A NET-ZERO CARBON ROADMAP FOR EDINBURGH

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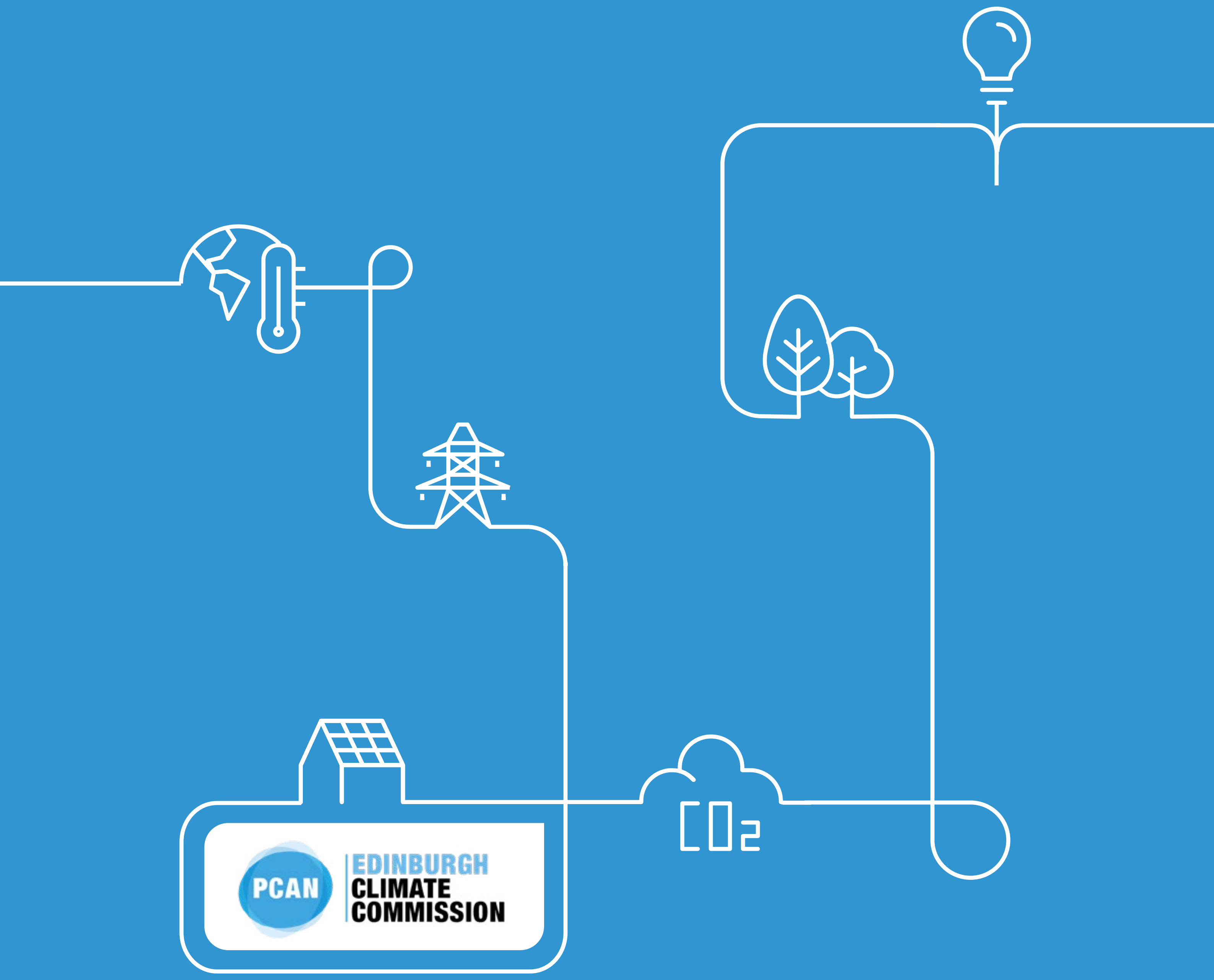

UKRI Economic and Social Research Council
PCAN PLACE-BASED CLIMATE ACTION NETWORK
UNIVERSITY OF LEEDS
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wrc

Please reference as:

Williamson, R., Sudmant, A., Gouldson, A. & Brogan, J. (2020)

A Net-Zero Carbon Roadmap for Edinburgh, Edinburgh Climate Commission/ Place-Based Climate Action Network.

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PREFACE

Background

Edinburgh signed its climate emergency declaration in May of 2019, thereby committing itself to work towards net-zero emissions by 2030. Produced by the ESRC Place-Based Climate Action Network (PCAN), this net-zero roadmap is designed to inform how Edinburgh can work towards that ambitious target in the coming years.

Policy Change and the Need to Deliver

In April 2019, Scotland became the first government in the world to declare a climate emergency, and committed to reach net-zero emissions by 2045. In June, the UK government passed legislation with a commitment to reach net-zero emissions by 2050. At the local level, 2019 also saw a wave of local climate emergency declarations with places setting their own, usually more ambitious targets to reach net-zero emissions. By February 2020, 68% of UK district, county, unitary and metropolitan councils, including 20 Scottish authorities, had declared a climate emergency. It is clear though that declaring a climate emergency is just the first step – declarations need to be turned into action plans, and these need to be delivered before we can claim to have responded effectively.

Covid and a Green Recovery

Clearly the world changed dramatically with the Covid pandemic. From a climate perspective, the first, and we hope main phase of national lockdown in the spring and early summer of 2020 did reduce our carbon footprint for a short period – and it triggered some changes in our behaviour that could help us in the longer term – but for long-term change we clearly need to establish other drivers that effectively address the climate challenge in the context of a healthy, inclusive and vibrant city.

Edinburgh Climate Commission published its report ‘Forward, Faster, Together: Recommendations for a Green Economic Recovery in Edinburgh’ in July 2020. To help Edinburgh to recover from the pandemic and tackle climate change in a joined up way, the report called for Edinburgh to apply five principles:

1. GO FASTER: Accelerate the transition to net-zero; lock in carbon reductions and low carbon behaviours; lock out a rollback to business-as-usual.

2. DO BETTER: Measure what matters; judge success against more than economic indicators; include biodiversity, wellbeing and carbon reductions.

3. BUILD STRONGER: Unleash potential of local communities and producers; showcase innovation and positive adaptation; empower everyone to play their part in building a city resilient to future crises.

4. THINK BIGGER: Covid-19 has broken the belief that big change can’t be done. The scale of our ambition, the breadth of our imagination; our commitment to collaborate and our willingness to embrace change must match the challenge of achieving net-zero carbon emissions.

5. BE BOLDER: Use the voice, as the capital of Scotland, to set the pace for climate action ahead of COP26; recognise the moral limits of markets and lead the debate on delivering a sustainable future.

This roadmap shows measures by which Edinburgh could apply these principles to radically reduce its carbon footprint whilst also becoming a better place, with cleaner air, improved public health, reduced poverty and inequality, increased employment and enhanced prosperity.

Edinburgh Climate Commission

The Edinburgh Climate Commission was established in 2020 to support the city to make positive choices on issues relating to climate mitigation and adaptation. Members of the Commission are drawn from key organisations and groups across the city from the public, private and civic sectors.

The Edinburgh Climate Commission is an independent voice in the city, providing authoritative advice on steps towards a low carbon, climate resilient future to inform policies and shape the actions of local stakeholders and decision makers. It monitors progress towards meeting the city’s carbon reduction targets, recommends actions to keep the city on track and advises on the assessment of the climate-related risks and adaptation opportunities in the city and on progress towards climate resilience.

The Commission aims to foster collaboration on projects that result in measurable contributions towards meeting the city’s climate reduction targets and the delivery of enhanced climate resilience. It promotes best practice in engagement on climate change in order to support robust decision-making and acts as a forum where organisations can exchange ideas, research findings, information and best practice.

https://www.edinburghclimate.org.uk

EDINBURGH CARBON ROADMAP
PATHWAY TO NET-ZERO*

PCAN EDINBURGH CLIMATE COMMISSION

BACKGROUND

1.5°C
The level of global temperature rise at which we risk triggering dangerous climate change

2030
The point at which - at current rates - the world will have locked into more than 1.5°C of warming

GLOBAL TO LOCAL

CO_2

22m tonnes
Edinburgh's share of the global carbon budget (to keep to 1.5°C of warming)

Edinburgh is emitting
2.5m tonnes
of carbon a year. At this rate, we will have used up our budget by
2031

BASELINES AND TARGETS

42%
The decline in Edinburgh's carbon emissions since 2000

This needs to be increased to

67% by 2025
80% by 2030
100% by 2050

Edinburgh has committed to work towards being
CARBON NEUTRAL
by
2030

That leaves a **big gap** but we can close it by the following options

COST-EFFECTIVE OPTIONS

Cost-effective options such as
better housing and transport
could close the 2030 gap by
51%

These would reduce Edinburgh's energy bill by
£553m
per year, and would create nearly
11,790
years of extra employment

MORE AMBITIOUS OPTIONS

More ambitious but expensive options could
close the 2030 gap by
65%
These would have **benefits for** health, equality, travel and the environment

H_2 O_2

Doing all of the above leaves a
35%
shortfall to reach by
2030

REACHING OUR TARGET

Edinburgh can close the gap by
100% by 2030
through a range of
INNOVATIVE INTERVENTIONS

These include
decarbonising heating and planting trees - changing some behaviours and consumption habits would take us further still

Net Zero by 2030

*Net-zero, like "carbon neutral", refers to achieving an overall balance between emissions produced and emissions taken out of the atmosphere, with any residual emissions removed through carbon sinks.

EXECUTIVE SUMMARY

Background

- Scientific evidence calls for rapid reductions in global carbon[1] emissions if we are to limit average levels of warming to 1.5°C and so avoid the risks associated with dangerous or runaway climate change.
- Globally, the Intergovernmental Panel on Climate Change (IPCC) suggests that we will have used up the global carbon budget that gives us a good chance of limiting warming to 1.5°C within a decade. This science underpins calls for the declaration of a climate emergency.
- Dividing the global carbon budget up by population gives Edinburgh a total carbon budget of 22million tonnes from 2020. Based only on the fuel and electricity used directly within its boundaries (i.e. its Scope 1 and 2 emissions), Edinburgh currently emits c.2.5 million tonnes of carbon a year, and as such it would use up its carbon budget by 2031.
- This assessment does not include its broader carbon footprint – for example relating to longer distance travel or the goods and services that are produced elsewhere but consumed within Edinburgh (i.e. its Scope 3 emissions).

Baselines and Targets

- Scope 1 and 2 carbon emissions from Edinburgh have fallen by 42% since the turn of the millennium. With on-going decarbonisation of Scottish electricity, and taking into account population and economic growth within the city-region, we project that Edinburgh's 2005 level of emissions will have fallen by a total of 50% in 2045.
- If it is to stay within its carbon budget, Edinburgh needs to adopt science-based carbon emissions reduction targets that build on the emissions reductions already achieved to secure 67% on its 2000 level of emissions by 2025, 80% by 2030, 88% by 2035, 93% by 2045 and 100% by 2050.
- Without further activity to address its carbon emissions, we project that Edinburgh's annual emissions will exceed its carbon budget by 1,248,341 tonnes in 2030, and 1,881,100 tonnes in 2050.

[1]For simplicity, we use the term "carbon" as shorthand for all greenhouse gases. All figures in this report relate to the carbon dioxide equivalent (CO2e) of all greenhouse gases unless otherwise stated. Note that our assessment therefore differs from other assessments that focus only on CO^2.

Cost-Effective Options

- To meet these carbon emissions reduction targets, Edinburgh will need to adopt low carbon options that close the gap between its projected emissions in future and net-zero emissions. This can be partially realised through cost-effective options more than pay for themselves through the energy cost reductions they would generate whilst generating wide social and environmental benefits in the area.
- More specifically, the analysis shows that Edinburgh could close the gap between its projected emissions in 2030 and net-zero emissions by over 50% purely through the adoption of cost-effective options in houses, public and commercial buildings, transport and industry.
- Adopting these options would reduce Edinburgh's total projected energy bill in 2030 by £553 million per year whilst also creating 11,790 years of employment in the city. They could also help to generate wider benefits, including helping to tackle fuel poverty, reducing congestion and productivity losses, improving air quality, and enhancements to public health.
- The most carbon-effective options for the city to deliver these carbon cuts include improved heating, lighting and insulation in houses, cooling and insulation in offices, shops and restaurants, and a range of measures across the transport sector including modal shift to non-motorised transport and the wider up-take of electric vehicles.

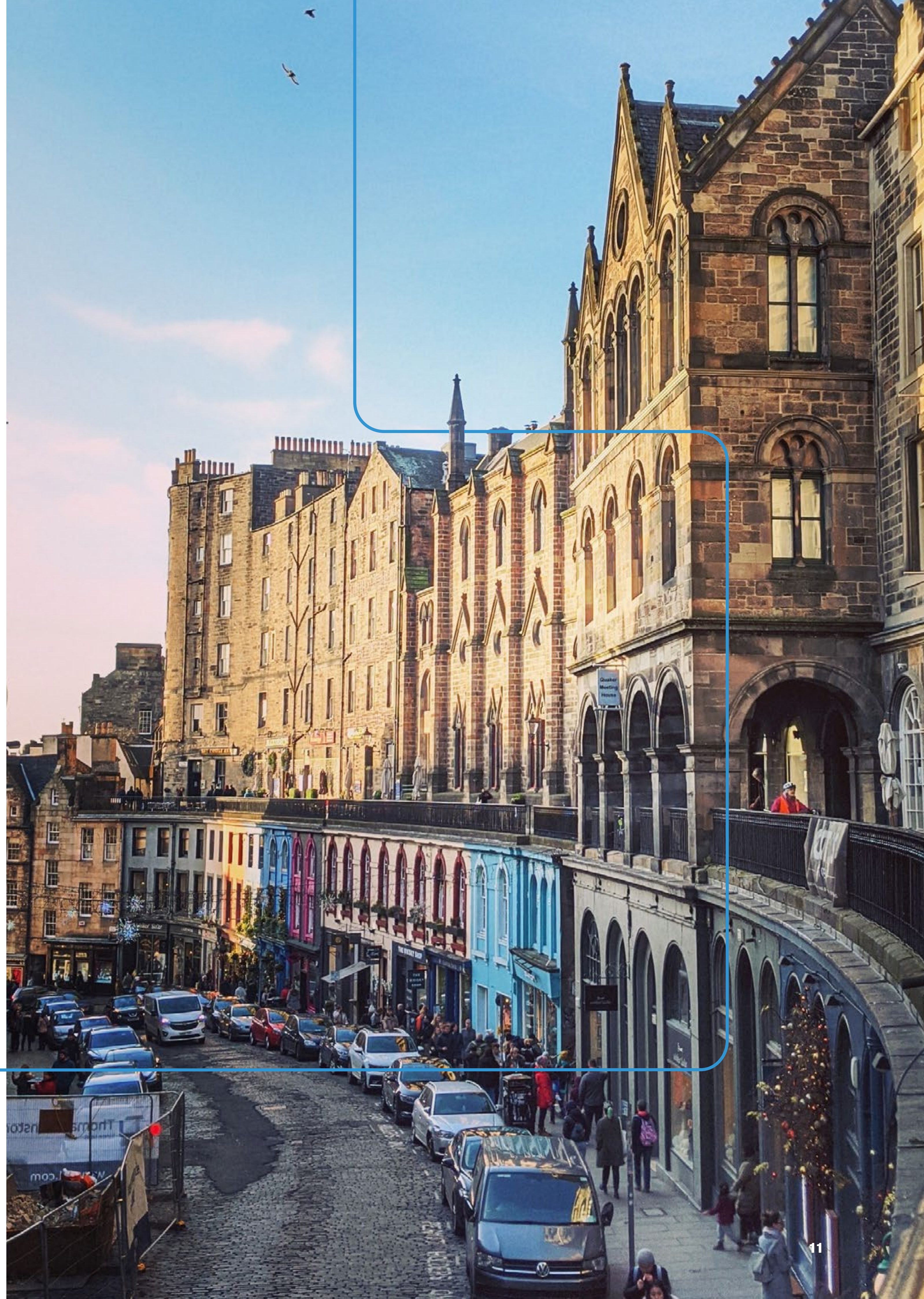
More Ambitious Options

- The analysis also shows that Edinburgh could close the gap to net-zero emissions in 2030 by 65% through the adoption of options that are already available, but that some of these options would not pay for themselves directly through the energy savings that they would create. Many of these options would, however, create wider indirect benefits both economically and socially in the city.
- This means that although it can achieve significant reductions in emissions by focusing on established cost-effective and technically viable measures, Edinburgh still has to identify other more innovative interventions that could deliver the last 35% of the shortfall between projected emissions in 2030 and a net-zero target.
- Options identified elsewhere that could be considered in Edinburgh include promoting the use of low carbon vehicles, electrification of heating and cooking, and planting trees. Carbon emissions could be cut further still through behavioural and consumption-based changes such as the promotion of active travel (e.g. walking and cycling), reductions in meat and dairy consumption and the generation of food waste, and reduced consumption of concrete and steel with more emphasis on green infrastructure.
- As well as reducing Edinburgh's direct (Scope 1 and 2) carbon footprint, some of these more innovative measures (e.g. reducing meat and dairy or concrete and steel consumption) could start to focus on tackling Edinburgh's broader consumption-based (i.e. Scope 3) carbon footprint.

EXECUTIVE SUMMARY

Next Steps

- Edinburgh needs to adopt a clear and ambitious climate action plan. The case for the adoption of such a plan is supported by the evidence that much – but not all – of the action that is required can be based on the exploitation of win-win low-carbon options that will simultaneously improve economic, social and health outcomes across the city.
- The climate action plan should adopt science-based targets for emissions reduction. As well as longer term targets, it should adopt five-yearly carbon reduction targets.
- The action plan should focus initially on Edinburgh's direct (Scope 1 and 2) carbon footprint as these emissions are most directly under the city's influence, but in time it should also widen its scope to consider its broader (Scope 3) carbon footprint.
- The action plan should also set out the ways in which Edinburgh will work towards achieving these science-based targets, drawing on the deployment KPIs listed in this report. Action should also be taken to monitor and report progress on emissions reductions.
- It is important to stress that delivering on these targets will require action across the city and the active support of the public, private and third sectors. Establishing an independent Edinburgh Climate Commission has already helped to draw actors together and to build capacities to take and track action.
- Leadership groups should be formed for key sectors such as homes, public and commercial buildings, transport and industry, with clear plans for delivery of priority actions in each sector. All large organisations and businesses in the city should be asked to match broader carbon reduction commitments and to report back on progress.

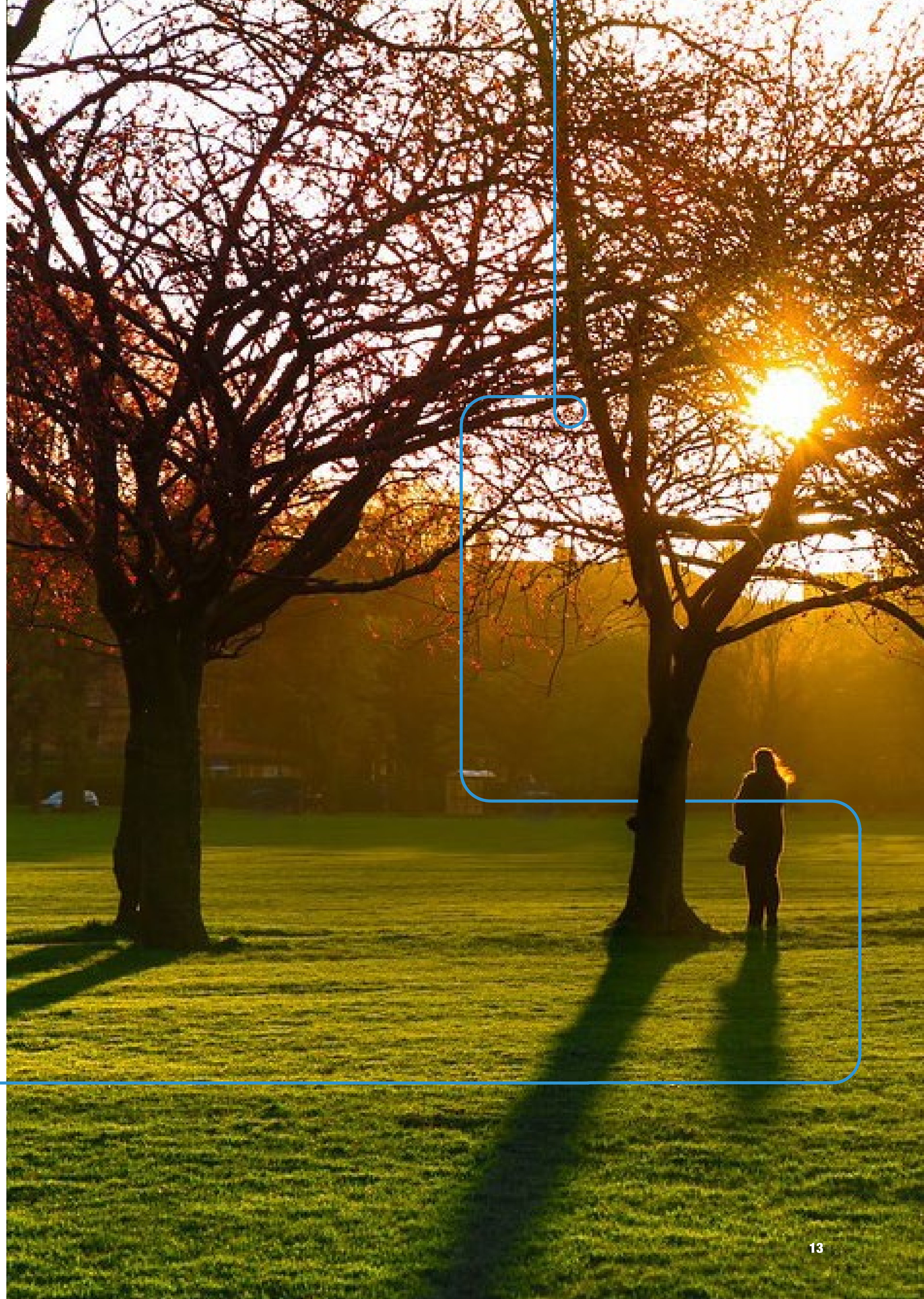


INTRODUCTION

Climate science has proven the connection between the concentration of greenhouse gases in the atmosphere and the extent to which the atmosphere traps heat and so leads to global warming. The science tells us – with a very high level of confidence – that such warming will lead to increasingly severe disruption to our weather patterns and water and food systems, and to ecosystems and biodiversity. Perhaps most worryingly, the science predicts that there may be a point where this process becomes self-fuelling, for example where warming leads to the thawing of permafrost such that significant quantities of greenhouse gases are released, leading to further warming. Beyond this point or threshold, the evidence suggests that we may lose control of our future climate and become subject to what has been referred to as dangerous or "runaway" climate change.

Until recently, scientists felt that this threshold existed at around 2ºC of global warming, measured as a global average of surface temperatures. However, more recent scientific assessments (especially by the IPCC in 2018) have suggested that the threshold should instead be set at 1.5ºC. This change in the suggested threshold from 2ºC to 1.5ºC has led to calls for targets for decarbonisation to be made both stricter (e.g. for the UK to move from an 80% decarbonisation target to a net-zero target, which it did in 2019), and to be brought forward (e.g. from 2050 to 2030, which the UK has not done, although many local authorities and other places have set themselves this ambitious goal).

Globally, the IPCC suggests that from 2020 we can only emit 344 billion tonnes of CO_2 if we want to give ourselves a 66% chance of avoiding dangerous climate change. We are currently emitting over 37 billion tonnes of CO_2 every year, which means that we will have used up our global carbon budget within a decade. It is this realisation – and the ever accumulating science on the scale of the impacts of climate change – that led to calls for organisations and areas to declare a climate emergency and to develop and implement plans to rapidly reduce carbon emissions.



OUR APPROACH

(a). Measuring an Area's Carbon Footprint

Any area's carbon footprint – measured in terms of the total impact of all of its greenhouse gas emissions – can be divided into three types of greenhouse gas emissions.

- Those coming from the fuel (e.g. petrol, diesel or gas) that is directly used within an area and from other sources such as landfill sites or industry within the area. These are known as Scope 1 emissions.
- Those coming from the electricity that is used within the area, even if it is generated somewhere else. These are known as Scope 2 emissions. Together Scope 1 and 2 emissions are sometimes referred to as "territorial" emissions.
- Those associated with the goods and services that are produced elsewhere but imported and consumed within the area. After taking into account the carbon footprint of any goods and services produced in the area but that are exported and consumed elsewhere, these are known as Scope 3 or consumption-based emissions.

In this report[2] we focus on Scope 1 and 2 emissions, and exclude consideration of long-distance travel and of Scope 3 or consumption-based emissions. We do this because Scope 1 and 2 emissions are more directly under the control of actors within an area, and because the carbon accounting and management options for these emissions are better developed.

We stress though that emissions from longer distance travel (especially aviation) and consumption are very significant, and also need to be addressed.

(b). Developing a Baseline of Past, Present and Future Emissions

Having a baseline of carbon emissions is key to tracking progress over time. We use local authority emissions data to chart changes in emissions from 2005 to 2018. We also break this down to show the share of emissions that can be attributed to households, public and commercial buildings, transport and industry.

We then project current emissions levels for the period through to 2050. To do this, we assume on-going decarbonisation of electricity in line with government commitments and a continuation of background trends in a) economic and population growth, and b) energy use and energy efficiency. Specific numbers for the key variables taken into account in the forecasts are presented in the technical annex published separately. As with all forecasts, the level of uncertainty attached increases as the time period in question extends. Even so, it is useful to look into the future to gauge the scale of the challenge to be addressed in each area, especially as it relates to the projected gap between the forecasted emissions levels and those that are required if an area's emissions are to be consistent with a global strategy to limit average warming to 1.5ºC.

[2] Further details of the data, assumptions and methodology are set out in a separate technical annex that is available at https://pcancities.org.uk/reports

(c). Setting Science-Based Carbon Reduction Targets

To set science-based carbon reduction targets for an area, we take the total global level of emissions that the IPCC suggests gives us a 66% chance of limiting average levels of warming to 1.5ºC, and divide it according to the share of the global population living in the area in question. This enables us to set the total carbon budget for an area that is consistent with a global budget. To set targets for carbon reduction, we then calculate the annual percentage reductions from the current level that are required to enable an area to stay within its overall carbon budget.

(d). Identifying and Evaluating Carbon Reduction Opportunities

Our analysis then includes assessment of the potential contribution of approximately 130 energy saving or low carbon measures for:

- **Households and for both other public and commercial buildings** including better insulation, improved heating, more efficient appliances, some small scale renewables
- **Transport** including more walking and cycling, enhanced public transport, electric and more fuel efficient vehicles
- **Industry** including better lighting, improved process efficiencies and a wide range of other energy efficiency measures.

We stress that the list of options that is assessed may not be exhaustive; other options could be available and the list can potentially be expanded.

For the options included, we assess the costs of their purchase, installation and maintenance, the direct benefits (through energy and fuel savings) of their adoption in different settings and their viable lifetimes. We also consider the scope for, and potential rates of deployment of each option. This allows us to generate league tables of the most carbon- and cost-effective options that could be deployed within an area.

It is important to note that we base the analysis on current capital costs, although future costs and benefits are adjusted for inflation and discounting factors. This could be overly cautious if costs fall and benefits increase as some options become more widely adopted, or if the costs increase as the rates of deployment increase. It is also important to note that, although we consider the employment generation potential of different options, we do not consider the wider indirect impacts of the different options relating to their social, economic or environmental implications.

Beyond the range of currently available options, we also consider the need for more innovative or "stretch" options to be developed and adopted within the area if it is to meet its carbon reduction targets. These need to be developed in each area, but the some of the ideas for innovative options identified elsewhere include targeting a full transition to net-zero homes and public/commercial buildings by 2030, promoting the rapid acceleration of active travel (e.g. walking and cycling), tackling food waste, reducing meat and dairy consumption and reducing concrete and steel consumption/promoting adoption of green infrastructure.

OUR APPROACH

(e). Aggregating Up to See the Bigger Picture

Based on this bottom up analysis of the potential for different options to be adopted within the area, we then aggregate up to assess the potential for decarbonisation within that area, and the costs and benefits of different levels of decarbonisation. We then merge the aggregated analysis of the scope for decarbonisation with the baseline projections of future emissions to highlight the extent to which the gap between the projected and required emissions levels that can be met through different levels and forms of action.

To break this gap down, we merge interventions into three broader groupings:

- **Cost-Effective (CE)** options where the direct costs of adoption are outweighed by the direct benefits that they generate through the energy savings they secure, meaning the portfolio of measures as a whole has a positive economic impact in present value. These options may also generate indirect benefits, for example through job creation, fuel poverty and improved air quality and public health.
- **Cost-Neutral (CN)** options where the portfolio of interventions mentioned above is expanded to consider investments that may not be as cost effective on their own terms, but where the range of measures as a whole will have near-zero net cost.
- **Technical Potential (TP)** options where the direct costs are not (at present) covered by the direct benefits. However, the cost of many low carbon options is falling quickly, and again these options could generate important indirect benefits such as those listed above.

As it is unlikely that adopting all of the cost-effective or even technically viable options will enable an area to reach net-zero emissions, we also highlight the need for a fourth group of measures:

- **Innovative or “stretch” options** that include low-carbon measures that are not yet widely adopted. Some of the options within this group may well be cost- and carbon-effective, and they may also generate significant indirect benefits, but whilst we can predict their carbon saving potential, data on their costs and benefits is not yet available.

(f). Developing Targets and Performance Indicators

Linked to the analysis detailed above, we extend our evaluation of potential emissions reductions across Edinburgh’s economy to substantive, real-life indicators for the levels of investment and deployment required to achieve targets. These Key Performance Indicators (KPIs) illustrate the scale of ambition required to reach the emissions savings presented in the Technical Potential scenario and are disaggregated by sector.

(g). Focusing on Key Sectors

As well as presenting an aggregated picture, we also focus on the emissions saving potential in the housing, public and commercial buildings, transport, industry and waste sectors. We focus in on overall investment needs and returns, and present more detailed league tables of the most carbon- and cost-effective options that could be adopted in each sector.

DEVELOPING A BASELINE OF PAST, PRESENT AND FUTURE EMISSIONS FOR EDINBURGH

Analysis shows that Edinburgh's baseline (Scope 1 and 2) emissions have fallen by 42% since 2000, due to a combination of increasingly decarbonised electricity supply, structural change in the economy, and the gradual adoption of more efficient buildings, vehicles and businesses.

With full decarbonisation of UK electricity by 2045, and taking into account economic growth (assumed at 1.5% p.a.), population growth (assumed at 0.1% p.a.) and on-going improvements in energy and fuel efficiency, we project that Edinburgh's baseline (Scope 1 and 2) emissions will only fall by a further 9% by 2030, 13% by 2037, and 15% by 2045. This is a total of just over 50% between 2000 and 2045.

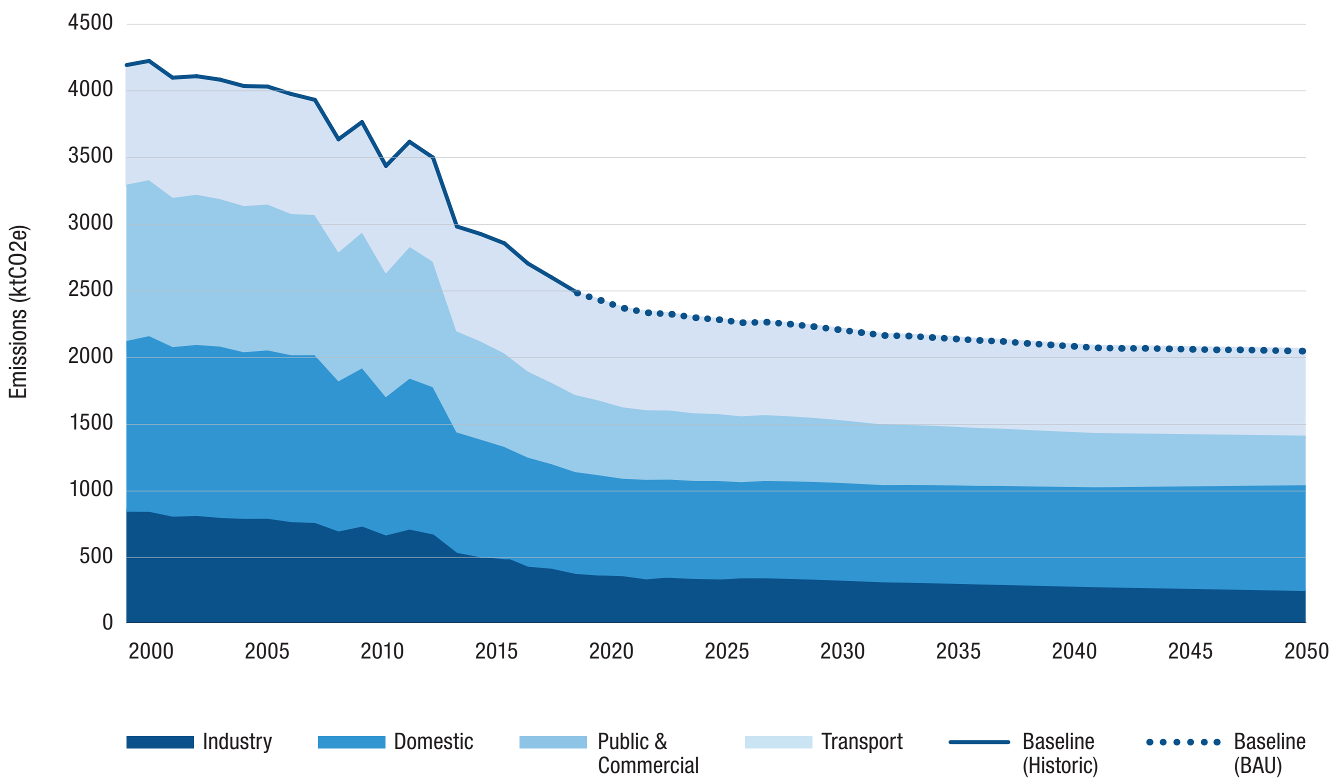


Figure 1: Edinburgh's Scope 1 and 2 Carbon Emissions (2000-2050)

Currently, 31% of Edinburgh's emissions come from the transport sector, with housing responsible for 29% of emissions, public and commercial buildings for 23% and industry 17%. Emissions related to land use contribute 0.4% and are not considered technically in this report. By 2030, under BAU, we project emissions from transport will increase very slightly (c.0.01%) with c.3% increase in the proportion of emissions from housing. Small decreases are forecast in the proportion of emissions from public and commercial buildings and industry, largely as a result of expansion in the domestic buildings sector over this period.

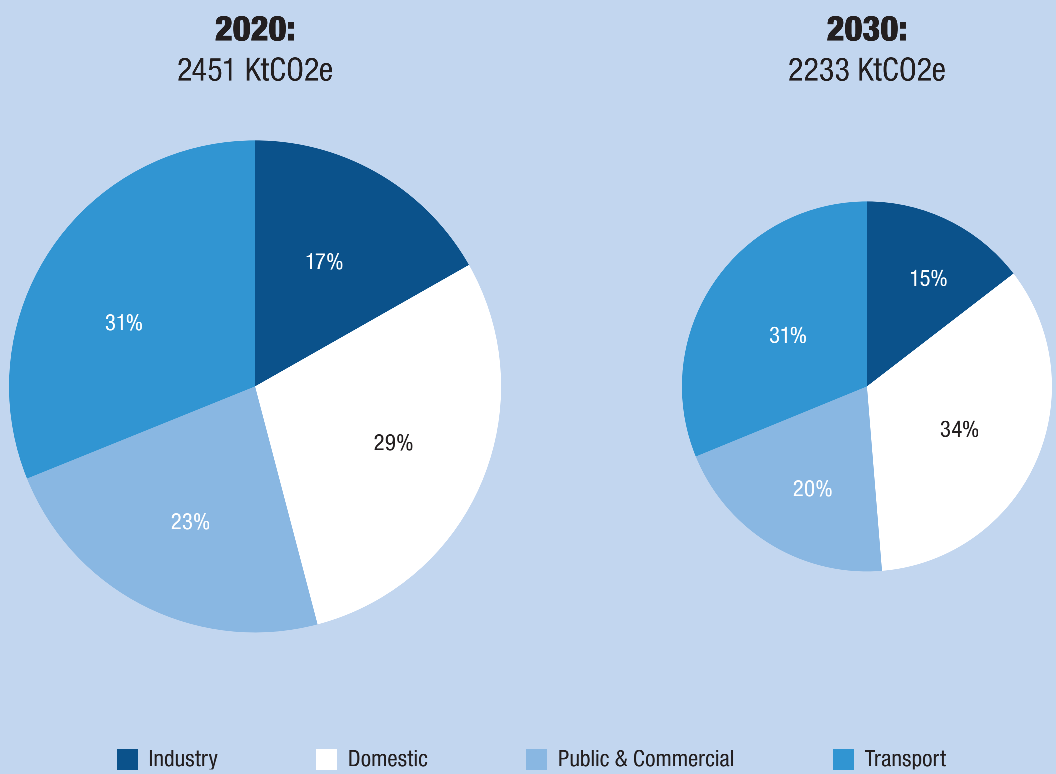


Figure 2: Edinburgh's 2020 and Projected 2030 Emissions by Sector

DEVELOPING A BASELINE OF PAST, PRESENT AND FUTURE EMISSIONS FOR EDINBURGH

Related to this emissions baseline, after evaluating the range of energy sources Edinburgh consumes (spanning electricity, gas, all solid and liquid fuels across sectors) we find that in 2019, £823 million was spent on energy across the city. Transport fuels generated the majority of this demand (42%), followed by domestic buildings (33%) then public and commercial buildings and industry (21% and 4% respectively). By projecting demand and energy prices into future with reasonable assumptions over population, inflationary measures and efficiency gains across the economy, we find that Edinburgh's business-as-usual (BAU) energy expenditure will likely grow to just over £872 million per year in 2030 and £1.02 billion per year in 2045, with transport expenditure growing to over half (51%) of Edinburgh's total (see Figure 3 below).

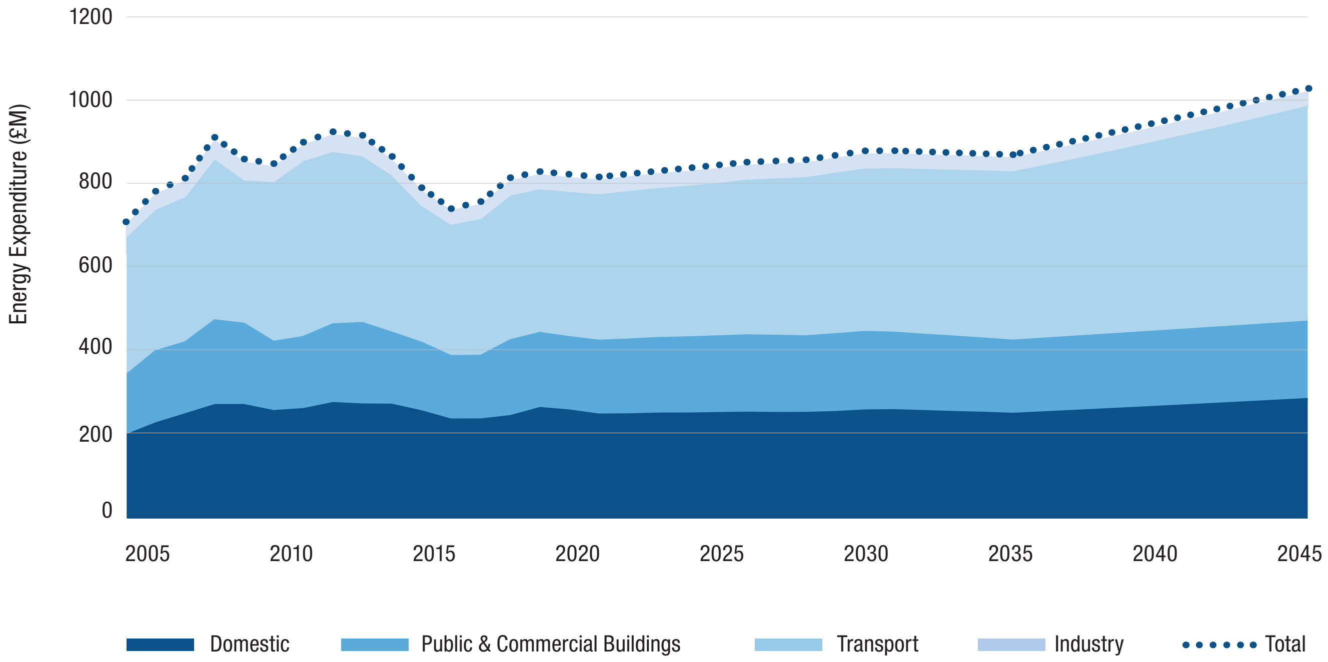
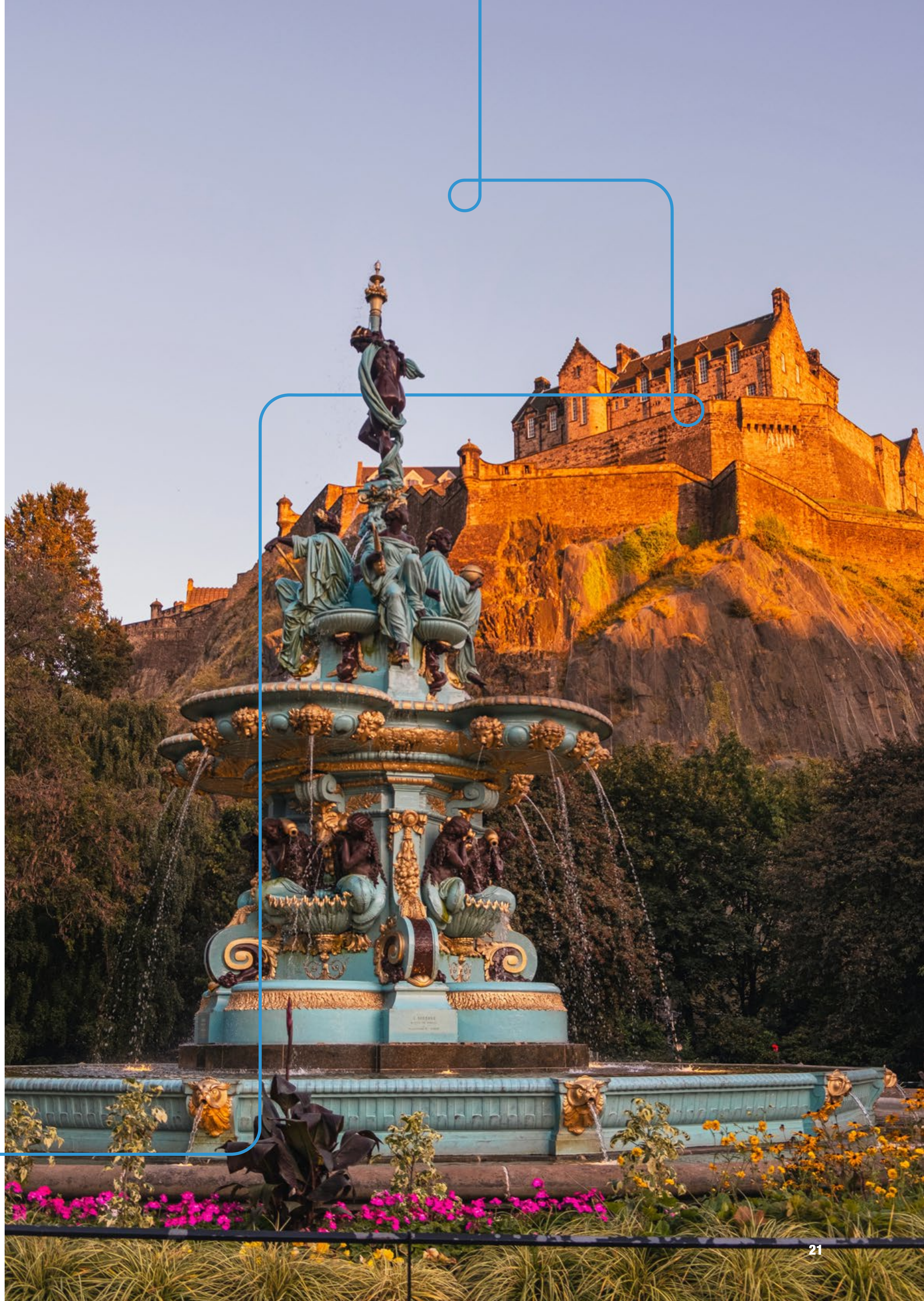


Figure 3: Edinburgh's Present and Projected Energy Expenditure by Sector



SETTING SCIENCE-BASED CARBON REDUCTION TARGETS FOR EDINBURGH

The Intergovernmental Panel on Climate Change (IPCC) has argued that from 2020, keeping within a global carbon budget of 344 gigatonnes (i.e. 344 billion tonnes) of CO_2 emissions would give us a 66% chance of limiting average warming to 1.5ºC and therefore avoiding dangerous levels of climate change. If we divide this global figure up on an equal basis by population, and adjust the budget to consider other gases that contribute to climate change, this gives Edinburgh a total carbon budget of 22.1 megatonnes over the period between the present and 2050.

At current rates of emissions output, Edinburgh would use up this budget in just over a decade at some point during the winter of 2031. However, Edinburgh could stay within its carbon budget by reducing its emissions by c.8% year on year. This would mean that to transition from the current position where emissions are 42% lower than 2000 levels to a local pathway that is consistent with the world giving itself a 66% chance of avoiding dangerous, runaway climate change, as an absolute minimum Edinburgh should adopt the following carbon reduction targets (on 2000 levels):

67%
by 2025

80%
by 2030

88%
by 2035

93%
by 2040

97%
by 2045

100%
by 2050

Such a trajectory would mean that the majority of all carbon cuts needed for Edinburgh to transition to a 1.5ºC consistent pathway need to be delivered by 2030.

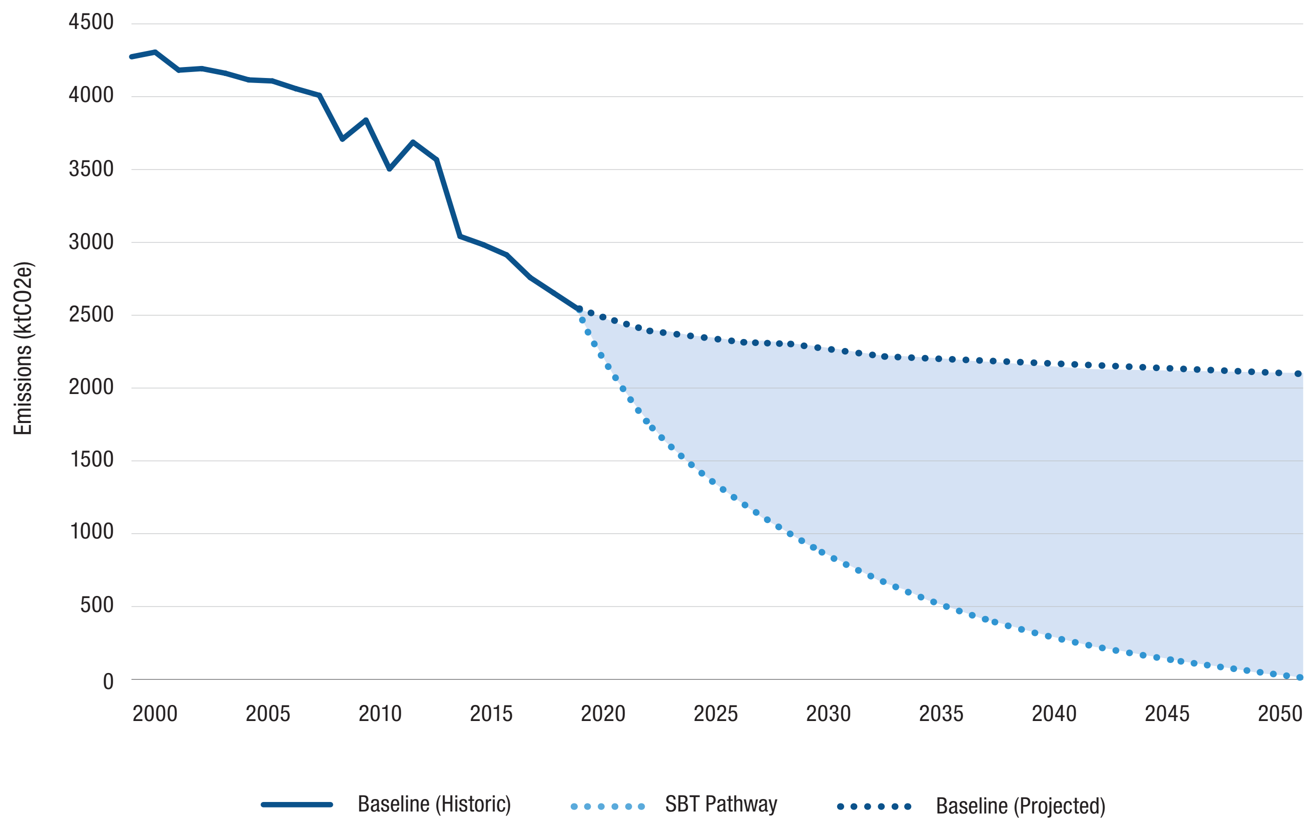


Figure 4: Edinburgh's Baseline and Science-Based-Target Emissions Pathways

AGGREGATING UP: THE BIGGER PICTURE FOR EDINBURGH

a) Emissions reductions

Our analysis predicts that the gap between Edinburgh's business-as-usual (BAU) emissions in 2030 and the net-zero target could be closed by 51% (1.1 MtCO2e) through the adoption of Cost-Effective (CE) options, by a further 6% (148 ktCO2e) through the adoption of additional Cost-Neutral (CN) options and by an extra 8% (165 ktCO2e) through the further adoption of all technically viable (TP) options. This means that Edinburgh still has to identify the innovative or stretch options that could deliver the last 35% (805 ktCO2e) of the gap between the business-as-usual scenario and net-zero.

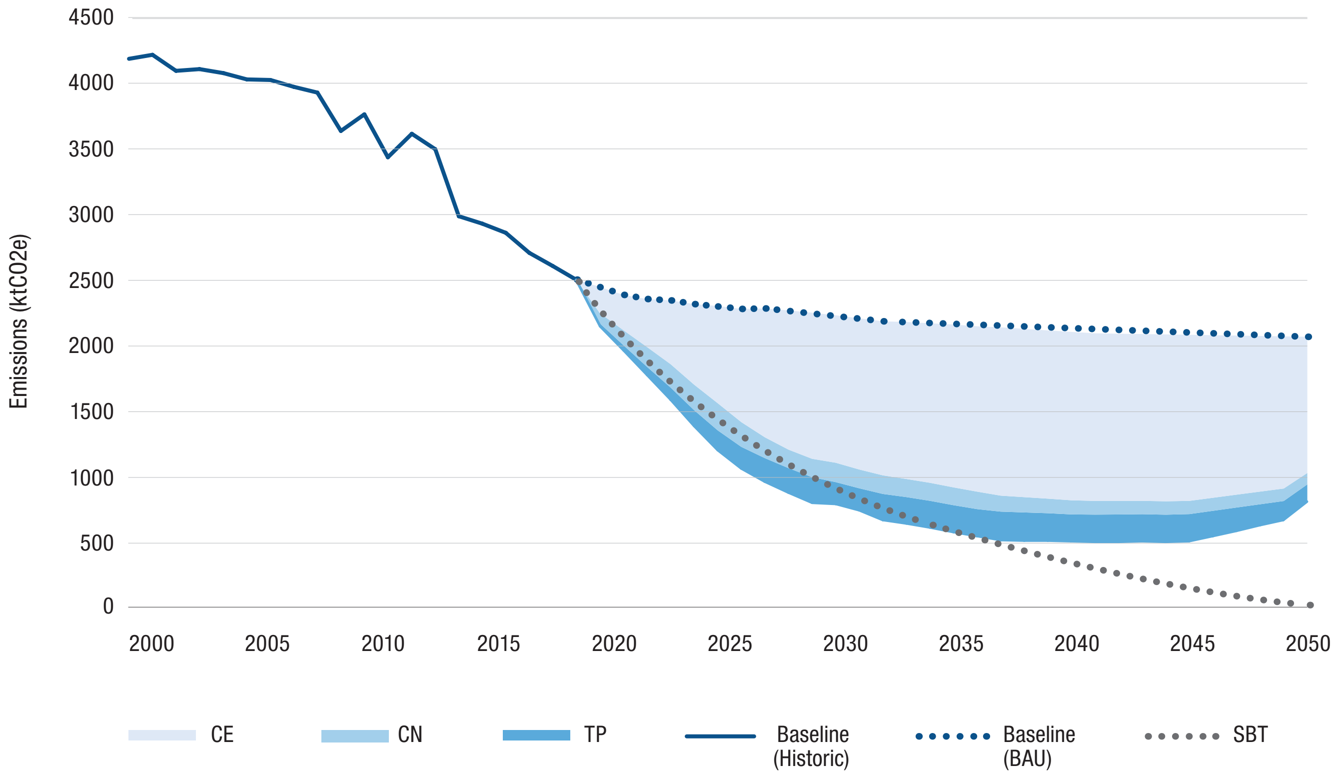


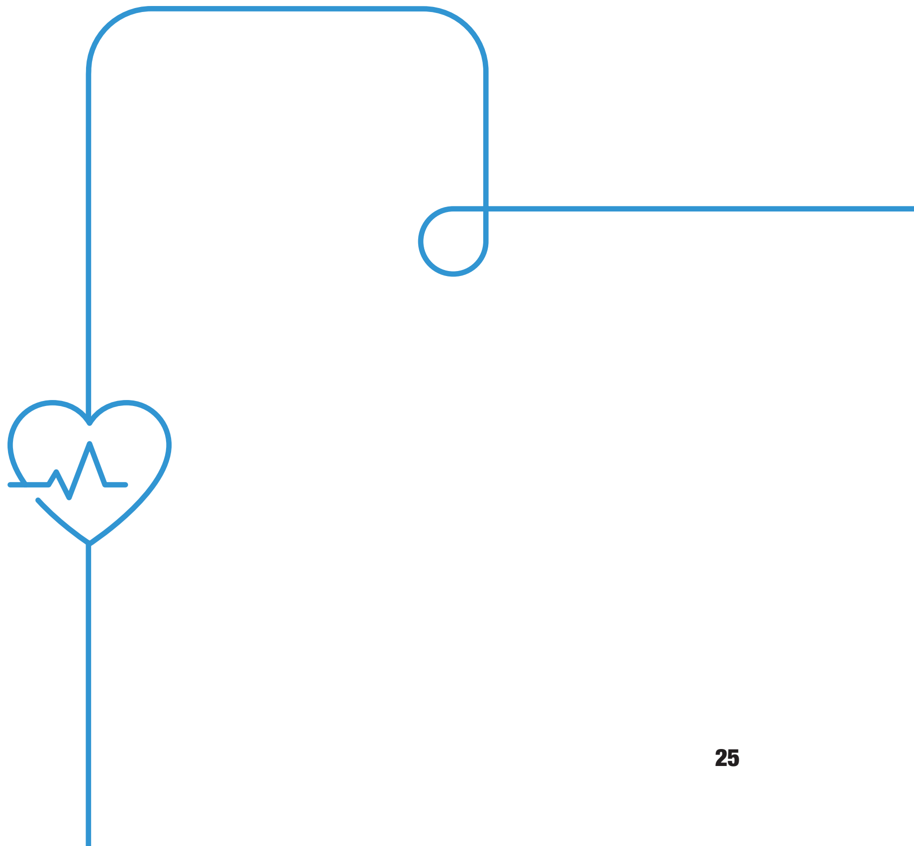
Figure 5: Edinburgh's BAU Baseline with Cost-Effective (CE), Cost-Neutral (CN), Technical Potential (TP)

		2025	2030	2035	2040	2045
Reduction on BAU Baseline (2050)	**CE**	32%	51%	58%	61%	61%
	CN	41%	57%	64%	66%	66%
	TP	48%	65%	73%	76%	76%
Reduction on 2020 Emissions	**CE**	36%	55%	63%	67%	67%
	CN	45%	61%	68%	71%	71%
	TP	51%	68%	77%	79%	79%

Table 1: Edinburgh's Potential Five-Year Emissions Reduction Percentages

b) The most carbon- and cost-effect options

Figure 6 (see p26) presents the emissions savings that could be achieved through different groups of measures in Edinburgh. Appendices 1 and 2 present league tables of specific measures and their potential emissions savings over this period.



AGGREGATING UP: THE BIGGER PICTURE FOR EDINBURGH

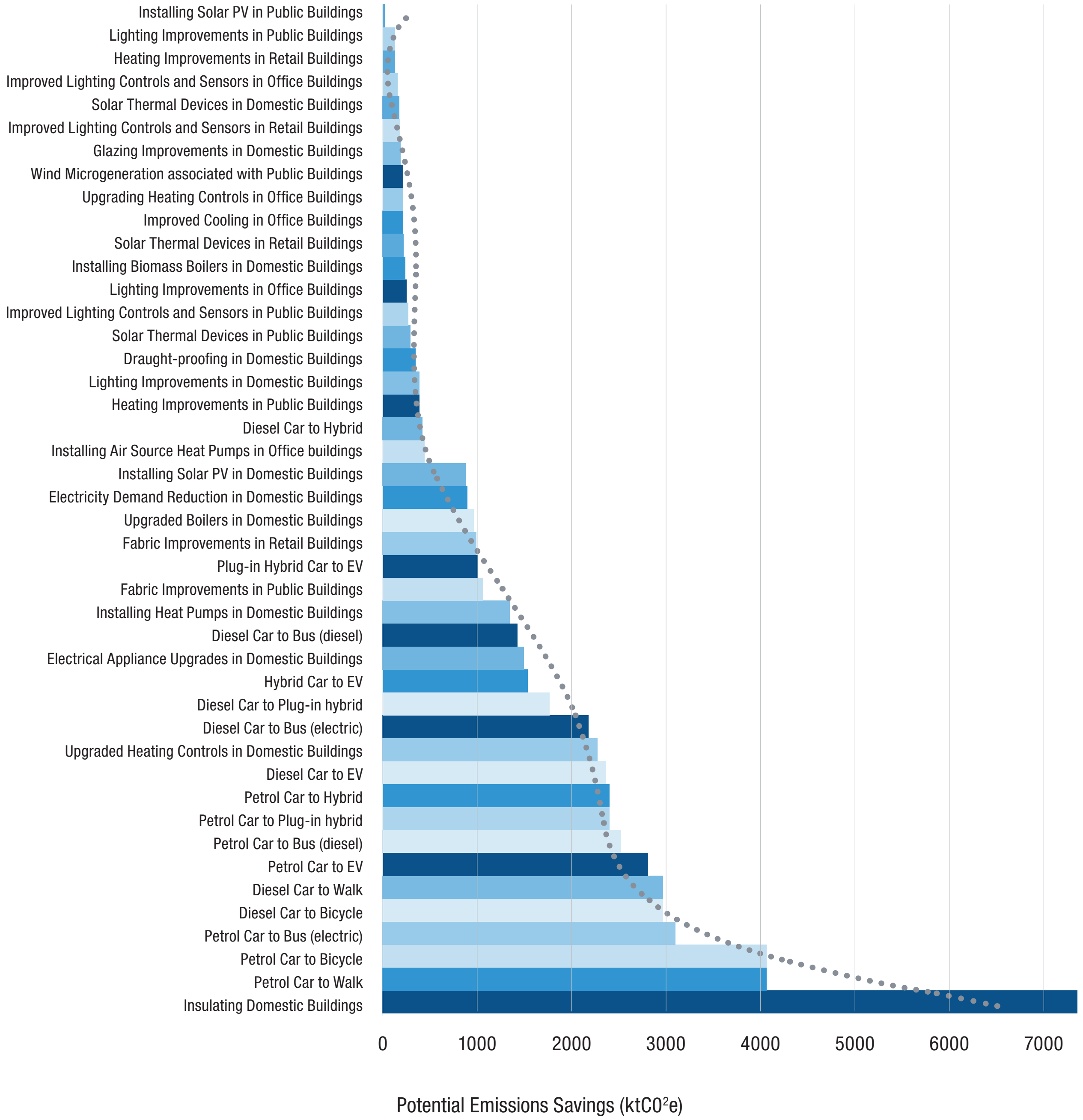


Figure 6: Simplified Emissions Reduction Potential by Measure for Edinburgh

Simplified league tables of the most cost- and carbon-effective options in Edinburgh are presented below (see Appendices 1 & 2 for more detailed league tables).

Rank	Measure	Cost Effectiveness (£/tCO2e)
1	Compressed Air Systems in Industry	-528
2	Pump Upgrades, Repairs and Maintenance in Industry	-484
3	Shift from Diesel Car to Diesel Bus Journeys	-458
4	Fabric improvements in Retail Buildings	-408
5	Shift from Petrol Car to Diesel Bus Journeys	-373
6	Shift from Diesel Car to Bicycle Journeys	-345
7	Shift from Diesel Car to Walking Journeys	-345
8	Shift from Petrol Car to Walking Journeys	-323
9	Shift from Petrol Car to Bicycle Journeys	-322
10	Fabric improvements in Public Buildings	-296

Table 2: Edinburgh's Top Ten Most Cost-Effective Emission Reduction Options

Rank	Measure	Emissions Reduction Potential (ktCO2e)
1	Shift from Petrol-Car to Pedestrian & Bicycle Journeys	8,154
2	Insulating Domestic Buildings	7,376
3	Shift from Diesel Car to Pedestrian & Bicycle Journeys	5,954
4	Shift from Petrol Car to HEV/EV Journeys	5,224
5	Shift from Petrol Car to Electric Bus Journeys	3,109
6	Shift from Petrol Car to Diesel Bus Journeys	2,533
7	Shift from Petrol Car to Hybrid Journeys	2,407
8	Electrical appliance upgrades in Domestic Buildings	1,501
9	Shift from Diesel Car Journeys to Diesel Bus	1,433
10	Installing Heat Pumps in Domestic Buildings	1,351

Table 3: Edinburgh's Top Ten Most Carbon-Effective Emission Reduction Options

AGGREGATING UP: THE BIGGER PICTURE FOR EDINBURGH

Some of the ideas for innovative options identified elsewhere, that could also be considered for Edinburgh, include targeting a full transition to net-zero homes and public/commercial buildings by 2030, promoting the rapid acceleration of active travel (e.g. walking and cycling), tackling food waste, reducing meat and dairy consumption and reducing concrete and steel consumption/promoting adoption of green infrastructure. These are highlighted at the end of our report (“Innovative Stretch Measures for Edinburgh”).

c) Investment needs, paybacks and employment creation

Exploiting the cost-effective options in households, public and commercial buildings, transport, industry and waste could be economically beneficial. Although such measures would require investments of £4.01 billion over their lifetimes (equating to investments of £401m a year across all organisations and households in the city for the next decade), once adopted they would reduce Edinburgh’s total energy bill by £553 million p.a. in 2030 whilst also creating 11,790 years of employment (596 full-time jobs for the next 20 years).

By expanding this portfolio of measures to at no net cost to Edinburgh’s economy (the Cost-Neutral scenario), investments of £7.59 billion over their lifetimes (or £759m a year for the next decade) would generate 18,235 years of employment (911 full-time jobs for the next 20 years) whilst reducing Edinburgh’s emissions by nearly two-thirds on 2030 levels.

Exploiting all technically viable options would be more expensive (at least at current prices, £8.21 billion or £821m a year for the next decade) but realise further emissions savings – eliminating 65% of the projected shortfall in Edinburgh’s 2030 emissions, whilst saving hundreds of millions of pounds on an annual basis.

		2025	2030	2035	2040	2045	2050
Cumulative Investment (£M)	**CE**	2,658	3,976	4,001	4,013	4,013	4,013
	CN	4,774	7,492	7,523	7,591	7,591	7,591
	TP	5,128	8,135	8,200	8,207	8,207	8,207
Annual Energy Expenditure Savings (£M)	**CE**	335	553	681	770	728	550
	CN	356	535	661	769	722	523
	TP	370	597	708	777	743	458

Table 4: Potential Five-Year Investments and Energy Expenditure Savings

Sector	Scenario	Investment (£M)
Domestic	**CE**	833
	CN	1,789
	TP	1,875
Public & Commercial	**CE**	868
	CN	1,781
	TP	1,799
Industry	**CE**	1,345
	CN	2,350
	TP	2,862
Transport	**CE**	966
	CN	1,671
	TP	1,671

Table 5: Potential Investments by Sector & Economic Scenario

		Total	Domestic	Industry	Transport	Public & Commercial
Years of Employment	**CE**	11,790	1,782	4,602	1,322	4,083
	CN	18,235	3,826	8,040	2,287	4,083
	TP	24,542	4,010	9,793	2,287	8,463
Jobs (20-year Period)	**CE**	590	89	230	66	204
	CN	1,147	191	402	114	419
	TP	1,228	200	490	114	423

Table 6: Potential Job Creation by Sector & Economic Scenario

DEVELOPING TARGETS AND PERFORMANCE INDICATORS

To give an indication of the levels of activity required to deliver on these broader targets, the tables below detail total deployment across different sectors in Edinburgh through to 2050. We also give an indication of the rate of deployment required in the city if it is to even come close to its climate targets. These lists are not exhaustive, and also apply by measure; any one building or industrial facility will usually require the application of several measures over the period. These figures effectively become Key Performance Indicators (KPIs) for the delivery of climate action across the city.

Domestic Homes

Measure	Total Homes Applied	Mean Annual Rate of Installation (homes)
Upgraded Cold/Wet Appliances	87,446	4,858
Cavity wall Insulation	73,909	4,106
Draughtproofing & Fabric Improvements	13,240	736
Floor Insulation	109,956	6,109
Gas Boiler Installation Upgrades	80,392	4,466
Heat Pumps	123,796	6,878
Loft Insulation	40,665	2,259
Low Energy Lighting	156,627	8,701
Solar PV	158,595	8,811
Tank Thermostats & Insulation	27,377	1,521
Glazing Upgrades	31,467	1,748
Heating Controls & TRV	50,898	2,828

Table 7 (a): Edinburgh's Sectoral Emissions Reduction KPIs for Domestic Homes

Public & Commercial Buildings

Measure	Floorspace Applied (m2)	Mean Annual Rate of Installation (m2)
High Efficiency Boiler Upgrades	1,184,827	65,824
Air Source Heat Pumps	1,775,042	98,613
Air Tightness & Fabric Improvements	879,131	48,841
Daylight Sensing Systems	3,528,449	196,025
Heating Controls & Timers	1,642,197	91,233
LED Lighting Upgrades	1,491,656	82,870
Movement Sensing (PIR)	6,101,924	338,996
T5 Lighting (Conversions)	2,510,160	139,453
T5 Lighting (New Installations)	1,159,372	64,410

Table 7 (b): Edinburgh's Sectoral Emissions Reduction KPIs for Public and Commercial Buildings

Transport

Measure	Deployment
High Quality Protected Cycling Highways Built	5 kilometres
Additional Electric Buses Procured and In Service	103 per annum
Increase in Public Transport Ridership	7 million trips per annum
Additional EVs Replacing Conventional Private Cars	7,861 per annum

Table 7 (c): Edinburgh's Sectoral Emissions Reduction KPIs for Transport

FOCUSING ON KEY SECTORS IN EDINBURGH

At full deployment (technical potential) across Edinburgh, we calculate that there is potential to avoid 10.9 MtCO2e in emissions that will otherwise be produced in the city between 2020 to 2030. The transport sector will contribute most significantly toward this total, with a decarbonisation potential of between 2.8 MtCO2e (cost-effective scenario) and 2.7 MtCO2e (technical potential) in the period. However, domestic housing , industry and public and commercial buildings also play a major role; upgrading and retrofitting of Edinburgh's built environment (including the domestic, public and commercial sectors) could reduce emissions by up to c.5.6 MtCO2e over the same period at full technical potential, with industry similarly showing the potential to decarbonise nearly 2.4 MtCO2e under the same conditions.

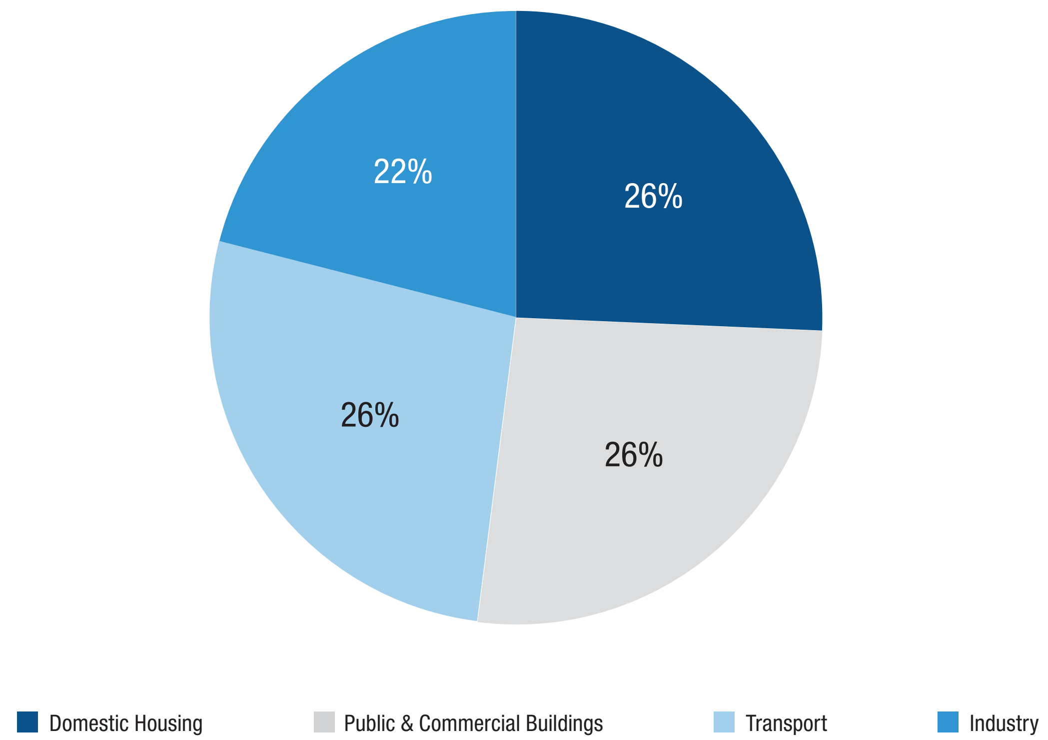


Figure 7: Edinburgh's Emissions Reduction Potential (2020-2030) by Sector

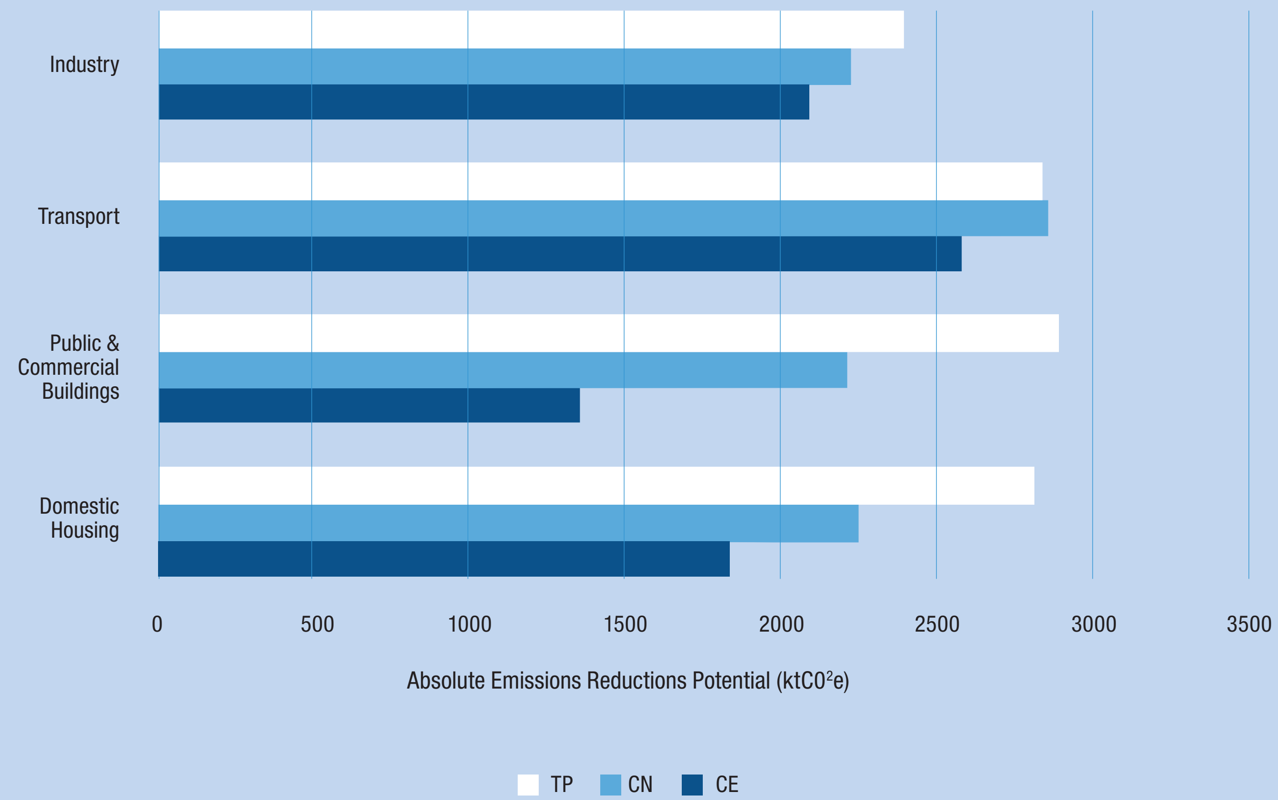


Figure 8: Edinburgh's Emissions Reduction Potential By Sector & Economic Scenario (2020-2030)

FOCUSING ON KEY SECTORS IN EDINBURGH

In the following section, summaries of the emissions reduction potential and economic implications of investment are presented for the four main sectors this analysis.

For display and continuity purposes, each sector is displayed with a summary of the same metrics:

(1) Emissions reduction potential over time in the three economic scenarios
(2) Five-year totals for cumulative emissions savings, investment requirements and annual energy expenditure reductions
(3) A simplified table of the most cost-effective low carbon measures applied in each sector across Edinburgh.

7(a). Housing

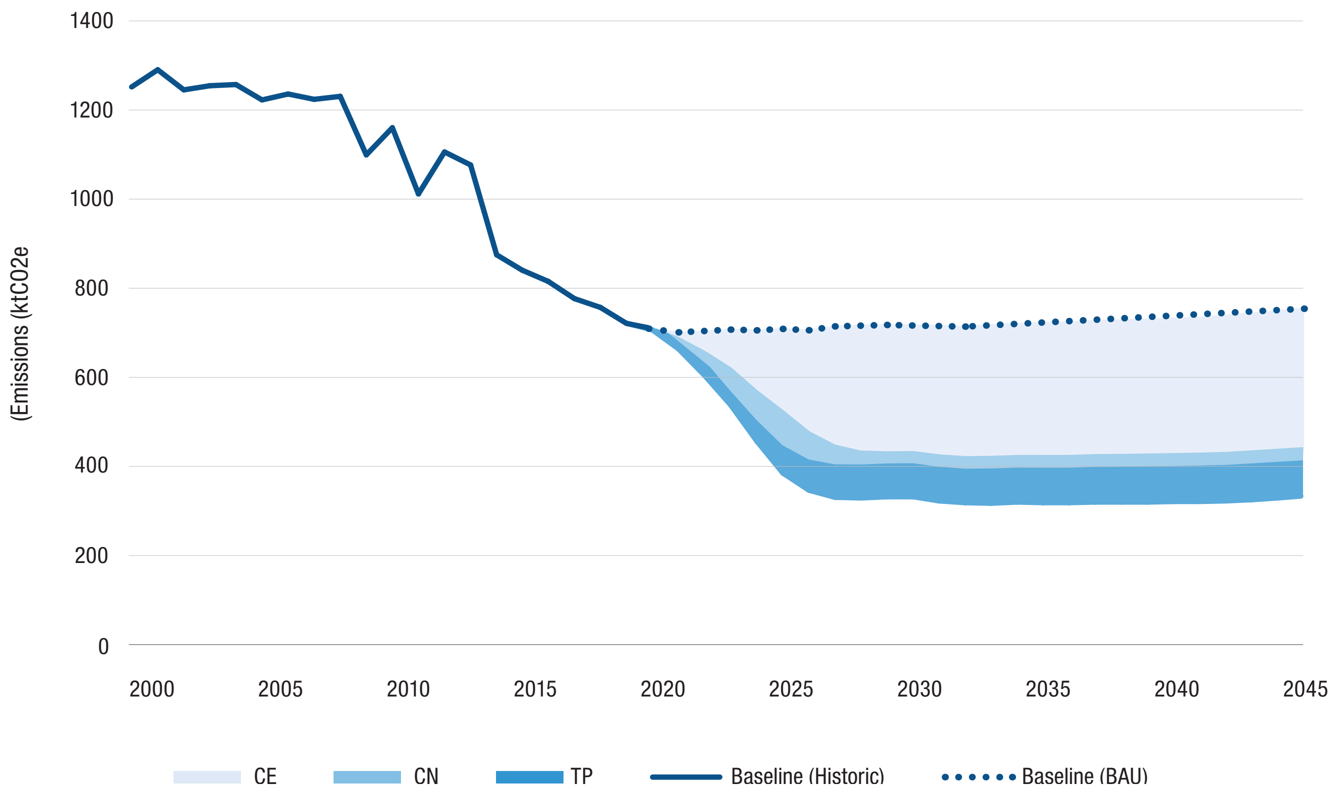


Figure 9: Housing BAU Baseline with Cost-Effective, Cost-Neutral and Technical Potential Scenarios

		2025	2030	2035	2040	2045	2050
Emissions Reductions (ktCO2e)	**CE**	477	1,838	3,384	4,846	6,405	7,999
	CN	710	2,237	3,836	5,475	7,153	8,869
	TP	887	2,796	4,796	6,844	8,941	11,086
Annual Energy Expenditure Savings (£M)	**CE**	91	136	179	206	206	211
	CN	89	114	149	190	184	179
	TP	95	154	185	201	190	104
Cumulative Investment (£M)	**CE**	591	821	833	833	833	833
	CN	1,168	1,750	1,789	1,789	1,789	1,789
	TP	1,180	1,856	1,875	1,875	1,875	1,875

Table 8: Housing Emissions Reductions, Expenditure Savings and Investment Levels

Rank	Measure	Cost Effectiveness (£/tCO2e)
1	Appliance Upgrades	-152
2	Lighting Improvements	-151
3	Electricity Demand Reduction	-120
4	Insulating (Various Forms)	-111
5	Draught-Proofing	-99
6	Installing Heat Pumps	-81
7	Glazing Improvements	-80
8	Upgraded Heating Controls	-61
9	Installing Biomass Boilers	-43
10	Solar Thermal Devices	-32

Table 9: The Most Cost-Effective Measures for Housing

FOCUSING ON KEY SECTORS IN EDINBURGH

7(b). Public & Commercial Buildings

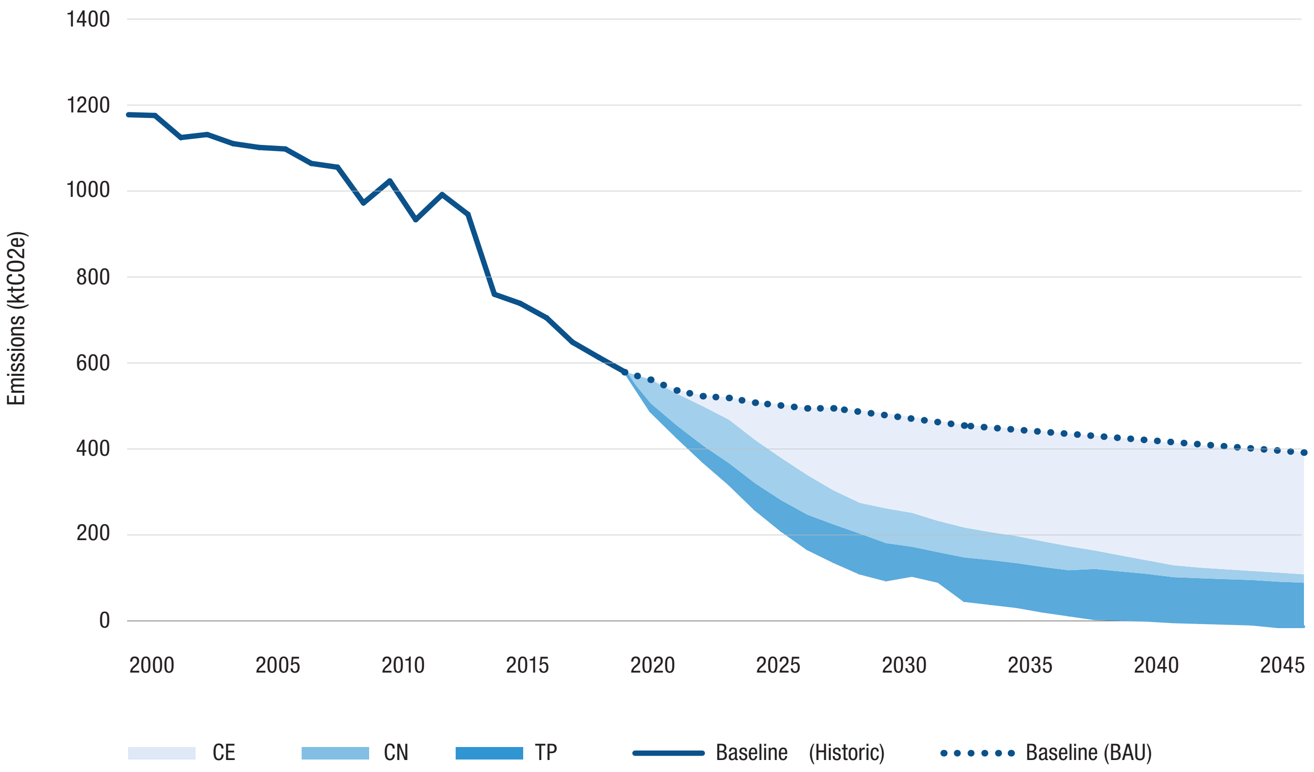


Figure 10: Public and Commercial Buildings BAU Baseline with Cost-Effective, Cost-Neutral and Technical Potential Scenarios

		2025	2030	2035	2040	2045	2050
Emissions Reductions (ktCO2e)	**CE**	302	1,310	2,533	3,898	5,320	6,742
	CN	822	2,232	3,784	5,343	6,875	8,395
	TP	1,079	2,893	4,912	7,008	9,045	10,879
Annual Energy Expenditure Savings (£M)	**CE**	77	145	172	193	182	154
	CN	85	129	159	184	172	144
	TP	91	149	168	177	184	155
Cumulative Investment (£M)	**CE**	582	859	868	868	868	868
	CN	1,097	1,755	1,781	1,781	1,781	1,781
	TP	1,132	1,780	1,799	1,799	1,799	1,799

Table 10: Public and Commercial Buildings Emissions Reductions, Expenditure Savings and Investment Levels

Rank	Measure	Cost Effectiveness (£/tCO2e)
1	Fabric & Window improvements in Public Buildings	-301
2	Improved cooling & ventilation in Retail Buildings	-271
3	Improved cooling systems in Office Buildings	-148
4	Fixed lighting and light improvements in Public Buildings	-137
5	Fixed lighting and window improvements in Retail Buildings	-124
6	Heating system improvements in Public Buildings	-84
7	Improved cooling in Public Buildings	-84
8	Heating improvements in Office Buildings	-64
9	Lighting improvements in Office Buildings	-62
10	Heating improvements in Retail Buildings	-38

Table 11: The Most Cost-Effective Measures for Public and Commercial Buildings

FOCUSING ON KEY SECTORS IN EDINBURGH

7(c). Transport

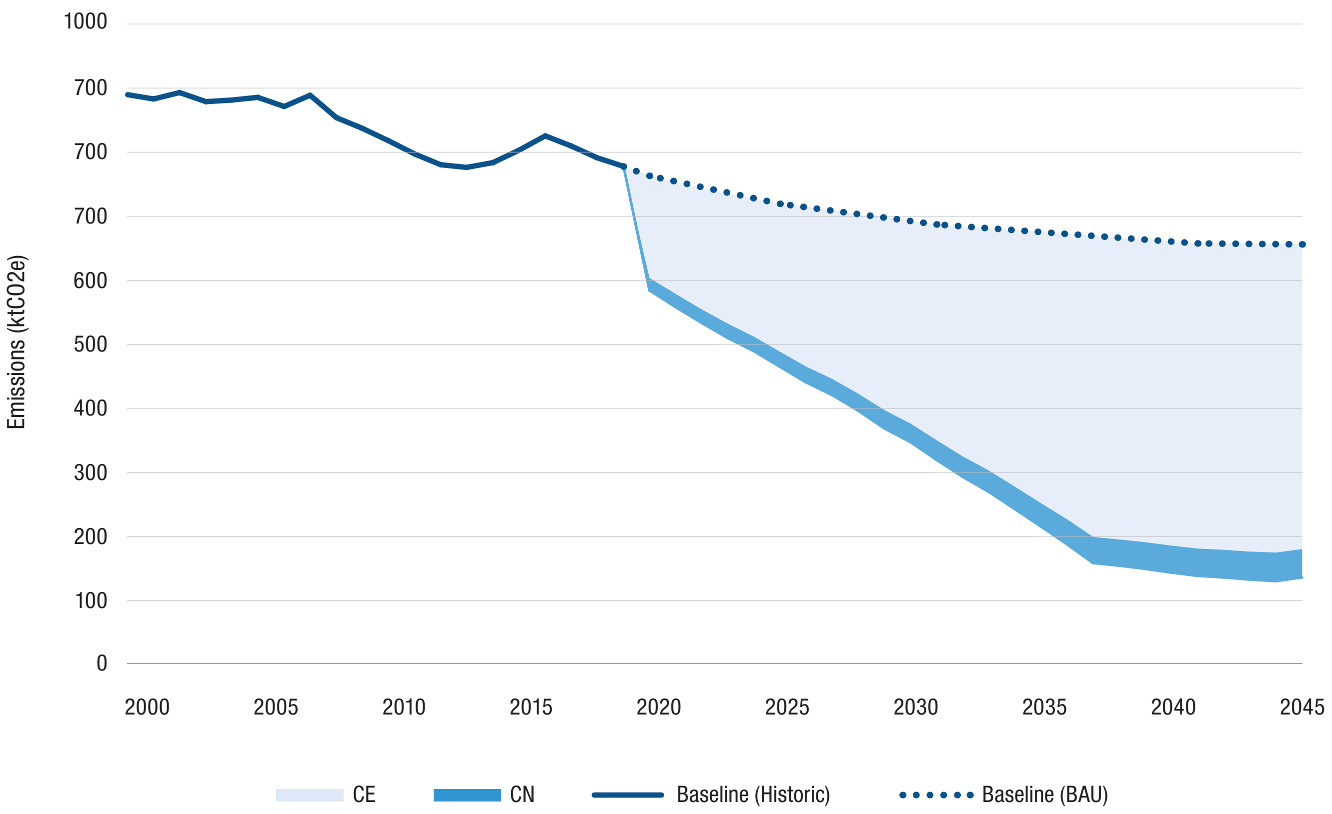


Figure 11: Transport BAU Baseline with Cost-Effective and Cost-Neutral Scenarios[3]

		2025	2030	2035	2040	2045	2050
Emissions Reductions (ktCO2e)	**CE**	1,170	2,577	4,471	6,801	9,188	11,446
	CN	1,299	2,839	4,900	7,432	10,037	12,515
	TP	1,299	2,839	4,900	7,432	10,037	12,515
Annual Energy Expenditure Savings (£M)	**CE**	87	121	159	194	189	184
	CN	96	131	172	207	204	199
	TP	96	131	172	207	204	199
Cumulative Investment (£M)	**CE**	678	951	966	966	966	966
	CN	1,100	1,636	1,671	1,671	1,671	1,671
	TP	1,100	1,636	1,671	1,671	1,671	1,671

Table 12: Transport Emissions Reductions, Expenditure Savings and Investment Levels

Rank	Measure	Cost Effectiveness (£/tCO2e)
1	Shift from Diesel Car to Diesel Bus journeys	-458
2	Shift from Diesel Car to Bicycle journeys	-345
3	Shift from Petrol Car to Pedestrian journeys	-323
4	Shift from Diesel Car to HEV journeys	-136
5	Shift from Petrol Car to Electric Bus journeys	-129

Table 13: The Most Cost-Effective Measures for Transport

[3] Due to the high inherent cost effectiveness of many transport modal-shift options, the TP scenario has been removed and emissions pathways are covered by CE and CN only.

FOCUSING ON KEY SECTORS IN EDINBURGH

7(d). Industry

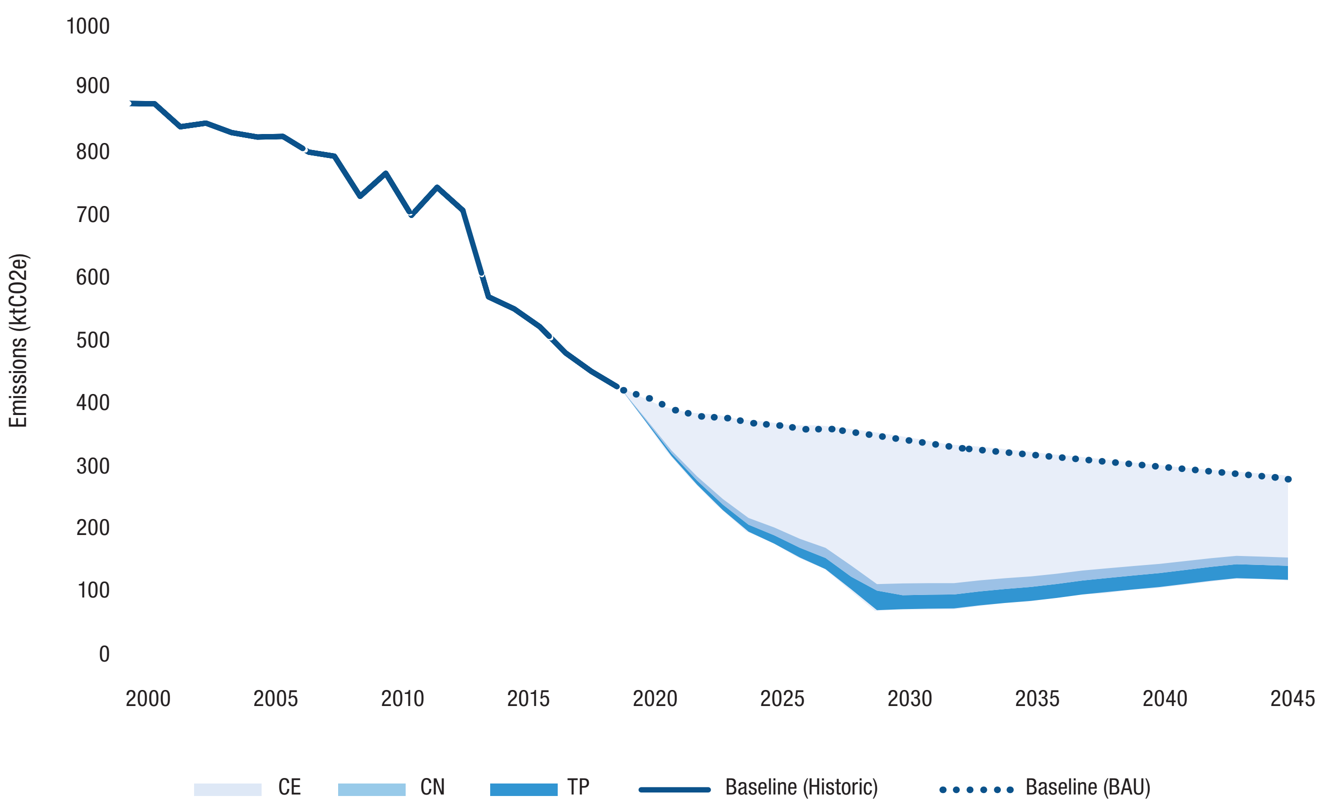


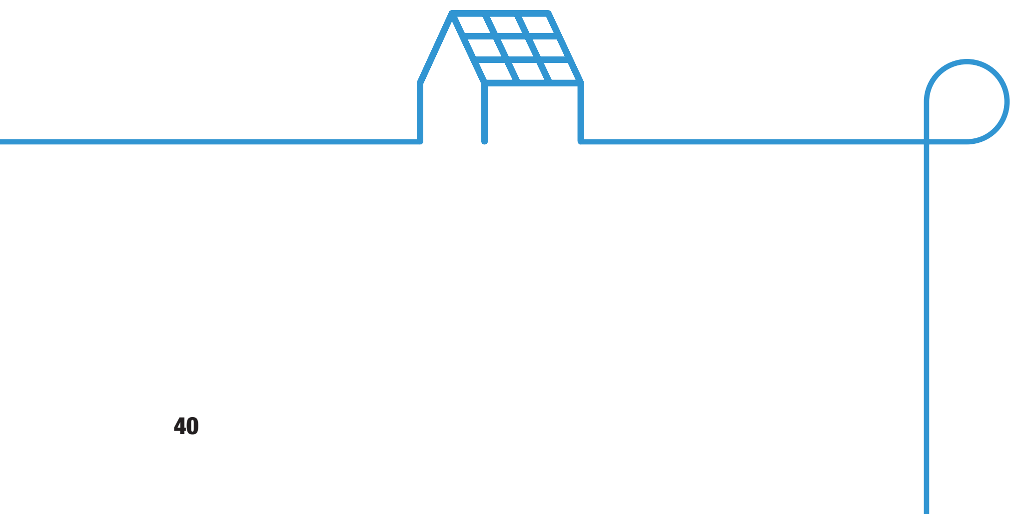
Figure 12: Industry BAU Baseline with Cost-Effective, Cost-Neutral and Technical Potential Scenarios

		2025	2030	2035	2040	2045	2050
Emissions Reductions (ktCO2e)	**CE**	737	2,126	3,528	4,728	5,747	6,332
	CN	782	2,250	3,741	5,019	6,107	6,732
	TP	830	2,405	4,009	5,400	6,601	7,293
Annual Energy Expenditure Savings (£M)	**CE**	81	152	171	177	151	86
	CN	86	161	181	188	162	93
	TP	87	163	184	191	166	95
Cumulative Investment (£M)	**CE**	807	1,345	1,345	1,345	1,345	1,345
	CN	1,410	2,350	2,350	2,350	2,350	2,350
	TP	1,717	2,862	2,862	2,862	2,862	2,862

Table 14: Industry Emissions Reductions, Expenditure Savings and Investment Levels

Rank	Measure[4]	Cost Effectiveness (£/tCO2e)
1	Furnace and heater improvements in Industry	-11
2	Upgraded boilers and steam-piping in Industry	-3
3	Improvements to Fans in Industry	2
4	Upgrades to motor-driven and pumping equipment in Industry	3
5	Upgraded Compression Systems in Industry	5
6	Upgraded Cooling Mechanisms in Industry	7

Table 15: The Most Cost-Effective Measures for Industry



[4] For display purposes interventions in industry have been aggregated here into process type.

INNOVATIVE STRETCH MEASURES FOR EDINBURGH

Even with full delivery of the broad programme of cross-sectoral, city-wide low carbon investment described above, there remains an emissions shortfall of 35% between Edinburgh's 2030 BAU baseline and the net-zero target. Here we briefly consider the productivity of certain interventions (set out in Table 16 below) that may well be able to plug this gap into the future. Many of these so-called "stretch options" are innovative by nature but they will be required to reach Edinburgh's targets in future.

		2025	2030	2035
Annual Emissions Reduction Potential (ktCO2e)	Zero Carbon Heavy Goods Transport	26	462	1,117
	Industrial Heating and Cooling Electrification	9	63	74
	11.6k Ha. Reforested Annually 2020-29*	620	1,598	1963
	Electrification of Domestic Heating	16	286	832
	Electrification of Domestic Cooking	5	95	277
	Electrification of Commercial/Public Heating	11	136	238

Table 16: Decarbonising Potential of Stretch Measures (* Sequestration Values)

Figure 13 below shows the impact that the adoption of these stretch measures would have on Edinburgh's carbon emissions. The blue dotted line shows emissions after adoption of all technically viable options and the stacked areas of colour show the remaining emissions after innovative stretch measures but without tree planting. For illustration, the grey dotted line shows that, in theory, Edinburgh could offset its residual emissions through a UK based tree planting scheme; however this would require the planting of 517 million trees, which, even with the densest possible planting, would require 116,306 hectares of land, equivalent to an area of 441% of the total land area of the city.

Carbon emissions could be cut further still through with the adoption of behavioural and consumption-based changes such as the promotion of active travel (e.g. walking and cycling), reductions in meat and dairy consumption and the generation of food waste, and reduced consumption of concrete and steel with more emphasis on green infrastructure. Such consumption-based changes – which would impact on the broader Scope 3 carbon footprint of the city – will be the focus of future work.

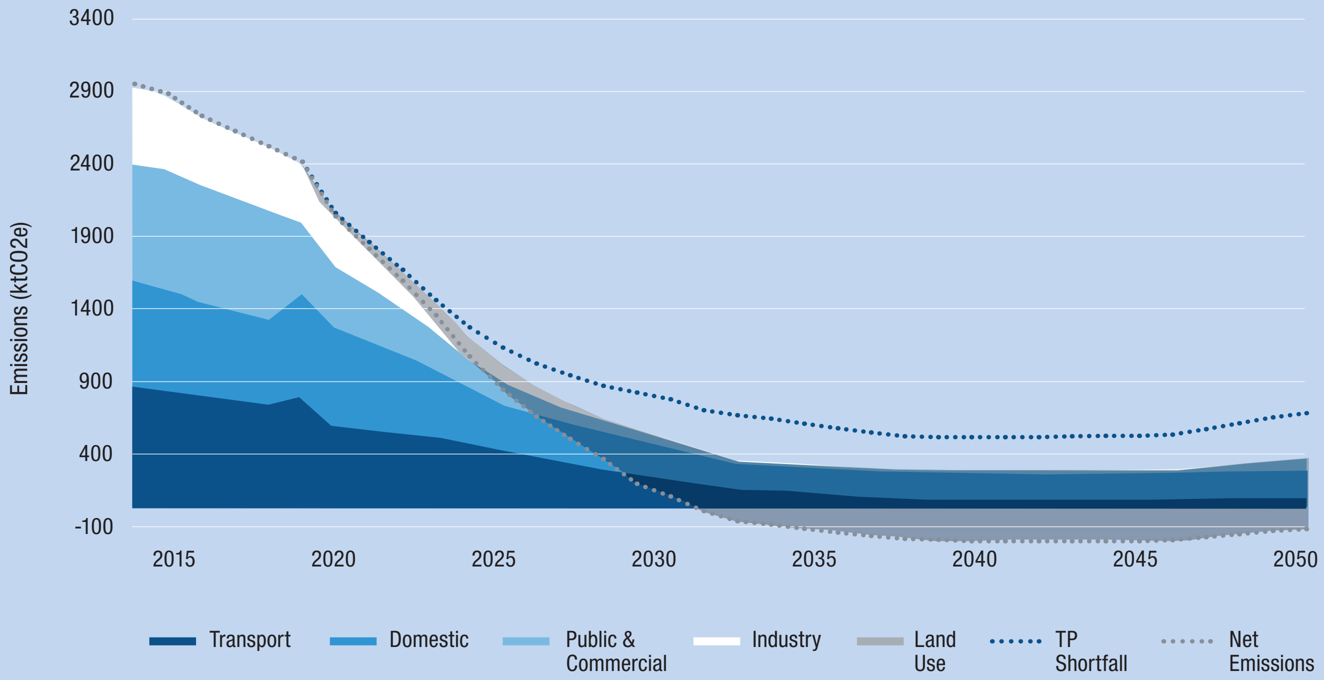


Figure 13: Sectoral Emissions Shortfall Reduction with Stretch Measures

NEXT STEPS FOR EDINBURGH

Based on the analysis presented here, we recommend that if Edinburgh wants to stay within its share of the global carbon budget, it needs to adopt a clear and ambitious climate action plan.

The case for the adoption of such a plan is supported by the evidence that much – but not all – of the action that is required can be based on the exploitation of win-win low carbon options that will simultaneously improve economic, social and health outcomes acrossthe city.

A climate action plan for Edinburgh should adopt science-based targets for emissions reduction, including both longer term targets and five-yearly carbon reduction targets.

The action plan should focus initially on Edinburgh's direct (Scope 1 and 2) carbon footprint as these emissions are most directly under the city's influence, but in time it should also widen its scope to consider its broader (Scope 3) carbon footprint.

The action plan should clearly set out the ways in which Edinburgh will work towards achieving these targets, drawing on the deployment KPIs listed in this report. Action should also be taken to monitor and report progress on emissions reductions.

It is important to stress that delivering on these targets will require action across the city and the active support of the public, private and third sectors. The establishment of an independent Edinburgh Climate Commission is helping to draw actors together and to build capacities to take and track action.

The Edinburgh Climate Commission has been set up to act as a critical friend to the city, helping to promote stakeholder engagement, build buy-in and create a sense of common ownership of the climate challenge, and to support, guide and track progress towards climate targets.

With the support of the Commission, cross-sectoral leadership groups should be formed for key sectors such as homes, public and commercial buildings, transport and industry, with clear plans for the delivery of priority actions in each sector. All large organisations and businesses in the city should be asked to match the broader carbon reduction commitments made by the city as a whole and to report back on progress.

APPENDIX 1. LEAGUE TABLE OF THE MOST CARBON-EFFECTIVE OPTIONS FOR EDINBURGH

Measure	Emissions Reduction Potential (ktCO2e)
Insulating Domestic buildings	4292
Condensing & Insulation Measures to Boilers & Steam Piping in Industry	2516
Petrol Car to Walk	2373
Petrol Car to Bicycle	2373
Petrol Car to Bus (electric)	1809
Diesel Car to Bicycle	1732
Diesel Car to Walk	1732
Improving Efficiency of Boilers and Steam Piping in Industry	1652
Petrol Car to EV	1639
Petrol Car to Bus (diesel)	1474
Petrol Car to Plug-in hybrid	1401
Petrol Car to Hybrid	1401
Diesel Car to EV	1381
Upgraded heating controls in Domestic buildings	1328
Diesel Car to Bus (electric)	1272
Diesel Car to Plug-in hybrid	1030
Hybrid Car to EV	896
Electrical appliance upgrades in Domestic buildings	874
Diesel Car to Bus (diesel)	834
Installing heat pumps in Domestic buildings	786
Pump Upgrades, Repairs and Maintenance in Industry	768
Fabric improvements in Public buildings	621
Plug-in hybrid Car to EV	589
Fabric improvements in Retail buildings	580
Upgraded boilers in Domestic buildings	564
Fan Correction, Repairs, & Upgrades in Industry	528
Electricity demand reduction in Domestic buildings	523
Installing solar PV in Domestic Buildings	513
Compressed Air Systems in Industry	511
Compressors and Variable Speed Systems in Industry	402

Measure	Emissions Reduction Potential (ktCO2e)
Furnace Efficiency and Heat Recovery Mechanisms in Industry	318
Installing air source heat pumps in Office buildings	259
Diesel Car to Hybrid	246
Heating improvements in Public buildings	227
Lighting improvements in Domestic buildings	227
Draught-proofing in Domestic buildings	203
Solar thermal devices in Public buildings	172
Improved lighting controls and sensors in Public buildings	158
Lighting improvements in Office buildings	147
Installing biomass boilers in Domestic buildings	140
Solar thermal devices in Retail buildings	130
Improved cooling in Office buildings	128
Upgrading heating controls in Office buildings	127
Wind microgeneration associated with Public buildings	126
Refrigeration Efficiency and Technical Upgrades in Industry	124
Glazing improvements in Domestic buildings	110
Improved lighting controls and sensors in Retail buildings	108
Solar thermal devices in Domestic buildings	104
Improved lighting controls and sensors in Office buildings	92
Heating improvements in Retail buildings	82
Lighting improvements in Public buildings	82
TOTAL	**41773**

APPENDIX 2. LEAGUE TABLE OF THE MOST COST-EFFECTIVE OPTIONS FOR EDINBURGH

Measure	Cost Effectiveness (£/tCO2e)
Compressed Air Systems in Industry	-528
Pump Upgrades, Repairs and Maintenance in Industry	-484
Diesel Car to Bus (diesel)	-458
Fabric improvements in Retail buildings	-408
Petrol Car to Bus (diesel)	-373
Diesel Car to Bicycle	-345
Diesel Car to Walk	-345
Petrol Car to Walk	-323
Petrol Car to Bicycle	-323
Fan Correction, Repairs, & Upgrades in Industry	-311
Fabric improvements in Public buildings	-296
Improved cooling in Retail buildings	-267
Compressors and Variable Speed Systems in Industry	-247
Petrol Car to Plug-in hybrid	-214
Electrical appliance upgrades in Domestic buildings	-170
Lighting improvements in Domestic buildings	-159
Lighting improvements in Public buildings	-150
Improved cooling in Office buildings	-145
Diesel Car to Plug-in hybrid	-136
Petrol Car to EV	-133
Lighting improvements in Retail buildings	-130
Petrol Car to Bus (electric)	-129
Petrol Car to Hybrid	-114
Heating improvements in Public buildings	-93
Electricity demand reduction in Domestic buildings	-92
Improved cooling in Public buildings	-84
Heating improvements in Office buildings	-65
Improving Efficiency of Boilers and Steam Piping in Industry	-65
Lighting improvements in Office buildings	-64
Diesel Car to Bus (electric)	-63
Insulating Domestic buildings	-62
Heating improvements in Retail buildings	-43
Diesel Car to EV	-41
Draught-proofing in Domestic buildings	-39
Installing heat pumps in Domestic buildings	-29
Fabric improvements in Office buildings	-28
Glazing improvements in Domestic buildings	-28
Upgraded heating controls in Domestic buildings	-26
Installing biomass boilers in Domestic buildings	-19
Upgrading heating controls in Office buildings	-19
Solar thermal devices in Domestic buildings	-13
Upgraded heating controls in Public buildings	-13
Diesel Car to Hybrid	-12
Upgraded boilers in Domestic buildings	-9
Upgraded heating controls in Retail buildings	-6
Installing air source heat pumps in Retail buildings	-1
Installing solar PV in Domestic Buildings	3
Hybrid Car to EV	3
Installing air source heat pumps in Public buildings	8
Refrigeration Efficiency and Technical Upgrades in Industry	17
Solar thermal devices in Retail buildings	20
Improved lighting controls and sensors in Retail buildings	32
Installing air source heat pumps in Office buildings	33

PLACE-BASED CLIMATE ACTION NETWORK (PCAN)

The Place-based Climate Action Network (PCAN) is about translating climate policy into action "on the ground" in our communities. The network commenced in January 2019 with the aim of establishing an agile, effective and sustainable network for climate action embedded in localities and based around partnerships with local authorities. Its objective is to build broader capacity to effect transformative change.

PCAN is an ESRC-supported network that brings together the research community and decision-makers in the public, private and third sectors. It consists of five innovative platforms to facilitate two-way, multi-level engagement between researchers and stakeholders: three city-based climate commissions (in Leeds, Belfast and Edinburgh) and two theme-based platforms on adaptation and finance, with a business theme integrated into each climate commission.

Our vision is for PCAN to produce a replicable model that delivers climate policies on a global to local scale, facilitating and inspiring places across the UK, and this has started to take off: alongside the original PCAN climate commissions we are delighted to support new commissions that have established in places such as Lincoln, Surrey and Croydon, with ever more new commissions coming on stream across the UK.

The five-year project is led by an experienced team of researchers with strong track records of engaging with public, private and third-sector decision-makers. PCAN builds on the policy connections, networking capacity and research strengths of its host institutions: Queen's University Belfast, the University of Edinburgh, the University of Leeds and the London School of Economics and Political Science.

For more information, go to **https://pcancities.org.uk** or contact **pcan@lse.ac.uk**

A NET-ZERO CARBON ROADMAP FOR EDINBURGH

PARTNERSHIPS

UKRI Economic and Social Research Council

PCAN PLACE-BASED CLIMATE ACTION NETWORK

THE UNIVERSITY of EDINBURGH

UNIVERSITY OF LEEDS

QUEEN'S UNIVERSITY BELFAST

LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

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PLACE-BASED CLIMATE ACTION NETWORK

Published November 2020