Policy Brief

Urban planning and data-driven approaches enable low-carbon cities

Evidence from Berlin and Porto integrated spatial studies

Key messages

Urban form is a powerful circular economy lever

Evidence from Berlin and Porto shows that **location, density, and accessibility to jobs, services, and public transport are key drivers of low-carbon outcomes**.

Spatial planning drives system-wide impacts

Urban form is a major determinant of operational and embodied emissions, accounting for **up to 72% of transport emissions variation in Berlin and 65% of energy and material demand drivers in buildings and mobility in Porto.**

Location is a primary climate lever

Site selection locks in emissions pathways for decades. In Berlin, current housing plans could generate **up to 62% higher mobility-related CO_2 emissions** than spatially optimised alternatives.

Compact, mixed-use neighbourhoods deliver co-benefits

Evidence from Berlin and Porto shows that **compact, well-located, mixed-use development reduces transport emissions** while improving energy and material efficiency.

Policy recommendations

Make accessibility a core planning objective

- Embed accessibility to jobs, services, and public transport into spatial planning, housing, and mobility policies at national and local levels.
- **Set minimum accessibility standards and use accessibility and travel-related CO_2 indicators** to guide site selection and development decisions.
- Shift the focus from moving people faster to bringing destinations closer together.

Focus on compact, transit-oriented development

- Direct new housing and redevelopment to **compact, walkable locations near public transport, jobs, and services**.
- Prioritise development around existing transit hubs and ensure measures are in place to manage land speculation, reducing car dependency and supporting accessible, low-carbon communities.

Promote circular urban regeneration and compact development

- Prioritise **renovation, reuse, repurposing, and targeted densification** in well-connected urban areas before expanding into new sites.
- Align housing and retrofit programmes with compact city objectives to reduce energy, material use, and transport emissions, while supporting sustainable mobility.
- Monitor **rebound effects** to ensure efficiency gains deliver net environmental benefits.

Strengthen data-driven urban planning

- National, regional, and city-level policymakers should develop **interoperable data platforms and open data systems** to support integrated planning across buildings, mobility, and resource use.
- Building permits, building certificates, and public transport operators' mobility data are key data sources for integrated urban planning. Embedding these data into city strategies helps align departments, identify synergies and trade-offs, monitor progress, and support **evidence-based decisions**.

Policy context

Urban areas are central to delivering EU priorities under the European Green Deal, the EU Mission for Climate-Neutral and Smart Cities, and the Energy Performance of Buildings Directive, which promote climate neutral cities, zero-emission buildings, renovation, and local energy systems. The Circular Economy Action Plan also recognises the need to reduce resource use and emissions but gives limited attention to the role of cities and spatial planning. As the EU advances its Affordable Housing Plan, **housing delivery should support circularity objectives by prioritising refurbishment, reuse, and better use of existing floor space, while planning new housing in well-connected locations that reduce building footprints and enable low-emission mobility**.

Why this matters

- **Buildings** account for **26% of global energy-related CO_2 emissions**, while **transport** accounts for **23%**, together making up roughly half of all energy-related CO_2 emissions worldwide [1].
- **Housing** and **food** account for over **70% of EU material demand**.
- **Urban sprawl** locks in car-dependent travel patterns for decades [8], making spatial structure a key climate policy lever [2].
- **Urban form** influences travel behaviour, energy use and material demand, with denser and more compact development requiring less energy and fewer materials.

Previous research showed links between urban form and travel behaviour, but it was difficult to separate built environment effects from individual travel preferences. Meanwhile, most urban decarbonisation strategies address transport, buildings, and resource use separately, overlooking opportunities to deliver savings considering the synergies across the three dimensions.

What the evidence shows

CircEUlar studies in Berlin and Porto show that **urban planning can significantly cut emissions and resource use**. The Berlin study examined residents' travel patterns to show how the design of the city influences travel-related CO_2 emissions. The Porto study found that the way the city is physically shaped, namely, its layout and density, influences the city's energy and material demand.

Together, these studies identify destination accessibility and population density as the most powerful levers for reducing emissions

Destination accessibility drives transport emissions – the case of Berlin [3,9]

Analysis of more than 32,000 Berlin residents shows that where people live has a major impact on travel-related CO_2 emissions, even after controlling for individual residential and travel preferences. Residents in central, mixed-use areas emit 26 percentage points (pp) less CO_2 than the city average, while those in exurban areas emit 35pp more – a gap of 61pp. Overall, **the built environment explains 72% of neighbourhood-level variation in travel-related CO_2 emissions**, even after accounting for residential self-selection (people choosing neighbourhoods that match their travel preferences). **Destination accessibility is the most important factor, accounting for 63% of the total built environment effect**. This is followed by population density (12%), transit accessibility (8%), street connectivity (5%), and land-use diversity (2%).

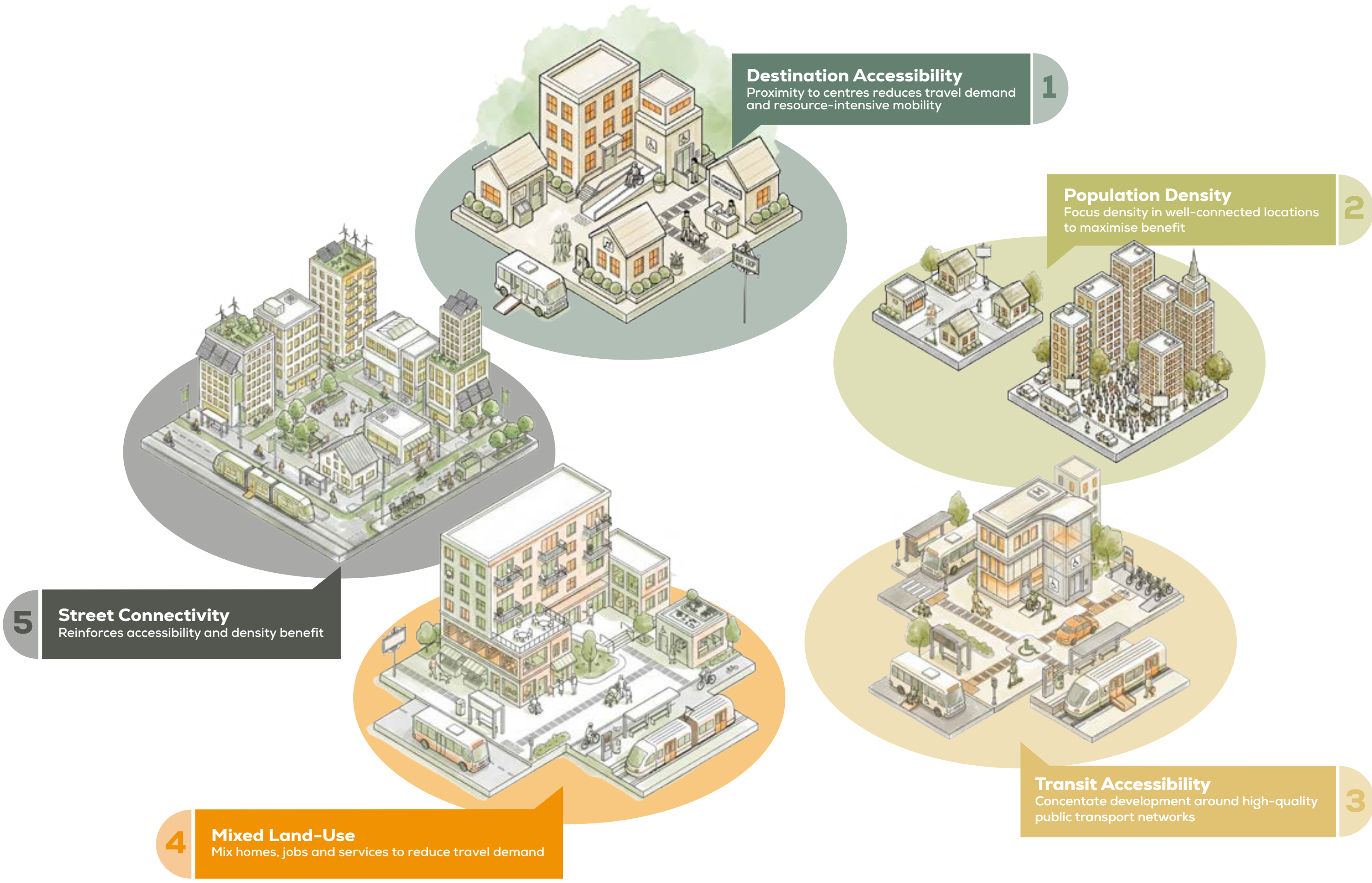
Failing to account for self-selection can overestimate these effects by 13–18%. Responses are strongest among middle-aged, high-income, car-owning households. Applied to Berlin's 64,000 planned new housing units, the analysis shows that 15 of 22 planned housing projects are likely to raise per-capita CO_2 emissions above the city average, mainly due to their distance from the city centre. A transit-oriented development scenario – focusing housing within a 7-minute walk of rail – would deliver 15pp below the city average and 27pp below planned settlements. A more ambitious compact development scenario, concentrating housing in the 20 lowest-emission neighbourhoods, could achieve a 43pp reduction compared to planned sites. Overall, **current housing plans are estimated to produce emissions 62% higher than this low-carbon optimum**.

Density drives energy and material efficiency – the case of Porto [6,7]

In Porto, analysis of urban form, socio-economic, and behavioural factors shows that **urban form is among the strongest drivers of resource use, accounting for up to 65% of the variation across buildings and mobility**. Density is a key determinant of urban performance. Densification in central, well-connected areas reduces motorised travel demand, while increasing building heights can support sustainable mobility where land is scarce. A balanced mix of land uses can reduce mobility demand, lowering energy use and material consumption, as illustrated by the 15-minute city.

Urban form also affects building energy and material demand, alongside factors such as building age, type, and occupancy. Renovation can extend building lifespans and reduce resource demand. For example, using vacant floor areas in Porto would be sufficient to accommodate expected population growth until 2050. In cities where this potential is limited (e.g. Berlin, with scarcer vacant space), reconfiguration (e.g. rightsizing) and repurposing may offer viable alternatives, delivering important efficiency gains. Outcomes depend on where interventions occur, requiring spatially targeted planning. In most cases, **energy and material savings reinforce one another. When trade-offs do occur, such as increased cooling demand, they are typically smaller than the overall benefits**.

Drawing on evidence from Berlin and Porto, in the figure below, urban form levers are ranked by their impact on emissions and resource demand to support planning, zoning, and investment decisions.



Urban form is a high-impact climate lever. In Berlin, compact, transit-accessible development can cut emissions by up to 43pp compared with current plans [3,4]. In Porto, dense, well-located, mixed-use development reduces transport emissions while improving energy and material efficiency [5,6]. Together, the findings show that **spatial planning is essential for low-carbon, resource-efficient, circular cities**. Across both case studies, **the location of developments emerges as the primary emissions lever. Berlin highlights destination accessibility**, while Porto demonstrates the role of density and land-use mix in reducing energy and material demand.

Densification must be location-sensitive: density alone is not enough, as its climate benefits depend on where it occurs. Inner-city and transit-accessible areas deliver the greatest reductions, while poorly connected peripheral growth can increase emissions. Overall, **urban form shapes mobility, energy, and material demand simultaneously, meaning integrated spatial planning approaches deliver the greatest system-wide benefits.** This requires embedding spatially granular, data-driven analysis into planning decisions to guide site selection and appraisal.

Research Methodology

The Berlin analysis uses travel diary data from around **118,000 trips made by 32,201 residents** across 190 neighbourhoods to examine how urban form, such as density, land-use mix, destination accessibility, and access to public transport, affects per-capita travel-related CO_2 emissions. Using double machine learning, the analysis isolates the impact of the built environment from socio-economic and behavioural factors and applies the model to **22 planned housing developments (~64,000 units)** and alternative compact and transit-oriented scenarios to estimate future emissions impacts.

For Porto, a machine-learning model based on artificial neural networks was used to analyse high-resolution urban data at block level, integrating urban form, socio-economic and behavioural drivers of both energy and material demand. Representative indicators were collected for **18 predictors** (urban form, socio-economic and behavioural) and **5 targets** (energy and material demand for buildings and mobility). The analysis considered **1,481 urban blocks.** The model identified cross-sectoral and spatial patterns, assessed the relative importance of different drivers, and explored alternative urban circularity pathways to 2050.

References

Numbers in brackets correspond to this reference list.

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EUBUCCO - European building stock characteristics in a common and open database for 322+ million individual buildings
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CircEUlar project

CircEUlar is a Horizon Europe project (2022-2026) led by the International Institute for Applied Systems Analysis (IIASA) and involving 11 European partners. It develops integrated modelling frameworks and circular pathways for a net-zero economy, with detailed analysis of mobility and buildings as material-intensive demand sectors, and digitalisation as a potential enabler of circularity. Combining quantitative modelling, qualitative research, and stakeholder engagement, the project generates evidence to support Europe's climate and circular economy objectives. **Visit our website: https://circeular.org/**

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