Template for public sector renovation strategies

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About the project

EmBuild is a coordination and support project implemented by a consortium of ten institutions based in eight countries throughout Europe under the Horizon 2020 Framework Programme for Research and Innovation. Overall coordination rests with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

The main objectives of EmBuild are to increase the capacity of public authorities at regional/municipal level to collect the necessary data to prepare ambitious, sustainable and realistic renovation strategies for public buildings, analyse and identify cost-effective approaches to renovations, guide investment decisions and facilitate private sector involvement. EmBuild is supporting municipalities and towns in Bulgaria, Croatia, Germany, Romania, Serbia and Slovenia. In addition, the project will focus on analysing policies and implemented measures that stimulate cost-effective deep renovation of buildings and identify best practices in 6 partner countries.

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Introduction

This guidance and template aims to be a useful tool to support public authorities in developing renovation strategies, with a particular focus on the renovation of public buildings. Such strategies should encourage renovation of all buildings, but as a minimum renovation of the buildings owned by public authorities, which have a key role to play in stimulating the market energy efficiency improvements in the entire building stock.[1]

For small and medium sized municipalities, the renovation of public building could be considered "lighthouse projects", which can demonstrate the potential of building renovation and stimulate the market, to achieve greenhouse gas reductions. Renovation of public buildings could be financed partly by EU funds, alleviating the financial burden from the municipalities. With regard to the residential building stock, a longer term approach to driving investment decisions is key.

The EmBuild project will provide support to municipalities to follow this guidance and develop renovation strategies for public buildings with input from its tasks and deliverables – links to relevant input is included under each section. The Annex provides an outline of what should be in included in a renovation strategy for public buildings and where the EmBuild project will provide support. This guidance is compatible with existing templates and guidance for Sustainable Energy Action Plans (SEAPs) and Sustainable Energy and Climate Action Plans (SECAPs) - developed in the context of the Covenant of Mayors, and National Energy Efficiency Action Plans (NEEAPs) - developed in relation to implementation of the EU Energy Efficiency Directive. Therefore, where municipalities have already developed such plans, duplication is not necessary, and where they are not in place those of other municipalities could be used as further reference.

Renovation strategies should cover the following elements:

1. An overview of the building stock based, as appropriate, on statistical sampling
2. Identification of cost-effective approaches to renovations relevant to the building type and climatic zone
3. Policies and measures to stimulate cost-effective deep renovations of buildings, including staged deep renovations
4. A forward-looking perspective to guide investment decisions of individuals, the construction industry and financial institutions; and
5. An evidence-based estimate of expected energy savings and wider benefits.

This is in line with what is required for national renovation strategies. Therefore, this guidance is structured according to each of these elements. The focus is on renovation of public buildings but this guidance can also be relevant to strategies targeting renovation of commercial residential buildings

The approach to developing national renovation strategies developed by BPIE [1] sets out the method for establishing the strategy itself.

[1] Public buildings of local, national and world cultural or architectural heritage are subject to special legislation and are not included in this guidance.

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Figure 1- BPIE's 5-phase approach to renovation strategy development

The content, and thus this guidance, is developed during phases 2 and 3, to enable phase 4. That is not to say, the other phases should be overlooked.

Phase 1, identifying key stakeholders and sources of information is an important first phase. This template and guidance attempts to help with the latter, by linking to resources available to help with completion of each section. Identifying key stakeholders ensures the involvement of the key representatives from administrations, including those working on energy, the building sector, and finance and input from external stakeholders such as sectoral experts, the finance community and representative industry bodies. It may also be the case that there are existing development, housing or similar strategies or plans that cover renovation. These should be identified and feed into the development of the renovation strategy.

Phase 2 and 3 are covered by sections 1 to 5 of this guidance.

Phase 4 brings together sections 1 to 5. This is where the renovation strategy should come together as a comprehensive document. It is highly recommended to consult key local stakeholders on a draft strategy. This will ensure that local issues and he needs of different groups, from industry to consumers, are taken into account.

Phase 5 takes account of feedback from the consultation process. This is also the stage of developing the necessary legislative mechanisms to implement the strategy in line with the roadmap of key dates, targets and milestones. It may be useful to establish a taskforce including local stakeholders to take on implementation actions and ensure wide communication. Strategies should be regularly revised and updated, for national strategies this is required every 3 years. This review should evaluate the impact of policies and measures to date and the potential of possible future measures.

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Context

National governments are required to establish "long term strategies for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private"[2]. These can only be successful with the involvement of regional and local authorities, since they will be required to design and implement detailed action plans to implement national plans. These plans allow policies and measure tailored to address local challenges. National renovation strategies should develop over time (updates of national plans is required every 3 years), taking account of new strategies at local and regional level.

Furthermore, national governments are required to renovate 3% of buildings owned and occupied by central government every year[3]. This requirement aims to ensure that public buildings lead by example and provide the stimulus for developing the market for energy efficiency improvements in the entire building stock. The experience of implementing this at national level can be rolled out to or up from regional and local governments.

There is a clear link between Sustainable Energy Action Plans (SEAPs) and Sustainable Energy and Climate Action Plans (SECAPs) developed in the context of the Covenant of Mayors[4] and renovation strategies. The SEAPs and SECAPs usually include plans for renovation of the public building stock, with detailed characterization of the existing buildings as part of the greenhouse gas emissions inventory, selection of renovation projects to be executed within the scope of the plans, financing sources and expected energy and CO_2 savings – together with their contribution to the overall decrease of greenhouse gas emissions compared to a selected baseline year. Similarly, national energy efficiency plans required by the national authorities[5] usually include all projects related to the renovation of the public buildings, with all the necessary data included in the reports. Therefore, where such plans already exist (together with other planning tools as the EE5/European Energy Award programme), their structure and content should be reinforced by the renovation strategies covered by this guidance, and vice versa.

[2] In accordance with Article 4 of the EU Energy Efficiency Directive 2012/27/EU.

[3] In accordance with Article 5 of the EU Energy Efficiency Directive 2012/27/EU.

[4] The Covenant of Mayors rings together local and regional authorities voluntarily committed to implementing EU climate and energy objectives on their territory. http://www.eumayors.eu/index_en.html

[5] In accordance with Article 24 of the EU Energy Efficiency Directive 2012/27/EU.

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Template

Section 1: An overview of the building stock

The aim of this section is to provide a comprehensive assessment of the building stock. This should start with the buildings owned and/or used by municipalities, but can be later expanded to cover all buildings. The basis of a renovation strategy is establishing a good understanding of the building stock. A detailed, bottom-up, breakdown by building type, age, energy carrier, climatic zone, energy performance, occupancy and ownership is a fundamental knowledge requirement to underpin subsequent steps in the strategy.

1.1 Content

Buildings should be categorized according to year of construction and possible past renovation attempts, general uses, associated energy consumers, calculated, measured or estimated energy consumption and heating system types.

As minimum, for public buildings, for each building its floor area (expressed in square metres) and data on the energy performance should be collected in the overview. Data on energy performance means data on energy consumption or total energy use, or data from Energy Performance Certificates (EPCs). The EPCs required for buildings (over 250m²) occupied by public authorities and visited by the public[6] could provide a useful source of data and information on the public buildings. These may have already been compiled, to some extent, at a national level, where inventories of buildings owned and occupied by central government should be developed[7].

Table 1 is an outline of what should be included in an overview of the building stock and advice on the content. This is based on guidance from the European Commission [2] and BPIE [1], and the experience of the EmBuild project partners.

Step 1: Identify main building categories: Public buildings: i) Offices/administrative buildings ii) Educational buildings iii) Hospitals/health establishments iv) Sport facilities Commercial buildings: i) Offices ii) Health establishments Hotels iii) Sports facilities iv) Warehouses/data centres v) Retail premises (including restaurants) vi) Other Residential buildings: i) Single-family houses ii) Apartments/multi-residential dwellings Other types of energy-consuming buildings	*The starting point should be buildings owned and/or occupied by municipalities. This could include social housing but is expected to be mainly public buildings used for administrative offices and local services.* *Residential and commercial buildings need only to be included where the strategy will include such buildings.*
Step 2: Identify age bands which have a material bearing on building energy performance: i) Traditional construction types, including	*These age bands can be adapted according to age bands used by the national statistics and the introduction and development of*

[6] As required by Article 12 of the EU Energy Performance of Buildings Directive 2010/31/EU

[7] As required by Article 5 of the EU Energy Efficiency Directive 2012/27/EU

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historic/heritage buildings (typically pre-1900) i) Buildings constructed prior to regulations on energy performance (e.g. 1901-1960) ii) Early phase building regulations (1961-1990) iii) Mid-phase building regulations (1981-2000) iv) New (2001-2012)	*energy efficiency criteria.* *The date ranges for categories such as early and mid- phase buildings regulations depends on when such regulations were introduced.*
Step 3: Identify main climatic zone[s] that have an impact on building energy performance	*For municipalities, this is likely to be limited to one zone.*
Step 4: Quantify the number, type, size (treated floor area) of each combination of building type and age band.	*If there are 9 building types and 5 age bands, this results in a matrix of up to 45 combinations. However, it will be possible to group many of the non-residential building types/age bands, so the number of combinations will in practice be less than this. This is particularly the case when focusing on public buildings.*
Step 5a: Identify split by owner – public/private/mixed **Step 5b: Identify split by tenure** – owner occupied/rented/ mixed	*This section is only relevant when looking at all building categories.*
Step 6: Identify the energy use and performance characteristics of each building combination: i) Construction type and U-value of main building elements: (1) Floor (2) Walls (3) Windows and External Doors (4) Roof ii) Air infiltration rate iii) Energy systems (In all cases, please identify typical replacement lifecycles): (1) HVAC system type/performance level/controls (2) Hot water provision (3) Lighting systems/controls iv) Maintenance regimes (e.g. mandatory annual safety checks/servicing) v) Energy use for: (1) Heating (2) Cooling (3) Ventilation (4) Hot water (5) Lighting (6) Appliances vi) Energy carriers: (1) Gas (natural gas or LPG) (2) Liquid fuels (oil, etc.) (3) Solid fuels (coal, etc.) (4) Renewable energies: (a) Solar energy for hot water generation (b) Solar PV (c) Wind (d) Heat pump (type and Coefficient of Performance)	*Some of this information may be difficult to obtain, particularly for old buildings and those partially renovated over time. The purpose of this step is to identify energy performance and technical characteristics of typical building archetypes.*

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(e) Biomass (wood-chips, wood-pellets) (f) Biogas (g) Other (specify) (5) District heating (identify energy carriers)	

Table 1: Outline of an overview of the national building stock

1.2 Resources

EmBuild

The EmBuild project has developed several sources of information that can be used by municipalities for appraising their building stock:

- Meta-data database (EmBuild Deliverable 2.5) – This spreadsheet database (field shown in figure 1) can be used to structure gathering data on the building stock owned and used by municipalities.

Basic Data									
Building	Owner	Municipality	Type/Purpose	Status	Address	Postal code	City	Region	Country

Pre refurbishment data									
Year of construction	Area in m2	Conditioned area in m2	Heating system	Main energy source for heat	Connection to district heating network	Energy number (kWh/m2/p.a)	Use of Heat (in kWh/p.a) (or 3-year average)	Use of electricity (in kWh/p.a) (or 3-year average)	Other / Comments

Documentation & Costs							
Energy Certificate	Detailed energy audit	Building permit	Estimated energy savings for heat in kWh/p.a.	Estimated electricity savings in kWh/p.a.	Estimated investment costs in EUR	Main area of refurbishment	Year of refurbishment

Financing					
Total cost of refurbishment in EUR	Financing scheme (ESCO, own sources, etc..)	Subsidies	Own participation	Simplified payback period for investment	Other/ comments

Post refurbishment data			
Use of Heat (in Kwh/p.a)	Use of electricity (in kWh/p.a.)	Actual energy savings of Heat (in kWh/p.a.)	Actual electricity savings (in kWh/p.a.)

Figure 1: Fields for data collection

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- Building stock appraisals (EmBuild Deliverable 2.5 and 2.7) - This includes examples of the methods that municipalities have used to appraise their building stock. Table 2 presents some of the main characteristics of the building stock appraisal methods used in Slovenia and Croatia. The report also includes an overview of the information available at national level in the countries covered by EmBuild.

Sample	Data collection method	Calculation method
24 public Buildings in City Municipality of Celje, Slovenia	• Energy management information system (EMIS) E2 manager • Detailed energy audits (REP) • Thermographic analysis of the building envelope • Construction physics calculation model for heat loss based on measurements of building dimensions • Validation of data with available WebGIS databases (prostor3, iObčina)	• Methodology for carrying out energy audits • Rulebook on energy efficiency of buildings (PURES) • Technical Guideline TSG-1004: 2010 • URSA 4.0 Building engineering physics • Internally developed Excel tools
52 public buildings in the City Municipality of Velenje, Slovenia	• Simplified energy audits (PEP) • Local Energy Concept (LEK) • Energy management information system (EMIS) DEM	• Rulebook on energy efficiency of buildings (PURES) • Technical Guideline TSG1-004: 2010 • Internally developed Excel-tool
24 out of 31 municipalities in the Savinja Statistical Region, Slovenia	• Energy management information system (EMIS) DEM • Municipalities own data (invoices) • - WebGIS databases (prostor3, iObčina)	• Estimation of potential energy savings compared to estimated investments
Three counties in Croatia (more than 500 public buildings)	• Energy management information system • Energy performance certificates	• Methodology for carrying out energy audits • Internally developed Excel tools • Estimation of potential energy savings compared to estimated investments

Table 2: Summary table of the examples of building stock appraisals presented in EmBuild D2.7

- Questionnaire for Preliminary analysis of the building stock (EmBuild Deliverable 3.1) – This checklist was developed for experts to carry out a preliminary, fast and rough analysis of a building during onsite visits. It has three sections: data collection, reporting of possible measures and a renovation plan for the single building. The report guides the way through the building and gives examples for the possible equipment. With the traffic-light-like colours (figure 2) it indicates if the existing infrastructure and building construction can be considered energy-efficient (green), acceptable (orange) or if action is needed (red).

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Building: *Name, address, etc*			
year of construction:	*building / technical infrastructure*		
building type:	*e.g. administration building, school*		
energy carrier for heat:	*oil / natural gas / electric energy ...*		
type of heat supply:	☐ single stoves ☐ constant temp. boiler	☐ low temp. boiler	☐ condensing boiler ☐ heat pump ☐ CHP ☐ district heating
age:	☐ > 20 years	☐ 10 – 20 years	☐ < 10 years
heating system:	*radiators, floor heating, ventilation with heating etc.*		
heating circuit pumps:	☐ unregulated multi-level	☐ with electronic control	☐ high-efficient pumps
insulation of heating pipes :	☐ none with voids	☐ sufficient	☐ good
control and regulation system:	☐ faulty broken ☐ hard to operate	☐ ok, but no documentation (available)	☐ central control ☐ single room control ☐ building control system
heating times adapted to building use	☐ no	☐ unknown	☐ yes
heating curve adapted to the standard of the building:	☐ no	☐ unknown	☐ yes
hydraulic balanced system:	☐ no	☐ unknown	☐ yes
ventilation:	*with windows, mechanical etc.*		
Mechanical ventilation:	☐ no heat recovery ☐ no maintenance ☐ no automatic control	☐ heat recovery < 60% efficiency ☐ cleaning or changing filters ☐ simple automatic control	☐ heat recovery > 60% efficiency ☐ periodical professional maintenance ☐ automatic frequency control
Cooling	☐ SEER<2.5 ☐ automatic controled by temperature	☐ 2.5<SEER<3.5 ☐ automatic control by temperature and occupancy schedule	☐ SEER>3.5 ☐ automatic control by temperature – limited range, occupancy schedule and open windows
domestic hot water:	☐ none ☐ decentral ☐ central ☐ circulation		

Figure 2: EmBuild checklist for preliminary analysis developed under EmBuild D3.1

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- Template for energy audits for municipal buildings (EmBuild Deliverable 3.4) - This template will collect detailed analysis according to the several steps (steps 1 to 7 are particularly relevant for this section):

  1. Gather more in-depth information of the building
  2. Gather energy consumption data of the quantities of fuel and electric energy
  3. Climate correction of the consumption data
  4. On-site visit for data acquisition; additional information to preliminary analysis
  5. Calculation of the energy balance of the building
  6. Comparison of energy demand and climate-corrected energy consumption
  7. Calculation of the energy performance characteristics of the building and determination of the energy class
  8. Optional: Calculation of possible single measures for energy efficiency – energy savings, CO2 reductions, monetary savings and estimated investment
  9. Calculation of packages of measures– energy savings, CO2 reductions, monetary savings, estimated investment, expected energy performance characteristics and energy class – to meet a defined energetic standard (cost optimal, nZEB etc.)
  10. Calculation of financial indicators for different packages of measures – pay-pack period; internal rate of return; net present value;
  11. Compilation of the results and comparison of alternatives

Sustainable Energy and Climate Action Plans

Sustainable Energy and Climate Action Plans, developed within the frameworks of the Covenant of Mayors, require similar information on the municipal building stock. In the calculation of the Baseline Emission Inventory (BEI), the energy consumption of the public buildings is included.

Emission Inventory HOME

Baseline Emission Inventory

A. Final energy consumption

ⓘ Please note that for separating decimals dot [.] is used. No thousand separators are allowed.

Sector	FINAL ENERGY CONSUMPTION [MWh]															
			Fossil fuels								Renewable energies					
	Electricity	Heat/cold	Natural gas	Liquid gas	Heating oil	Diesel	Gasoline	Lignite	Coal	Other fossil fuels	Plant oil	Biofuel	Other biomass	Solar thermal	Geothermal	Total
BUILDINGS, EQUIPMENT/FACILITIES AND INDUSTRIES																
Municipal buildings, equipment/facilities																0
Tertiary (non municipal) buildings, equipment/facilities																0
Residential buildings																0
Public lighting																0

Figure 3: Extract of Sustainable Energy and Climate Action Plan template where data on energy consumption of public buildings (and other types of buildings) can be found.

In other management systems, such as the European Energy Award (eea), it is required to track the annual energy consumption of buildings under the realm of municipalities.

National information

Data from local and/or national statistics can be useful for developing strategies. Detailed data from national energy suppliers can also be useful when planning measures.

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World Bank

Under the Tool for Rapid Assessment of City Energy (TRACE) of the World Bank[8], cities fill a template and then compare with peers with similar to them scale (inhabitants, etc.).

1.3 Good examples

There are number of good examples from across Europe that can provide inspiration or an outline of what should be included in the overview of the building stock.

UK

The UK renovation strategy provides a comprehensive and very detailed statistical overview of the building stock. This includes a detailed analysis of building types, ages, tenure status, energy performances, energy demand and energy supply both for residential and non-residential buildings. The overview is based on recent data from different sources. [3]

Spain

The Spanish renovation strategy includes a short analysis of the distribution of dwellings according to municipality size. [4]

Croatia and Serbia

The United Nations Development Programme (UNDP) has supported the development of a database of, currently, 4000 public buildings. In Croatia data is available for more than 2.500 public buildings across the 79 cities and 18 counties. This could provide a useful reference for developing the overview of public buildings in other countries. The UNDP database is also in place in Serbia.

Serbia

In municipality of Vrbas, an energy management system was established within the Vrbas Land Development Agency that gathered energy and water consumption related data for every publicly owned building. This system was part of the Development Strategy for the period between 2010-2015, and Energy Management Office was established in 2011. In 2015, the Office received the ISO 50001 certificate for energy management systems. By introducing only low and no cost measures, based on regular monitoring of the gathered data, the municipality saved 17% of energy used in public buildings.[9]

Detailed inventories of public buildings in four municipalities in Serbia were developed in cooperation with the Serbian Ministry of Mining and Energy and as part of the project with Norwegian assistance to Serbia for introduction of the new energy efficiency policy and establishment of energy planning on a local level. Based on these consumption based inventories local energy action plans were developed. These action plans result in recommendations for refurbishment of public buildings, but generally more detailed energy audits are necessary.[10]

[8] More information is available here: https://esmap.org/TRACE.

[9] More information is available here: https://rs.boell.org/sites/default/files/uploads/2017/01/vreme_1345_vrbas_a_role_model_for_serbia.pdf

[10] Local energy action plans available here: http://www.mre.gov.rs/dokumenta-efikasnost-izvori.php

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Section 2: Identification of cost-effective approaches to renovations

Building on the overview of the building stock, the next step is a comprehensive appraisal of cost effective renovation opportunities. This feeds directly into the next section where the policy package is defined.

2.1 Content

This section identifies possible packages of measures and their cost-effectiveness.

Measures targeting public buildings (shown in table 3), developed at national level to comply with the requirement to renovate 3% of buildings owned and occupied by central government[11], may provide some inspiration.

Type of measure	Examples from EU countries
Buildings renovation	▪ Existing financial schemes for public building renovations (many Member States) ▪ Energy performance Contracting; ESCO (Austria, Portugal) ▪ Energy Efficiency and Renewable Sources Fund (Bulgaria)
Renewable energy	▪ PVs installation for own consumption (Malta, Poland)
Energy management	▪ Appointing energy officers in each building (Ireland, Portugal) ▪ Operations optimisation (Denmark, Austria) ▪ Metering for energy and water (Croatia) ▪ Smart meter installation (Malta) ▪ Control of Air condition (Malta)
Inspections	▪ Inspections of down time electricity use (Finland) > analysis of energy consumption during off-times (nights, weekends and holidays)
Rationalisation measures / Property management	▪ Reduction of area and selling off (France) ▪ Moving over to energy efficient construction (Denmark) ▪ Penalties and bonuses in contracts with property management companies (Finland)
Public procurement / Sustainability procurement	▪ Switching to energy saving devices (Denmark) ▪ Rental contracts being renewed will take the form of Green Lease contracts (Finland)
Behaviour change	▪ Raising awareness of building users (France, Denmark) ▪ Large scale behavioural change campaign (Ireland) ▪ Reallocation of employees in offices and habitual behaviour of employees (Netherlands)

Table 3: Examples of measures taken/planned under the alternative approach to achieving 3% renovation of central government buildings.

BPIE [1] has developed a checklist of possible actions, which provides a solid framework on which to base the renovation strategy. These measures may not be applicable in all circumstances and it is likely that they would need to be introduced over time (i.e. not in a single policy cycle). Nevertheless, the list illustrates a wide range of actions that should be considered. Some maybe more appropriate at a national level, but elements of some measures could be considered at local and regional level, such as establishing experience and knowledge sharing platforms.

[11] Article 5 of EU Energy Efficiency Directive 2012/27/2EU

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STRATEGIC	Establish support across the political spectrum for deep renovation of the building stock
	Establish an independent committee to monitor and report progress on the strategy on an ongoing basis, including making recommendations for improvements and periodic updates
	Undertake systematic appraisal of barriers to renovation in each segment of the market and develop policy responses to address each barrier
	Establish objective to eradicate fuel poverty through energy performance improvements to the housing stock
	Develop holistic cross-policy targets that integrate with and deliver on goals in related fields, e.g. sustainable urbanisation, resource efficiency, sustainable construction etc.
	Establish a wide stakeholder group as a forum for consultation, policy formulation and feedback on practical issues and barriers to renovation
	Demonstrate leadership through accelerated deep renovation of public buildings, thereby developing supply chain capacity and providing a knowledge base for private/commercial renovation activity
LEGISLATIVE & REGULATORY	Identify trigger points and develop respective regulation that could be used to encourage, or require, building energy performance improvement[41]
	Design Energy Efficiency Obligations that encourage the delivery of deep renovation
	Facilitate the upgrade of all social housing to high energy performance levels
	Address restrictive practices concerning local deployment of low/zero carbon technologies to ensure that a positive environment for buildings integrated renewables is established
	Remove or implement measures to overcome restrictive tenancy laws which disincentivise or otherwise inhibit energy performance improvement
	Mandate improvement of least efficient stock to higher energy performance level, e.g. through restrictions on sale or rental of buildings in lowest energy performance categories
TECHNICAL	Develop renovation standards that are progressively and regularly strengthened in response to experience and new technological solutions
	Analyse potential for district heating systems to provide efficient, low carbon energy
	Ensure proper monitoring and enforcement of compliance with building codes
	Develop packaged solutions that can be readily replicated in similar building types
	Introduce quality standards/certification systems for installers & products (including packaged solutions)
FISCAL/FINANCIAL	Secure sources of finance, including those identified in EED Article 20 and EU/international funding sources, and develop mechanisms that effectively leverage private capital
	Factor in monetary value of co-benefits (e.g. health, employment) in public funding decisions
	Develop funding vehicles, tailored to specific market segments, that provide a simple ("one-stop-shop") and commercially attractive source of finance for deep renovation
	Develop mechanisms to encourage deep renovation via third party financing, e.g. ESCOs, EPCs
	Strengthen energy/carbon pricing mechanisms to provide the right economic signals
	Remove fossil fuel subsidies to eliminate perverse incentives that discourage investment
	Consider "bonus-malus" mechanisms, e.g. property taxation systems (which reward high energy performing buildings while penalizing poorly performing ones) and energy pricing
COMMUNICATION / CAPACITY BUILDING	Establish publicly accessible databases demonstrating energy performance of renovated buildings and information on how to undertake deep renovation
	Gear up skills and training programmes covering the key professions and disciplines
	Establish knowledge and experience-sharing networks across regions/Member States
	Encourage development of local supply chain industry for maximising macro-economic benefits and to minimise embedded CO_2 emissions
	Develop promotional and dissemination activities that sensitise building owners to opportunities for deep renovation and that provide stepwise support throughout the renovation process
	Communicate regularly and publicly on progress with the renovation strategy
R&D	Support research, development and demonstration projects into new & improved technologies and techniques to deliver deep renovation, including how to scale up best practice to multiple buildings

Figure 4: Checklist of possible actions

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Table 4 is an outline of what should be included and considered when identifying potential approaches., and advice on the content. This is based on guidance from the European Commission [2] and BPIE [1], and the experience of the EmBuild project partners.

Step 1: Identify opportunities for retrofit of energy efficiency measures for each building category: i) Fabric measures - building envelope ii) Exterior windows and doors iii) Technical facilities – heating/ventilation/cooling/hot water iv) Air tightness / infiltration v) Lighting vi) Appliances vii) Shading, sunblinds to avoid cooling in summer	
Step 2: Identify opportunities for retrofit of renewable energy measures: i) Solar energy for hot water generation ii) Solar energy for generation of electric energy (Photovoltaics) iii) Optimal use of passive solar energy iv) Wind v) Heat pumps vi) Biomass vii) Biogas viii) Geothermal hot water	
Step 3: Identify opportunity to connect to a district heating system	
Step 4: Identify package[s] of measures that can achieve at least 60% energy saving (deep renovation) or at least up to the prevailing energy performance requirements for new buildings of the same category	
Step 5: Identify cost effectiveness of the different packages of measures been determined using cost optimality methodology, taking account of: i) Costs: Total installed cost of renovation measures, less any avoided cost due to end-of-life replacement or by undertaking renovation alongside other building maintenance, new construction or modernisation measures. Transaction costs, including costs of temporary relocation of occupants ii) Benefits (where possible quantified): Economic Benefits: Energy Cost Savings; Economic Stimulus; Impact on GDP; Property Values; Industrial Competitiveness; Impact on Public Finances; Energy Import Bill Societal Benefits: Reduction in Fuel Poverty; Health Benefits; Increased Comfort/Productivity Environmental Benefits: Carbon Saving; Air quality improvement Energy System Benefits: Energy Security; Avoided New Generation Capacity; Reduced Peak Loads	*The cost optimal method that should have been devised at national level can be used. More on cost-optimality can be found in guidance from BPIE* [5]. *Determining the financial framework for policies, overlaps with section 5, in this section the financial planning should be developed, since this will inform the policy package chosen and ensure good planning. . Issues, such as limited borrowing capacities and accounting rules need to be taken into account.* The EmBuild project will develop tools and training to support municipalities with valuing the benefits.
Step 6: Determine a prioritised set of renovation packages for each	*Focusing initially on public sector buildings*

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building category (based on the cost and benefit appraisal above), considering: i) The exemplary role of the public sector ii) Targeting the least energy efficient building stock as a priority	*can facilitate the build-up of the necessary skills, expertise and workforce that will be required to renovate the whole of the building stock.* *Similarly, it can help to target the least energy efficient buildings, but deep renovation should remain the goal of step-wise approach to renovation.*
Step 7: Determine whether deep renovations are best undertaken as a single package, or staged over a period of time (step by step implementation)	

Table 4: Outline of what should be included and considered when identifying potential approaches

2.2 Resources

EmBuild

The EmBuild project has developed several sources of information that can be used by public authorities at regional and municipal level to help to identify cost-effective approaches to renovation.

- Meta Data excel spreadsheet database (EmBuild Deliverable 2.5) – Excel sheet for systematic collection of building energy data necessary for the development of the energy strategies.
- Questionnaire for preliminary analysis (EmBuild Deliverable 3.1) - The results of the questionnaire will give a first overview of the renovation measures that should be considered for each type of building.
- Catalogue of low and no cost measures (EmBuild Deliverable 3.2) - This catalogue provides a good overview of the renovation measures that could be considered first as the first step towards deep renovation.
- Template for energy audits for municipal buildings (EmBuild Deliverable 3.4) - This template will collect detailed analysis that will allow the energy balance of the measures to be calculated. The template includes several steps relevant to this section (steps 8-11 are particularly relevant for this section):

  1. Gather more in-depth information of the building
  2. Gather energy consumption data of the quantities of fuel and electric energy
  3. Climate correction of the consumption data
  4. On-site visit for data acquisition; additional information to preliminary analysis
  5. Calculation of the energy balance of the building
  6. Comparison of energy demand and climate-corrected energy consumption
  7. Calculation of the energy performance characteristics of the building and determination of the energy class
  8. Optional: Calculation of possible single measures for energy efficiency – energy savings, CO_2 reductions, monetary savings and estimated investment

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9. Calculation of packages of measures– energy savings, CO2 reductions, monetary savings, estimated investment, expected energy performance characteristics and energy class – to meet a defined energetic standard (cost optimal, nZEB etc.)

10. Calculation of financial indicators for different packages of measures – pay-pack period; internal rate of return; net present value;

11. Compilation of the results and comparison of alternatives

- Workshops, webinar and explanatory videos will be produced on how to conduct appraisals of the building stock, including data analysis and identifying low- and no-cost measures.
- The report on barriers to deep renovation (Deliverable 4.1) provides a first overview of the barriers to renovation in each country from which municipalities can identify the barriers most relevant to them.
- A study on wider benefit of a deep renovation and a technical guide on methodologies for measuring wider benefits will be developed (Deliverable 6.1 and 6.2) and webinars will be held on how to measure benefits (deliverable 6.4)

2.3 Good examples

Bulgaria

Within the EMBUILD project a detailed energy analysis of the Multifunctional Hall "Mladost" in the residential complex "Slaveikov" in Burgas, Bulgaria was carried out. The analysed building is among the priority buildings of the municipality for energy renovation. At present, the building and its installations are in poor condition and it is not possible to ensure the required levels of indoor climate throughout the year. According to its energy performance characteristics, the building is rated with energy class F.

Three different combinations of energy saving measures were analysed:

1. Minimum requirements – where implementation of measures leads to the achievement of energy class B, which corresponds to the energy efficiency requirements in the Bulgarian legislation;
2. Maximum savings – where implementation of the measures leads to the maximum energy class and includes the maximum number of applicable renewable energy measures;
3. Optimal cost efficiency at maximum savings – which includes only those measures in Package 2 are cost-effective.

The third package is considered the most advantageous, according to the cost-benefits analysis. It can achieve 76.7% energy savings and the building is expected to comply with the requirements for energy class A.

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Section 3: Policies and measures to stimulate deep renovation

This section sets out a holistic policy package designed to address barriers to deep renovation. This should build on existing policies at national, regional and local level, in line with global, EU and national targets, as well as consider new policies drawing from the measures identified in section 2.

3.1 Content

There are three distinct elements of this section: reviewing existing policies and measures, analysing barriers and finally designing the policy package to be implemented. This package needs to take account of the barriers identified, existing policies and cost-effective approached identified in section 2.

National governments are required to evaluate and take measures to remove regulatory and non-regulatory barriers to energy efficiency[12]. This may be useful input for municipalities' own assessment of barriers. It may be useful to approach barriers by considering them in the following categories:

- Legislative and regulatory barriers: these concern barriers due to the existing legal framework, including overlaps between laws and complex administrative process, or lack of legislation.
- Fiscal and financial barriers: these include barriers due to energy prices, lack of funds or grants, and transaction cost, affecting investments.
- Communication and capacity barriers: these include barriers due to insufficient communication about the advantages of deep renovation and insufficient technical capacity/knowledge to promote, plan and implement deep renovation.
- Technical barriers: these include barriers due to lack of knowledge on the existing building stock and possible measures.
- Research and Development (R&D) barriers: these include barriers such as insufficient research or pilot projects which develop understanding and knowledge.

Action to address these barriers is not always creation of new policies or measures, but also changes to existing policies. This is particularly the case for legislative and regulatory barriers.

Focusing a renovation strategy on public buildings can be the first step to overcoming barriers to renovation of the whole building stock, since many of the barriers to renovation of public buildings are the same as those for residential and commercial buildings, for example, lack of skills in the construction sector – the same skills are needs for renovation of all buildings and renovation public buildings can provide useful demonstration projects which build skills and awareness of renovation.

Table 5 is an outline of what should be included in this section. This is based on guidance from the European Commission [2], and the experience of the EmBuild project partners.

Step 1: Identify existing policies and measures, including: i) Regulatory (EU, national, regional and local) ii) Fiscal (tax incentives, grants, subsidies, loans, etc.) iii) Information campaigns iv) Voluntary agreements v) Other
Step 2: Identify barriers to deep renovation and policies/measures to overcome them (including existing

[12] Article 19 of the EU Energy Efficiency Directive 2012/27/EU

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policies and measures identified and packages identified in section 2)
Step 3: Set out a holistic policy package based on packages identified in section 2 and addressing identified barriers, with a particular focus on measures to be introduced within the next 3 years

Table 5: Outline of what should be included in section 3

3.2 Resources

EmBuild

The EmBuild project has developed several sources of information that can be used by municipalities to identify policies and measures:

- Building stock appraisal (EmBuild Deliverable 2.7) - This report gives an overview of the regulatory and fiscal policies related to deep renovation.
- Barriers that hinder deep renovation in the building sector (EmBuild Deliverable 4.1) - This report describes barriers to deep renovation faced by municipalities in Bulgaria, Croatia, Germany, Romania, Serbia and Slovenia identified from interviews and questionnaire with local actors. The barriers are divided in six categories: legislative and regulatory, fiscal/financial, communication/capacity building, technical, research and development and strategic.
- Country factsheets (EmBuild Milestone 2) - These factsheets list the barriers to deep renovation faced by municipalities in Bulgaria, Croatia, Germany, Romania, Serbia and Slovenia, as described by local actors, and suggest potential solutions and measures to overcome them. Available in English and in national languages.

Sustainable Energy and Climate Action Plans

Sustainable Energy and Climate Action Plans, developed within the frameworks of the Covenant of Mayors, require similar information to renovation strategies. Under mitigation actions (see figure 5), key actions need to be defined for municipal buildings (as well as tertiary, and residential buildings), alongside costs and estimates of the energy and CO2 savings.

Mitigation Actions

							MONITORING		
Key Actions	Area of intervention	Policy instrument	Origin of the action	Responsible body	Implementation timeframe		Status of implementation	Implementation cost spent so far	Implementation cost
					Start	End		€	€
MUNICIPAL BUILDINGS, EQUIPMENT/FACILITIES									
TERTIARY BUILDINGS, EQUIPMENT/FACILITIES									
RESIDENTIAL BUILDINGS									

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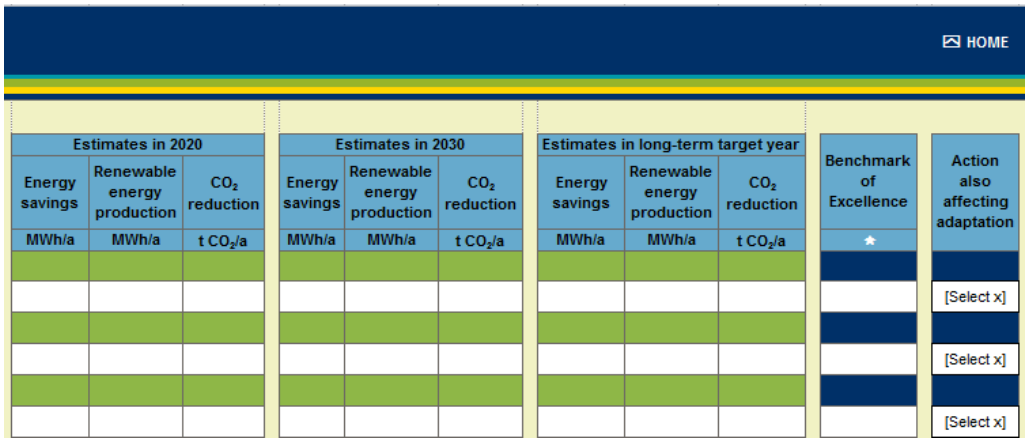

Figure 5: Extract of Sustainable Energy and Climate Action Plan template where information on mitigation actions for public buildings (and other types of buildings) can be found

3.3 Good examples

Denmark

The Danish renovation strategy included a well-articulated, wide, complete and ambitious set of policy measures [6]. Most of them are already implemented and the new ones are intended to be an upgrade of the existing measures (such as energy performance requirements). The document describes the policy measures in detail, providing a background and a rationale for each line of intervention. Existing and new measures are clearly identified and a sufficiently precise timeline for their implementation is provided. The strategy outlines initiatives across 4 sectors, including public buildings: Initiatives aimed at all construction segments; Initiatives targeted at single family dwellings; Initiatives targeting multi-family buildings, commercial buildings and public buildings; and Initiatives targeted at strengthening the skills and innovation to promote energy renovation.

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Section 4: Forward looking perspective to guide investment decisions

This section should provide a comprehensive costed forward perspective identifying investment needs over time. It should cover more than simply financing but provide a long-term outlook to guide investment decisions of individuals, the construction industry and financial institutions. For public buildings, where the public authority is likely to be main investor supported by regional, national and EU funds this may be simpler than for residential and commercial buildings, where there are many different actors involved. However, it is still important to engage the construction industry and banking institutions since public projects can act as demonstration projects and help to build the capacity and knowledge of investors and industry.

4.1 Content

In national renovation strategies, Member State governments need to develop different scenarios of renovation options. At municipal level, at least one scenario to 2030 and 2050 should be developed. However, a clear roadmap for the implementation is essential. This should link the renovation strategy to the long-term goals which will guide the actions of the investors and the business sector, such as when training of construction workers is needed in relation to the skills needed to meet such goals.

It is essential to provide key actors with sufficient time and certainty to prepare and plan for changes in a sustainable way. In this context, policies should be designed to provide appropriate long-term signals to the market, and communicated in a way that consumers and all stakeholders understand the overall objective and plan their investment strategies with confidence. A roadmap with key dates, targets, milestones for the introduction of legislation and support mechanisms should be considered an essential requirement of renovation strategies. [4]

One of the key challenges is access to good quality data on the costs and savings of renovation activities, and also forecasting these forward over the next 30-40 years. Available information on the costs of deep renovation may be limited to demonstration or pilot projects, which may not be representative of the costs in a larger scale rollout. Inevitably, certain assumptions will need to be made based on incomplete data, but in some countries e.g. Germany, catalogues on costs for building renovation are available (BKI Baukostenindex, BMWI etc.). Collecting data once measures are in place would help to prove the effectiveness of deep renovations and build a good knowledge base for future revisions and updates to the strategy. National actions to collect data may be underway or should be encouraged to enable a more accurate picture of the true costs and benefits of building renovation to be built up.

This section should identify the scale of investment needed and should be explicit about how financing will be achieved

EU funding instruments and programmes can be used by municipalities, these include:

- European Structural & Investment Funds (ESIF): €18 billion is allocated to energy efficiency over the period 2014-2020, including €13.4 billion for energy efficiency in public and residential buildings, €3.3 billion for energy efficiency in enterprises, with a focus on SMEs, and €1.7 billion for high-efficiency cogeneration;
- European Fund for Strategic Investments (EFSI) is a €16 billion guarantee from the EU budget, complemented by a €5 billion allocation of European Investment Bank (EIB)'s own capital, aiming to unlock additional investment of at least €315bn over a three year period. As of mid-May 2017, EFSI has contributed to trigger around €194 billion of investment, from which 24% in the energy sector.
- ELENA: This EU project development assistance facility aims to help private and public project promoters develop ambitious and large-scale (>€30 million) investments in the area of energy efficiency, distributed renewable energy and urban transport. Since its establishment in 2009, the

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ELENA facility managed by the EIB has already awarded around €110 million of EU support, triggering an estimated investment of more than €4 billion on the ground.

- Private Finance for Energy Efficiency (PF4EE) provides a risk-sharing facility designed to reduce the credit risk faced by financial intermediaries when lending to the energy efficiency sector. It is managed by the EIB. The PF4EE facility also includes technical assistance to financial intermediaries for developing energy efficiency lending. With a total EU contribution of €80 million, the facility is expected to support total investment up to about €540 million for 2014-2017.
- The European Energy Efficiency Fund (EEEF) provides tailored financing (both debt and equity instruments) in particular for energy efficiency projects but also for renewable energy and clean urban transport projects. Beneficiaries are local or regional public authorities or entities acting on their behalf. It was established in 2011 with a global volume of €265 million.

One of the recommendations of the Commission is to increase the proportion of climate related expenditure (2014-2020) to at least 20%. This represents a potentially very large pot of funding from which to secure resources for programmes to support the renovation strategy, particularly given that buildings have the largest potential for carbon reduction and the many other benefits that can be attained as a result of improving the energy performance of buildings.

Figure 6 lists potential sources of funding for EU and non-EU countries.

European Fund for Strategic Investments (EFSI)

- **Purpose:** It aims to overcome current market failures by addressing market gaps and mobilising private investment. The most financially viable projects are selected without any geographic allocation.
- **Energy focus:** Development of the energy sector in accordance with the Energy Union priorities (Gas, Energy Efficiency, Renewables etc.).
- **Financial Instrument:** Loans, guarantees and equity financing.
- **Total funds**: €21 Billion (€16 Billion in guarantees from the EU and €5 Billion from the European Investment Bank).

European Energy Programme for Recovery (EEPR)

- **Purpose:** It provides financial grants for projects in the field of energy in order to contribute to the economic recovery, the security of energy supply and the reduction of greenhouse gas emissions.
- **Energy focus:** Development of the energy sector in accordance with Energy Union priorities (Gas,Storage, Energy Efficiency, Renewables etc.).
- **Financial Instrument:** Mainly grants, but also loans, equity and guarantees through the European Energy Efficiency Fund.
- **Total funds**: €3.96 Billion.

European Regional Development Fund (ERDF)

- **Purpose:** It is aimed at reinforcing economic and social cohesion within the European Union by redressing the main regional imbalances.
- **Energy focus:** From at least 12% (in least developed countries) to at least 20% for supporting the shift towards a low-carbon economy in all sectors.
- **Financial Instrument:** Mainly grants, but increasingly financial instruments.
- **Total funds**: €196.58 Billion.

Cohesion Fund (CF)

- **Purpose:** It is aimed at Member States whose Gross National Income (GNI) per inhabitant is less than 90% of the EU average. It aims to reduce economic and social disparities and to promote sustainable development. For the 2014-2020 period, the Cohesion Fund concerns Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia.
- **Energy focus:** Support the shift towards a low-carbon economy in all sectors.
- **Financial Instrument:** Mainly grants, but increasingly financial instruments.
- **Total funds**: €63.4 Billion.

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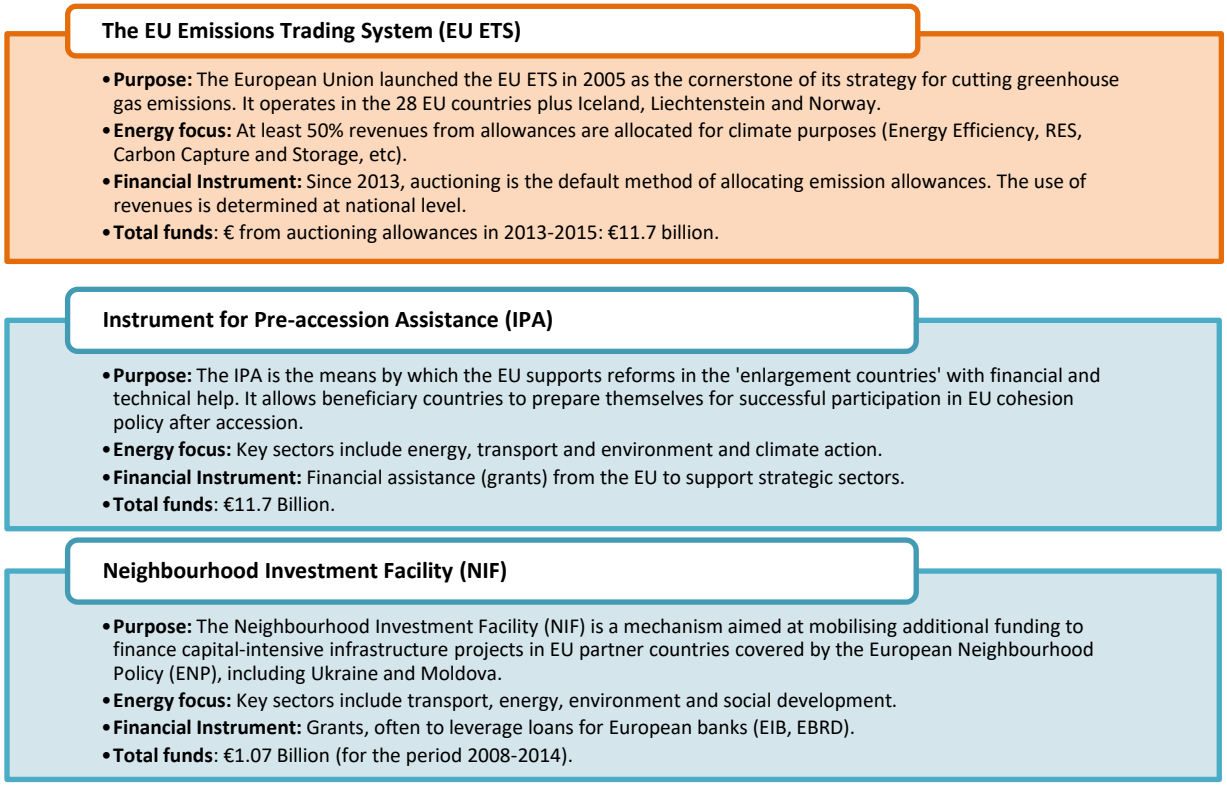

Figure 6 - EU Funding Streams for EU and non-EU countries

At the same time as maximising the allocation of EU and other public funding sources to the renovation of buildings, it is important to use public funding to leverage private financing. This is particularly important for financing the renovation of residential and commercial buildings, and means leveraging the building owners' own resources and those of the investment community. National governments should have considered this in their national renovation strategies so should provide support.

Technical guidance on financing the energy renovation of buildings from the European Commission is also a useful source of inspiration to inform this part of the strategy [5].

Table 6 is an outline of what should be included and considered in setting out a forward-looking perspective, and advice on the content. This is based on guidance from the European Commission [2] and BPIE [1] , and the experience of the EmBuild project partners.

Step 1: Quantify total annual investment requirements to 2050 to deliver policy package	
Step 2: Identify existing sources of funding for building energy renovation i. Local public funds ii. National public funds iii. EU Structural/Cohesion funds iv. Banks and other sources of finance, e.g. pension	*Where strategies also include residential and commercial buildings, the private equity of the owners is an important additional source of funding.*

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funds and investment trusts	
Step 3: Identify possible new funding sources and mechanisms	
Step 4: Set out roadmap with key dates, targets, milestones for the introduction of policies and measures	

Table 6: Outline of content to be included in a forward-looking perspective

4.2 Resources

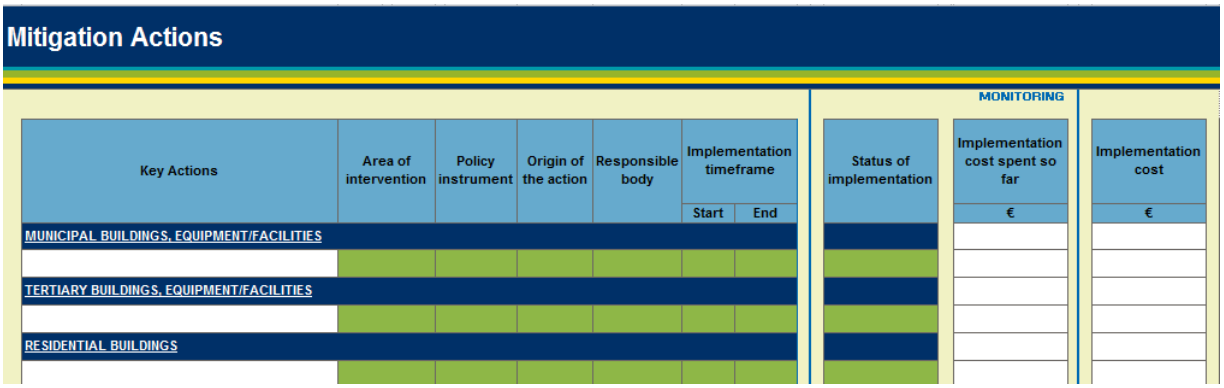
EmBuild

The EmBuild project has developed specific support for the development of this section:

- How to improve investment climate at local level (EmBuild Deliverable 5.1, 5.2, 5.4) - These reports aim to present existing and/or innovative approaches/mechanisms/scenarios for active involvement of stakeholders at public level and to facilitate and stimulate application of such measures in practice.

Sustainable Energy and Climate Action Plans

Sustainable Energy and Climate Action Plans, developed within the frameworks of the Covenant of Mayors, require similar information to renovation strategies. Under mitigation actions (se figure 7), key actions need to be defined for municipal buildings (as well as tertiary, and residential buildings), alongside costs and estimates of the energy and CO_2 savings.



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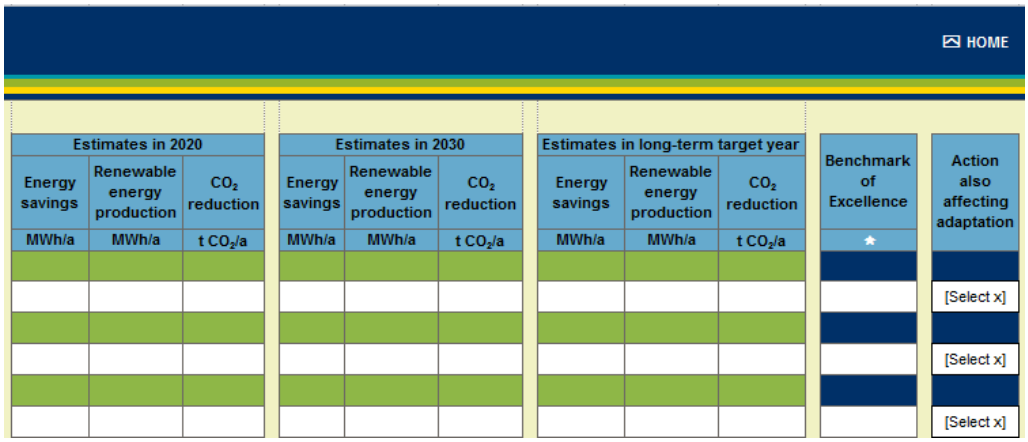

Figure 7: Extract of Sustainable Energy and Climate Action Plan template where information on mitigation actions for public buildings (and other types of buildings) can be found

European Commission

Technical guidance on financing the energy renovation of buildings from the European Commission can be a useful source of inspiration to inform this part of the strategy [7].

4.3 Good examples

Greece, Spain, Czech Republic

For the Greek, Spanish and Czech renovation strategies, scenarios with horizon to 2020 or 2050 were defined for residential and non-residential buildings. A detailed description of the results of the scenario analysis expressed in terms of number of properties renovated, investment (including public subsidy level), energy savings, carbon emission reduction and jobs created were included.

Croatia

The transformation of Bračak castle, in north-west Croatia, into modern energy efficient Energy Centre in Bračak is a good example of renovation of public building. The building went from an E class energy grade prior to reconstruction to a B and C with annual savings of 70 percent of heating energy after reconstruction. The centre secures 88 percent of its own energy from renewable sources and has reduced emission of CO2 by 50.4 tons.

The Regional Energy Agency Northwestern Croatia started preparations for the reconstruction project in 2011 with the Krapinsko-zagorska županija (the district) preparing the paperwork for the reconstruction of the property and its transformation into an energy centre in 2012. Work on started in 2015 and the Energy Center Bračak was opened on March 17, 2017.

Funding was gathered from the Fund for Environmental Protection and Energy Efficiency of Croatia (FZOEU) (EUR 2.8 million) and EU Structural Funds and funds from the region (EUR 0.4million).

The project included installation of energy efficient outer windows and doors, 80 kW heating boiler, high-efficiency VRV cooling system of an installed power of 95.2 kW, high-efficiency ventilation system with recuperation, and a gas-powered micro-cogeneration system producing 6 kW of electric power and 14.9 kW of heating power to heat water. The latest technical solutions were used when restoring the building but bearing in mind that the cultural heritage aspect had to be preserved. [8]

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Section 5: Identification of wider benefits and energy savings

This section should identity and value the energy savings and wider benefits of the proposed policy package over time. This should go beyond an estimation of energy savings to look at other benefits of renovation, such as job creation, reduction in public expenditure, improvement of working environment, etc.

5.1 Content

Monetisation of the benefits that arise in addition to the energy cost savings is often overlooked. The cost of a public subsidy provided to stimulate deep renovation may be more than offset by the benefits that result from it. In the context of public buildings, energy efficiency improvements can ease pressure on public finances (i.e. budgets of public authorities), by generating increased tax revenues through increased economic activity and by reducing expenditure on energy131 and unemployment benefits132. It is also not only about saving money as improvements in energy efficiency, leading to improved indoor air quality and thermal comfort, have productivity benefits. These result from fewer days of work missed. It is estimated that every €1 invested in insulation, results in €0.78 benefit in reduced days of work missed [9]. Productivity improvements due to better air quality can reach 8-11% [10]. Furthermore, the environment benefits from reductions in carbon emissions and energy use which can enhance organisational image and improve public relations [11].

There have been many studies looking at the multiple benefits of renovation and wider energy efficiency improvements, which can provide additional inspiration for this section. The IEA's report on "Capturing the Multiple Benefits of Energy Efficiency" provides a particularly comprehensive overview [12].

Table 7 is on outline of the content and elements to consider when identifying benefits. This is based on guidance from the European Commission [2] and BPIE [1] , and the experience of the EmBuild project partners.

Step 1: Identify the attractiveness to building owners of their direct energy cost saving benefits
Step 2: Identify the societal benefits arising from deep renovation (building on benefits identified in section 2)
Step 3: Identify ways in which externalities (e.g. societal benefits from reduced CO2 emissions, increased energy security etc.) can be internalised for the benefit of the investor

Table 7: Outline of elements to consider when identifying benefits

5.2 Resources

EmBuild

The EmBuild project has developed specific support for the development of this section:

- Study of the wider benefits of deep renovation measures (Deliverable 6.1) - This consists of a detailed and profound data analysis to evaluate wider benefits that follow up deep renovation measures and respectively energy savings, which can be used by municipalities as a source of input.
- Technical guide on methodologies for measure wider benefits (Deliverable 6.4) and associated webinar (Deliverable 6.4) – This will provide support to public authorities on measuring the benefits of building renovation, beyond only energy savings.

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5.3 Good examples

Romania

The national Romanian renovation Strategy provides a very detailed estimation of the benefits arising from building renovation activities. Four renovation scenarios (i.e. baseline, modest, intermediate and ambitious) were analysed in terms of energy savings, employment generated and carbon emission reduction at 2050. Individual and societal benefits have been identified as well. Moreover, the Romanian strategy attempts to assign an economic value to wider benefits (i.e. Economic stimulus, societal health, environmental and energy system benefits) and to assess the overall social benefits associated to building renovation. [13]

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Annex: Outline of a renovation strategy for public buildings and supporting resources

	Supporting resources
Section 1: An overview of the building stock	*EmBuild:* *Meta-data database (D2.5)* *Building stock appraisals (D2.5 and D2.7)* *Questionnaire for analysis of the building stock (D3.1)* *Template for energy audits (D3.4)* *Sustainable Energy and Climate Action Plans:* *Baseline Emission Inventory*
Step 1: Identify main building categories: Public buildings: i) Offices/administrative buildings ii) Educational buildings iii) Hospitals/health establishments iv) Sport facilities	
Step 2: Identify age bands which have a material bearing on building energy performance: i) Traditional construction types, including historic buildings (typically pre-1900) ii) Buildings constructed prior to regulations on energy performance (e.g. 1901-1960) iii) Early phase building regulations iv) Mid-phase building regulations v) New (2001-2012)	
Step 3: Quantify the number, type, size (floor area) of each combination of building type and age band.	
Step 4: Identify the energy use and performance characteristics of each building combination: i) Construction type and U-value of main building elements: (1) Floor (2) Walls (3) Windows and External Doors (4) Roof ii) Air infiltration rate iii) Energy systems (and typical replacement lifecycles): (1) HVAC system type/performance level/controls (2) Hot water provision (3) Lighting systems/controls iv) Maintenance (e.g. mandatory safety checks/servicing) v) Energy use for: (1) Heating (2) Cooling (3) Ventilation (4) Hot water (5) Lighting (6) Appliances vi) Energy carriers: (1) Gas (natural gas or LPG) (2) Liquid fuels (oil, etc.) (3) Solid fuels (coal, etc.) (4) Renewable energies: (a) Solar energy for hot water generation (b) Solar PV (c) Wind (d) Heat pump (type and Coefficient of Performance)	

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(e) Biomass (wood-chips, wood-pellets) (f) Other (specify) vii) District heating (identify energy carriers)	
Section 2: Identification of cost-effective approaches to renovation	*EmBuild:* *Meta-data database (D2.5)* *Questionnaire for analysis of the building stock (D3.1)* *Catalogue of low and no cost measures (D3.2)* *Template for energy audits (D3.4)* *Webinars and videos on how to conduct appraisals of the building stock* *Report on barriers to deep renovation (D4.1)* *Study, technical guide and webinar on how to measure wider benefits of deep renovation (D6.2, D6.3, D6.4)*
Step 1: Identify opportunities for retrofit of energy efficiency measures for each building category: i) Fabric measures - building envelope ii) Exterior windows and doors iii) Technical facilities – heating/ventilation/cooling/hot water iv) Air tightness / infiltration v) Lighting vi) Appliances vii) Shading, sunblinds to avoid cooling in summer	
Step 2: Identify opportunities for retrofit of renewable energy measures: i) Solar energy for hot water generation ii) Solar energy for generation of electric energy (Photovoltaics) iii) Optimal use of passive solar energy iv) Wind v) Heat pumps vi) Biomass vii) Biogas viii) Geothermal hot water	
Step 3: Identify opportunity to connect to a district heating system	
Step 4: Identify package[s] of measures that can achieve at least 60% energy saving (deep renovation) or at least up to the prevailing energy performance requirements for new buildings of the same category	
Step 5: Identify cost effectiveness of the different packages of measures been determined using cost optimality methodology, taking account of: i) Costs: Total installed cost of renovation measures, less any avoided cost due to end-of-life replacement or by undertaking renovation alongside other building maintenance, new construction or modernisation measures. Transaction costs, including costs of temporary relocation of occupants ii) Benefits (where possible quantified): Economic Benefits: Energy Cost Savings; Economic Stimulus; Impact on GDP; Property Values; Industrial Competitiveness; Impact on Public Finances; Energy Import Bill Societal Benefits: Reduction in Fuel Poverty; Health Benefits; Increased Comfort/Productivity Environmental Benefits: Carbon Saving; Air quality improvement Energy System Benefits: Energy Security; Avoided New Generation Capacity; Reduced Peak Loads	

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Step 6: Determine whether deep renovations are best undertaken as a single package, or staged over a period of time (step by step implementation)	
Section 3: Policies and measures	*EmBuild:* *Building stock appraisals (D2.7)* *Report on barriers to deep renovation (D4.1)* *Country factsheets on barriers to deep renovation (MS2)* *Sustainable Energy and Climate Action Plans:* *Mitigation actions*
Step 1: Identify existing policies and measures, including: i) Regulatory (EU, national, regional and local) ii) Fiscal (tax incentives, grants, subsidies, loans, etc.) iii) Information campaigns iv) Voluntary agreements v) Other	
Step 2: Identify barriers to deep renovation and policies/measures to overcome them (including existing policies and measures identified and packages identified in section 2)	
Step 3: Set out a holistic policy package based on packages identified in section 2 and addressing identified barriers, with a particular focus on measures to be introduced within the next 3 years	
Section 4: Forward looking perspective	*EmBuild:* *How to improve the investment climate at local level (D5.1, D5.2, D5.4)* *Sustainable Energy and Climate Action Plans:* *Mitigation actions*
Step 1: Quantify total annual investment requirements to 2050 to deliver policy package	
Step 2: Identify existing sources of funding for building energy renovation i) Local public funds ii) National public funds iii) EU Structural/Cohesion funds iv) Banks and other sources of finance, e.g. pension funds and investment trusts	
Step 3: Identify possible new funding sources and mechanisms	
Step 4: Set out roadmap with key dates, targets, milestones for the introduction of policies and measures	
Section 5: Identification of wider benefits	*EmBuild:* *Study on the wider benefits of deep renovation measures (D6.1)* *Technical guide on methodologies to measures wider benefits (D6.4)*
Step 1: Identify the attractiveness to building owners of their direct energy cost saving benefits	
Step 2: Identify the societal benefits arising from deep renovation (building on benefits identified in section 2)	
Step 3: Identify ways in which externalities (e.g. societal benefits from reduced CO2 emissions, increased energy security etc.) can be internalised for the benefit of the investor	

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