

The Journey to Net Zero Cities

The UK's export and expertise capability

The Business of Cities for Connected Places Catapult

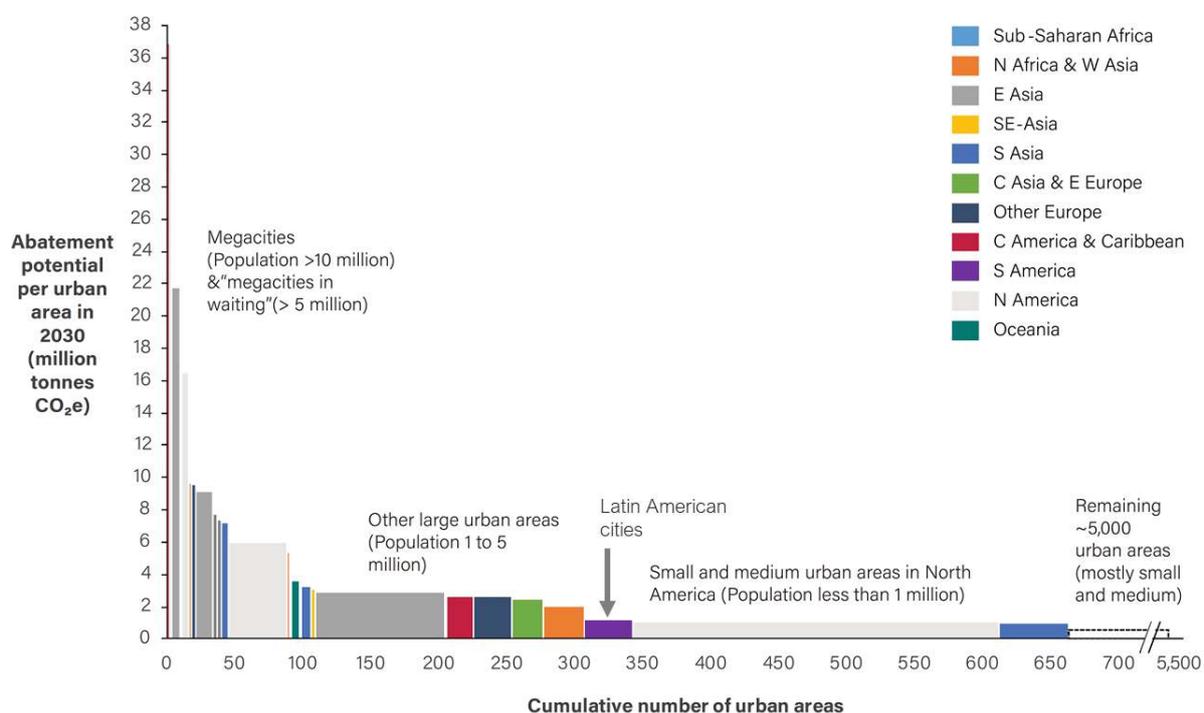
April 2021

Introduction

The global journey to 'net zero'¹ depends to a very large extent on what happens in cities.

Net zero - where total greenhouse gas emissions are equal or lower than emissions removed from the environment – is shaped in large part by CO₂, which is responsible for 75% of greenhouse gas emissions globally. Cities account for over 70% of these CO₂ emissions.² An increased pace in the decarbonisation of cities – which we take here to mean all ways of reducing cities' CO₂ emissions – will be essential to the journey to net zero.³ This imperative applies to cities large and small, and cities in established and emerging economies. All cities will play their part.

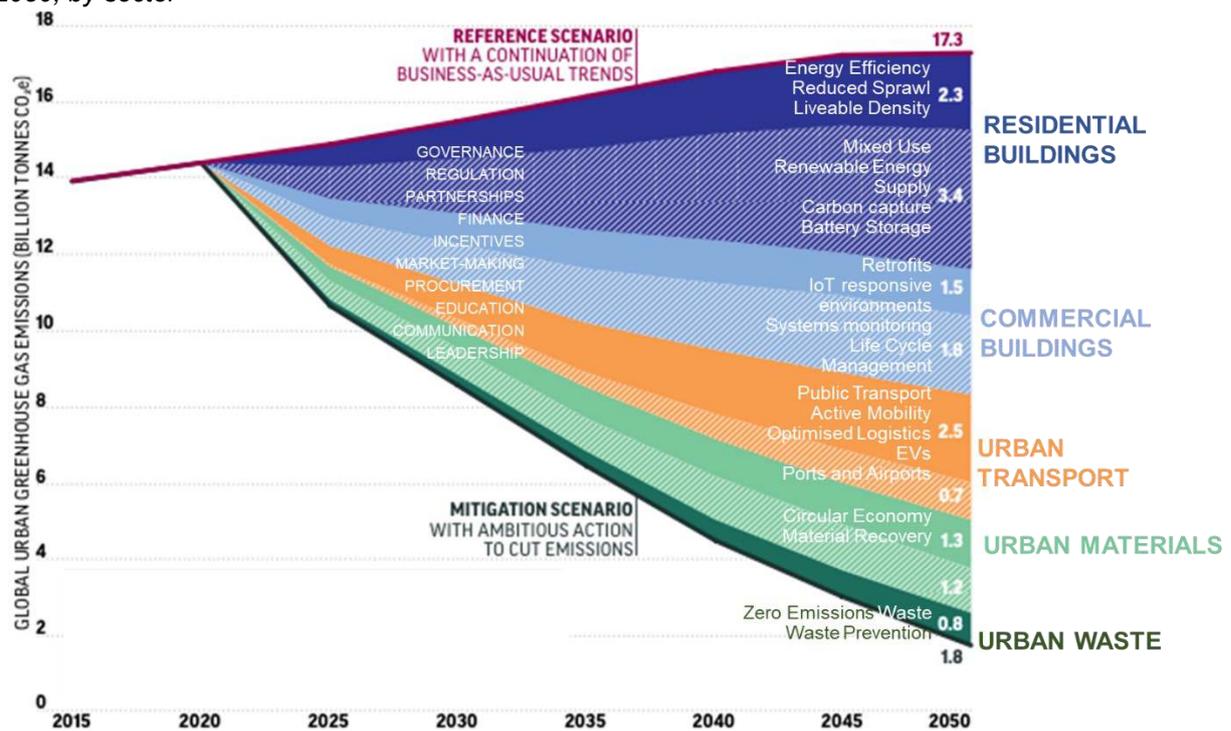
Figure 1: Greenhouse gas emission abatement potential in CO₂ equivalent for different types of city around the world



Source: Adapted from Coalition for Urban Transitions (2019).⁴ The height of each bar represents GHG abatement potential per urban area in 2030, the width indicates number of urban areas within different population classes and world regions (as indicated by labels and shading, respectively).

There is no one system or catalyst that will decarbonise cities. It will require millions of small and large interventions, not only into buildings, transport, energy, waste and materials, but more broadly into city systems, assets, services, planning and business models. Digitisation, integration, efficient retrofits, co-ordinated governance, aligned incentives and applied technologies will all be required (see Figure 2). The abatement contribution of medium-sized cities in particular is striking in the pursuit of targets for 2030 and beyond.

Figure 2: Technically feasible potential to reduce greenhouse gas emissions from cities collectively by 2050, by sector



Source: Adapted from Coalition for Urban Transitions (2019).⁵

These efforts synchronise with other core benefits cities are seeking - cleaner air, better mobility, cost savings for citizens and companies, higher liveability and talent retention. Latest forecasts suggest that the economic benefits of decarbonising cities may amount to £17.5 trillion in Net Present Value by 2050.⁶

Part of understanding and crystallising our roles and responsibilities in this global quest is knowing where and how to make a difference. For the UK, the questions are these: **what is the UK really world-class at? In which areas does it have the leading-edge ideas, innovations, capabilities and lessons to support the rest of the world?**

This short review is a non-exhaustive, outside-in scan based on national and international studies and analysis and interviews with key stakeholders. It is **not** designed to be a fully comprehensive and in-depth analysis that captures all UK actions in the net zero space in full. Rather, it presents an overview of specific sectors to provide an informed view commensurate with the purpose of a briefing note. It considers both the current UK expertise and deployments, as well as the future potential of specific sectors, niches and cities to amplify their impact. The studies reviewed include:

- Studies from UK Catapults such as the Connected Places Catapult and Energy Systems Catapult.
- Analysis undertaken by and on behalf of the UK government.
- National government reviews and policy briefs.
- Global benchmarks and comparative studies of city performance.
- Global big data platforms of real-time investment and innovation activity in cities.
- Interviews with key participants in the ecosystem in the UK and internationally.

The UK net zero context

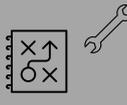
The UK was the first nation to industrialise and urbanise, and one of the first nations to experience de-industrialisation and urban decline. The UK is now leading a cycle of low-carbon re-urbanisation, both at home and in particular through world-class capabilities of companies that have understood that sustainable net zero cities require integrated approaches.

As a source of solutions and innovations, the UK is on a path to becoming a distinctive net zero market in that it simultaneously possesses:

- World-leading sector-specific capability in areas essential for financing and building net-zero cities in an integrated way.
- A competitive 'first mover' advantage in niche technologies and place-based innovations that can be scaled globally to city governments and users.
- Research, insight and applied urban experience in of addressing a wider suite of implementation agendas that support the net zero urban transition.
- Know-how around systems integration, breaking down siloes, and creating the regulatory and policy environment needed to spur change.
- Experience at the UK city level of seeking to innovate around efficient and low-carbon city-building despite significant institutional deficits and place fragmentation. The UK's own institutional context has spurred UK cities to develop distinctive appetite for net zero-related collaboration, innovation, sharing practices, and internationalising their companies and reputation.

These can be mapped in the following visual:

The UK's core net zero export advantage

	 New Technologies & Services	 Business Models, Behaviour Change, Planning and Systems Integration	 Capacity Building	 Policy Leadership & Innovation
Model	B2B, B2C, B2G	B2B, B2G	G2C, R&I	C2C, G2G
 Financing the net zero Future	<ul style="list-style-type: none"> Financing green cities Green bonds Platforms to simplify investing in green 	<ul style="list-style-type: none"> Pioneering Green Investment Bank models Digital marketplaces Design of public private partnerships 	<ul style="list-style-type: none"> Green finance education and training Enhancing bankability of projects Project design and communication Advice broker for local banks and firms Green bond market intelligence and advisory 	<ul style="list-style-type: none"> Financial regulation and standards Applying track record of climate-related financial disclosures
 Low Carbon Urban Energy	<ul style="list-style-type: none"> Advanced battery storage (silicon, lithium-sulfur) Flexible and affordable solar power solutions Carbon Capture and Storage Renewable energy optimisation 	<ul style="list-style-type: none"> Creation of flexible energy networks Systems engineering Optimisation and integration of smart grid technologies Digital technologies for energy efficiency and distribution 	<ul style="list-style-type: none"> Diverse energy research base Footprinting, target setting and climate action planning expertise Demand-side management and energy storage optimisation 	<ul style="list-style-type: none"> Energy market design and regulation expertise Applying high regulatory ambition
 Clean Urban Mobility	<ul style="list-style-type: none"> EV hardware and supporting infrastructure Smartphone apps and mobile payments E-Freight technologies 	<ul style="list-style-type: none"> Design of subscription services Systems integration 	<ul style="list-style-type: none"> Design of PPPs for metropolitan transport systems Diverse research base for next-generation mobility 	<ul style="list-style-type: none"> Pioneering Low Emission Zones and setting rigorous vehicle emissions standards Proactive adoption of net-zero urban mobility solutions and modal split initiatives Integrated transport authorities
 Low Carbon Urban Built Environment	<ul style="list-style-type: none"> Architectural design Digital Twin technology Building Information Modelling (BIM) Digital technologies for urban service delivery Civil engineering expertise Green construction techniques 	<ul style="list-style-type: none"> Integrated approaches and masterplanning Whole life cycle, circular economy approaches 	<ul style="list-style-type: none"> Tools and frameworks for planning, delivery and integrated governance 	<ul style="list-style-type: none"> Implementing bold net zero city-level plans Encouraging carbon literacy

The UK's cities are also leading the charge for net zero internationally and despite limited capacity are growing their reach and influence on net zero agendas (see below).



Sources: Press releases and media articles.⁷

UK net zero SMEs

The UK is home to exceptional growth-oriented SMEs with niche capabilities and experience to support cities to shift more rapidly towards net zero. These include areas such as smart streetlighting, lithium-ion battery storage, electric vehicle charging infrastructure and subscription models, and mobile ticketing and payments-as-a-service, where the UK is rapidly establishing itself as a global pacesetter.

Opportunities

As observed in the sections below, UK SMEs have many globally relevant capabilities in sectors essential to accelerating progress to net zero, especially in the 'softer' domains related to regulation, incentives, systems engineering and integration. Their export and scalable expertise potential will in future benefit from:

- A co-ordinated system to alert SMEs to non-UK language advertised opportunities, and to support them to respond efficiently.
- Ongoing support to UK cities to build capacity and resources to mobilise around net zero and showcase progress in an internationally relevant way to overseas decision makers and investors.
- More structured support to share UK global expertise and to combine the different sectors that contribute to a low-carbon system into a smart integrated offer.
- Support for UK net zero expertise as a package, how it can complement existing capabilities in cities, and link to supply and delivery on the ground.
- Improved institutional machinery to support small UK companies in sustained city-wide partnerships abroad.
- Greater alignment between the geometry of institutions seeking to export services and know-how and the geometry of solutions required.

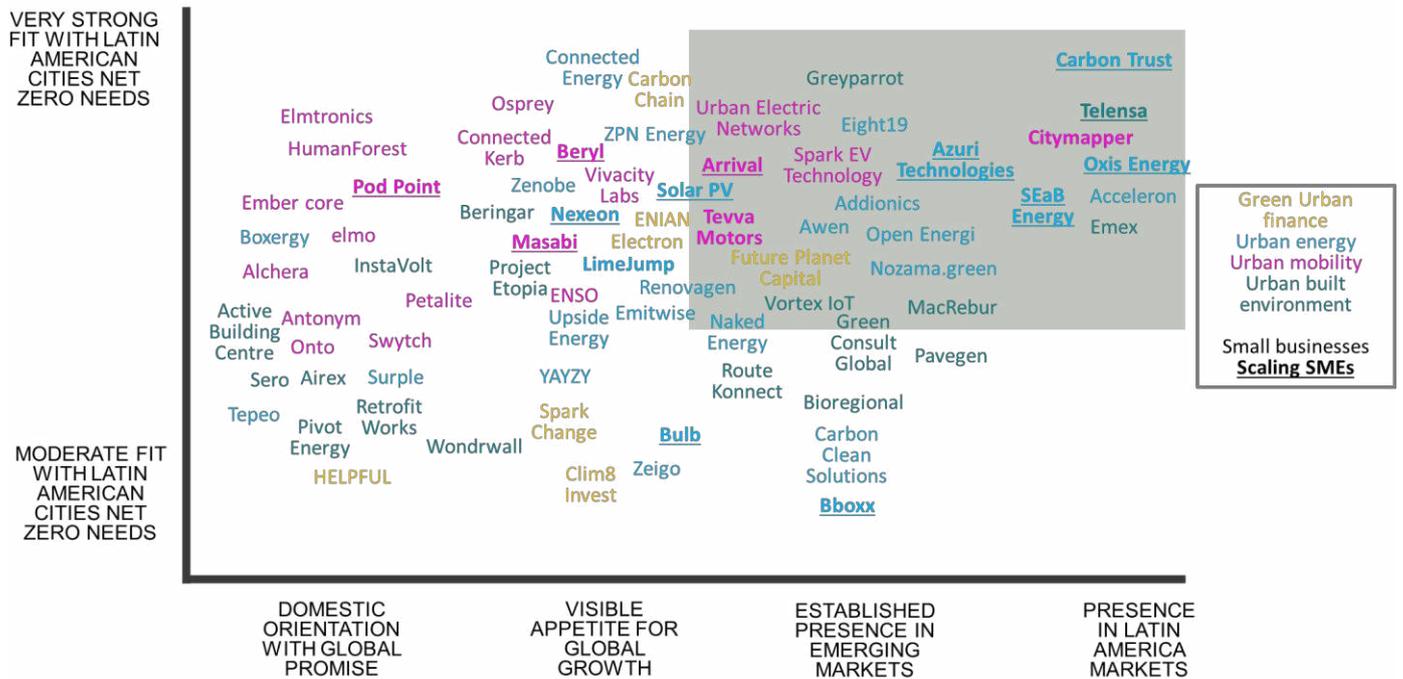
Opportunities in Latin America

As cities across the world transition towards a net zero goal in the finance, energy, mobility and built environment sectors, more opportunities are being created for UK SMEs to export their technology and services, business models, and policy and regulation expertise. This briefing note includes examples of partnerships that are already underway, with a particular focus on cities in Latin America.

An indicative scan based on publicly available company databases, practitioner recommendations and existing UK export missions points to a broad range of opportunities for UK SMEs to serve and support the transition to net zero in Latin American countries, based on their current market presence and offering to markets and users in Latin American cities (see the illustrative chart below).⁸

In general, the most important areas for mitigation in Latin American cities – particularly smaller and medium sized cities – are around decarbonising transport, energy and waste.⁹ For example, recent data suggests that the mobility sector accounts for nearly half of Brazil's urban abatement potential to 2050, and that throughout Brazil around 40% of cumulative abatement potential is held in cities with fewer than 300,000 inhabitants.¹⁰

Figure 3: Illustrative chart to map a sample of UK startups and SMEs in net zero-related sectors and their potential fit with Latin American cities' net zero needs. Chart is indicative and has not been verified by the businesses themselves.



Note: The shaded box marks the companies that seem on initial evidence to have the highest potential to help Latin American cities accelerate towards net zero. Other businesses may well have specific contributions to make not accounted for in this short review. The fit with Latin American cities needs has been assessed through research into a range of cities in Latin America, with a particular focus on their inherited assets, ambitions to become net zero and particular sectors, platforms and projects being prioritised to catalyse decarbonisation.

UK Advantage 1: Financing the net zero Future

Sector	Major players and enablers	Examples of scaling SMEs and small businesses	Examples of key knowledge institutions
Green urban finance	Green Investment Group Barclays HSBC Natwest	CarbonChain , Clim8 Invest , Electron , Future Planet Capital , HELPFUL , Regal 38183 , Spark Change , ENIAN	Green Finance Institute UK Centre for Greening Finance and Investment University of Oxford Sustainable Finance Programme

The UK is recognised as a global leader in green finance. London in particular is a well-established and leading centre for sustainable finance services, providing a transferable wealth of experience and connections.¹¹ UK SMEs in the fintech industry are helping to lead innovations and facilitating the flow of green finance, by simplifying investments into green instruments and companies, and increasing transparency of carbon emissions in investment portfolios. Meanwhile large banks and FTSE 100 companies provide investment for environmental projects and business ventures, seed-funding to assist the scale up of green tech companies, and expertise on financial models for green initiatives.

UK expertise in this area encapsulates:

- **‘Green finance’ expertise** – expertise regarding how to strengthen sustainability reporting and standards, disclosure and monitoring, and sustainability compliance.
- **‘Financing green’ expertise** – in terms of the track record of supplying investment into city systems and assets that can underpin a shift to decarbonisation.

In general, the current UK approach to ‘financing green’ in Latin American markets especially relates to building capacity around how to structure projects to enhance their attractiveness to private sector and capital markets. Initiatives relating to the greening of the financial system are newer but provide much room for contribution.

Within these two main areas, UK expertise is focused on:

Technology and services

- **Financial capital.** The UK is home to unique pools of private and institutional capital and expertise in financing green projects in cities, which can be leveraged to deliver net zero innovations at scale, and finance renewable energy and sustainable infrastructure at pace. UK based asset managers are leading the restructuring of pension funds to direct investments towards sustainable assets. Meanwhile UK Export Finance is one of the world’s most flexible export credit agencies. Its lower minimum domestic content requirement (20%) has been instrumental in helping to provide the debt financing necessary for UK exporters to win and fulfil contracts with overseas buyers – especially in sectors like renewable energy and electric vehicles where large upfront working capital and contract bond requirements can be a barrier for SMEs.
- **Green bonds.** The London Stock Exchange and its dedicated global sustainable investment centre was the first global exchange to introduce a dedicated green bond segment, and is home to the first certified green bonds.¹² The Climate Bonds Initiative, which has a strong regional presence in Latin America, is developing a large liquid green and climate bonds market to help drive down costs for climate projects in developed and emerging markets.
- **Green finance platforms that simplify investing in green finance.** Many UK SMEs and start-ups are at the forefront of global efforts to improve the ease for citizens and institutions to invest in carbon instruments.

Business models and systems integration

- **Green Investment Bank model to raise investment in cities:** UK green banks provide a world-leading successful and tested model for specialised public finance institutions that mobilise private investment into green economy solutions. This can be replicated in emerging markets to improve the viability of projects in the waste, water and energy sectors.
- **Creation of digital marketplaces.** Some SMEs are utilising technology platforms and smartphone apps to simplify investments into low carbon sectors.

Capacity building

- **Green finance education and training.** The Green Finance Institute (GFI) offers a transferable Green Finance Education Charter to educate professionals in the finance sector on green and sustainable principles, and a programme to match experts with cities in Latin America to provide financial and policy expertise.¹³ Meanwhile the Oxford Sustainable Finance Programme runs the leading short course on sustainable finance globally, and the Chartered Banker Institute's Green Finance Certificate has helped more than 30,000 banking and finance professionals to gain the world's first global benchmark qualification for sustainable finance.¹⁴
- **Capacity building for bankability of clean urban infrastructure projects.** The UK has demonstrated exportable leadership and technical skills in structuring facilities and projects to catalyse finance capital, thus helping build local financing capacity and green finance skills.
- **Project design and communication.** The UK is uniquely placed to help to structure and communicate projects to make them more attractive to green finance. Financial experts can also assist with the design of business models for tenders.
- **Facilitation of Public Private Partnerships.** The UK financial sector excels in structuring and facilitating public private partnerships that can help to create an enabling environment for stimulating, shaping and de-risking private sector activity and investment. This can be used to meet appetite in Latin American cities for partnerships with private sector contribution.
- **Advice to local and regional banks on facilitating green investment.** UK firms have an established track record of building capacity, reducing barriers and providing clear pathways to unlocking commercial green finance in Latin American cities.
- **Green bond market intelligence and advisory.** The Climate Bonds Initiative provides market intelligence on the evolution of the global green bonds market, showcases green infrastructure opportunities and provides advisory services that can help investors, governments and developers understand what investments will drive a low carbon economy.¹⁵

Policy and regulation:

- **Financial regulation and standards.** The British Standards Institution (BSI) is leading global efforts to define best practices for sustainable finance, through its Sustainable Finance Standardisation Programme. In 2020, the BSI published a publicly available framework with the aim of strengthening the ability of financial institutions of all sizes and in all regions to align their decision making to global initiatives like the Paris Agreement.¹⁶ The GFI assembles world leading public and private sector financial and policy experts to collaborate on financial innovations that can help unlock investment to facilitate a transition to net zero.
- **Applying track record of Climate-Related Financial Disclosures.** The UK Financial Stability Board's Task Force for Climate-Related Financial Disclosures provides a framework for companies and other organisations around the world to develop more effective climate-related financial disclosures, encouraging them to identify and then disclose details of the material risks and opportunities arising from climate change under different scenarios.¹⁷

Presence in Latin America

The UK, facilitated by government partnerships, is experienced at applying investment and financial expertise to assist decarbonisation in Latin American cities.¹⁸ The UK-Colombia Partnership for Sustainable Growth leveraged the City of London's expertise to help turn the finance industry in Colombia green and the UK Partnering for Accelerated Climate Transitions (UK-PACT)

initiative provided finance structuring for over 100 companies in Colombia's industrial sector, including in the Santander department.¹⁹ UK Export Finance supported a loan of up to 85% to help Mexico City finance a contract for double-decker buses from Alexander Dennis in order to decongest the city centre, and its team of International Export Finance Executives, including representatives in Colombia, Mexico and Brazil, helps to promote the UK's ability to support exports through guarantees and loans to buyers and exporters as well as to provide advice on financing options in-country.²⁰ Meanwhile UK investment banks are well placed to advise and structure green bonds and regular issuances in Colombia's capitals market, and there are opportunities for UK green finance actors to help build the capacity of financial institutions. Both Colombia and Chile have a high interest in establishing green banks based off successful global models and are encouraging existing financial institutions to green their portfolios.²¹

Examples of UK expertise and leadership in Green Finance

Global Leadership

1. The UK government is the largest contributor to the **International Development Association** and is a founding member of the **Climate Investment Funds**, to which it has invested almost £1.8 billion since 2008.²²

Institutional Depth and Capacity

2. The UK hosts organisations including the Green Investment Bank, the London Energy Efficiency Fund, the Climate Bonds Initiative and Climate Change Capital.²³
3. To date, 155 **green bonds** and 7 green issuers are listed on the Sustainable Bond Market on the London Stock Exchange (LSE). As of 2020, the amount raised in green bonds on the LSE is £22 billion.^{24,25}
4. Camco Clean Energy have pioneered renewable energy finance by creating a **Renewable Energy Performance Platform**. This has mobilised business investment in small scale renewable energy projects in Sub-Saharan Africa, including in rapidly urbanising cities such as Abuja, Kano and Bujumbura.^{26,27}
5. **Unilever** is providing £860 million in a climate and nature fund to be used by its brands over the next 10 years to enable more decisive and meaningful climate action.²⁸
6. **Barclays** have created an Energy Banking Team and pledged £100 billion of investment by 2030.²⁹
7. All major UK banks offer **green loan programmes**.³⁰

Capacity building

8. **The Green Finance Institute** is working to develop a Green Bank Design Platform to consolidate and match UK expertise to those in need of assistance.³¹ City governments can use this to set up green banks and financial vehicles that will attract private investment for low-carbon solutions. It will also map out the skills required to support the successful formation of green banks, and connect expertise to where it is needed most.
9. The **Climate Finance Accelerator**, a UK funded technical assistance programme, leverages UK-based green finance experts, who have provided assistance to policy makers and finance experts in Colombia, Mexico, Nigeria and Vietnam.³²
10. The UK-PACT **Green Recovery Challenge Fund** is a £12 million capacity-building fund to support low-carbon transitions in ODA-eligible countries, including in Latin America.³³

Successful SMEs

11. **Clim8 Invest** – a UK sustainable investing app – provides consumers with a simple means for investing in a targeted portfolio of publicly listed companies that are already making an impact in the race to decarbonisation.
12. **SparkChange** has created a technology platform that simplifies institutional investments in carbon instruments. The platform provides investors with direct exposure to the value of physical carbon allowances and an ability to bypass complex and costly requirements associated with current market entry mechanisms.
13. **CarbonChain** offers carbon foot printing and carbon risk assessments of trade finance portfolios, to help improve emissions in the supply chains of polluting industries, including oil and gas, metals and agriculture.
14. **Regal 38I38** provides green financial services and a virtual sustainable banking platform based on Green Blockchain technology, specifically for Emerging Countries. This platform helps clients make investment decisions that meet environmental criteria.

UK Advantage 2: Low Carbon Urban Energy

Sector	Major players	Examples of scaling SMEs	Examples of small businesses	Examples of key knowledge institutions
Low Carbon Urban Energy	Arup, Mott Macdonald, Anglo American, BP, Centrica, Cornwall Insight, Delta EE, EA Technology, ICF Consulting, Octopus Energy, OVO Energy, PA Consulting, Palladium International, RSK Group, SSE Renewables	Azuri Technologies Bboxx Bulb Carbon Trust LimeJump Nexeon Oxford PV Oxis Energy SEaB Energy	Acceleron , Addionics , Awen , Boxergy , Carbon Clean , Connected Energy , Eight19 , Emitwise , Naked Energy , Nozama.Green , Open Energi , Renovagen , Surple , Tepeo , Upside Energy , YAYZY , Zeigo , Zenobe , ZPN Energy	Faraday Institution EPSRC at the UKRI UK Battery Industrialisation Centre UK CCS Research Centre UKERC

UK businesses are at the international forefront of a number of net zero urban energy technologies. Capabilities encompass all stages of the energy life cycle, from research and design to financing and development, and the scaling-up, implementation and management of urban energy technologies. Urban services and consulting firms, alongside startups and scaling SMEs, have demonstrable and transferable expertise in the urban green energy sector. The UK's innovative SMEs are more highly specialised in energy and other sectors both directly and indirectly related to net zero.³⁴

In particular, UK expertise is focused on:

Technology and services:

- **Advanced battery storage.** Many UK startups and SMEs are driving next generation battery energy storage solutions for cities. These range from using new silicon and lithium materials for battery applications and smart 3D structures to improve performance, to creating batteries based on recyclable materials that can be used for a range of urban applications including electric vehicles and connecting renewable energy to grid infrastructure.
- **Flexible and affordable solar power solutions.** UK energy providers and SMEs are at the leading edge of urban solar technologies. This includes the development of space-efficient solar panel designs with lower manufacturing costs, which can be adapted to any rooftop or building, and the scaling up of solar power into urban environment via pay-as-you-go systems.
- **Carbon Capture and Storage (CCS) technology.** UK firms and universities have been sharing knowledge on CCS with many countries around the world, including China and Mexico.³⁵ The UK CCS research institute is a major interface of international research and leads an international working group to accelerate deployment of CCS globally.
- **Renewable energy optimisation.** SMEs and research institutions are pioneering technologies for energy optimisation. For example, UK SMEs are designing energy harvesting solutions that increase energy efficiency from solar cells, which can be used in urban solar panels.

Systems integration:

- **Creation of flexible energy networks.** The UK is world leading in the design of new flexible and hybrid energy markets, including smart energy grids and the first zero-carbon gas grid, as it works to unlock the capacity of its own network. Energy network providers are leading efforts to share technology for automation and control, design solutions to adapt networks to changing energy needs, and share the regulation structure needed to set up new markets.

- **Systems engineering expertise.** The UK energy sector has transferable expertise in bringing together different energy vectors and removing the siloes between systems, including the digital, transport, heat and building sectors. This includes transferable experience working with energy providers to help plan the whole system via visioning and target setting exercises.
- **Optimisation and integration of smart-grid technologies.** Many UK SMEs deploy expertise on the optimisation and integration of smart energy systems, for example on where and how to co-locate storage and generation facilities and the installation of smart meters.
- **Digital technologies for energy efficiency and distribution.** SMEs and network providers use data analytics and cloud-based software to optimise energy efficiency and distribution processes. The use of AI, digital platforms, and new control and automation technologies is helping to reduce complexity and increase transparency around the uptake of renewable energy, for example by using machine learning to create a networking platform that reduces the complexity of energy contractual processes.

Capacity building:

- **Footprinting, target setting and energy action planning.** The UK has a unique cadre of world-leading environmental consulting start-ups capable of partnering with businesses, organisations and governments to advise on the measuring and monitoring of urban carbon footprints and set targets for energy transition. The UK is also home to the 1st mobile banking compatible app that allows consumers to track the carbon footprint of their purchases.³⁶
- **Diverse energy research base.** UK enterprises, universities and research institutes also provide demonstrable expertise in green urban energy research that can help accelerate the transition to net zero. Several larger players have formed dedicated research institutes and innovation platforms to share knowledge and collaborate with global research institutions and industry experts. The UK is also home to a multitude of research institutions and SMEs who collaborate on green innovations in hydrogen, solar and hybrid energies.
- **Demand-side management and energy storage optimisation.** UK SMEs are leading efforts to create new smart meters, smart tariffs and data software systems that optimise the storage of renewable energy and the use of energy through time to reduce the use of grid intake. For example, the Equiwatt energy management app rewards customers for cutting consumption during peak times.

Policy leadership:

- **Energy market design and regulation expertise.** The UK is a leader in the energy policy and regulatory space, as the challenges faced by its own energy industry have encouraged it to innovate and adapt. The UK's reformed regulations that have underpinned the creation of an output-based energy market have been critical to the launch of a more competitive and flexible energy market. UK companies, including management consulting firms, can offer market design and policy expertise for cities looking to copy this regulatory setup, for example through guiding cities on how to use policy and financial incentives to encourage investment into low-carbon energy solutions. This is especially relevant to middle-income countries, where energy markets tend to be more vertically integrated and there are fewer incentives for competition.³⁷
- **Applying high regulatory ambition. The UK and its cities are leading by example in the decarbonisation of their energy systems, having set ambitious targets and climate action plans.** UK cities have decarbonised rapidly since the beginning of the 21st century.³⁸ In particular, UK cities stand out for:
 - Their experience in reducing emissions whilst diversifying their economies, which can provide important and transferable insights for Latin American governments.
 - Their track record of setting up net zero advisory groups that convene multiple sectors and municipalities from across metropolitan areas.
 - Applying an effective model of climate legislation, which can help inform the institutional and regulatory frameworks required for implementation of national policies in cities.

Presence in Latin America

Many UK urban services firms already have an established presence in middle income countries in Latin America, including Colombia and Chile. For example, Mott Macdonald has undertaken projects in Calama in Chile and Bogota and Medellin in Colombia for over 40 years, including designing the Medellin Metro system and 5 airport masterplans in Colombia.³⁹ It has worked in the region's urban environment, power and transport sectors for over 40 years, and is a partner globally in 100GW+ worth of renewable energy projects.⁴⁰ Partnership between the UK and Latin America also occurs through government projects. The UK-PACT project involves UK companies providing financial and technical analysis to help scale renewable energy clusters in emerging markets.⁴¹ In Colombia the project has helped to scale up the solar cluster in Tolima.

Examples of UK expertise and leadership in Low Carbon Urban Energy

Global Leadership

1. The UK has **decarbonised faster than any other country** so far in the 21st century, with emissions decreasing by 3.7% on average each year. The UK was the fastest G20 country to decarbonise its economy since 2000, and has cut emissions by 40% between 1990 and 2018, even as the economy has grown by 70%.⁴²
2. **Mott Macdonald** is the #1 technical advisor for renewable energy infrastructure.⁴³
3. The Climate Group **EP100**, including Arup and Mott Macdonald, encourages knowledge sharing to accelerate the energy-transition.

Successful SMEs

4. **Acceleron** is using new battery technologies to create the world's first recyclable, upgradeable and serviceable lithium-ion batteries.
5. **Bboxx** has developed "plug and play" solar home systems that are currently operating in 11 African and Asian countries.⁴⁴ It has also created a digital IoT platform to enable remote monitoring of building energy usage.
6. **Emitwise** has created smart data software to help commercial businesses calculate and monitor their carbon footprints.
7. **Carbon Clean Solutions** has researched and created a modular, scalable CCS solution that can be adapted to any site.
8. The **Carbon Trust** has helped to unlock the Colombian FENOGUE Fund to finance energy access and energy efficiency under the UK-PACT project.
9. **OXIS Energy** partnered with CODEMGE and Mercedes Benz in 2020 to develop the world's first Li-S manufacturing plant in the city of Juiz de Fora, Brazil. OXIS will supply the technology to produce Li-S cells.^{45,46}
10. **Zeigo** launched a digital platform for Power Purchase Agreements. Artificial Intelligence simplifies the contractual process, connecting corporate energy buyers with generators and suppliers of renewable energy.

Ambitious Cities

11. **UK cities** together reduced their emissions by 29% from 2005-2015 in comparison to the national average of 27%. In Exeter, the top performer, emissions fell by 44%.⁴⁷
12. The Mayor of London launched the **London Power** energy company aiming to make low-carbon energy accessible and affordable to London residents.
13. **Manchester** has mobilised 60 organisations into an ambitious climate change partnership, to share best practices, set collaborative targets and provide transparent updates. These account for 20% of the city's greenhouse gas emissions.⁴⁸

Ambitious Governments

14. The **2050 Calculator** was developed by the UK government to help explore emission reduction pathways. To date it has been used in over 15 countries, including Colombia.⁴⁹
15. The UK jointly launched the **Powering Past Coal Alliance** at COP23 to provide knowledge-sharing to help other countries to move away from unabated coal power.⁵⁰

UK Advantage 3. Clean Urban Mobility

Sector	Major players	Examples of scaling SMEs	Examples of small businesses	Examples of key knowledge institutions
Clean Urban Mobility	Arrival London Electric Vehicle Company (LEVC)	Beryl Bulb CityMapper Onto Masabi Pod Point Tevva Motors	Alchera , Antonym , Connected Kerb , Ember Core , elmo , Elmtronics , ENSO , HumanForest , Osprey , Petalite , Spark EV , Swytch , Urban Electric Networks , Vivacity Labs	Coventry University Institute for Future Transport and Cities Network Rail (within UKRRIN) The Welding Institute UCL Centre For Transport Studies UCL Energy Institute MaaSLab University of Birmingham University of Exeter Future of Mobility Centre University of Oxford Transport Studies Unit

UK businesses and research institutions have acquired significant and transferable expertise in low carbon urban mobility in a range of city contexts.⁵¹ Investment into transforming the UK's domestic transport sector has supported businesses to become well placed to share best practices globally within cities and the urban businesses looking to serve them. Much of the UK contribution in this space lies in its expertise in providing the hardware, software and systems to incentivise a switch to electric mobility and improve sustainability of road-based transport systems on the one hand, and its experience creating the data tools that can help to promote smarter use of existing transport assets and underpin large scale systems improvement on the other.

In particular, expertise lies in:

Technologies and services:

- **Electric vehicles (EVs) hardware.** The UK is a leader for new energy efficient EV models that meet low emission targets – for electric buses, cars, taxis, and private bikes. SMEs have created new production methods that can help with delivery of EV models at scale.
- **Building out the necessary supporting infrastructure.** SMEs have become agile providers of electric infrastructure in cities, namely on-street, rapid-charging points and hubs. Large public transport institutions and universities have expertise in how to connect electric transport to the existing grid infrastructure and transport network.
- **Smartphone apps and mobile ticketing for public transport.** UK SMEs are spearheading digital innovations to support net zero transport. This includes smartphone apps for city-wide bikeshare schemes and the effective integration of big open transport data sets to optimise travel efficiency. UK firms lead in 'fare payments as a service', mobile ticketing, and contactless payments systems for public transport, which help to drive modal shift.
- **E-freight technologies.** UK SMEs have agile expertise in E-trucks for freight and urban deliveries, developing and manufacturing battery packs and on-board battery-management technology capable of enhancing cost effectiveness.

Business models and systems integration:

- **Subscription services, pay as you go schemes and new leasing models.** UK companies possess a niche in designing subscription services, pay-as-you go schemes and new leasing models. These are necessary to drive consumer uptake by reducing the cost of commitment from city customers, and de-risking potential investments. Such expertise can support the wider adoption of EVs in cities in middle-income countries.

- **Integrated and retrofitted transport infrastructure.** Metropolitan institutions, such as TfL and Transport for the West Midlands have accumulated expertise in developing and retrofitting existing trains and railways with new technologies.

Capacity building:

- **Design of Public Private Partnerships (PPPs) for metropolitan transport systems.** The UK has substantial capabilities in structuring and managing PPP agreements and since 2018, it has been leading new ways of structuring partnerships that are flexible and adaptable to technical changes, such as through the harnessing of big data in the operation of integrated transport systems.⁵² The UK public and private sector can provide support for complexities in partnership design, procurement processes and stakeholder management in transport infrastructure projects and systems in middle-income cities.
- **Diverse research base.** UK research institutions, business and cities are undertaking globally leading research in urban green mobility. Many universities have dedicated research centres that are well engaged with industry experts and government institutions to share knowledge, particularly in:
 - Low-emission power systems for rail infrastructure, often with a specific focus on hydrogen.⁵³
 - Exploring the readiness of grid infrastructure for electric vehicles.
 - Solving challenges in integrating electric transport systems into the existing networks, including supply chain issues, electric vehicles and charging infrastructure, and electric rail networks.⁵⁴

Policy leadership:

- **Pioneering Low Emissions Zones and setting rigorous emission vehicle standards.** UK cities have been at the forefront of global efforts to increase the stringency of vehicle emissions restrictions. Around 10% of the world's urban low emission zones are located in UK cities including Glasgow, Norwich, Bristol and York. London launched the world's first Ultra-Low Emission Zone with increased restrictions, and Oxford has plans to implement the world's first Zero Emission Zone scheme in 2021.
- **Proactive adoption of net-zero urban mobility solutions and modal split initiatives.** Some cities, including Milton Keynes and Leicester, have been involved in developing and deploying their own electric vehicle fleets, or promoting electric vehicles for public transport in city centres. Others, such as London and Manchester have been adapting road infrastructure to make space for more cycling, by widening pavements, creating pedestrian areas and low-traffic neighbourhoods in city centres and building extensive safe and connected bike lane networks.
- **Experience creating integrated metropolitan transport authorities.** Several UK cities boast world-renowned transport authorities that oversee the development and delivery of all metropolitan public transport services. Many UK cities have integrated delivery into a co-ordinated network under a strong single governance structure, which allows for clear strategic visions, alignment of stakeholders, the ability to raise sustainable local funds and an increased ease of use as a result of metropolitan-scale payments systems such as the TfL Oyster Card. Transport for London (TfL) is considered to be a world-leading transport authority which is integrated with other policy areas (e.g. housing and land use planning), and many cities, such as Auckland and Sydney, have organised their own authorities around this model.^{55,56}

Presence in Latin America

Many UK green transport SMEs have appetite for global expansion and mass adoption.⁵⁷ Citymapper already serves users in over 41 metropolitan areas, including Mexico City and Sao Paulo.⁵⁸ Other small SMEs have also begun to gain a foothold in global markets, through knowledge sharing and expanding R&D facilities abroad.⁵⁹ The Colombian government recognises the UK as its partner of

choice on rail development, and there many future opportunities for partnerships in green urban mobility.⁶⁰

Examples of UK expertise and leadership in Clean Urban Mobility

Global Leadership

1. 1 in 5 **zero emission cars** sold in Europe are made in the UK.⁶¹

Successful SMEs

2. **Arrival** has a unique manufacturing process for multiple types of EVs, moulding modular materials into shape in micro factories, rather than using sheet metal in traditional production lines.⁶²
3. **Ecofleet** uses EVs & optimisation software to reduce carbon emissions in last mile deliveries from warehouse to clients.
4. **Elmo** has developed the world's first "total cost of ownership" subscription service for EVs.
5. **Green Tomato Cars** operates the largest zero-emission taxi passenger fleet in Europe.
6. **Masabi**, a mobile ticketing company, has worked with 5+ transport authorities globally.
7. **Octopus Energy** develops EV charging for off-peak periods to improve cost and efficiency for consumers.
8. **OVO Energy** is an experienced provider of vehicle-to-grid products.
9. **Riding Sunbeams** pilots solar farms to power railway infrastructure in cities.

Ambitious Cities

10. **Coventry** is a **hub for low-carbon transport** - it hosts LEVC, a global leader and the UK's only manufacturer of fully electric taxis. A new clean transport hub has been announced, to spearhead research into EVs, hydrogen and biomethane for transport.⁶³
11. **Leicester City Council** is one of the many cities that is investing heavily in electrifying its vehicle fleet and is piloting 22 local on-street electric vehicle charging infrastructure points to encourage uptake of EVs.⁶⁴
12. London launched the UK's first **Ultra Low Emission Zone**, which incentivises larger players to invest in smaller firms operating in the e-Mobility space.⁶⁵
13. **London's TfL** is leading the way in promoting electric vehicles with more than 400 electric buses now in operation across London, and more than 3,500 Zero Emission Capable Black Taxis now licensed and in operation around the city. TfL also uses waste heat from the London Underground network to provide supply local homes and other amenities.⁶⁶
14. **Milton Keynes** developed the UK's first fully electric bus and launched the first fully dedicated non-road based network for cycling and walking, named redways.⁶⁷

UK Advantage 4: Low Carbon Urban Built Environment

Sector	Major players	Examples of scaling SMEs	Examples of small businesses	Examples of key knowledge institutions
Low Carbon Urban Built Environment	<p>AECOM, Arup, Mott Macdonald (advanced urban services, masterplanning and civil engineering)</p> <p>Deloitte, EY, Mott Macdonald, PwC (energy systems)</p> <p>Foster & Partners, Atkins, BDP (sustainable buildings and design)</p>	<p>Green Consult Global</p> <p>Active Building Centre</p> <p>Bioregional</p> <p>Green Alliance</p> <p>Energy Saving Trust</p> <p>Ansys Granta</p>	<p>Airex, Beringar, Emex, Grey parrot, InstaVolt, Lixea, MacRebur, Pavegen, Pivot Energy, Project Etopia, Reath, Route Konnect, Sero, Space Syntax, Telensa, Topolytics, Vortex IoT, Wondrwall</p>	<p>UCL CASA</p> <p>UKGBC</p> <p>UKRI and University of Glasgow Big Urban Data Centre</p> <p>University of Cambridge Martin Centre for Architectural and Urban Studies</p> <p>University of Cambridge Centre for Digital Built Britain</p>

The UK has a globally competitive advanced urban built environment sector with experience to accelerate net zero in cities.⁶⁸ Architecture, engineering and consulting firms, alongside tech startups and scaling SMEs, deliver technical and strategic expertise in **spatial design, physical developments and digital innovations** which provide large urban development efficiencies.⁶⁹

In particular, expertise is focused on:

Technology and services:

- **Architectural design.** The UK has deeply embedded green design and commercial capabilities to serve new individual energy efficient and smart buildings and for wider urban green infrastructure.
- **Deployment of digital twin technology.** The UK leads at applying digital twin technology for urban infrastructure projects, to provide analytical insights into where buildings and urban assets can improve energy efficiency. Researchers and industry experts have together fostered an emerging digital ecosystem and are setting ethical parameters.⁷⁰
- **Standards for Building Information Modelling (BIM).** The UK is world-leading in setting rigorous and implementable international standards for BIM software, whose virtual infrastructure designs increase efficiencies in the design, construction and management of green city infrastructure.
- **Digital technologies to smooth the at-scale, integrated delivery of urban services.** UK SMEs are applying data analytics and other digital technologies to scale urban streetlighting, smart buildings and heating systems and intelligent transportation. Their deployment of affordable IoT and other data analytics tools is helping cities to:
 - Increase building energy efficiency and provide owner-occupiers with the tools to develop data-driven real estate strategies.
 - Create smart urban systems that integrate renewable energy, construction and intelligent digital technologies.
 - Develop more intelligent and agile transport systems that are better suited to shifts in demand.
 - Build out smart streetlighting systems that combine energy efficiency with other public realm benefits (air quality sensors etc).

- **Civil engineering expertise.** The UK's world-leading civil engineering sector pursues whole lifecycle approaches to new infrastructure and system retrofits in cities around the world.⁷¹
- **Green construction techniques.** The UK's construction sector, which generated exports worth £1.6billion in 2018,⁷² is mobilised by the UK Green Building Council to share expertise and develop green urbanism techniques with developers, designers, occupiers and policy makers, and use low-carbon materials during construction.

Planning and systems integration:

- **Integrated approaches and masterplanning.** UK firms are known for integrated, full system planning approaches that are capable of aligning infrastructure plans with sustainability targets. Target-setting and certifications are a hallmark of their approaches to sustainable building design. The UK also has many sources of expertise to integrate and embed net zero policies from the start of long-term developments in city-wide networks and place-based plans.
- **Whole life cycle, circular economy approaches.** UK SMEs are applying data analytics and machine learning to increase transparency and automation and reduce waste in waste facilities and recycling chains. For example, Reath are developing the world's first global Open Data Standard for reusable packaging, and Greyparrot's automated waste monitoring system is helping to analyse large waste flows.⁷³ UK research institutions are also leading global research and innovation in the circular economy, specifically in materials manufacturing and construction, the bioeconomy, recycling technologies and value from waste.

Capacity building:

- **Tools and frameworks for planning, delivery and integrated governance.** UK cities have at their disposal many tools and frameworks for the planning and delivery of low-carbon developments. This includes financial and fiscal tools such as tax increment financing and value capture mechanisms, a more established track record of integrated land use and transport planning, and mature systems for incorporating nature-based solutions as a way to simultaneously solve infrastructure challenges, enhance public spaces, and empower local leaders.

Policy and regulation

- **Bold city plans.** Many UK cities are leading by example and have developed replicable net-zero models. These have been achieved through international partnerships and pilot schemes. Cities such as London, Bristol, Glasgow, Manchester, Birmingham and Milton Keynes all stand out for:
 - Their experience in integrated place-based city strategies.
 - Applying digital technology to improve infrastructure (see below).
 - Policy innovations that encourage public-private partnerships and public carbon literacy.
 - Incorporating nature-based solutions.
- **Encouraging carbon literacy.** UK cities are increasingly advocating the education of its citizens and companies in regards to emission activities and low-carbon sectors. Education initiatives can be applied to city populations across the world.
- **Purposeful coalitions for the net zero agenda.** Actors in the low-carbon built environment sector are integrating their practical capabilities by forming replicable coalition groups that transcend siloed relationships between private sector, public sector and academic actors and encourage integrated place-based solutions to the net zero agenda in cities. For example, Mott Macdonald's Net-Zero Infrastructure Industry Coalition brings together academic institutions, local authorities, transport institutions and built environment actors to explore place-based and industry-wide solutions for challenges associated with the decarbonisation agenda in the engineering and infrastructure sectors.⁷⁴

Presence in Latin America

Many UK businesses and cities are already actively sharing expertise and best practices globally. Large urban service firms have an established global presence in middle income countries in Latin America, working on engineering, building design and master plans. Scaling SMEs in master planning and digital urban innovation have established international knowledge sharing and collaborations, such as Bioregional, who ran a 'One Planet Cities' programme which brought together businesses, community organisations, government councils and schools in the UK, Canada, Denmark and South Africa to share 10 principles to create and structure locally owned sustainability visions.⁷⁵ Meanwhile cities including Manchester and London have already adopted global approaches to their urban built environment, and have shared replicable models throughout Europe.

Examples of UK expertise and leadership in Low Carbon Urban Built Environment

Global Leadership

1. The UK is a global leader in the use of **BIM software**, with 70% industry usage.⁷⁶
2. The **Bloomberg Building** is widely considered to be the world's most sustainable office building.⁷⁷
3. The **National Digital Twin project** led by Cambridge's Centre for Digital Built Britain alongside Atkins and Ordnance Survey, is leading the global implementation of digital twin technology for urban infrastructure.⁷⁸
4. **Telensa** has developed the world's largest smart streetlighting control system. It provides a footprint of 2 million lights covering cities/regions worldwide.⁷⁹

Successful SMEs

5. **Bioregional Oxfordshire** supported the master planning of the UK's first eco-town.⁸⁰
6. **BlockDox** platform uses IoT and data analytics for smart buildings and intelligent transport.
7. **Pavegen** is a global leader in harvesting energy and data from footfall.
8. **Telensa** has been working in Brazil with local partners since 2015, and its market-leading smart street light and Central Management System has been selected to connect 22,000 streetlights for the major streetlight modernisation programme in Uberlandia, Brazil.⁸¹

Ambitious Cities

9. The **Accelerator Cities Project** saw 5 city authorities combine with industry experts to catalyse action on home retrofitting.⁸²
10. **Bristol** was crowned the European Green Capital for its 'One City' climate strategy model.⁸³
11. **Glasgow** has piloted energy efficiency, active mobility apps, and intelligent street lighting throughout the city.
12. **Manchester** led the Triangulum project to successfully model a low energy urban district and explore digital and smart networks in achieving transformation. It also offers a Carbon Literacy project, through which every individual in the city is entitled to a days' worth of certified learning on the carbon impacts of everyday activities, and has launched a Grow Green Project which supports investment in nature-based solutions for climate and water resilience in cities.⁸⁴
13. **Newcastle** partnered with ENGIE to use a District Energy solution for its innovation district.⁸⁵
14. Belfast, Edinburgh and Leeds have agile **Place-Based Climate Action Networks**.⁸⁶

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⁵² Having rejected traditional PFI and PF2 models.

⁵³ University of Exeter. The University of Birmingham is spearheading research into rail infrastructure- e.g. first hydrogen powered train under the HydroFlex programme. The Durham University project Network-H2 is to share knowledge to support the development of a hydrogen-fuelled transport network.

⁵⁴ Cardiff/Bristol universities are working with Aston Martin to identify challenges to an integrated, cross-sector electrified

transport system, focusing on energy networks, electric vehicle charging infrastructure, electric and hybrid aircraft and the electrification of the rail network.

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