managing, and implementing policies and measures. The concept of governance

recognizes the contributions of various levels of government (global, international, regional, local) and the contributing roles of the private sector, of nongovernmental actors, and of civil society to addressing the many types of issues facing the global community.

Greenhouse Gas (GHG)

Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and ozone (O3) are the primary GHGs in the earth's atmosphere. Moreover, there are a number of entirely human-made GHGs in the atmosphere, such as the halocarbons and other chlorine- and bromine containing substances, dealt with under the Montreal Protocol. Beside CO2, N2O and CH4, the Kyoto Protocol deals with the GHGs sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Hazard

The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.

Heat Island

The heat island effect is the phenomenon whereby atmospheric and surface temperatures are higher in urban areas than in the surrounding rural areas associated with the change in runoff, effects on heat retention and changes in surface albedo.

Impacts

Effects on natural and human systems. In this report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.

Lifecycle assessment

A widely used technique defined by ISO 14040 as a "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle". The results of LCA studies are strongly dependent on the system boundaries within which they are conducted. The technique is intended for relative comparison of two similar means to complete a product.
The approach considers the overall life cycle of the fuels/electricity. This includes all emissions of the energy chain that also take place outside the territory (such as transport losses, refinery emissions or energy conversion losses).

Maladaptation

Interventions and investments in a specific location or sector that could increase the vulnerability of another location or sector, or increase the vulnerability of the target group to future climate change. Maladaptation arises not only from inadvertent badly planned actions, but also from deliberate decisions focused on short-term benefits ahead of longer-term threats, or that fail to consider the full range of interactions, feedbacks and trade-offs between systems and sectors arising from planned actions.

Mitigation

Human interventions to reduce the sources or enhance the sinks of greenhouse gases (GHGs) and of other substances which may contribute directly or indirectly to limiting climate change.

Primary energy

It is defined in several alternative ways. Primary energy is the energy stored in natural resources (e. g., coal, crude oil, natural gas, uranium, and renewable sources). According to the International Energy Agency (IEA) definition, "primary energy is the energy that has not undergone any anthropogenic conversion". Primary energy is transformed into secondary energy by cleaning (natural gas), refining (crude oil to oil products) or by conversion into electricity or heat. When the secondary energy is delivered at the end-use facilities it is called final energy.

Renewable energy (RE)

Renewable energy sources, also called renewables, are energy sources that are replenished by natural processes at a rate that equals or exceeds its rate of use. Renewable energy sources include the following:

Hydropower: the electricity generated from the potential and kinetic energy of water in hydroelectric plants;

Geothermal energy: the energy available as heat from within the earth's crust, usually in the form of hot water or steam;

Wind energy: the kinetic energy of wind converted into electricity in wind turbines;

Solar energy: solar thermal energy (radiation exploited for solar heat) and solar photo-voltaic for electricity production.

Rebound effect

Phenomena whereby the reduction in energy consumption or emissions (relative to a baseline) associated with the implementation of mitigation measures in a jurisdiction is offset to some degree through induced changes in consumption, production, and prices within the same jurisdiction.

Resilience

The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.

Risk

The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. In this report, the term risk is used primarily to refer to the risks of climate-change impacts.

Risk and vulnerability assessment (RVA)

The Risk and Vulnerability Assessment is an analysis that determines the nature and extent of risk, by analysing potential hazards and assessing vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend. It allows the identification of areas of critical concern and therefore provides information for decision-making. The Risk and Vulnerability Assessment serves, along with the Baseline Emission Inventory, as the point of departure for the development of the Sustainable Energy and Climate Action Plan (SECAP).

Sustainable Development

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).

Transit Oriented Development

Urban development within walking distance of a transit station, usually dense and mixed with the character of a walkable environment.

Vulnerability

The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Resources and websites:

IPCC (Intergovernmental Panel on Climate Change) (2014). Working Group III - AR5 – Climate Change 2014: Mitigation of Climate Change.

IPCC (Intergovernmental Panel on Climate Change) (2014). Working Group II - AR5 – Climate Change 2014: Impacts, Adaptation, and Vulnerability.

http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Renewable_energy_sources

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