

Research and Innovation Needs to Decarbonise European Cities

Sustainable and inclusive decarbonisation of European cities is a pre-requisite for achieving carbon neutrality at the EU level. As melting pots and demand hubs, cities are responsible for a majority of greenhouse gas emissions. For a transition towards zero-carbon cities, in the EU as elsewhere, a holistic approach and extensive collaboration is needed that can move city action beyond simply increasing the number of localized low-carbon solutions. This DEEDS Policy Brief outlines key features of EU research and innovation needs and proposes policy measures to promote zero-carbon European cities.

OVERVIEW

- The decarbonisation of cities requires a systems-based approach, broad stakeholder collaboration and a deep understanding of synergies.

NO-REGRETS ACTIONS

- Mapping of city climate actions is required across offices and non-government sectors to capitalize on synergies.
- To ensure a fair transition, the potential socio-economic impacts of local climate policies, of urbanisation, and of the effects of climate change in cities must all be considered.
- Implementation and up-scaling of existing low- and zero-carbon technologies and energy efficiency, tailored to local contexts, are crucial. New smart and circular city approaches will play a key role.
- To move from localised low-carbon achievements to zero-carbon cities, strong city governance and a common vision will be needed. This includes clear zero-carbon targets and accompanying strategies to achieve them.
- Knowledge on cities' decarbonisation efforts exist, but is scattered. Developing a platform for sharing data and tools, along with good practices and lessons learned, will be crucial to accelerate decarbonisation of cities across Europe.

BACKGROUND

Cities are key actors in the fight against climate change. Globally, they account for 60 to 80% of global CO₂ emissions depending on the estimate.^{[1],[2]} In Europe, around three quarters of the population currently live in cities.^[1] This is in a context of growing urbanisation. Beyond being “melting pots” of diverse citizens, cities are places where decarbonisation strategies for energy, transport and buildings, as well as to some extent industry and agriculture, coexist and meet. The high density of energy use and infrastructure in cities creates high potential for cross-sectoral integration (e.g. opportunities for waste to energy conversion, for urban heat island mitigation, storm-water management and/or urban farming) and for complex infrastructures like smart-grids and multi-energy hubs. Cities are also knowledge hubs where expertise from universities, public agencies, companies and public-private partnerships intermingle.

This local expertise, the density of infrastructure and the possibility to leverage economies of scale are some of the many reasons to focus on cities in the European decarbonisation challenge. In many cases, cities have launched decarbonisation plans that are more ambitious than national climate targets. An example is the Covenant of Mayors programme, originally an EU initiative, which to date organizes more than 9000 cities around the world in ambitious decarbonisation commitments.^[3]

While cities seem a natural target for decarbonisation action, some key barriers exist. First, cities in the EU are very **diverse** (in terms of size, microclimate, technical context, affordability of low carbon investment, governance structure and influence, sustainability priorities, etc.). What works in one city does not necessarily work in another. Second, successful

[BOX 1] European cities are diverse

In order to find common R&I needs across cities for supporting the development of a zero-carbon transition we must first identify the differences and assess common needs. The below table summarizes how action on decarbonisation is differently motivated and differently organized in three European cities.

City	Jurisdictional powers	Decarbonisation efforts
STOCKHOLM Northern Europe 0.95 million people	Strong mayoral powers over buildings, city roads, land use, and water. The city owns most of the land and gets its financing from income taxes.	Heating and electricity, transport and waste management have been in focus for emissions reductions. New low-carbon solutions are tested in selected neighbourhoods
BARCELONA Southern Europe 1.6 million people	Strong mayoral power over public buildings and urban land use, but limited power over energy supply and transport infrastructure.	Climate change mitigation appears primarily in policies addressing other issues, e.g. improving local air quality and urban liveability.
WARSAW Eastern Europe 1.75 million people	Strong mayoral policy powers over public buildings, transport infrastructure, roads and water system.	Energy efficiency, transport and public awareness are priorities. Behavioural changes have been promoted through targeted incentives, and have been well received by local population.

decarbonisation of cities will **impact all aspects of city life**, from governments to businesses and citizens. Therefore, decarbonisation actions in cities need to be responsive to the needs of all city actors in order to succeed: this might not be trivial with a diverse population and concurring interests. Third, the **inertia of infrastructure** and the built environment in cities is large. This makes rapid decarbonisation particularly challenging. Fourth, **limited knowledge is shared** across cities on best practices for decarbonisation. This poses a risk that cities ‘reinvent the wheel’ in their decarbonisation efforts, ranging from concrete small-scale initiatives to broad urban planning legislation and forecasting scenarios.

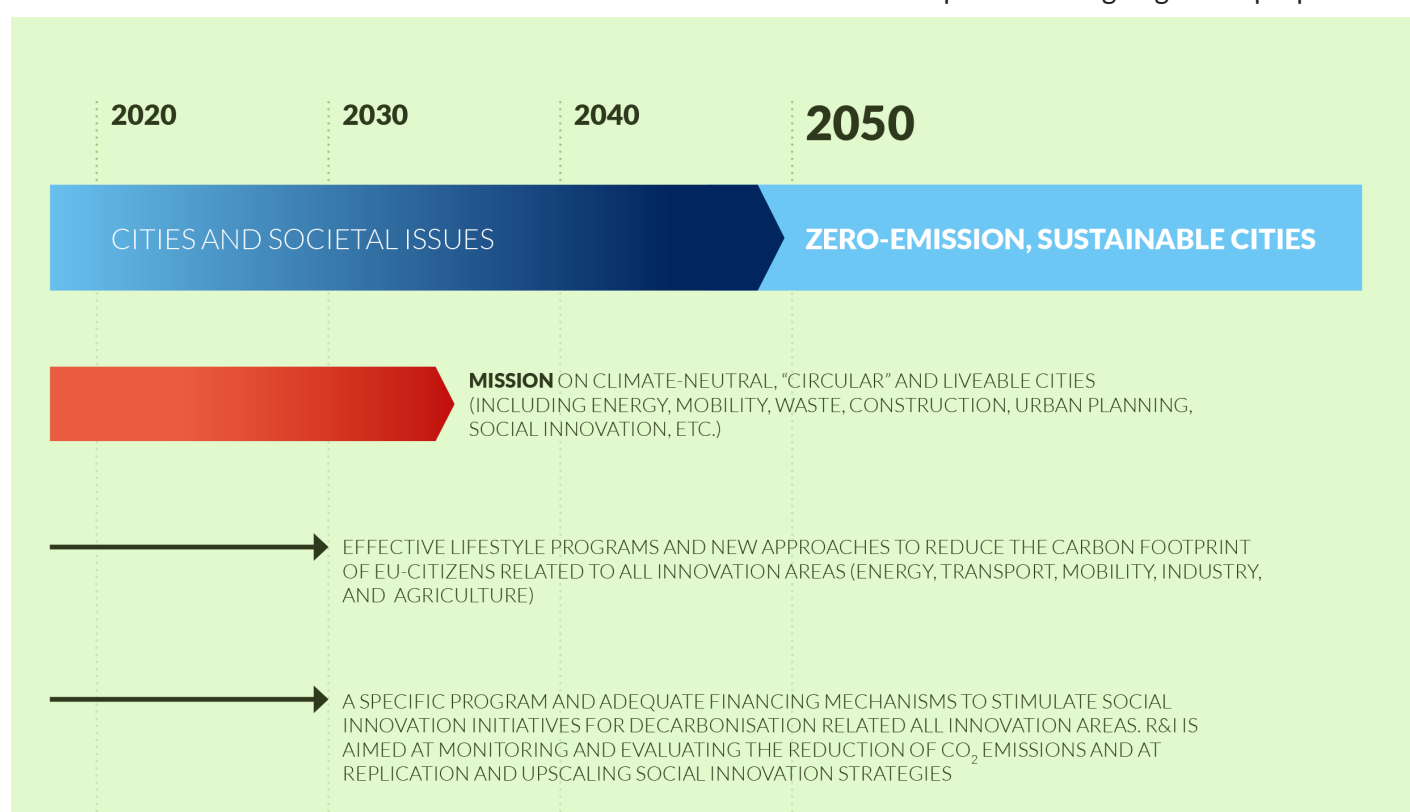
To overcome these barriers, this policy brief suggests key actions in research and innovation (R&I) to be taken for achieving net-zero emission cities. The actions are divided across the spheres of: 1) governance and urban

planning, 2) citizens engagement, and 3) smart and integrated technologies. (These recommendations are based on ^{[4]-[6]}.)

Governance and urban planning

Cross-city collaboration – including sharing of best practices, and of key mistakes and lessons learned – is necessary to efficiently transition to a zero-carbon Europe. To harvest the success of decarbonisation solutions in cities around Europe, initiatives in zero-carbon urban planning across EU cities need to be mapped. EU-level R&I is needed so as to develop, test and enable approaches for vertical, coordinated and multi-level governance for zero-carbon cities.

At the local scale, R&I is necessary for developing inclusive urban planning tools, to provide concrete measures of decarbonisation and mitigate short- and long-term socio-economic side effects of decarbonisation policies. Designing ‘fit for purpose’





participatory processes are necessary to increase engagement, 'buy-in' and ownership from citizens. These are crucial to realize a fair decarbonisation. For innovation of governance, new financing tools, incentives and procurement models have to be developed and tested to support up-scaling of low- and zero-carbon practices.

Citizens' Engagement

Broad citizen engagement is a prerequisite for a successful zero-carbon transition in cities. A deeper understanding of city- and citizen-specific requirements related to incentives, education and enabling environments is needed for citizens' creativity and behavioural changes to "take off".

- R&I is needed to understand the differences and similarities of different cities in terms of citizen-centric technical and zero-carbon innovation potential.
- This includes research on drivers for dietary changes, models for sharing of goods and services, the use of ICT, and participatory budgeting.
- Social and behavioural science research is needed to understand how citizens embrace decarbonisation policies.
- Innovation in communication with citizens is essential to realize the above. This includes new ways of visualizing the city (in terms of e.g. resource flows and supply chains) and producing common visions of the future that enhance a common understanding and spark citizen innovation and creativity.

Smart and integrated technologies

To realize zero-carbon European cities, all low- and zero-carbon technological solutions need to work together in integrated, smart and circular systems. This integration is particularly relevant for energy efficient buildings (new and old) and innovative mobility concepts. Digitalization will play a key role to make such integration possible.

- Much of conventional urban **transport** has the potential to be electrified and integrated with smart city concepts. Furthermore, solutions for switching from private cars to shared mobility or slow mobility (walking, biking as well as growing micro-mobility such as electric scooters) are particularly promising in cities. The benefits, drawbacks and "best fits" of all available zero-carbon mobility options in cities need to be further explored and integrated.
- Technologies to realize low energy buildings and local renewable energy production need further research, especially solutions that can be applied to old buildings.
- Energy efficiency and distributed energy R&I are also needed to understand cities' roles in their larger regions when local production of electricity and heat increases.
- Digitalization and ICT are at the core of smart and

zero-carbon cities. In order to evaluate how different designs and ICT technology options can enable smart cities, testing of different smart city schemes in real and diverse city contexts is essential. This evaluation must also focus on identifying the potential risks associated with new city systems, such as cyber security threats and vulnerabilities of interconnected systems.

- More R&I is needed for identifying and developing the technologies that **enable circularity** and for understanding how different circular solutions interact. While a wide array of possible circular solutions exists in cities, their success depends on how they can be integrated into existing city systems. Circular solutions need to be evaluated from a holistic perspective to limit sub-optimal solutions.
- R&I on financing schemes for both smart and circular systems is needed. This includes a need to develop and design investment models that are long-term and shared between public and private sector.

From local decarbonisation to zero-carbon cities

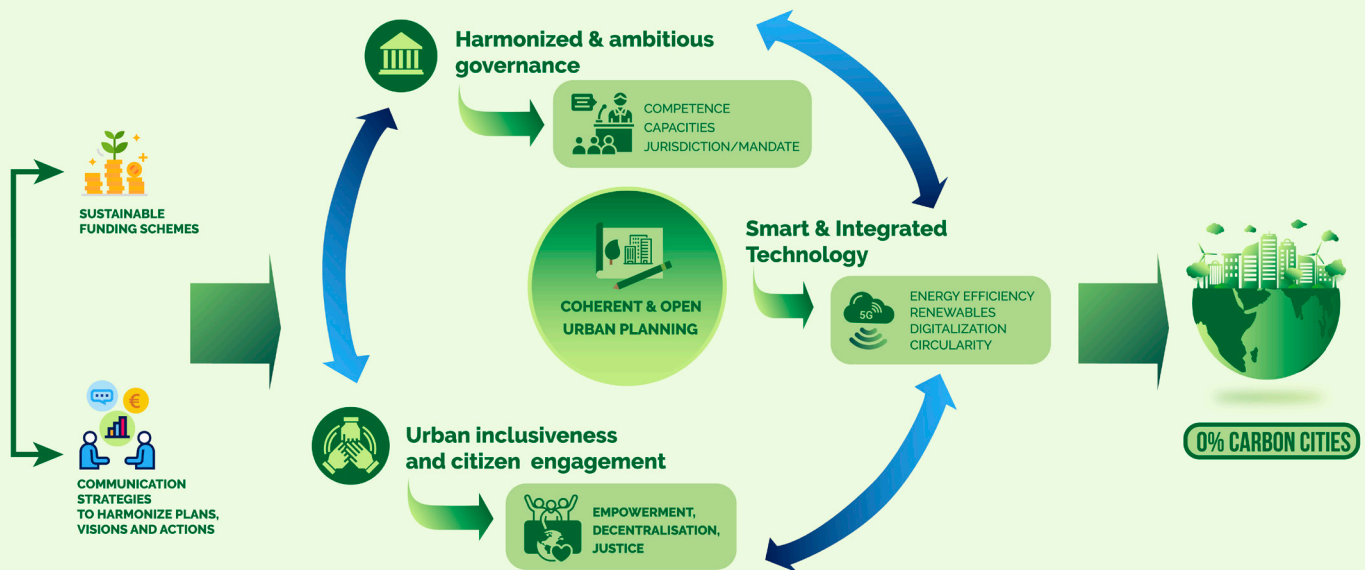
To stay within the carbon budget associated with limiting global warming to 1.5°C, European cities must go beyond localized low-carbon solutions towards becoming **net zero-carbon**. Such a transition requires a system-level approach and innovations beyond incremental efficiency and improvements of current solutions. To be successful, it must include efforts to mitigate the risks of a rapid transition, ranging from climate related hazards, to cyber security threats and the risks of exacerbated socio-economic inequalities from decarbonisation policies that create uneven economic burdens (see Box 3). All R&I priorities must be undertaken jointly and in a cohesive strategy at both the local and the European scale, and harmonization of policy is required.

[Box 2] Innovation needs

- Digitalization can interconnect and optimize key urban infrastructure systems, from mobility to water and waste operations, to goods logistics and energy demand management. However, its impacts on overall GHG emissions need to be carefully assessed to avoid rebound effects.
- The circular and sharing economy can enable cities break the correlation between urban prosperity and emissions (and resource use). While many solutions on city and neighbourhood scale exist, innovation is needed to realize them efficiently, spur buy-in from citizens and link various circular and sharing solutions together in the most resource and emission efficient way.
- Participation and democratic processes is necessary for the long-term sustainability of city decarbonisation measures. Innovation is needed in public involvement and engagement processes, to ensure acceptance to change and harvest solutions from creative citizen groups.



CITIES & CITIZEN DECARBONISATION



POLICY MEASURES

Harmonization of cities' climate action

Climate action in cities can help to resolve a number of challenges that span across all policy sectors. As an example, policies to improve liveability and public health in cities can result in reduced carbon emissions, and vice versa.^{7,8} Cities in particular have much to gain from seeking such co-benefits of climate action.

Harmonizing governance

Integrated urban planning and cross-sectoral governance are key for going beyond sectoral silos. This includes cross-integration between policy formulation on climate mitigation and adaptation, transport, housing, job creation, and public health.

To create such integration, cities need strong leadership and determination, subject to the city's powers and mandate (which vary between cities, see Box 1). Creating a shared, ambitious and long-term vision of the low-carbon transition is one way to demonstrate this, and can be an effective way to align the actions of multiple actors towards the same goal.

This will demand a **participatory** approach with representation of all citizen groups and city stakeholders. It also needs to include an active search for climate solutions that have **synergies** with actions to improve other aspects of urban life.

When moving from planning and vision building to implementation, **setting up a monitoring function**

in each city can help in ensuring that the sum of decentralised climate actions leads to real and deep decarbonisation. This may require curation of piecemeal actions to ensure that they are efficient in terms of resource use and economics, and do not compromise other sustainability goals or decrease the city's climate change resilience.

Harmonizing citizen engagement

City policies are needed that encourage action **by all**. This requires the development of a support framework that enables, encourages, and interconnects dispersed action around the city. To move beyond low-carbon city actions towards net zero-carbon solutions, an environment that encourages revolutionary innovation needs to be nurtured. For instance, new financing models can mitigate the financial risks for small actors.

Local policy-makers also need to push policies that ensure action **for all**. To ensure a decarbonisation that is fair, the development of the zero-carbon city vision must take a bottom-up approach. In the resulting vision all citizens must be represented so that all citizens can feel ownership.

Harmonizing policies that enable and optimize integrated and smart cities

While smart city concepts and circular urban solutions need to grow from creative businesses and engaged citizens, political initiatives are crucial to make this development possible.

Government authorities (at the local, national or



European level) need to provide a regulatory framework and standards for ICT solutions (to enable integration), as well as standards for energy efficiency, low-energy buildings and distributed generation. Government operated and owned facilities should lead the way in implementation, both for testing and scaling smart, circular, and zero-carbon solutions.

A key policy measure is a revision and the redesign of public procurement models to push for climate-friendly options in the public sector.

These policies need to be designed so as to ensure fairness in their effect, and to avoid exacerbating social inequalities.

POLICY RECOMMENDATIONS

While the recommendations presented here are categorized in three different categories (governance and urban planning, citizens engagement, and smart and integrated technologies), they are highly interconnected and must go hand in hand for achieving zero-carbon cities. A system-level approach that combines all areas of innovation is needed to move from localised low-carbon achievements to zero-carbon cities. This will involve many actors and diverse actions.

First, strong city governance and vision are needed. This needs to be followed by clear targets and strategies that support the vision. Second, all zero-carbon technology solutions will have to be implemented and used tailored to the local context, combined in 'smart city' concepts that can meet the needs of the citizens. Third, for the transition to happen, citizens' engagement is crucial. As widespread behavioural change is a prerequisite for zero-carbon technological innovations to reach their full potential. Therefore, policies that encourage changes in consumption patterns and support a circular economy are as important as investments in ICT infrastructure that can enable those changes. Lastly, cities need to incorporate risk mitigation in their decarbonisation strategies to ensure a resilient and sustainable development. Affordability risks linked to new tax policies need to be addressed, as well as the potential vulnerabilities of an increasingly interconnected digital infrastructure and, not least, the risks associated with extreme weather events, sea level rise, and unpredictable food supplies.

In summary, for local policy makers the priority must be to both enable and steer the transition in order to ensure that it is:

- Holistic and integrated both across decarbonisation efforts and within the broader urban development, and
- Democratic, inclusive, and fair, building on collaboration with all city actors.

Local efforts will require support from national and European levels. Mapping best practices and supporting knowledge sharing is an important task, and dedicated

investments both for cities and for R&I on urban solutions is an important other one.

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Endnotes

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[Box 3] Risks & Mitigation – for a resilient transformation

To build sustainable zero-carbon cities, all transformations need to be made with adequate understanding of the uncertainties and vulnerabilities of the new solutions – and the stumbling blocks during the transition, in particular:

- ICT risks: increasingly interconnected and autonomous city infrastructure increases the societal and economic consequences of interruptions (intended and unintended).
- Investment risks: the transition to zero-carbon cities require substantial investments, much of which need to come from individuals and small enterprises – hence, governments need to provide increased security and guarantees, so that decarbonisation action is not financially high-risk. This requires long-term finance and investment rules and regulations that stabilize the “playing field” in favour of zero-carbon solutions.
- Climate risks: cities are anticipated to be vulnerable to the impacts of climate change. Adaptation strategies to more extreme weather events, heat waves and flooding needs to be developed in conjunction with decarbonisation strategies. This includes ensuring that the emission-reducing solutions implemented are “climate proof” and consistent with resources.