

Smarter, greener cities:

Ten ways to modernise
and improve UK urban
infrastructure



Contents

03 About the UK Green Investment Bank

04 Foreword

05 Introduction

06 Infographic

08 Anaerobic digestion

10 On-site combined heat and power

12 District heating

14 Distributed renewables

16 LED streetlighting

18 Energy from waste

20 Energy efficiency building retrofits

22 Low carbon public transport fleets

24 Electric vehicle charging infrastructure

26 Data and communications infrastructure

28 Next steps

29 Further information

The UK Green Investment Bank: Driving investment in the UK's green economy

The UK Green Investment Bank is the first bank of its kind in the world. We back energy infrastructure projects which are green and profitable. We are the most active green investor in the UK.

www.greeninvestmentbank.com

Financing vital new infrastructure

In over 200 communities right across the UK we've taken on the complex and challenging projects, large and small. Each of these projects needed our help to go ahead and will generate renewable heat and power, keep waste out of landfill, and reduce our energy use.

Innovating so others can follow

We're leading the way in financing new technologies, helping to create new markets, and building new financial products. Because we are doing this on fully commercial terms we are encouraging other private investors to join us and follow us.

Mobilising private capital

We're working with over 70 co-investors to drive investment in the UK's green economy. For every £1 we invest, we bring in £3 of additional private capital for UK-based green projects.

Delivering a UK-wide impact

Our activity is supporting the introduction of new innovative technologies on a large scale, strengthening the UK's supply chain, creating thousands of new jobs, and helping to lower the cost of renewable energy and energy efficiency.

Foreword

In every part of the world cities are growing in size and importance. Urban areas are now home to over half the world's population and account for 80% of our economic output. They also consume 70% of our energy. Each week the global urban population grows by 1.4m people; the equivalent of a new Birmingham.

This pattern is the same in the UK. Over 80% of our population lives in urban areas and all but one of the UK's 64 cities are growing.

This growth places huge pressure on cities. More people mean greater demand on transport, telecommunications, energy, water, waste, and building infrastructure.

We also – rightly - now expect more from our infrastructure. Thinking strategically and making smart infrastructure choices can help us cut air pollution, reduce traffic congestion, improve energy efficiency, increase energy production, strengthen resilience, and perhaps most importantly, contribute to our cities' 'livability'. Indeed the quality of life a city offers increasingly determines its competitiveness, whether you are a fast growing city in Asia or a well-established European city.

In the UK we have the extra complexity of balancing these demands through the provision of new infrastructure as we renew and improve the old. We need to find infrastructure solutions that allow us to protect our world famous cityscapes and the countryside that surrounds them.

Fortunately we now have a range of well-established technologies which can help us do that. This reports sets out ten illustrative examples of the kind of infrastructure that will make our cities truly smarter, bringing real social, economic and environmental benefits.

Each of the technologies we profile in this report is tried and tested and available to be deployed, at scale, right across the UK, straight away. Taken together they represent an investment opportunity in excess of £25bn over the next five years alone.

The UK Green Investment Bank was set up to help finance this type of green infrastructure investment. We are here to help progress the tough projects and find innovative solutions to make sure developers have the upfront capital required to finance them.

The UK was, famously, the birthplace of the industrial revolution that triggered a global movement of people towards cities. We are known the world over for the elegant and effective infrastructure built to support that growth. The challenge for us now is to build a new generation of infrastructure that will equip us for future generations as well as the Victorians equipped us for the past.



Shaun Kingsbury
Chief Executive, UK Green Investment Bank

Introduction

This report focuses on ten different areas of green infrastructure investment. These are:

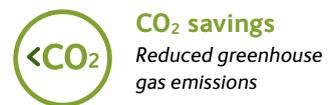
- Anaerobic digestion
- On-site combined heat and power
- District heating
- Distributed renewables
- LED streetlighting
- Energy from waste
- Energy efficiency building retrofits
- Low carbon public transport fleets
- Electric vehicle charging infrastructure
- Data and communications infrastructure

Each section offers an overview of the area of investment, a projection of the scale of the opportunity that it offers across the UK, and some case studies of where the technology is already successfully operating.

The report is intended to be illustrative of the type of infrastructure investment opportunities available to cities now, using established technologies, which can be deployed at scale across the UK. It is not intended to be comprehensive and should be read as an introduction to these areas of infrastructure. Estimates of investment requirement aim to give an indication of the potential market opportunity and should not be interpreted as an authoritative market sizing.

Throughout the report we have given an indication of the green benefits that can be attributed to each area of investment.

These benefits are shown as icons throughout the report and include:



LED streetlighting

A significantly more energy efficient alternative to existing lighting technologies. [See p16](#)

Energy efficiency building retrofits

Energy efficiency retrofit measures can be applied to public buildings such as hospitals and commercial buildings such as office blocks. [See p20](#)

Data and communications infrastructure

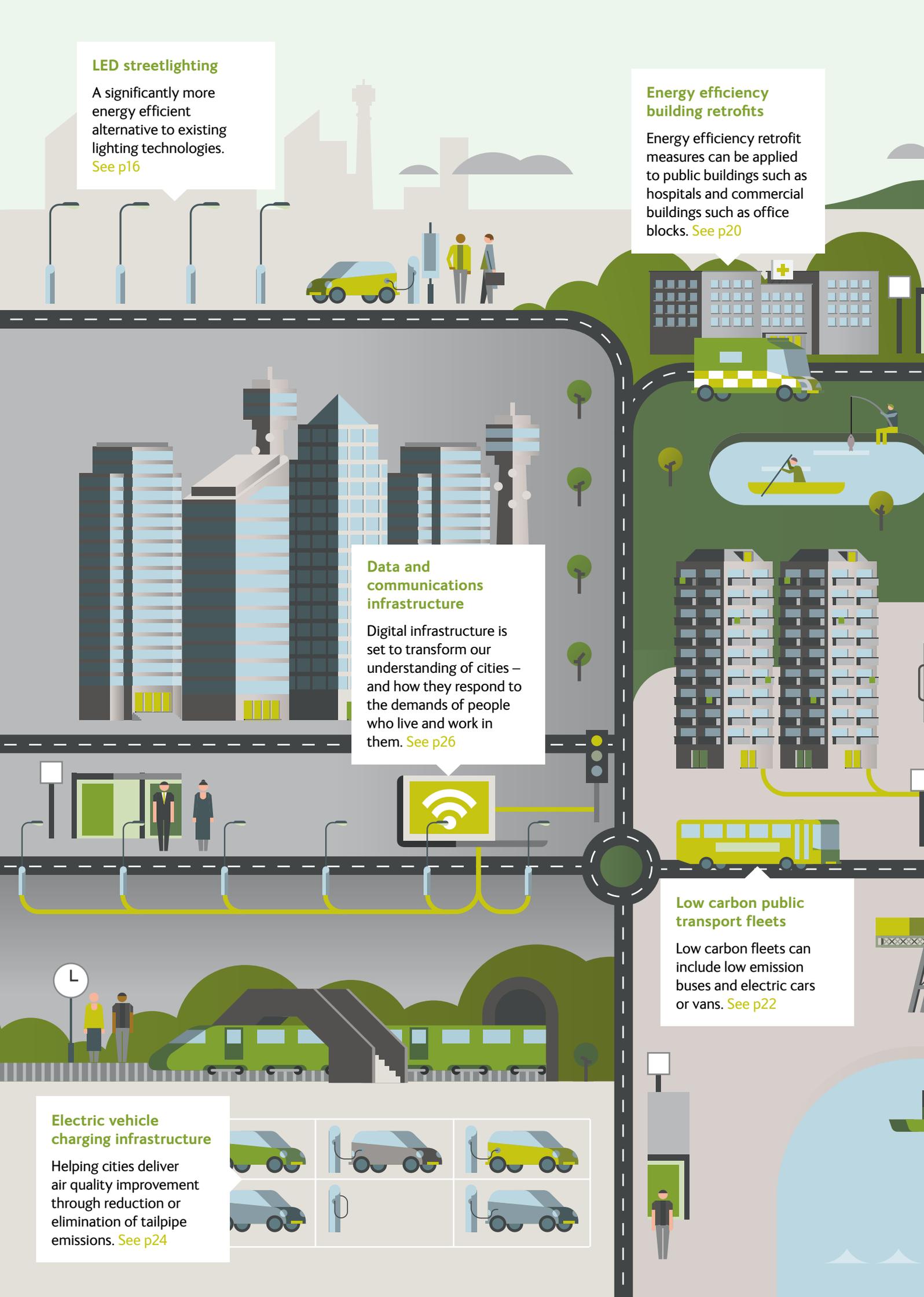
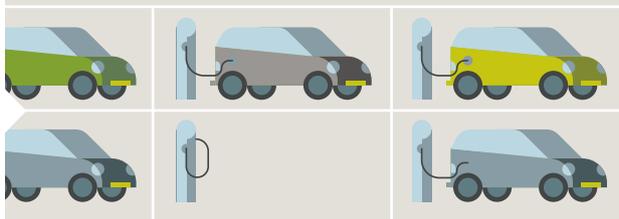
Digital infrastructure is set to transform our understanding of cities – and how they respond to the demands of people who live and work in them. [See p26](#)

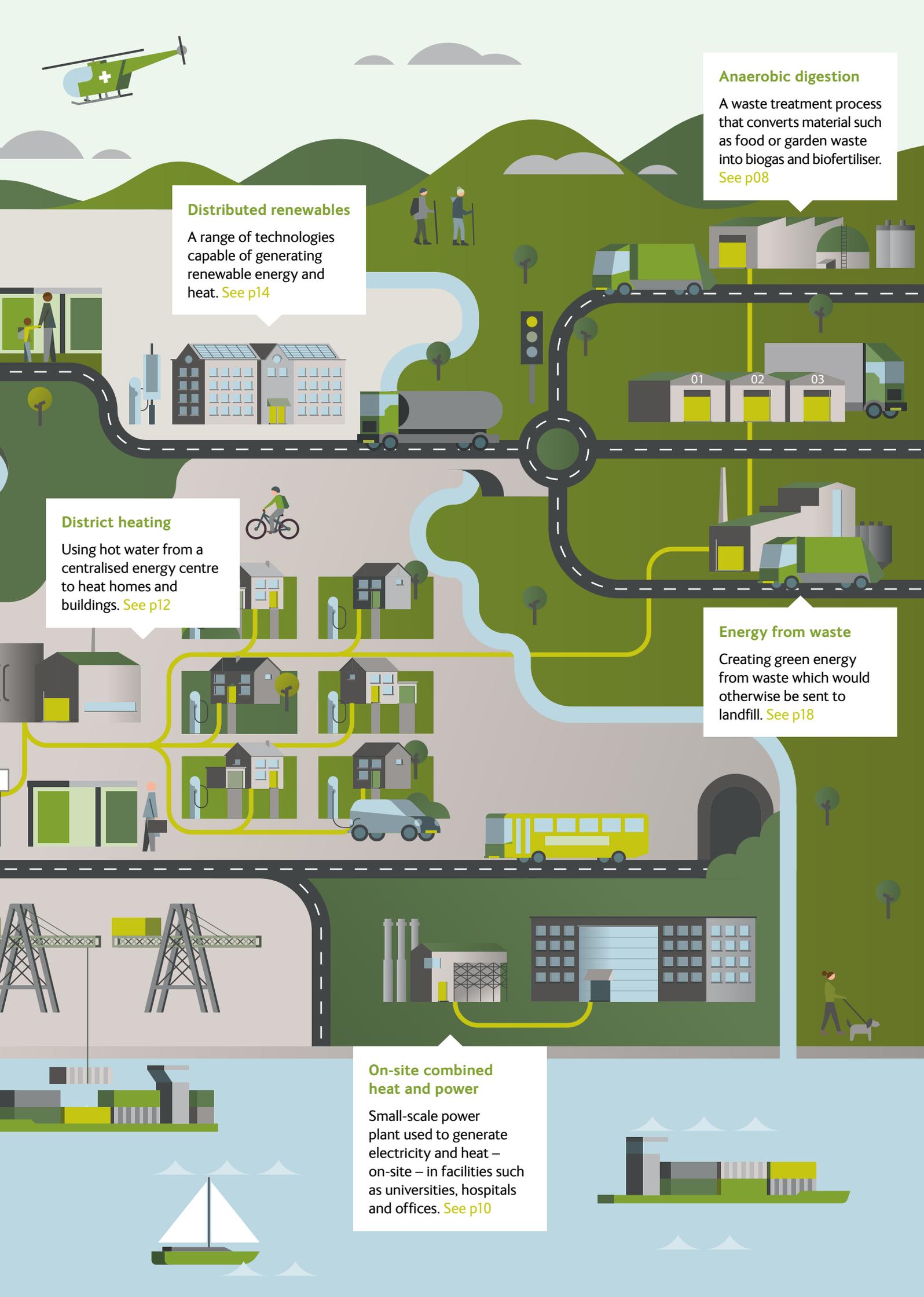
Low carbon public transport fleets

Low carbon fleets can include low emission buses and electric cars or vans. [See p22](#)

Electric vehicle charging infrastructure

Helping cities deliver air quality improvement through reduction or elimination of tailpipe emissions. [See p24](#)





Anaerobic digestion

A waste treatment process that converts material such as food or garden waste into biogas and biofertiliser. See p08

Distributed renewables

A range of technologies capable of generating renewable energy and heat. See p14

District heating

Using hot water from a centralised energy centre to heat homes and buildings. See p12

Energy from waste

Creating green energy from waste which would otherwise be sent to landfill. See p18

On-site combined heat and power

Small-scale power plant used to generate electricity and heat – on-site – in facilities such as universities, hospitals and offices. See p10

Anaerobic digestion



Anaerobic digestion (AD) is a waste treatment process that converts organic material such as food or garden waste into biogas and biofertiliser. The biogas can be fed into the grid or burned on-site to produce renewable electricity and heat, which can be used by neighbouring businesses, public buildings or homes. The biofertiliser can be used in agriculture. Across the UK AD offers a potential investment opportunity of between £500m and £1bn to 2020.



AD is a natural process in which micro-organisms break down organic matter or biowaste, such as food waste, slurry and crop residues, into biogas and a residual digestate, which can be used as a biofertiliser.

The biogas – a mixture of carbon dioxide and methane – can be used in a number of ways: directly in engines for Combined Heat and Power (CHP); burned to produce heat; or cleaned to become biomethane and used in the same way as natural gas or as a vehicle fuel. Recent installations produce biomethane to inject directly into the national gas grid. Displacing fossil fuels in these applications realises savings in CO₂ emissions.

The biofertiliser, made from the left-over indigestible material and micro-organisms, contains valuable plant nutrients like nitrogen and potassium. Used as a renewable fertiliser or soil conditioner it displaces traditional, fossil-fuel and chemical alternatives.

Each of the UK's national governments are actively promoting and supporting the development of new AD plant.

Renewable electricity produced by AD facilities is entitled to support under Feed in Tariff (FiT) or new Contracts for Difference schemes, or under the Renewable Obligation scheme up to March 2017. Heat supply and injection to the gas grid are supported under the Renewable Heat Incentive.

At present there are over 150 operational AD plant in the UK, of which around half (c.100 MW) are waste-fed. Industry sources¹ and DECC data² suggest that with the right market and regulatory conditions, construction of projects currently under development could double or even treble the UK's capacity of waste-fed AD plants.

A fuller report on AD by the UK Green Investment Bank can be found at www.greeninvestmentbank.com/investment-sectors/waste-and-bioenergy.

Case study:
**Dagenham
Biogas Plant,
London**

London's first commercial-scale AD and composting facility, the £21m Dagenham Biogas plant, is located on a 4.7 acre site within the 60 acre London Sustainable Industries Park. The plant is capable of processing up to 50,000 tonnes of food and green waste each year, from households and businesses across London.

The plant is also an integrated element of the local energy infrastructure. Over 1 MW of heat is supplied to its nearest neighbour, Closed Loop Recycling, supporting operations of the world's

first food grade PET and HDPE plastic bottle recycling plant. The plant also generates c.1.5 MW of renewable electricity; enough to power c.2,000 homes.

14,000 tonnes of compost and 36,000 tonnes of digestate are also produced each year for agricultural use. Expected to reduce CO₂ emissions by 185,000 tonnes³ over its 20 year lifetime, the Dagenham Biogas Plant scheme was the first project investment from the UK Green Investment Bank.

Case study:
**GwyrAD,
Caernarfon,
Wales**

The GwyrAD plant near Caernarfon in North Wales was commissioned by Gwynedd Borough Council and developed and operated by Biogen on council land. The plant processes all of the council's food waste – over 11,000 tonnes per year – into renewable electricity and digestate. The plant also provides a local facility to recycle food waste from commercial customers in the area⁴.

The plant was the first in Wales to achieve certification under the Biofertiliser Certification Scheme, allowing the digestate co-product to be

certified as biofertiliser. Farmers are increasingly looking to biofertiliser as a cost effective, environmentally friendly and home-grown alternative to expensive, fossil-based fertilisers imported from overseas.

Construction of the £6m plant began in September 2012 and it became fully operational in August 2013⁵. The onsite 499 kW gas engine generates 3.5 GWh per annum of renewable electricity which is exported to the grid; this is equivalent to the electrical supply to 700 homes.

¹ NNFCC data collated for DECC & Defra at <http://www.biogas-info.co.uk/> ² Renewable Energy Planning Database – December 2014, January 15 2015 ³ TEG Biogas Ltd shortlisted for AD and Biogas Industry Awards, TEG news release, 9 June 2014 ⁴ <https://www.gwynedd.gov.uk/en/Residents/Bins-and-recycling/What-goes-into-the-bin/What-happens-to-food-waste.aspx> ⁵ First Minister opens £6m anaerobic digestion plant in Gwynedd, Welsh Government press release, 15 April 2014

On-site combined heat and power



Combined heat and power (CHP) schemes are small-scale power plant used to generate both electricity and heat – on-site – in facilities such as universities, hospitals, offices and residential flats. Fuel is burned at high temperature driving an engine or turbine to produce electricity. Heat from the same process is captured for use on-site. Across the UK on-site CHP offers a potential investment opportunity of around £500m to 2020.

CHP schemes, integrated within buildings, are usually supplied as a packaged unit, ranging from 100s of kW to a few MW of generation capacity. These plant are designed to provide electricity and heat in a single highly efficient process. Gas engines are the most common form of technology used, but gas turbines and fuel cells are also available. CHP schemes can use a wide variety of fuel sources such as natural gas, biogas, biomass or biofuels.

CHP schemes operate in over 1,000 buildings in the UK, typically in hospitals, offices and commercial buildings, leisure centres and universities. Campuses and residential developments can be supplied by CHP via local heat networks. In the right circumstances combining CHP with cooling plant – in tri-generation systems – can provide a lower carbon alternative to meet cooling demand in buildings, refrigeration and data applications.

Much of the recent expansion of CHP has been in new developments – driven by requirements of building regulations and local planning policies. CHP is also being retrofitted into existing buildings where its use can deliver major reductions in energy costs, realise savings for users through exemptions from the Climate Change Levy⁶ and contribute to the achievement of an organisation's carbon emission reduction targets.

In London, where local planning policies encourage CHP, over 100 MW of largely building-integrated CHP capacity has been approved in new developments over the past four years⁷.

⁶ <https://www.gov.uk/combined-heat-power-quality-assurance-programme> ⁷ Monitoring the implementation of London Plan energy policies in 2013, GLA, June 2014



Case study:
**University
 of Edinburgh**

The successful expansion of the University of Edinburgh has put pressure on its energy infrastructure and costs: over 25 years the University's student population has trebled to 32,000. In 1999 there were 1,000 computers in the university network; in 2009 the total was more than 16,000.

The response of the university has been to pursue a programme of CHP retrofit, integrated with local heat networks and building energy management systems. Between 2003 and 2005 the University invested £12m in energy infrastructure, with gas-fired CHP units installed in three energy centres supplying heat to over

50 buildings on local campuses through district heating⁸. These centres meet 80% of the power needs of their campuses and save an estimated £1.5m and 8,500 tonnes of CO₂ each year⁹.

The final phase, completed in 2014 and serving nearly 20 academic and student accommodation buildings, has seen an £8m investment in one site. This includes a 1.4 MWe CHP engine, a 100,000 litre thermal store, two 9 MWth boilers, a district heating network, and two private HV electrical networks. This latest stage of the university's energy infrastructure development is estimated to save a further £170,000 and over 1,000 tonnes of CO₂ a year¹⁰.

Case study:
**Guy's and St
 Thomas' NHS
 Foundation
 Trust**

Guy's and St Thomas' is one of the busiest NHS Foundation Trusts in the UK, employing 12,000 staff and serving over 1m patients every year. Located across two sites in South London, and with much of its building stock dating from the 1980s or earlier, energy has been a major consideration for the Trust.

By 2004 the annual energy bill had reached £10m, prompting the Trust to initiate an energy efficiency investment programme in 2007 alongside an environmental engagement and awareness campaign. Over the first 18 months an initial £2m

was invested in a range of energy efficiency projects – including boiler upgrades, insulation and lighting. This was followed in 2009 with a £10m investment in two 3 MW CHP engines, one on each site. These plants provide the sites with all heat and hot water in summer, and half the required heat in winter, as well as covering around half of the Trust's electricity needs¹¹.

This investment in CHP engines has cut the Trust's annual energy bills by £2m per year – paying back in only five years – and has reduced its carbon footprint by over 11,000 tonnes of CO₂ a year¹².

⁸ <http://www.theade.co.uk/medialibrary/2011/11/11/9eaf3895/Edinburgh%20Uni%20CHP%20article.pdf> ⁹ Briefing paper: Trigeneration at University of Edinburgh, February 2013
¹⁰ <http://www.vitalenergi.co.uk/casestudies/university-of-edinburgh-chp/#casestudy-overview> ¹¹ <https://www.carbontrust.com/media/5880/cts203-guys-and-st-thomas-nhs-trust.pdf>
¹² NHS Sustainable Development Unit, Guy's and St Thomas' NHS Foundation Trust 'Combined heat and power (CHP) case study'

District heating



Used extensively in continental Europe and Scandinavia, modern district heating systems involve the supply of hot water from a centralised energy centre to heat nearby homes, public buildings and businesses. Across the UK district heating systems offer a potential investment opportunity of over £500m to 2020.

Heat networks have been operating successfully in a handful of UK cities since the 1980s to meet a growing need for reliable and affordable supplies of heat. Early schemes exploited a range of alternative energy sources, from municipal waste in Nottingham and Sheffield to geothermal energy in Southampton.

Modern district heating systems connect an energy centre, producing heat, with customers' homes and premises. Heat is transported as hot water through a network of highly-insulated underground pipes and then transferred to customers via a heat exchanger – domestic units are smaller than a standard boiler.

Networks are at their most efficient when recovering heat rejected from other processes – most frequently power generation but also industrial processes. For example, the network in the French port of Dunkerque is supplied by the local steel mill.

Heat networks help to exploit local waste and renewable energy resources by capturing the heat produced by energy from waste plant, biomass CHP and boilers, and heat pumps. This diversity can maximise carbon savings and improve a city's energy resilience.

District heating systems can serve entire cities or smaller communities and work best in dense urban areas.

The UK opportunity is greatest in the area of new developments where progressive planning policies can ensure district heating systems are integrated during construction. Major new networks have been installed recently in London, Exeter and Birmingham as part of regeneration, retrofit or new-build developments.

Support for local authorities developing heat networks is offered by the Heat Network Development Unit in England and Wales and through the Heat Network Partnership in Scotland.

Case study:

Aberdeen Heat and Power

Aberdeen Heat and Power's (AH&P) heat network was established to provide clean and affordable energy to housing tenants of Aberdeen City Council.

Originally set up to develop and operate a small heat network supplying 288 homes in four housing blocks, not-for-profit AH&P has grown to become a core component of the energy infrastructure supplying Aberdeen's public buildings and social housing. Generating heat in three distributed energy centres with a mix of boilers and gas-fired CHP plant the network now supplies 33 of the city's 59 multi-residential blocks and 13 public buildings – including an ice arena, swimming pool, and Aberdeen City Council Town House. None of the residents connected to the scheme are now in fuel poverty and carbon savings of 40%, compared to the original electric heating, have been achieved. Expansion of the network is continuing, with eight further residential blocks to be connected in 2015 and development of a strategic plan for district heating across the high heat density areas of the city¹³. With expansion into the city centre a wholly owned subsidiary of AH&P has been set up to enable commercial customers to be connected into the heat network.

Development of the network has been funded from the City Council housing capital budget alongside grant funding from the Scottish Government, the Community Energy Saving Programme and the Community Energy Programme¹⁴. In February 2015, AH&P received a further £1m for the District Heating Loan Fund to support the expansion of the network¹⁵.

Case study:

Bunhill Heat and Power

Islington Council's Bunhill Heat and Power network was commissioned in 2012 as part of a wider strategy to reduce fuel poverty and yield financial and environmental benefits to the community. Bunhill energy centre houses a 1.9 MWe gas CHP engine and 115m³ thermal store, supplying a local heat network of around 1km in length. Heat is distributed through insulated pipes to over 700 local homes across three local housing estates, to Ironmonger Row Baths, and to Finsbury Leisure Centre.

The £3.8m energy centre and heat network were funded by grants secured from the Greater London Authority and the Homes and Community Agency. The council manages the operation of the scheme, gaining revenue from electricity and heat sales.

Islington are now building on this scheme, with Phase 2 of the project set to connect a further 454 homes. A ground-breaking feature of the scheme extension is the goal of capturing waste heat from an electricity substation and from London Underground, with low grade heat recovery from the Northern Line ventilation shaft.



¹³ Reasons for using a not-for-profit mutual structure, Presentation to Vanguards Workshop, Janice Lyon, 05/12/14 http://www.heatandthecity.org.uk/_data/assets/pdf_file/0020/167060/PM4_-_Not_for_Profit_Mutual_-_Aberdeen_-_Janice_Lyon_150.pdf ¹⁴ Aberdeen Heat and Power Ltd – draft Case Study for DH Delivery Structures Guidance, Scottish Futures Trust, 2014 http://www.heatandthecity.org.uk/_data/assets/pdf_file/0006/158739/SFT_DH_Case_studies_AHP.pdf ¹⁵ <http://news.scotland.gov.uk/News/Granite-City-green-heat-revolution-15f3.aspx>

Distributed renewables



Distributed renewables encompass a range of technologies capable of generating renewable electricity or supplying renewable heat. The largest opportunity is in rooftop solar photovoltaics (PV) which have seen widespread uptake and offer considerable further potential for use in the urban environment. Across the UK, rooftop solar alone offers a potential investment opportunity of between £2bn and £4bn to 2020.



¹⁶ This has been through achieved through introduction of measures such as the 'Merton Rule', the Planning and Energy Act 2008. In London, the Mayor's spatial strategy for London, the London Plan, has set the level of achievement for the use of renewables in new development. ¹⁷ Consultation on the transferability of building-mounted solar PV installation, DECC, November 2014

The use of distributed renewables in new urban development has been supported for over a decade now by local authorities and city governments using planning powers¹⁶ to set targets for their use on top of standard national building regulation requirements.

The introduction of Feed in Tariffs (FITs) has accelerated the deployment of distributed renewable systems across towns and cities, due to their focus on typically smaller generation technologies more suited to an urban environment.

Councils, housing associations and other public sector organisations are now investing in retrofitting distributed renewables on their own assets – from town halls and housing estates, fire stations and leisure centres, bus depots and car parks. Businesses are similarly developing projects in cities, retrofitting PV into office blocks, and on warehouse and factory roofs.

Of all the distributed renewable technologies deployed, the most significant uptake has been in solar PV, with over 5 GW of capacity added since the FIT policy started in April 2010. Urban areas are likely to see a boost in PV as the Government has recently committed to focus support on the uptake of rooftop projects, typically between 50 kW – 5 MW, where projects have fared less well to date. DECC's 2014 Solar Strategy set a target of 1 GWp of PV on the government's estate, including an initiative to boost the use of solar in 24,000 schools in England and Wales. DECC has also proposed changes to help stimulate the uptake of PV on commercial roof space¹⁷.

Complementing power generation is a growing uptake of renewable heating technologies. Supported by the Renewable Heat Incentive, heat pumps are an energy efficient technology that can harness the ambient energy in the air, ground or water. Water and ground source pumps are particularly suited to larger buildings and integration with heat networks.

Case study:
Selby Kingspan Insulation PV system

Kingspan Insulation's manufacturing facility in Selby, West Yorkshire has seen the addition of the UK's largest rooftop solar PV retrofit. The 2,500 kWp solar PV system covers over 15,000m² of roof space and is expected to generate 2.14 GWh of electricity a year¹⁸. The installation is the major element of a

comprehensive energy refurbishment which has also seen a full LED lighting system upgrade with smart controls. As a result of the project, the building's EPC rating has improved from an 'F' to an 'A'. The measures are expected to save 79.2 GWh over 25 years, cutting energy bills by £5.2m.

Case study:
Kings Cross station PV system

The newly redeveloped King's Cross Station has a total of 1,392 glass laminate solar units covering 2,500m² on the Main Train Shed roof¹⁹. The custom made glass-laminate solar PV units – manufactured in the North East of England by specialist PV manufacturer Romag – are integrated into the barrel vaulted roofing structures spanning the main platforms of the Grade 1 listed building. A public screen shows the installation's real time electricity

generation. Providing approximately 10% of the station's electricity, the installation is expected to generate 175 MWh and should save over 100 tonnes of CO₂ emissions per year²⁰. The £1.3m 240 kWp²¹ array has been operating since September 2012 and is part of Network Rail's green building programme – which also includes a 4,400-panel array running along the roof of a railway bridge spanning the Thames at London's Blackfriars station.

Case study:
One New Change ground source heat pump

Europe's largest heat pump is installed in a new build development opposite St Paul's Cathedral, the One New Change office and shopping complex, owned by Land Securities. The open loop ground source heat is made up of 192 piles and can provide up to 2,300 kW cooling and 2,400 kW heating.

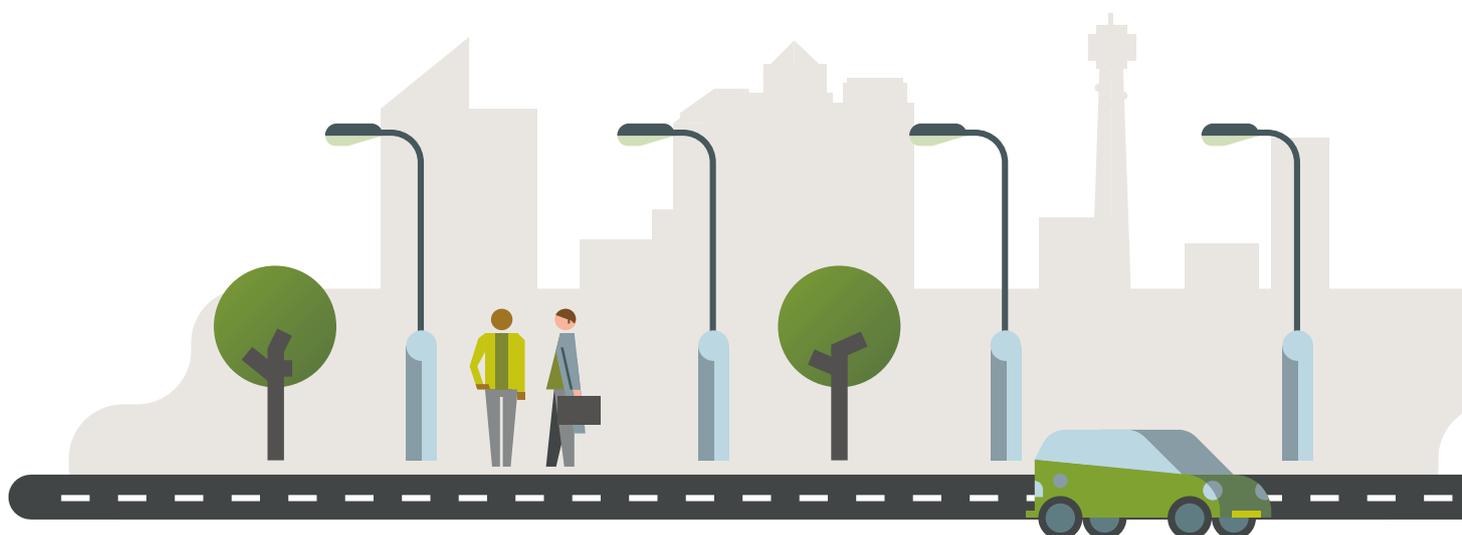
The most recent monitoring statistics record that the energy savings helped reduce annual CO₂ emissions by 170 tonnes²².

¹⁸ <http://refurbprojects-online.com/2015/01/uks-largest-solar-pv-refurb/> ¹⁹ <http://www.networkrail.co.uk/aspx/6288.aspx> ²⁰ <http://www.romag.co.uk/projects/kings-cross-station/>
²¹ <http://www.sundog-energy.co.uk/news/15-news/147-sundog-energy-to-provide-solar-power-system-to-kings-cross-station> ²² GI Energy One New Change case Study, October 2013

LED streetlighting



LED streetlights provide a step-change improvement in efficiency and performance from existing lighting technologies. The latest generation LEDs use 50-80% less energy, can last up to six times longer and provide better and more controllable light in a city's streets and public spaces. Across the UK low energy streetlighting offers a potential investment opportunity of around £2bn to 2020.



Across the UK there are over 7m streetlights, the majority of which are ageing and inefficient. Less than 10% of these lights have either been converted to low energy standards or are in a procurement process for conversion. Over £300m is spent annually on energy for streetlights. For many councils, streetlighting can be the single largest component of their electricity bill as well as their largest source of carbon emissions.

Of the UK's 7.4m lighting columns, 2.3m are older than 30 years and 1.1m are over 40 years old. To keep pace with natural deterioration, 185,000 lighting columns need to be replaced each year. Streetlighting consumes 640,000 kW each hour, the equivalent electricity consumption of 674,000 households.

Beyond the benefits of reduced energy consumption, LED streetlights offer enhanced utility and operational advantages to cities:

- Improved visibility for pedestrians and traffic
- Operation through Central Management Systems allowing for lighting control, remote dimming, and monitoring
- An operating life of up to 100,000 hours of operation – compared to 15-25,000 hours for traditional alternatives – which can be extended even further by the use of smart controls
- Utilisation of lighting columns to introduce further smart infrastructure, including electric vehicle charging points, sensing equipment and wireless networks providing greater data capacity and coverage.

Some councils have already embarked on installation programmes for LEDs, through self-funding, grant-funding and PFI projects. However, despite the benefits offered by these lighting types, uptake by local authorities to date has been slow. With streetlighting now within the scope of the Carbon Reduction Commitment (CRC) Energy Efficiency Scheme the cost to councils of inefficient lighting is likely to rise.

A fuller report on streetlighting by the UK Green Investment Bank can be found at www.greeninvestmentbank.com/investment-sectors/energy-efficiency.

Case study:
Birmingham

Birmingham City Council is working with Amey on the £70m rollout of 90,000 LEDs across the city – Europe's largest LED streetlight scale-up project to date.

The project is expected to bring energy savings of 50% compared to conventional technologies and an annual cost saving of £2m.

The initiative is an integral part of a much larger £2.6bn highway infrastructure modernisation through a 25-year PFI contract.

Case study:
Glasgow

Through its Sustainable Energy Action Plan, Glasgow City Council is targeting a 30% reduction in its carbon emissions by 2020. Accounting for 16% of the city's energy spend, with running costs of around £4.1m a year and with a growing carbon tax liability, tackling the city's streetlighting has been an obvious early priority. The first phase of a replacement programme is now underway, with the installation of 10,000 LED lamps on some main arterial routes. The new lights are planned to be in place by the end of 2016 and are forecast to provide net cost savings of £8.4m and a reduction of 46,000 tonnes of carbon over 18 years. With an

operating life six times that of the standard sodium lamps they will replace, maintenance costs will also be lower.

To support the city in its plans to convert its 70,000 streetlights to high efficiency LED lighting, Glasgow has been working in partnership with the UK Green Investment Bank to develop a value-for-money loan product that can facilitate an invest-to-save programme. The city is the first recipient of the GIB Green Loan, which is available to other local authorities to help accelerate their investments in low carbon infrastructure.

Energy from waste



Energy from waste (EfW) plants create green energy from waste which would often otherwise be sent to landfill. The waste is either incinerated or heat treated to generate electricity and heat. Energy can be recovered from a variety of waste resources including residual household, commercial and industrial or wood waste. Across the UK the investment opportunity in EfW, to 2020, is estimated to be £5bn.

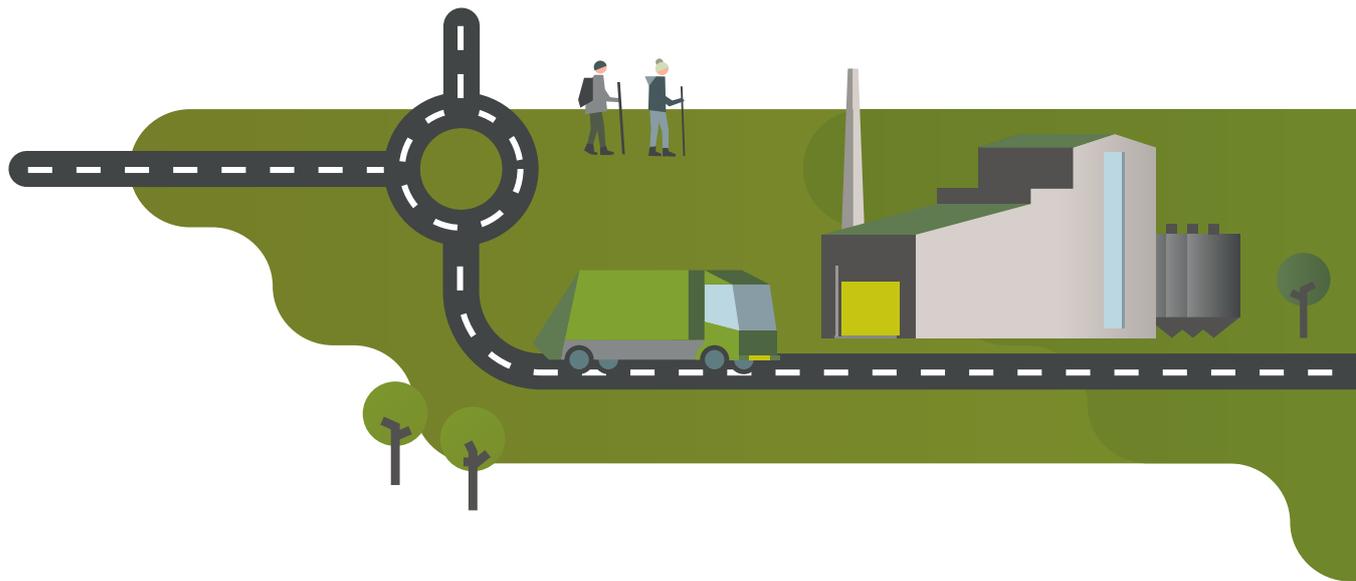
The UK's waste hierarchy gives priority to waste prevention, re-use and recycling or composting. For the remaining waste, energy recovery is generally preferable to disposal in landfill. EfW has a value-for-money role in reducing the environmental impacts of waste management.

Most of the EfW facilities operating today simply produce electricity from traditional combustion technology. A combination of technological advances, a changing waste stream, and the need to make more efficient use of energy resources is driving evolution and change:

- Advanced Conversion Technologies (ACTs), such as gasification and pyrolysis, treat the waste to produce a gas, which can then be used in a range of combustion and power generation plants. These smaller-scale technologies can present a lower footprint, increasing the scope for their use in urban and industrial sites and with commercial and industrial waste streams.
- Heat recovery, in waste-based CHP plants, achieves greater resource efficiency. Supplying the heat to local businesses, public buildings and households via district heating schemes increases the benefits of energy recovery to the local community.

Identified treatment capacity could translate into an investment opportunity of approximately £5bn for energy recovery infrastructure (including ACT technologies)²³, with an emphasis on processing commercial and industrial waste. This infrastructure could produce electricity equivalent to meet the needs of nearly 1m homes, create around 1,000 long term jobs and up to 6,000 jobs at peak of construction.

A fuller report on the UK residual waste market by the UK Green Investment Bank can be found at www.greeninvestmentbank.com/investment-sectors/waste-and-bioenergy.



Case study:
**Sheffield
Energy
Recovery
Facility**

An EfW plant was originally established in Sheffield in the 1970s, supplying heat to local homes via a district heating network. Building upon that success, a new Energy Recovery Facility was opened in 2007, significantly increasing the scale of operations. The new facility can receive up to 225,000 tonnes of municipal waste, generate up to 21 MW of electricity and supply up to 45 MW of heat. The power produced is estimated to meet the needs of more than 25,000 homes²⁴. The heat is supplied through an expanded heat network to

over 140 buildings, including homes, hospitals, leisure centres, offices, theatres and university buildings. This supply of heat is estimated to reduce emissions of CO₂ by 21,000 tonnes a year²⁵.

The plant, operated by Veolia Environmental Services, employs conventional combustion and steam-raising plant, generating electricity using a steam turbine and utilising further heat to supply the district heating network.

Case study:
**Birmingham
BioPower**

Birmingham BioPower has selected an innovative gasification technology for its urban EfW plant in Tyseley, Birmingham.

This state of the art plant will be the first of its kind in the UK to use the technology, which is already proven in North America. The gasification process converts the recovered wood fuel into syngas which is burned to raise steam in a boiler, which in turn generates electricity through a steam turbine.

The 10.3 MW plant is due to become operational in early 2016, when it will generate enough power for 17,000 homes. Over its 20 year life it is expected to divert around 1.3m tonnes of waste wood from landfill and reduce greenhouse gas emissions by around 2.1m tonnes. The £47m plant has benefited from funding from the UK Green Investment Bank and will earn revenues from the sale of electricity and Renewable Obligation Certificates.

²³ The UK residual waste market A market report by the UK Green Investment Bank July 2014

²⁴ http://veolia.co.uk/sheffield/sites/g/files/dvc461/f/assets/documents/2014/11/Sheffield_ERF_Brochure.pdf

²⁵ <https://www.sheffield.gov.uk/environment/waste/reducingrecycling/districtheating.html>

Energy efficiency building retrofits



Retrofit measures for commercial and public buildings are well-proven and can be readily implemented. Energy efficiency measures can typically be applied in office buildings, retail premises and warehouses, shops, industrial units, hospitals, schools and universities. It is estimated that energy efficiency retrofit of public and commercial buildings presents an investment need of around £3bn in the period to 2020.

Buildings account for around 40% of total UK greenhouse gas emissions today. Although Government policies will require all new non-domestic developments to be 'zero carbon' from 2019, new buildings account for less than 1% of the overall building stock each year. Over three quarters of the UK's building stock was built before 1985 and nearly a third before 1940; in 2050 it is expected that half of these buildings will still be in use²⁶.

Most of the typical retrofit measures are well-proven in the UK and internationally. They include energy efficient lighting and controls, replacement or refurbishment of boiler plant, building energy management systems, upgrading of heating, ventilation and air conditioning systems and insulation of external walls and roofs.

These measures can be readily applied across offices, retail and other commercial premises. In the public sector they can be applied across many public bodies and in buildings ranging from

council offices to police and fire stations, NHS sites, schools and universities. A programme of energy efficiency retrofit can often go hand-in-hand with the installation of solar photovoltaics or other distributed renewables.

Buildings are a significant contributor to carbon emissions in the public sector. The Carbon Trust estimates that the public sector spends over £2.5bn each year on energy use in England alone and that capital investment could help reduce these bills by up to 30%²⁷. Beyond these cost savings there is further incentive for retrofit of public buildings from increasing Carbon Reduction Commitment (CRC) and Climate Change Levy (CCL) costs.

In the private sector offices are a common focus for retrofitting projects, taking up almost 20% of retrofits monitored²⁸. The opportunity to realise savings through retrofit of buildings such as warehouses, laboratories, data centres, restaurants and bars and retail space remains largely untapped.

²⁶ UK National Energy Efficiency Action Plan, DECC, April 2014 ²⁷ Breaking down barriers to public sector energy efficiency implementation, Carbon Trust 15 October 2013

²⁸ Building Efficiency: Reducing energy demand in the commercial sector, Building Efficiency: Reducing energy demand in the commercial sector November 2013 ²⁹ BREEAM (BRE Environmental Assessment method) is an environmental standard for buildings, which determines best practice in sustainable design and in the UK is used to describe a building's environmental performance

Case study:

One Embankment Place, London

Having seen the benefits of a highly energy-efficient building in their new offices at 7 More London – the first office project in England to be awarded a BREEAM²⁹ 'Outstanding' rating³⁰ – professional services firm PwC set out to achieve the same environmental credentials in the refurbishment of their 1990s-built Embankment Place office. The measures installed were required to have a payback of less than four years.

The measures adopted to meet this standard included a comprehensive metering strategy, improved Building Management System technology, use of LEDs in meeting rooms and common areas, and low-power lift braking. Features such as increased levels of natural light, clearer access to stairs, extensive use of chilled beams and trench heating, the addition of green walls, and a roof terrace herb garden helped deliver an improved working environment for employees. Much of the building's energy needs are supplied by two CHP units – fuelled by biodiesel produced from locally-sourced waste vegetable oil.

On completion the project was awarded a 96.31% BREEAM score, the highest to be awarded anywhere in the world³¹. PwC estimates suggest that measures employed across the site will help reduce the building's overall utility costs by over £250,000 a year³².

Case study:

Derby City Council

Faced with the challenge of accommodating all its staff in its 1940s city centre headquarters, Derby City Council remodelled the building to meet ambitious energy standards. The refurbished offices now incorporate reinsulated walls and roof, high-performance glazing, improved airtightness and enhanced natural lighting. River water cooling of fresh supply air is also used and a 48,000 litre rainwater harvesting tank is located in the basement. In addition, the Council House incorporates solar thermal and photovoltaic panels as well as an air source heat pump³³.

The Council also decided to invest in the development of a hydro-electric project on the River Derwent, which runs beside the Council House, to access the supply of renewable electricity. The £1.7m hydro-electric project is expected to generate up to 50% of the electricity needs of the Council House and to earn around £200,000 annually through electricity sales and FiT revenues.



³⁰ <http://www.pwc.co.uk/corporate-sustainability/7morelondon.jhtml> & <http://www.grontmij.co.uk/mediacentre/news/Pages/7morelondon.aspx>

³¹ PwC HQ achieves highest ever BREEAM Outstanding score, BRE Press Release, 13 December 2013 ³² PwC creates the most sustainable building in the world, Guardian, 15 May 2014

³³ <http://www.derby.gov.uk/council-and-democracy/council-house-facilities/faqs/>

Low carbon public transport fleets



Conversion of public vehicle fleets to low carbon alternatives can help cities tackle air pollution and cut operating costs. While the focus to date has been on the adoption of low emission buses, electric vehicles are increasingly being introduced to the fleets of local authorities, NHS trusts and other public bodies. Across the UK the investment opportunity in low carbon public vehicle fleets, to 2020, is estimated at around £3bn.



Transport is a major source of greenhouse gas emissions, accounting for a quarter of the UK's total. Tackling its contribution to deteriorating urban air quality is of increasing priority for city administrations. London has been the first to establish a Low Emission Zone, a coordinated effort which is helping to drive the adoption of low emission vehicles for public, commercial and private use within the City.

A range of technologies are being employed to reduce emissions of NO_x, particulates or CO₂ from bus fleets such as diesel/electric hybrid, all-electric powertrains, hydrogen fuel cells and adaptation of conventional engines to use compressed natural gas (CNG) and biofuels.

From 2011-2013 the Green Bus Fund, administered by the Department for Transport in England, and the Scottish Green Bus Fund have provided £100m in funding to bus operators to support the initial up-front costs of purchasing

low carbon buses. The Green Bus Fund has brought forward 1,250 low emission buses now operating across more than 20 cities including London, Newcastle, Nottingham, and Manchester.

The UK Government's Office for Low Emission Vehicles announced in 2014 that a further £30m will be available over three years from 2015 to support further investment in low carbon bus fleets³⁴ in England and Wales. In addition, £20m of funding has been announced for ultra-low emission taxis as part of the wider £500m package to grow the market for Ultra Low Emission Vehicles over the period to 2020. This coordinated package is providing for investment in fleets alongside the roll-out of a network of charging infrastructure.

Alongside public transport, low emission vehicles are now being employed in other public services. Councils and NHS Trusts are among those now using electric vehicle fleets for a range of applications suited to the characteristics of these vehicles.

Case study:

Reading Transport Greenwave buses

Reading's Greenwave programme³⁵ has seen the introduction of 34 single decker buses running on CNG, along with a gas compression plant for depot refuelling from the gas grid. The switch to this cleaner fuel has provided immediate air quality benefits, with CNG buses offering a 30% to 50% reduction in NO_x tailpipe emissions compared to diesel, and negligible emissions of particulates. The buses typically have lower maintenance requirements and are smoother and quieter to operate than their diesel counterparts. Reading Transport reports that running costs are around half those of the equivalent diesel bus³⁶. Passenger numbers have also increased.

A further element of the project is the indirect use of renewable gas, or biomethane, as a fuel for the fleet. Originally the fuel had been transported to the site by tanker, but under the Green Gas Certification Scheme biomethane from anaerobic digestion is injected into the natural gas grid, with an equivalent volume of gas extracted for re-fuelling the buses. The gas re-fuelling station is now being expanded to support the conversion of 113 taxis to use the fuel and will also be available to commercial gas vehicles³⁷.

Case study:

Nottingham's Electric Bus Fleet

When fully operational in September 2015, Nottingham's fleet of 56 electric buses³⁸ will be one of the largest in Europe³⁹. This fleet has grown in tandem with a city-wide recharging network.

Nottingham expects a range of benefits from its electric bus programme, including a reduction of air pollutants in its two Air Quality Management Areas. It will also see a reduction in fuel and operating costs, with annual fuel savings expected to reach nearly £1m a year over the next three years.

The success of its electric bus fleet is leading to further development of the city's low carbon transport infrastructure. Hackney taxis using the city centre ranks are to be converted to electric or electric hybrid; the electric vehicle charging infrastructure is being extended; and an electric bike hire network is being introduced. Electricity for the bus fleet will be sourced from local generation, including from solar PV and the city's energy from waste plant, helping to further cut costs and CO₂ emissions. In time the city aims to convert all 500 commercial buses to Low Carbon Emissions Bus status.

³⁴ Investing in ultra low emission vehicles in the UK, 2015 to 2020, OLEV April 2014 ³⁵ <http://www.reading-buses.co.uk/greenwave/>

³⁶ <http://www.route-one.net/industry/baroness-kramer-opens-reading-buses-gas-fuelling-station/> ³⁷ <http://www.bbc.co.uk/news/uk-england-berkshire-29109909>

³⁸ <http://www.nottinghamcity.gov.uk/electricbuses> ³⁹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/344669/green-bus-fund-table.pdf

Electric vehicle charging infrastructure



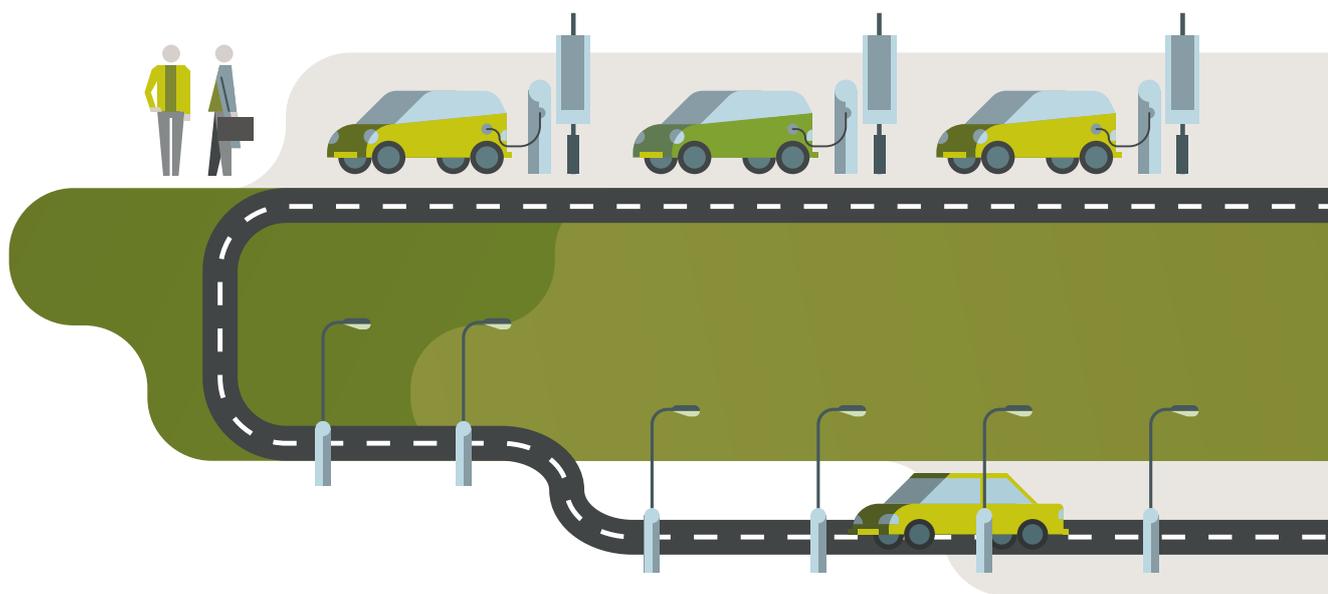
Electric vehicles (EVs) can help cities deliver air quality improvement through reduction or elimination of tailpipe emissions. In some cities this will be encouraged by establishment of low emission zones. With electricity providing a low-cost alternative to petrol or diesel, and with reduced maintenance costs, drivers and fleet operators can benefit from overall lower running costs.

Ultra Low Emission Vehicles are a new generation of vehicles which eliminate or reduce tailpipe emissions of CO₂, NO_x and particulates. These pollutants are contributing to deteriorating air quality in many of our towns and cities. Vehicles based around an electric drivetrain eliminate tailpipe emissions entirely and so can provide a significant contribution to improving air quality.

The growing uptake of EVs presents a new infrastructure challenge for cities. They dispense with an engine, instead relying entirely on battery storage for their on-board energy supply and giving a typical range per charge of around 100 miles – much reduced in comparison to traditional vehicles. The key to unlocking the benefits of EVs is a network of charging points.

Plug-in Hybrids (PHEVs) give more flexibility and supplement the pure electric capability of an EV with an internal combustion engine to extend the range of the vehicle. The engine makes PHEVs less reliant than EVs on a comprehensive charging network.

Charging infrastructure, and the strategies for its deployment, can be flexible to meet the needs of users and the environment. Some standard chargers can fully charge an EV in as little as four hours, whereas fast chargers can provide an 80% charge in 30 minutes. Chargers can be located at the home, the workplace, en-route or at commercial or public sector premises. Much of today's investment is linked to a programme of learning and evolution to optimise future arrangements for a city's own circumstances.



Case study:
'Charge Your Car': North East England

EV drivers across the North East – from Berwick to Darlington – are now benefiting from a fully comprehensive network of charge points. For local journeys, a network of over 1,000 charge points have been installed on streets, in shopping centres, car parks, leisure facilities, workplaces and drivers' homes. This network has provided the platform for a local taxi firm to adopt EVs and cut fuel costs – from an average of £207 for 500 miles in a diesel vehicle to less than £17 in a Nissan LEAF⁴⁰. And with 12 charge points along major spine routes, the UK's first quick charge point gateway⁴¹ provides drivers with the confidence to extend their journeys across the region.

The Charge Your Car initiative has been supported by the Government's Plugged-In Places programme.

Case study:
Plugged-In Midlands

Providing quick chargers at motorway service areas on the region's main transport corridors has helped meet the aim of facilitating intra- and inter-regional EV travel through the Plugged-In Midlands project. Involving a consortium of more than 50 Midlands organisations – including Birmingham, Coventry, Derby, Leicester and Nottingham City Councils – the project has yielded data on local through-route infrastructure requirements to inform development of national charging infrastructure. Supported with £2.9m of Government funding, over 600 charging points have been installed across both the East and West Midlands⁴².

⁴⁰ See DfT 'Driving the Future Today: A strategy for ultra low emission vehicles in the UK' OLEV September 2013

⁴¹ <http://www.zerocarbonfutures.co.uk/what-we-do/project-development/erdf/> ⁴² Plugged in Midlands Newsletter, July 2013

Data and communications infrastructure



Digital infrastructure is set to transform our understanding of cities – and how they respond to the demands of the people that live and work in them. This smart technology is increasingly valuable in measuring our impact upon a city’s environment, managing systems in real time, and developing more integrated approaches to infrastructure development. Across the UK the investment opportunity in data and communication infrastructure, to 2020, could be in excess of £10bn.

This digital infrastructure encompasses a suite of technologies that can be applied to enhance and optimise the performance of cities’ core systems, networks and utilities.

In transport, digital infrastructure will permit real time or predictive control of traffic flows, managing routes and volumes to optimise capacity, mitigate congestion and reduce pollution levels. Smart parking projects avoid lengthy searches for parking spaces improving air quality and reducing resource use.

In buildings, the weather, usage and performance data can be integrated with controls systems to optimise demand in real time, balance complementary needs for heating and cooling and enhance building energy efficiency. In the longer term, changes in patterns of demand will help to inform planning and make efficient investment decisions for new energy plant and network infrastructure.

For both energy and water, networks are optimised using a suite of technologies, from smart meters and sensors to advanced modelling and energy mapping tools. With intelligent digital

communications infrastructure the capture of real-time transmission and consumption data becomes possible, helping to manage peak loads, reduce system stress and enhance the resilience of water and energy networks.

For waste management, digital technologies are used to improve recycling and the processing, repair and re-use of used or damaged goods. Sensing technology creates productivity gains, as waste collection is scheduled in direct response to need.

Open-data offers the facility to use and re-use data in a way that not only contributes to transparency and accountability, but also creates opportunities for third parties to develop applications and services for the benefit of the community.

In planning, data to support decision-making will be available from a growing and diverse range of sources, from cars to street sensors, from mobile phones to drones and satellites. This resource will help to model and evaluate the impacts of alternative infrastructure choices and inform a city’s strategic planning process.

Case study:
**Future City
Glasgow**

Future City Glasgow is an ambitious £24m programme which will demonstrate how technology can make life in the city smarter, safer and more sustainable. Supported by Innovate UK, the public private collaboration involves Glasgow City Council, Police Scotland, housing providers, NHS Greater Glasgow and Clyde, universities, energy providers and Scottish Enterprise.

The Energy Efficiency Demonstrator programme will show how technology can help ensure energy efficiency strategies are built upon increasingly accurate data. Initiatives under the programme include a project to enable management systems in different buildings to “talk” to the power network and reduce their demand for energy by automatically adjusting their lighting and heating,

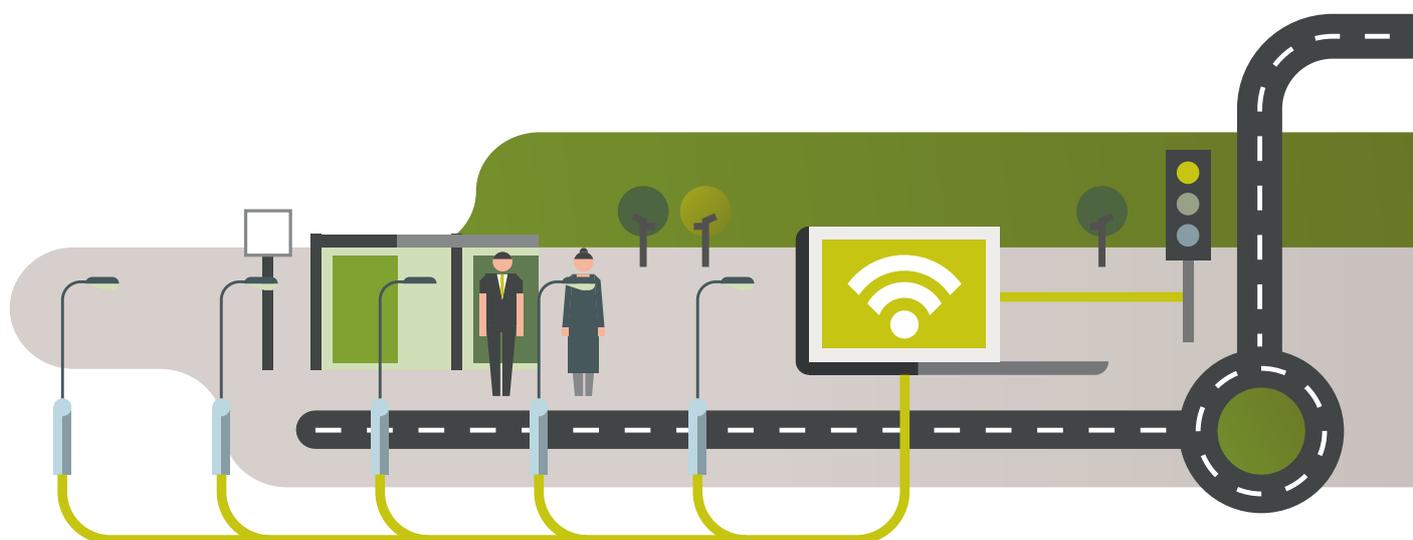
taking factors like the weather into account. Another pilot project is testing insulation methods for tenement flats, collecting data on their impact on energy consumption. Data on energy consumption in public buildings will also be made available via the Open Data Platform.

Intelligent street lighting projects will test the way LED lights can be equipped with digital sensors allowing them to be controlled remotely, and to respond to changes in the local environment, such as an increase in traffic. Such intelligent controls can push the average energy savings with LED lighting up to 80%. The UK Green Investment Bank is supporting Glasgow City Council to finance the first phase of their streetlighting conversion programme. See p.17 for more information.

Case study:
**‘Internet
of Things’,
Milton
Keynes**

BT, Open University, Future Cities Catapult and the Connected Digital Economy Catapult are working with Milton Keynes Council to explore how the Internet of Things could be used in cities to create innovative new services. The project creates the UK’s first city-wide, open access Internet of Things network – where a diverse variety of devices are connected to generate data that could help deliver new products for cities and their citizens.

One element of the programme will see sensors embedded in recycling bins across the city – informing the Council when they are full and ready for collection. Over time, this data will help improve the efficiency of waste management, allowing the Council to provide an improved service for residents. A later phase will see sensors tackling the problem of pest control, as well as monitoring cycle traffic and footfall across the city to build a better understanding of how people move around the urban environment.



Next steps

This report has been designed to illustrate the well-established infrastructure technology that is available now. The case studies we have provided are backed-up by many more, in the UK or abroad.

We have also provided an appendix which offers links to further information in each of the ten technologies. In almost all of the ten areas the UK Government and/or devolved administrations will offer support.

While each technology works in isolation their impact will be greater if they are well integrated as part of a wider strategy.

Investment in this type of infrastructure requires significant capital. The UK Green Investment Bank was set up to help finance the type of low-carbon energy infrastructure set out in this report. We have a dedicated team of sector experts to serve the waste, energy efficiency, and renewable energy sectors and can provide a comprehensive range of flexible financial solutions.

You can contact the UK Green Investment Bank team to discuss the opportunities set out in this report by emailing [**enquiries@greeninvestmentbank.com**](mailto:enquiries@greeninvestmentbank.com).

Further information

A range of agencies and organisations can provide advice, assistance or funding to support urban infrastructure development. Some of these operate across the UK whilst others operate on a national basis.

General

Scottish Futures Trust
www.scottishfuturestrust.org.uk

—
Low Carbon Infrastructure
Transition Programme
www.gov.scot/Topics/Business-Industry/Energy/Action/lowcarbon/SGIP/LCITP

—
Local Partnerships
www.localpartnerships.org.uk

—
Strategic Investment Board
www.sibni.org

—
Carbon Trust
www.carbontrust.com

—
Energy Saving Trust
www.energysavingtrust.org.uk

—
DEPDU (London)
www.londonheatmap.org.uk/Content/home.aspx

—
Salix Finance
www.salixfinance.co.uk

Anaerobic digestion

WRAP
www.wrap.org.uk/category/subject/anaerobic-digestion

—
Wales Centre of Excellence
for Anaerobic Digestion
www.walesadcentre.org.uk

—
Zero Waste Scotland
www.zerowastescotland.org.uk/content/introduction-anaerobic-digestion

Combined heat and power

gov.uk
www.gov.uk/combined-heat-and-power

District heating

Heat Networks Delivery Unit
www.gov.uk/government/publications/heat-networks-funding-stream-application-and-guidance-pack

—
Heat Network Partnership for Scotland
www.districtheatingscotland.com

—
District Heating Loan
www.energysavingtrust.org.uk/scotland/businesses/getting-support/district-heating-loan

Further information

Distributed renewables

Community Energy Hub
hub.communityenergyengland.org

Partnership Portal
www.localenergyscotland.org/partnershipportal

Renewable Energy Investment Fund
www.scottish-enterprise.com/services/attract-investment/renewable-energy-investment-fund/overview

Ynni'r Fro community programme
www.energysavingtrust.org.uk/organisations/content/ynnir-fro-community-programme

Urban Community Energy Fund
www.gov.uk/urban-community-energy-fund

LED streetlighting

Institution of Lighting Professionals
www.theilp.org.uk/home

Scottish Futures Trust
Streetlighting Toolkit
www.scottishfuturestrust.org.uk/publications/low-carbon-and-energy-efficiency

DECC Streetlighting Toolkit
www.localpartnerships.org.uk/our-work/growth/efficient-lighting/download-the-streetlighting-toolkit/view/form

Energy efficiency building retrofits

Building Better Partnerships
www.betterbuildingspartnership.co.uk

RE:FIT
www.localpartnerships.org.uk/our-work/growth/re-fit

RE:FIT London
www.refit.org.uk

Low carbon public transport fleets

Scottish Green Bus Fund
www.transportscotland.gov.uk/public-transport/scottish-green-bus-fund

Go Ultra Low
www.goultralow.com

Ultra low emission bus scheme
www.gov.uk/government/publications/low-emission-bus-scheme-preliminary-guidance

Plug-in car grant
www.gov.uk/plug-in-car-van-grants/overview

Electric vehicle charging infrastructure

Plugged-In Places programme
www.gov.uk/government/publications/plugged-in-places

Data and communications infrastructure

Future Cities Catapult
www.futurecities.catapult.org.uk

We are grateful to Syed Ahmed (Energy for London) and the Future Cities Catapult for their support in the preparation of this report.

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March 2015

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