# ENERGY AND CARBON MASTERPLAN

SUSTAINABLE GLASGOW


# Acknowledgements

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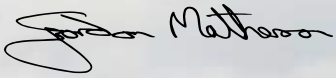
# Foreword

Glasgow is a city of transformation. From the birth of the industrial revolution and the heavy industry associated with the workshop of the world, to its cultural reinvention in the 1990s, Glasgow has never stood still. And now it is taking part in the most important transformation in its history – to become one of the most sustainable cities in Europe.
We want to share this transformative journey, to share our experiences, our learning and our expertise with others across the world, and in turn learn from them.
Glasgow has a massive opportunity to become a low-carbon hub – growing our economy and prosperity while being sustainable are two sides of the same coin. Carbon is the new currency for Glasgow. Sustainability isn't just theory for Glasgow, it has to deliver for our people and it has to make life better for our most vulnerable citizens and communities and it has to provide good quality jobs.

The Commonwealth Games of 2014 is an excellent example of Glasgow's transformation especially in the East End. Here the Games Athletes Village site has become a new, state-of-the-art, energy efficient housing development and new care home – all heated by a new and innovative Combined Heat and Power district heating system – on former industrial land next to the Clyde. This would never have happened without the Games or the stimulus of public sector money that the event brought to transform this site. The Legacy of the Games is not only therefore in the huge sporting and cultural achievements that it brought about for Glasgow but in the physical developments – such as the Athletes Village – that demonstrate the type of development that Glasgow can now achieve in the city: low carbon, highly energy efficient, well-designed and attractive housing with very low heating bills. Indeed, Glasgow is now being recognised as a national and international leader in sustainability and smart city living thanks to our participation in projects such as the STEP UP project and the TSB Future Cities Demonstrator. Glasgow is seen as a city that wants to play its part in ensuring that we meet our national, UK-wide and European carbon emission targets by delivering on our own 30% carbon reduction target. However, Glasgow also has a special responsibility to demonstrate how former former industrial cities can re-invent themselves and – learning lessons from our own past industrialisation – develop a new model for a sustainable energy based on new, renewable sources of energy and decentralised, integrated and smart energy and heating systems.

So I am pleased to introduce this Energy and Carbon Masterplan - which comes out of our participation in the STEP UP European energy planning project – produced in partnership with University of Strathclyde, Scottish Power Energy Networks and the Sustainable Glasgow initiative. It is a blueprint for what Glasgow wants to achieve in the future: A great city that is now taking its place amongst the smart and sustainable cities in Europe and across the world.



Gordon Matheson
Leader of Glasgow City Council

# Executive Summary

The Energy and Carbon Masterplan (ECM) sets out a vision of a transformed energy economy for Glasgow that is based on low carbon and increasingly de-centralised energy sources that are better able to meet Glasgow's energy needs and help Glasgow tackle climate change. The ECM builds and extends the current collaborative working arrangements on energy and sustainability in the city through the work of the Sustainable Glasgow initiative and is a key strategy in helping deliver Glasgow's aspirations to become one of Europe's most sustainable cities.

Glasgow's current energy needs are met largely through fossil fuels such as coal, oil and natural gas. This is because Glasgow imports the vast majority of its energy from beyond its boundaries through the national electricity and gas grid systems. In order to meet Glasgow's vision of a low carbon future, Glasgow needs to generate more of the electricity consumed locally from low and zero carbon sources, and look at other ways of heating homes - which accounts for over half of the energy consumed in the city. By looking at the city as a whole, energy systems can be designed so that they support each other, technically and financially, while meeting Glasgow's requirements for growth and supporting the needs of its communities.

Glasgow's energy consumption attributed to buildings (domestic, commercial, industry) and transport has reduced from 13,456 GWh/yr in 2006 to 11,528 GWh/yr in 2012 - a drop of 14.3%. However, Glasgow's energy use remains similar to 2006, mainly in the consumption of fossil fuels for transport, gas and electricity for buildings (used to light and heat its buildings, facilities and properties). The main sources of energy consumption in Glasgow for 2012 are from natural gas (48%) followed by electricity (25%) and petroleum products (27%). The main sectors using energy in Glasgow are the industrial and commercial sector (40%) and the domestic sector (35%). Road transport accounts for 25% of energy use.

The total $CO_2$ emissions produced in Glasgow in 2006 were 4,094,327 tCO2. This decreased to 3,563,624 $tCO_2$ in 2012 which is equivalent to 530,702 $tCO_2$, representing a 13% reduction. The main sector accounting for carbon dioxide emissions is buildings, which in 2012 accounted for 77% of emissions, comprising industry/commercial sector emissions (43% of the total) and domestic emissions (34% of the total). The transport sector also accounts for around 22% of Glasgow's total $CO_2$ emissions. Glasgow still needs to reduce its $CO_2$ emissions by 657,596 tonnes to meet the 30% reduction target, meaning there is a significant challenge to meet over the next five years.

It is possible that without action, Glasgow's carbon emissions would continue to rise or at least would not fall enough to meet the 30% $CO_2$ reduction target. A gap analysis on the existing Sustainable Energy Action Plan (SEAP) submitted in November 2010 showed that this is likely to be the case. With the additional impact that a reviving economy might bring, this means that Glasgow needs additional actions to compensate for a rise in energy use and $CO_2$ emissions caused by economic growth. The ECM therefore presents a new set of interventions aiming to meet the 30% reduction target.

The main opportunities for Glasgow lie in reducing the total energy the city uses and ensuring that the city uses energy efficiently. Coupled with this, the city needs to increase the proportion of energy it consumes that is sourced from low carbon and renewable sources. This can be facilitated though the expansion of wind energy, solar photovoltaic, geothermal energy, and energy recovery from waste. Some of the main proposals set out in the Plan are:

- Development of a number of co-ordinated district heating schemes in the city – expanding out from installed schemes and covering a mixture of commercial and residential premises within specified zones identified in the Local Development Plan.
- Phasing out coal, oil and older inefficient electric heating in Glasgow City Council buildings and housing across the city.
- Seek to facilitate improved energy efficiency and energy management systems across all sectors but particularly in residential housing.
- Roll out of LED lighting across the city.
- Further expansion of waste to energy schemes including greater use of food waste and anaerobic digestion.
- Further promotion of the use of electric vehicles and cycling as a key mode of transport, replacing the use of petrol and diesel vehicles.
- Lowering the carbon intensity of electricity consumed in Glasgow by promoting further expansion of low and zero carbon energy generation in the city through large and small-scale schemes.
- Continued engagement of Glasgow's citizens, businesses, and public sector organisations in the delivery of the new energy system for Glasgow.

Implementation of the Energy and Carbon Masterplan will be co-ordinated through existing officer and member structures in Glasgow City Council and the Sustainable Glasgow Board. The Environment and Sustainability Policy Development Committee will be the primary co-ordinating body as far as the council is concerned and the Sustainable Glasgow Board will co-ordinate stakeholder involvement as far as the partnership in Glasgow is concerned.

Covenant of Mayors progress and implementation of SEAP actions will be incorporated into the work of the City Energy and Carbon Management teams of the council which will monitor future progress and ensure that the council and partners are working together to deliver comprehensively on the SEAP. The council is putting in place a dedicated City Energy and Carbon team that will co-ordinate the delivery of the ECM.

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# 1 Introduction

# 1.1 What is the Energy and Carbon Masterplan?

This Energy & Carbon Masterplan (ECM) is an enhanced Sustainable Energy Action Plan (SEAP) for Glasgow which builds on the first SEAP (the Sustainable Glasgow Report 2010[1]) produced by Glasgow City Council and approved by the EU Covenant of Mayors[2] (see box below) in November 2010. The ECM provides a single, coordinated strategy and plan of actions and projects across the city to meet a target of reducing Glasgow's carbon dioxide emissions by 30% by 2020 from 2006 levels.

The ECM sets out a vision of a transformed energy economy for Glasgow that is based on low carbon and increasingly de-centralised energy sources that are better able to meet Glasgow's energy needs and help Glasgow tackle climate change. For these reasons Glasgow's SEAP is termed the 'Energy and Carbon Masterplan' because it provides a blueprint for how the city will provide sustainable energy for the future and become more resilient as a result. The ECM builds and extends the current collaborative working arrangements on energy and sustainability in the city through the work of the Sustainable Glasgow initiative[3] (see box below) and is a key strategy in helping deliver Glasgow's aspirations to become one of Europe's most sustainable cities.

The key objectives of Glasgow's ECM are:

- To provide a strategic framework for the development of a transformed energy system for Glasgow that is based on low carbon and increasingly de-centralised energy sources as a contribution to making Glasgow one of the most sustainable cities in Europe.
- To provide a series of actions and projects that will enable Glasgow to meet its target of a 30% reduction in $CO_2$ emissions by 2020 as a contribution to meeting the EU's 2020 climate and energy targets.
- To contribute to social and economic objectives such as the provision of affordable warmth and increased economic growth in Glasgow.
- To build collaborative working arrangements that will enable all partners to contribute to the development of a sustainable energy economy in Glasgow.

## EU Covenant of Mayors and Sustainable Energy Action Plans (SEAPs)

The Covenant of Mayors is the mainstream European movement involving local and regional authorities who voluntarily commit to increase energy efficiency and use of renewable energy sources on their territories. One year after joining the Covenant of Mayors, signatory cities pledge to adopt a SEAP and report every two years on its implementation. A city's SEAP refers to action at a local level within the remit of the local authority. The SEAP concentrates on measures taken to reduce $CO_2$ emissions and energy consumption by all users.

The Covenant of Mayors suggests SEAPs should focus on the following key sectors: buildings, equipment/facilities (residential, municipal, tertiary) and urban transport. The SEAP should also refer to actions related to local electricity and heat generation including development or district heating networks. The SEAP should also refer to other areas where the local authority can influence energy use through the planning process, and endeavour to influence changes in consumption patterns through working alongside stakeholders and citizens.

1 Sustainable Glasgow report available at: www.glasgow.gov.uk/index.aspx?articleid=4016
2 Covenant of Mayors website: www.covenantofmayors.eu/
3 Sustainable Glasgow website: www.sustainableglasgow.org.uk

## 1.2 The Vision for Glasgow

Glasgow has always been at the vanguard of developments that have shaped the modern global economy – from trans-Atlantic trade to James Watt's enhancements to the steam engine which then powered the Industrial Revolution. The city will continue to innovate in the future, drawing on the lessons from its history: For example, from the 1850's Glasgow pioneered some of the first innovations in municipal ownership in utilities and public services including the Glasgow Corporation Electricity Department which generated and supplied electricity to the city and also powered the tramways until 1962.

The current leadership of Glasgow City Council has an equally ambitious vision for the city; to make Glasgow one of Europe's most sustainable cities by 2020. By improving the lifestyles and opportunities for Glasgow's people and businesses, Glasgow's image as a leader in sustainable urban living will be enhanced, ensuring that sustainability and the development of a vibrant and growing city economy go hand-in-hand.

This vision is backed by an extensive economic analysis of current global trends by the Glasgow Economic Commission[4]. The commission identified that climate change and the need for energy security will drive a shift towards cleaner and renewable energy sources for the city requiring 'a massive investment in new energy infrastructure in order to shift towards a low carbon economy'. This creates both the impetus and opportunity for transformational change.

The implementation of the vision will help deliver major investment; create long-term jobs, reduce fuel poverty; support the development of a new clean energy sector in the city; create new revenue streams for the public sector and communities, improve air quality; and help regenerate communities.

The vision is supported by the council's Strategic Plan 2012 to 2017[5] and sets out priorities for the next five years. Key priorities that relate to the ECM are:

- We will develop Glasgow as the most sustainable city in Europe and work in the longer term, over the next 20 years to deliver this.
- We will set up an Energy Trust[6] by 2014 to deliver new energy systems to the city. It will make sure Glasgow receives a fair share of revenues and funding locally and nationally to support green initiatives.
- We will ensure that Glasgow meets and exceeds its carbon emissions targets for 2020.
- We will deliver an Energy and Carbon Masterplan for Glasgow which will provide the framework for shifting to a low carbon city.
- We will provide new and sustainable district heating systems in Glasgow.

The council remains committed to achieving the 30% reduction in $CO_2$ emissions from 2006 levels that it set out in the initial SEAP of 2010. Through the new range of measures detailed in this plan it will be possible to close the emissions gap which would have resulted from the previous SEAP.

4 Glasgow Economic Commission Final Report 2013
5 Glasgow City Council, Strategic Plan 2012 to 2017. Glasgow City Council (2012). www.glasgow.gov.uk/CHttpHandler.ashx?id=14572&p=0
6 The 'EnergyTrust' is now being taken forward as the Energy Services Company (ESCo) for Glasgow

## Sustainable Glasgow initiative

Sustainable Glasgow is a city-wide partnership formed in 2010 to help Glasgow become one of the most sustainable cities in Europe. It brings together partners from higher education and the public and private sectors, to work with local people, communities and businesses. It aims to help the city reduce its carbon emissions by 30% by 2020 and build a greener and more sustainable future for Glaswegians. By engaging across a broad partnership base and working to a broad definition of sustainability, the partnership aims to understand and influence the key social, economic, environmental, commercial and behavioural factors underpinning a sustainable, smarter, resilient city.

# 1.3 Legislative Context

## International

The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. Under the auspices of the United Nations (UN) it reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide which is relevant to the understanding of climate change. The IPCC state in their latest Synthesis Report[7] that continued emissions of greenhouse gases will cause long-lasting changes in the climate.

The report states that global warming is projected to continue under all scenarios with global surface temperature change by the end of the 21st Century likely to exceed 1.5 degrees celsius, relative to 1850. It also highlights that each of the last three decades has been successively warmer at the Earth's surface, than any period since 1850, and probably warmer than any time in the past 1,400 years. A warming of the atmosphere and oceans, accompanied by sea-level rise, a strong decline in Arctic and Antarctic sea ice combined with increasingly frequent 'extreme' weather events including unseasonal rainfall, droughts and hurricanes is likely. This means that the need to act to reduce carbon emissions together with the need to adapt to changes already occurring is urgent. The IPCC states that most of the world's electricity can – and must – be produced from low carbon sources by 2050.

## European

Europe 2020 is the EU's 10-year growth and jobs strategy that was launched in 2010. It seeks to overcome the crisis from which EU economies are now gradually recovering but also addresses shortcomings of our growth model, creating the conditions for smart, sustainable and inclusive growth. Five headline targets have been set for the EU to achieve by the end of 2020: employment, research and development, climate/energy, education, social inclusion and poverty reduction.

The climate/energy targets for 2020 are:

- Greenhouse gas emissions 20% (or even 30%, if the conditions are right) lower than 1990.
- 20% of energy from renewables (quotas sharing this target between member states gave Britain the binding national target of 15%).
- 20% increase in energy efficiency.

The greenhouse gas emissions target is the driver for the Covenant of Mayors initiative and is the basis of Glasgow City Council's commitment to achieve a 30% reduction in $CO_2$ emissions by 2020.

The EU has recently agreed new targets for 2030 which are:

- Reduce greenhouse gas emissions by 40% by 2030 (from 1990 levels).
- Increase the share of renewable energy to at least 27%.
- An indicative target of an improvement in energy efficiency of 27%.

These targets will be transposed into national plans but may also be reflected by the EU Covenant of Mayors which has currently set targets for signatories to exceed a 20% reduction by 2020.

A new governance framework is also proposed alongside these targets. This framework will be based on national plans for competitive,

[7] Inter-Governmental Panel on Climate Change, 5th Assessment Report (AR5) and Synthesis Report at http://ipcc.ch/

secure and sustainable energy. The commission is expected to provide further guidance in due course but the plans will be produced by member states under a common approach.

## United Kingdom

The UK has been signed up to the Kyoto Protocol on reducing carbon emissions worldwide since 1995. The UK Climate Change Act was passed in 2008 and includes the following:

- **2050 Target:** The act commits the UK to reducing emissions by at least 80% in 2050 from 1990 levels (with an interim target of 50% by 2025). The 80% target includes GHG emissions from the devolved administrations, which currently accounts for around 20% of the UK's total emissions. There is also a target to produce 30% of electricity from renewable sources by 2020.

- **Carbon Budgets:** The act requires the Government to set legally binding 'carbon budgets'; a cap on the amount of greenhouse gases emitted in the UK over a five-year period. The first four carbon budgets have been put into legislation and run up to 2027.

- **Carbon Reduction Commitment Energy Efficiency Scheme:** This is a mandatory cap and trade scheme aimed at providing year on year reductions in $CO_2$ consumption by all participants[8].

The current energy policy of the UK was set out in the Energy White Paper of May 2007 and Low Carbon Transition Plan of July 2009. The current focus of policy is on reforming the Electricity Market, rolling out smart meters and improving the energy efficiency of the UK's building stock through the Green Deal.

The UK Energy Act 2013 legislates for electricity market reform (EMR) to reduce dependence on fossil fuels for electricity generation.

## Scotland

The Climate Change (Scotland) Act 2009 set an emissions reduction target of 80% by 2050 from the baseline year, 1990. It also committed Scotland to a 42% reduction in emissions by 2020 and annual reductions between 2010 and 2050. As of January 2011, public sector bodies in Scotland (including Glasgow City Council) must comply with new guidelines set out by the Scottish Government.

The Scottish Climate Change Delivery Plan aims for four major transformational outcomes:

- A largely decarbonised electricity generation sector by 2030.

- A largely decarbonised heat sector by 2050 (with significant progress by 2030).

- An almost complete decarbonisation of road transport by 2050 (also with significant progress by 2030).

Table 1. EU, UK and Glasgow carbon and greenhouse gas targets

| Source | Baseline year | Target 2020 | Target 2030 | Target 2050 |
|---|---|---|---|---|
| EU policy framework for climate and energy | 1990 | – | 40% | – |
| EU Europe 2020 strategy, 2010 | 1990 | 20% $CO_2$ | | |
| Climate Change Act (UK), 2008 | 1990 | 34% $CO_2$ | | 80% $CO_2$ |
| Climate Change (Scotland) Act[1], June 2009 | 1990 | 42% GHG | 50% GHG | 80% GHG |
| Glasgow SEAP, 2010 | 2006 | 30% $CO_2$ | none | none |

[1]The reduction targets include emissions from international aviation and shipping, six GHG(greenhouse gases), including $CO_2$

[8] Qualification for the scheme is based on electricity usage. Organisations qualify if, during the qualification year, they consumed over 6,000 megawatt-hours (MWh) of qualifying electricity through settled half-hourly meters. Participants include supermarkets, water companies, banks, local authorities (including GCC) and all central government departments.

- A comprehensive approach to ensure that carbon (including the cost of it) is fully factored into strategic and local decisions about rural land use.

Scotland already meets nearly 30% of its electricity demand (equivalent), and nearly 3% of heat, from renewable sources. The Government is committed to generating an equivalent of 100% of electricity demand from renewable sources by 2020, along with at least 11% of heat from renewables. This exceeds the EU's 2020 renewable energy target of 20% and will be double the UK's agreed EU target of 15%.

More recently, the Draft Heat Generation Policy Statement (2014) by the Scottish Government has indicated how Scotland might reduce the amount of energy used for heat, diversify sources of heat, provide increased security of heat supply, greater local control and reduce the pressure on household energy bills.

The draft Statement seeks to stimulate potential investment to deliver de-carbonised heat through growing and emerging sectors such as district heating and geothermal energy, and support industries and business sectors through identifying opportunities for heat efficiency, heat recovery, and renewable sources. It also sets targets for district heating in Scotland of 40,000 homes to be connected by 2020.

A target to eradicate fuel poverty[9] by 2016 was also set by the Housing (Scotland) Act 2001.

The Scottish Declaration for Climate Change established in 2007 commits Councils to:

- Acknowledge climate change is occurring
- Welcome the opportunity to take action
- Make a commitment to action

As part of the declaration Glasgow City Council submits an annual report that takes a look at achievements to date and priorities for the year ahead.

## 1.4 Reducing carbon emissions and promoting sustainable energy

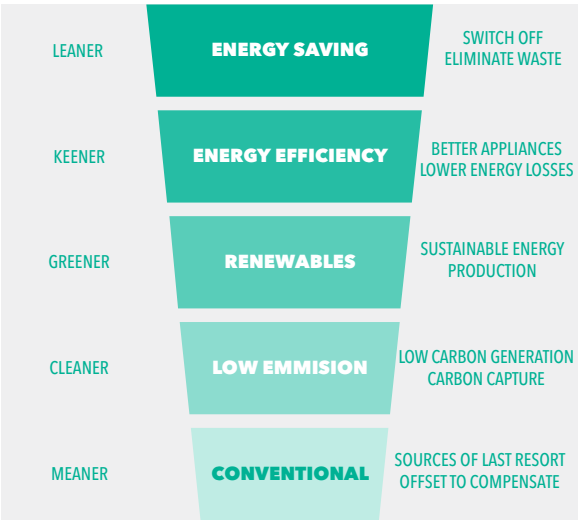
The actions included in this plan range across the sustainable energy hierarchy (Figure 1) which underpins this initiative. The guiding principle of the energy hierarchy is to reduce energy use before meeting the remaining energy demand by the cleanest means possible.

It is important to reduce energy demand, so that we do not have to generate as much energy to meet our needs, be this from renewable or low carbon sources or other sources such as fossil fuels or nuclear power. Energy reduction and efficiency measures are often 'quick wins' and inexpensive to implement, and can improve the health and wellbeing of those in fuel poverty. This is why in the action plan (section 4) there are many measures outlined for buildings (whether municipal, residential or commercial) that seek to reduce the demand for energy and increase the energy efficiency of the buildings before generating renewable energy.

Glasgow's current energy needs are met largely through fossil fuels such as coal, oil and natural gas (see section 2). This is because Glasgow imports the vast majority of its energy from beyond its boundaries in the form of petroleum products for transport and through the national electricity and gas grid systems. Electricity production in the UK is still largely dependent on coal and gas fired generation which has a higher level of carbon dioxide emissions than non-fossil fuel sources. In order to meet Glasgow's vision of a low carbon future, Glasgow needs to generate

[9] According to the Scottish Government, a household is in fuel poverty if in order to maintain a satisfactory heating regime; it would be required to spend more than 10% of its income (including Housing Benefit or Income Support for Mortgage Interest) on all household fuel use

Figure 1: The Sustainable Energy Hierarchy




more of the electricity consumed locally from low and zero carbon sources, and look at other ways of heating our homes - which accounts for over half of the energy consumed in the city.

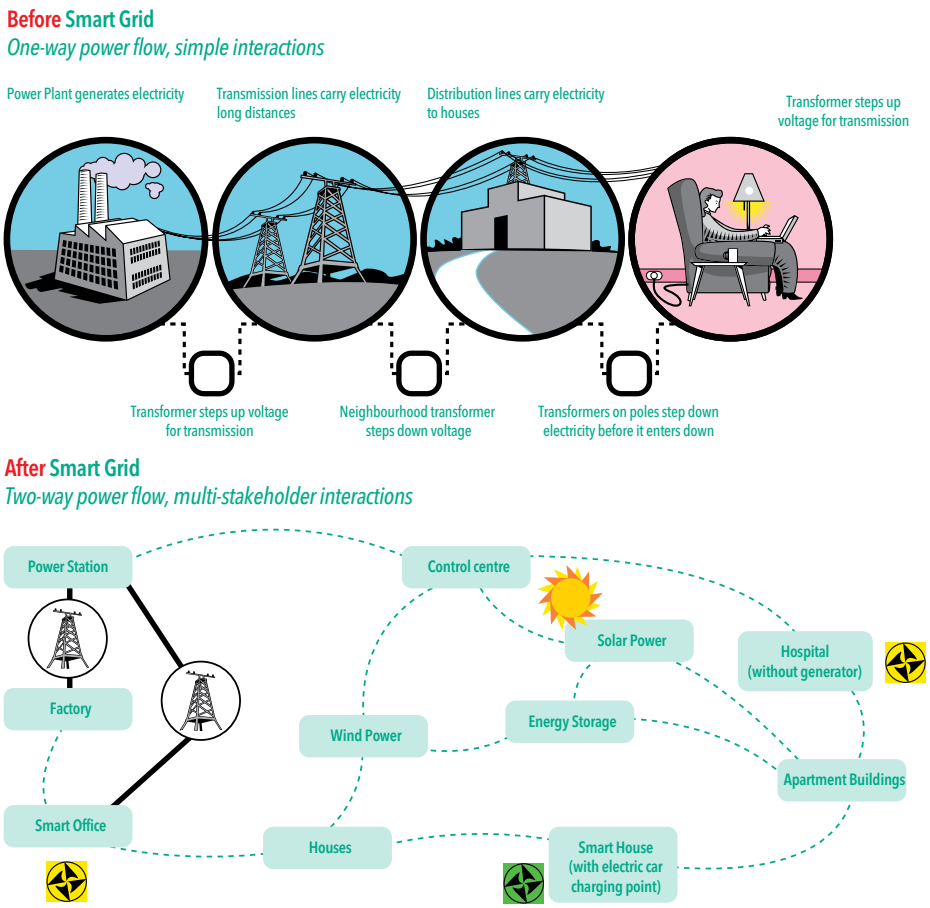
Though Glasgow is committed to implementing the energy hierarchy, demand for energy may increase in the city (see Scenarios in section 3) linked to increases in the population, the number of cars and the number of assets/devices that consume electricity. Meanwhile, our fossil fuels supply may only last for a few more decades; therefore, we need to find alternative sources of energy and more efficient ways to consume it. Decreasing reliance on personal car-based travel in favour of more active modes of travel is a key challenge for Glasgow. Expansion of renewables (solar, wind, hydroelectric power, geothermal energy and other technologies) will be required in the city, together with greater use of Combined Heat & Power (CHP) and district heating. Meeting energy demand in Glasgow over the coming years will require producing energy from renewable sources and also using energy much more efficiently through new technologies and new behavioural habits.

## Developing a 'smarter grid'

As Glasgow does not have the ability to be energy self-sufficient, electricity generated elsewhere in Scotland must be transmitted efficiently to houses and businesses in Glasgow. Improving the efficiency of this process will result in lower transmission losses, therefore less total energy will be needed to power everything we use. Supporting the creation of a 'smarter grid' which is more streamlined and efficient and more responsive to local peaks and troughs in demand – together with generating more electricity locally – is part of the vision for sustainable energy in the city. Eventually, the 'national grid' of vertical electricity distribution could be replaced by a more lateral smart grid system with wind and solar generating systems inputting to a sustainable and very cost local grid (see Figure 2).

Glasgow City Council and local housing associations may also, over time, become generators and suppliers of energy to homes through this local grid. Becoming more energy efficient will also require us to change how we design and build buildings, how we heat our homes and how we light our classrooms. New homes and buildings in Glasgow can be designed to harness energy from the sun to heat rooms and/or heat the water we use in our showers and kitchens. A good example of this is the 'Glasgow House' energy efficient prototype homes which were built by Glasgow Housing Association (GHA) and City Building in 2010 to

Figure 2: Before and after Smart Grid installation




Source: Adapted from www.freegrab.net

high standards of insulation and incorporating other features such as passive solar design and solar thermal roof panels to provide hot water another good example is the Glasgow 2014 Commonwealth Games Athletes Village.

Industrial processes produce waste heat, which can often be captured and sent out to homes and buildings to provide space heating and hot water. When combined with a power plant generating electricity and capturing the residual heat it is called "combined heat and power," and adopting it will require us to rethink the ways in which we live and work, making our cities and buildings more connected.

The aim of the ECM is to reduce carbon emissions through improved energy management and the development of new, integrated systems that will deliver clean, low carbon energy infrastructure. By looking at the city as a whole, energy systems can be designed so that they support each other, technically and financially, while meeting Glasgow's requirements for growth and supporting the needs of its communities.

These opportunities have the potential to deliver significant carbon emission reductions (see section 4) and will enable Glasgow to reduce its carbon emissions by 30% per cent by 2020 at the same time as creating jobs, tackling fuel poverty and regenerating the city.

# 1.5 Key challenges and opportunities for Glasgow

There are a number of key challenges opportunities that Glasgow needs to tackle:

**Climate Change:** Climate change represents both a key challenge and a key opportunity for Glasgow. The overwhelming scientific consensus in the IPCC is that climate change is largely attributable to human activity and that change is happening at an unprecedented rate. Glasgow City Council acknowledges that the reduction of carbon emissions and the transition to a low carbon economy are key addressing climate change. Cities have a vital role to play in supporting change by reducing the emissions of carbon dioxide and other greenhouse gases (GHGs), thereby contributing to Scotland's ambitious climate change targets. The 'mini-Stern' reports produced for other cities in the UK, and recently in an adaptation focussed format for Glasgow[10], demonstrate that the benefits of strong, early action on climate change will far outweigh the costs of not acting. At the same time the economic benefits in employment, skills development and other aspects of life in the city from actively pursuing a low carbon agenda are potentially enormous. Glasgow City Council is also participating in the Climate Ready Clyde initiative[11] and has signed the EU Mayors Adapt Initiative[12].

**Fuel Poverty/Affordable Warmth:** Fuel poverty is defined in Scotland as when a household's required fuel costs are above 10% of the total household income (including housing benefit and income support). Scotland has a target to end fuel poverty (as far as reasonably practicable) by November 2016. This represents a significant challenge for Glasgow as some 25% of the resident population is in fuel poverty (based on the most recent Housing Conditions Survey[13]) as shown in Map 1. Some of the actions in the ECM, such as extending district heating across the city, are aimed specifically at reducing fuel poverty and providing affordable warmth across the city in locations such as the Sighthill Transformational Regeneration Area[14]. These initiatives, combined with further energy efficiency measures and smart metering of homes, present an excellent opportunity to tackle fuel poverty in large parts of the city where it has endured for many years.

**Regeneration:** Another key challenge in Glasgow concerns the slower pace of city regeneration as the UK emerges from recession. Programmes that aim to redevelop city districts that are in need of regeneration have slowed since the financial crash and subsequent recession. However more recently Glasgow and the Clyde Valley authorities have developed a Glasgow City Region City Deal[15] with the UK government which will result in a Glasgow City Region Infrastructure Fund of £1.13 billion being made available to fund major road, rail and regeneration projects.

Regeneration had a major beneficial impact on many landscapes in Glasgow, and has played an important role in the history and demographics of the city. City regeneration in Glasgow now focuses on renovation and refurbishment of existing buildings and communities. Proposals in the ECM support this process through actions including retrofitting of energy efficiency measures and installation of schemes such as district heating on a community-wide basis.

Regeneration of Glasgow is also focussed on the city centre and other key areas (including Transformational Regeneration Areas) such as the East End, where projects like the Commonwealth Games Athletes' Village have had a beneficial effect. A key opportunity is how the city's ECM can contribute to this regeneration by integrating some of the actions and projects with more mainstream physical regeneration activity supported by initiatives such as the City Deal.

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10 Low Carbon and Climate Change Adaptation Opportunity Assessment for Glasgow. Scottish Cities Alliance
11 www.adaptationscotland.org.uk
12 www.mayors-adapt.eu
13 www.scotland.gov.uk/Publications/2013/12/3017/290982
14 Transformational Regeneration Areas were designated in 2009 across 8 sites in Glasgow backed by a partnership between Glasgow CC, GHA and Scottish Government
15 Glasgow and Clyde Valley City Deal can be found at: https://www.gov.uk/government/publications/city-deal-glasgow-and-clyde-valley

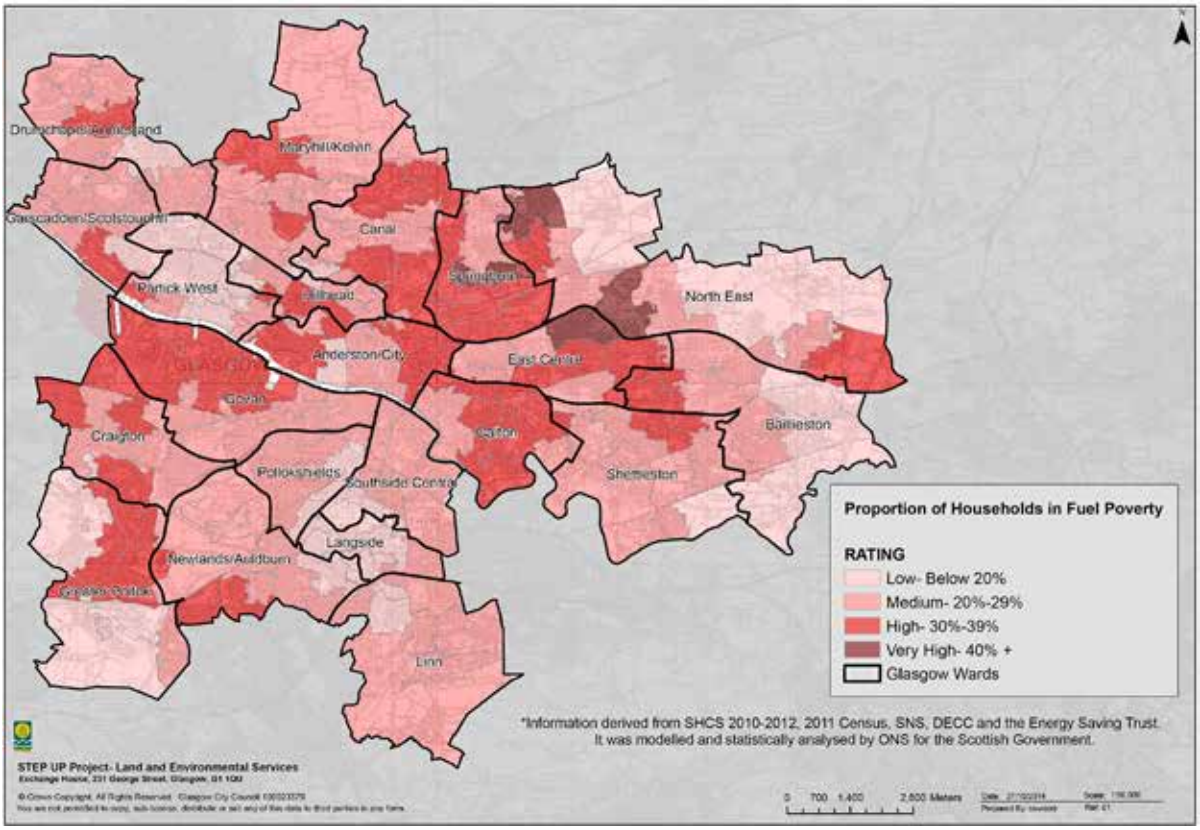
**Finance and Investment:** Finding finance and investment to support low carbon projects which are outlined in section 4 of this report remains challenging as the UK emerges out of recession and austerity cuts. Glasgow City Council has faced restrictions in its spending and borrowing in recent years, but opportunities exist to move beyond traditional funding sources and combine various funding streams for low carbon projects that will support the many innovative pipeline projects that are described in the ECM. As far as private finance is concerned the attractiveness of certain renewables, and other low carbon projects where there is not a rapid return on investment, means that limited public expenditure needs to be used to help stimulate the investment of private sector monies. The size and scale of each project is also an issue and small low carbon projects are generally more difficult to fund than larger projects. However, as outlined in section 5, there is an opportunity to finance low carbon projects by combining various funding streams at a strategic level into a revolving 'investment fund' that would support individually appraised local schemes in the city.

**Transport:** A major challenge for Glasgow is the issue of transport and mobility, as motorised road transport use in the city is high, and cycling and walking low, in comparison with other European cities such as Ghent, Copenhagen, Amsterdam and Freiburg. To compete internationally as a green city, Glasgow needs to provide a world-class sustainable transport system which is safe, reliable, integrated and accessible to all citizens and visitors, as well as supporting the physical, social, economic, cultural, environmental and economic regeneration of the city. Transport and mobility is critically important to the economic success of Glasgow, with opportunities to develop more sustainable transport in the city such as walking, cycling and public transport. Limited investment in road infrastructure can tackle key congestion points and provide links to enable public transport providers to provide more effective services.

**Energy Security:** A key challenge for Glasgow (in common with many other western cities) is energy security and the risk that Glasgow will

Commonwealth Games Athletes' Village, now 'The Village' housing development

Map 1: Fuel poverty in Glasgow




Source: Scottish House Conditions Survey 2012

not be able to secure sufficient energy at a suitable price in the future to meet the needs of its businesses and communities. Access to an adequate supply of affordable energy has become essential to the functioning and resilience of modern cities. The challenge and opportunity is to develop more secure, low carbon sources and supplies of energy for Glasgow as a whole and to be less reliant on imported fuel (such as gas) and more reliant on locally generated, renewable energy. This will mean that Glasgow could offer locational advantages to businesses in addition to reducing the costs of energy for domestic consumers.

Partnerships are a critical part of the ECM and the delivery of the low carbon energy future for Glasgow. The process of developing this masterplan has benefited from the involvement of a range of stakeholders and partners that lie both within and outside the Sustainable Glasgow partnership. There has been input from the public, private and voluntary and community sector through stakeholder events, meetings and surveys.

The STEP UP (Strategies Towards Energy Performance and Urban Planning) project has conducted a stakeholder analysis of the partners involved in the original SEAP and has developed a stakeholder engagement plan under which input from partners across different sectors is actively sought. There have been several stakeholder events held during the course of developing the ECM and both stakeholder and citizen surveys conducted to gauge the views of a wide variety of organisations.

First a stakeholders' survey was carried out, followed by a citizens' survey which provided citizens with an opportunity to have their say on energy, transport, green events and carbon reduction measures in Glasgow. This latter survey sought to specifically engage Glasgow's citizens about their individual energy use and environmental concerns.

# 1.6 Partnerships, stakeholder and citizen involvement

Over 125 organisations responded to the stakeholder survey and the main findings were that:

- Nearly 90% of respondents agreed with Glasgow's vision for sustainable energy and tackling climate change
- Half of the respondents agreed that Glasgow's 30% $CO_2$ reduction target by 2020 should be maintained
- Many respondents were willing to share energy consumption data
- About 80% of stakeholders responding wanted to be involved in the process of creating a new Energy and Carbon Masterplan for the city.

Over 500 citizens from all parts of Glasgow responded to a citizens' survey, the main findings were that:

- More than 50% of respondents think that energy efficiency and waste/ recycling are the most important aspects of Glasgow's green agenda
- Citizens recognise the importance of local renewable energy and support waste to energy, CHP/district heating and solar PV in particular
- Nearly 60% would support a District Heating system if made available in their area (31% were not sure)
- People would like to see more focus on walk/cycleways; housing stock and reducing waste in the city
- Nearly 80% of people would switch energy suppliers for price reasons but 80% haven't switched in the past 6 months
- ScottishPower and Scottish Gas are the main suppliers of energy to respondents.
- 85% of respondents have gas central heating and 8% electric heating
- 80% of respondents have energy efficient light bulbs in their homes and about 50% have controls on their central heating systems.

Image 1: Image Word Cloud from citizens survey results

## 1.7 The STEP UP project: enhancing the SEAP for Glasgow

STEP UP is a European Union (EU) funded energy and sustainable city planning project that aims to assist cities in enhancing their SEAPs and integrate energy planning into their sustainable city planning. The project is a partnership of twelve organisations from local government, research and commercial partners in the European cities of Ghent, Glasgow, Gothenburg and Riga.

Since the project's start date of November 2012, STEP UP has focused on developing SEAPs that:

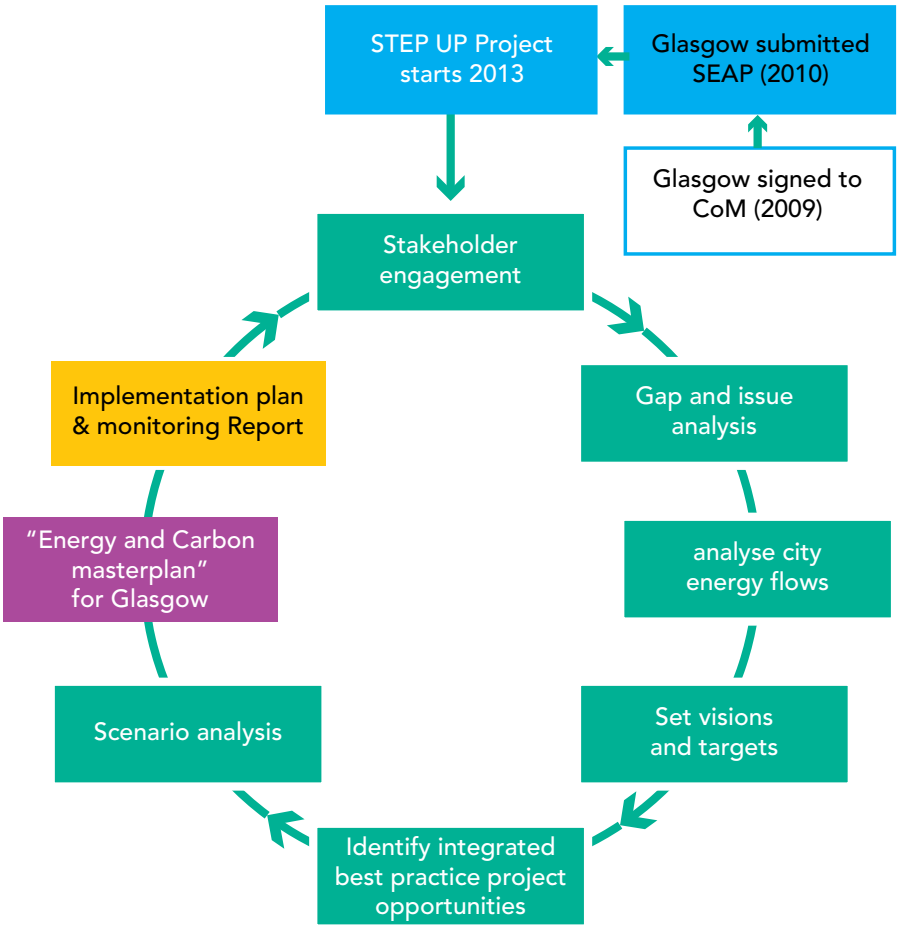
- Are based on solutions that have strong and realistic prospects for implementation
- Promote more integrated solutions with greater efficiency and improved economic pay-back
- Are potentially synergistic with other inititaives across the EU
- Are actively supported by key stakeholders and that are aligned with stakeholder objectives
- Can respond to changing circumstances, and
- Allow for improved implementation, monitoring and ongoing revision in future years.

STEP UP has also focussed on innovative projects and how these can be enhanced to achieve more integrated outcomes (see section 4 of the SEAP for examples). Glasgow has also benefited from the experience of other STEP UP cities in developing their own SEAPs, as well as the best practice that has emerged from cities in the wider STEP UP learning network.

One of the key outcomes from STEP UP is that from the experience of the four cities' SEAPs, and the processes that have formulated them - a new model for enhanced energy planning is being documented. This will have wide dissemination across Europe after the project ends.

This new model is shown diagrammatically in Figure 3 below. This shows the steps that Glasgow has taken to develop this enhanced SEAP. This process has been more detailed and is more robust than the process followed to develop the first SEAP for Glasgow. It includes a gap and issues analysis, extensive analysis of energy flows in the city (summarised in section 2 of this report) and a scenarios analysis.

Figure 3: Developing an enhanced SEAP: the STEP UP process

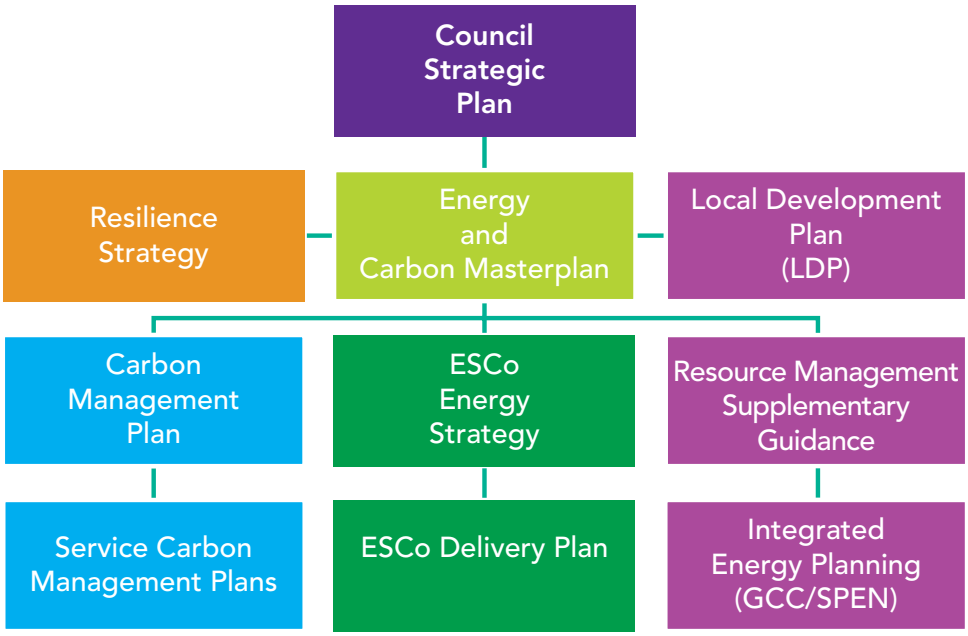



## 1.8 How the ECM links to other plans and strategies

The overarching plan for Glasgow City Council is the Strategic Plan (Figure 4). This provides the framework for the Energy and Carbon Masterplan.

The Energy and Carbon Masterplan helps inform the Local Development Plan (including Supplementary Guidance on Resource Management), which is currently being revised and will be approved in spring 2015, and also the phase 2 Carbon Management Plan 2013 - 2021. It also informs the emerging strategy being developed by the council to guide the work of the new Energy Services Company (ESCo) for Glasgow. These plans are being developed alongside each other, which is of benefit to the city. The plans have a shared vision and shared objectives, and can be implemented simultaneously with support from the council and other stakeholders. The Energy and Carbon Masterplan also sits alongside the Resilience Strategy being developed by the council over the next two years as part of its participation in the Rockefeller Foundation 100 Resilient Cities programme (www.100resilientcities.org/).

Figure 4. Glasgow City Council Strategy Framework




**Glasgow Local Development Plan**

Reducing the demand for energy and planning for renewable electricity and heat are key elements of climate change mitigation. Glasgow is taking a strategic approach to energy planning, seeking to reduce energy consumption and utilise cleaner and more renewable sources of energy. Installation of a wide range of renewable energy technologies, including energy storage, will be required.

Glasgow City Council is in the process of developing a new Local Development Plan (LDP) to guide development in the city over the next 10 years. The draft plan was published for consultation early in 2014, and it is anticipated that final plan will be subject to Examination in Public early in 2015. The policies contained in the draft plan in the Resources Management section are scheduled to be elaborated in associated Supplementary Planning Guidance to encourage sustainable development, renewable energy, district heating and energy efficiency in new developments.

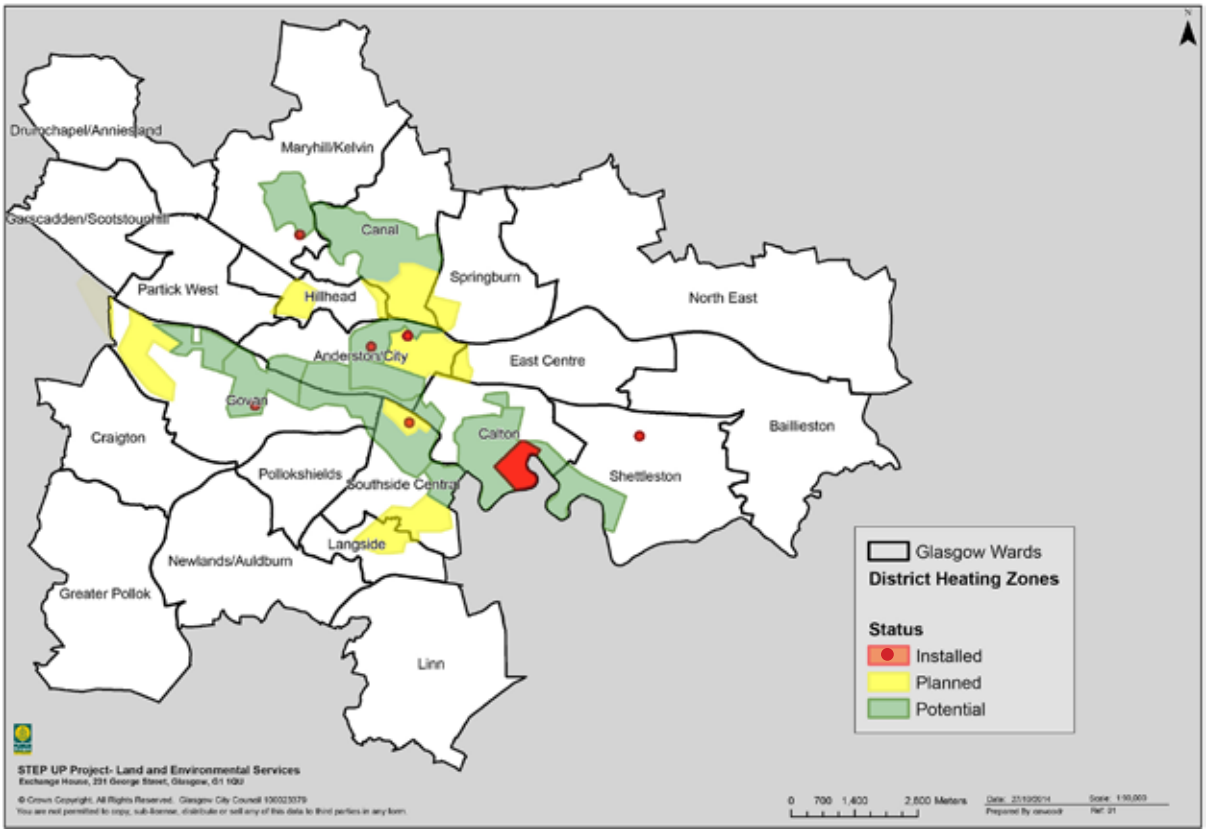
The council is keen to facilitate and encourage combined heat and power and district heating systems and to work towards improving the energy efficiency of, and reducing fuel costs for homes in the city. Map 2 provides an initial indication of the areas of the city with greatest potential for district heating networks – this position is being updated through heat mapping and the detailed outcomes will be set out in Supplementary Guidance. The council also aims to ensure that buildings in new development are designed and constructed to be energy efficient and make use of low and zero carbon generating technologies though policies in the LDP.

*Source: Glasgow Proposed City Development Plan (consultation edition) 2014*

The council supports an integrated approach to the planning and development of the

infrastructure that can often be necessary to facilitate new development. This includes sub-surface infrastructure such as utility services, district heating, energy and broadband infrastructure and transport, Sustainable Urban Drainage Systems (SUDS) and water management infrastructure. The council intends to bring forward a strategy to support such an approach. Updated Supplementary Guidance may be necessary to address any land use planning implications arising from such a strategy. This work will help highlight potential infrastructure opportunities and constraints across the city.

Map 2: District Heating Zones in Glasgow




Source: Glasgow City Council Local Development Plan

## 1.9 Progress made since the SEAP of 2010

A review of the first Glasgow SEAP was carried out to ascertain the likelihood of achieving the city's climate and energy targets. It included a Gap and Issue Analysis of the actions that Glasgow has implemented since the SEAP was approved by the Covenant of Mayors in November 2010, and what more remains to be done.

The Gap and Issue Analysis report looked at the city's Baseline Emissions Inventory (BEI, see section 2 below)[16] (covering the carbon emissions from the city from 2006 up to 2011) and the current status of the 30 key actions contained in the 2010 SEAP. The analysis identified: progress made; the policy context at local and UK level and how this may influence the updated SEAP; and the outcomes of engaging with different stakeholders to

16 http://www.eumayors.eu/+-Baseline-Emission-Inventory-+.html

identify opportunities and aspirations for improving the actions in the SEAP sectors.

The gap analysis report highlighted that the enhanced SEAP should now focus on projects which reduce dependency on carbon intensive electricity for home heating. Increasing lower carbon sources such as gas or biofuel in combined heat and power (CHP) plants and district heating schemes in the city could help Glasgow to achieve the 30% $CO_2$ reduction target by 2020.

However, this should not be seen as a 'dash for gas' as Scotland's intention is to move to 100% renewable electricity by 2020. From a local perspective, however, Glasgow will not be able generate enough electricity from renewable resources to reduce its carbon emissions substantially and therefore reliance on gas CHP replacing electrical heating in homes will be one way that it can significantly reduce its carbon emissions in the short term.

The review concluded that the previous SEAP laid the foundations for building the ECM for Glasgow. However, a new set of actions are required to reflect the gaps in the existing SEAP. These include the need for an increased focus on transport and waste issues, a need to reflect the new local and national policy framework and the success or otherwise of existing SEAP recommendations. The review also concludes that, based on stakeholder input to date, the ECM will require broader and deeper stakeholder involvement, continued strong political leadership by the council, ownership and governance by the Sustainable Glasgow Board, clear costing of actions, and improved data collection and carbon emissions monitoring in line with the revised SEAP template being implemented by the Covenant of Mayors.

## 1.10 The new Energy System for Glasgow

The challenges set out above remain as they were in the initial SEAP namely how can we continue Glasgow's economic regeneration while, at the same time, reduce our carbon emissions? The answer lies in a citywide approach as encapsulated in this plan. This strategic approach seeks to better understand both current and potential future energy demands in the city and seeks to meet these by using less energy and through the provision of more sustainable, low carbon energy sources.

The difference between the ECM and the initial SEAP is that, through the STEP UP project, Glasgow City Council and its partners (in particular the University of Strathclyde and ScottishPower Energy Networks) have been able to carry out a more thorough energy systems analysis showing the patterns of energy use across the city. The council has been able to use this information to shape a new set of actions that are set out in this report (see section 4).

These new actions mean that resources can be focussed where they can be used most effectively. The main opportunities lie in reducing the total energy the city uses and ensuring that the city uses energy efficiently. Coupled with this, the city will seek to increase the proportion of energy it consumes that is sourced from low carbon and renewable sources. This can be facilitated though the expansion of wind energy, solar photovoltaics, geothermal energy, and energy recovery from waste. Wherever possible the community will be involved and receive benefits from such projects.

The estimated contribution each action would make by 2020 to Glasgow's 30% carbon emissions reduction is set out in the SEAP action plan template and summarised in section 4. It is divided into six sectors - municipal, tertiary, residential buildings, public lighting, industry & transport, and others.

Designing and delivering a new energy system in this way will not only support the city's growth but it will also meet the needs of communities.

The new energy system will be more integrated so that actions and projects support each other both technically and financially and achieve integrated outcomes. This integrated approach will increase the opportunities available in Glasgow and will increase the positive impacts of each project. Some of the main proposals set out in this plan are:

- Development of a number of co-ordinated district heating schemes in the city – expanding out from installed schemes and covering a mixture of commercial and residential premises within the zones identified in this plan and in the LDP.
- Phasing out coal, oil and older inefficient electric heating in council buildings and housing across the city.
- Seek to facilitate improved energy efficiency and energy management systems across all sectors but particularly in residential housing.
- Further expansion of waste to energy schemes including greater use of food waste and anaerobic digestion.
- Further promotion of the use of electric vehicles and cycling as a key mode of transport, replacing the use of petrol and diesel vehicles.
- Lowering the carbon intensity of electricity consumed in Glasgow by promoting further expansion of low and zero carbon energy generation in the city through large and small-scale schemes.
- Continued engagement of Glasgow's citizens, businesses, and public sector organisations in the delivery of the new energy system for Glasgow.

Developing the projects that help implement this new energy system would bring new investment to the city, this could include support from UK and Scottish Government schemes for the development of low carbon energy systems but also through private sector investment, creating significant numbers of jobs in the construction industry, as well as long term jobs with new skills linked to clean energy systems.

# 1.11 Smart City Planning: Promoting integrated planning, cross-sectoral actions and projects

The principles that lie behind the ECM are based on integrated planning. This is the foundation of the Smart City planning approach of the EU[17]. The complexity of cities, and of the decision-making processes that underlie the management of cities, require a paradigm shift of the regulatory environment and existing governance mechanisms. Such a shift must include increased integration between different sectors.

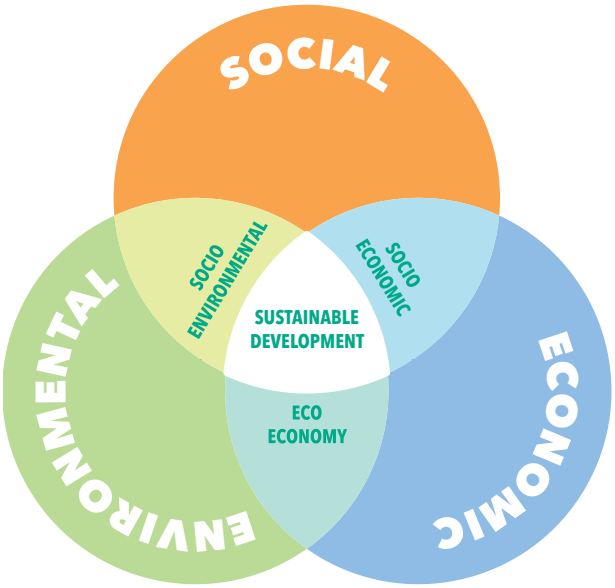
Cities face numerous challenges (described above) such as simultaneously combining competitiveness, economic growth and sustainable urban development. Financing city development with the cooperation of multiple actors, whilst taking into account the local, regional and national regulatory environment, is complicated. There is a need for a strong strategic vision which is then translated into policies, programmes and projects across different sectors.

The aim of this ECM is to help provide the strategic vision for what Glasgow will look like in terms of energy generated and consumption, short, medium and long-term goals provide a baseline for planning projects that will help realise these goals.

The ECM attempts to bring environmental, social and economic objectives together into a strategic framework as shown in Figure 4:

- **Environmental Objectives** are dominated by energy and carbon issues but also air and water quality and the use and remediation of land.
- **Social Objectives** are concerned with fuel poverty, employment, and social inclusion.
- **Economic Objectives** seek to develop beneficial economic outcomes of the selected measures.

Figure 4. Sustainable development




[17] For more information see the Smart Cities and Communities Stakeholder Platform at: http://eu-smartcities.eu/

This is shown diagrammatically in Figure 4, where the intersection of each of the development circles is sustainable development.

The actions in this plan have been developed to have beneficial social, economic and environmental outcomes in an integrated way and thus seek to promote sustainable development.

The integration of policies and projects in the masterplan is also emphasised by the co-operation between the public, private and academic sectors (evident in the University of Strathclyde, ScottishPower Energy Networks, and Glasgow City Council partnership of the Glasgow STEP UP Project); alongside the intersection of Information and Communications Technology (ICT), transport and energy sectors stemming from the EU2020 strategy approach.

ICT is increasingly supporting collaborative relationships among the private, public and academic sectors and as evident the Technology Strategy Board (TSB) Future Cities Demonstrator project[18] which Glasgow won in 2013. The TSB Future Cities project shows how public, private and academic sectors can use cutting-edge technology to enhance day-to-day life in public safety; transport, health, and energy (see Box).

The projects chosen through the STEP UP process and which form part of the ECM are smart and integrated. Examples include the Fast Link bus scheme along the banks of the River Clyde (part of Clyde Waterfront) which incorporates economic factors (creation of local jobs), environmental factors (reducing greenhouse gas emissions) and social factors (improving transport times and giving people a better journey).

Many projects in the action plan improve some or all of the indicators based on the results of appraisals through the STEP UP approach. This includes where the project will be located within the city to benefit social, economic and environmental factors and potential synergies with existing initiatives or projects. For example, increasingly district heating schemes will be focussed on areas where there are already extensive energy efficiency improvements to building fabric and potentially technology helping to deliver better building management and also where there may be integrated transport and active travel.

## Innovate UK Future City Demonstrator

Several of the actions and projects featured in this plan are a result of Glasgow's participation in the UK Government's Technology Strategy Board (now Innovate UK) Future City Demonstrator project. This aims to deliver a programme of projects that will make life in the city smarter, safer and more sustainable. There are several innovative demonstrator themes that include: energy efficiency, street lighting, active travel and social transport. Projects within these themes are experimenting with the use of open data, apps, portals and citizen science mapping. The public, academics and businesses are encouraged to get involved both by using the data and contributing their own knowledge. Future City Glasgow is collaboration between public and private sector agencies providing a range of services to the city. They include Glasgow City Council; Police Scotland; housing providers; NHS Greater Glasgow & Clyde; universities; energy providers and Scottish Enterprise.

[18] See http://futurecity.glasgow.gov.uk/ for more information

# 2 Glasgow's Existing Energy System

# 2.1 Glasgow's existing energy use and carbon emissions

The first step to delivering large-scale carbon emission reductions for Glasgow is to understand the existing pattern of energy use and resulting carbon emissions across the city. Glasgow is responsible for emissions of around 3.56 million tonnes of carbon dioxide (2012) linked to energy and transport use. This is around 8% of Scotland's total carbon dioxide emissions.

These emissions figures do not include emissions from the Glasgow city region conurbation (emissions related to Glasgow Airport are excluded for example). In addition, the figures do not include other greenhouse gases (GHG) such as methane emissions related to waste treatment and disposal (estimated as the equivalent of an additional 200,000 tonnes $CO_2$ per annum – or an additional 5% of Glasgow's total carbon emissions). In addition, carbon emissions incurred elsewhere, but linked to goods and services consumed in Glasgow (e.g. food consumed, the steel used in cars, the concrete used in buildings), are also excluded.

Life cycle assessment (LCA) is a method recommended by the Covenant of Mayors that takes into account emissions over the entire life cycle of the commodity. This method is not yet used in Glasgow's inventory but the council aims to investigate this over the next two years and, in the monitoring report on this plan (see section 5), the council will report on how it can develop its monitoring capability so that it can capture the carbon dioxide equivalent emissions[19] for the city. This would mean taking into account methane ($CH_4$) and nitrous oxide ($N_2O$)[20] emissions from landfills, industrial processes and/or wastewater treatment. All the data quoted for energy consumption and carbon emissions for Glasgow is based in the information provided by the Department of Energy and Climate Change (DECC), which has a two year time lag. Therefore, this report uses the figures for 2012 (released by DECC in Sept 2014).

### Factors affecting Glasgow's energy consumption and emissions

Cities are large consumers of energy - consuming around 75% of the world's energy and responsible for the production of approximately 80% of the world's GHG emissions[21]. There are many factors that influence the energy consumption and carbon emissions of Glasgow. The city uses energy for:

- Buildings (electricity, gas or other fuels) such as commercial, industrial, housing, schools, hospitals
- Goods and consumables that are imported from outside the city like food, electronics, white goods
- Transport of items and people into, out of, and around the city
- Raw materials used in the manufacture of other products and construction within the city
- Transport and treatment of waste
- Clean water provision and wastewater treatment.

All these processes generate carbon emissions, either through the direct use of fuels (e.g. petroleum for transport, gas for heating) or through the production and manufacture of products (e.g. building materials, goods and consumables).

Other factors affecting energy consumption and carbon emissions are climatic conditions, affluence (or deprivation) affecting the quantity and type of energy consuming goods purchased, and the behaviours of individual consumers. For example, Glasgow and Edinburgh are similar cities in terms of latitude and climate but with respect to $CO_2$ emissions Glasgow

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19 Carbon dioxide equivalent (CDE) and Equivalent carbon dioxide ($CO_2e$) are two related but distinct measures for describing how much global warming a given type and amount of greenhouse gas may cause, using the functionally equivalent amount or concentration of carbon dioxide ($CO_2$) as the reference

20 Nitrous oxide ($N_2O$) is a greenhouse gas. It should not be confused with NO and $NO_2$ (nitric oxide and nitrogen dioxide) which are air pollutants but are not typically regarded as greenhouse gases.

21 Cities and Climate Change: An Urgent Agenda. The World Bank. December 2010

has slightly higher industrial and commercial emissions as a more industrial city and slightly lower transport emissions as it is a less affluent city with lower car ownership.

Comparing Glasgow to other parts of the UK suggests that its per capita $CO_2$ emissions, at 6.0 tonnes, are lower than the Scottish average (7.0 tonnes) and also lower than other Scottish cities[22]. This may be due to Glasgow's economy which is now much more dependent on commercial and public sector activity rather than manufacturing (which is a higher energy consuming sector) or other factors that tend to lead to a lower than average carbon footprint, such as lower car ownership, lower household income, and smaller than average dwelling sizes.

## Energy Consumption

Glasgow's energy consumption attributed to buildings (domestic, commercial, industry) and transport has reduced from 13,456 GWh/yr in 2006 to 11,528 GWh/yr in 2012 - a drop of 14.3%. (Table 2). However, Glasgow's energy use by fuel remains similar to 2006, mainly in the consumption of fossil fuels for transport; gas and electricity for buildings (used to light and heat its buildings, facilities and properties).

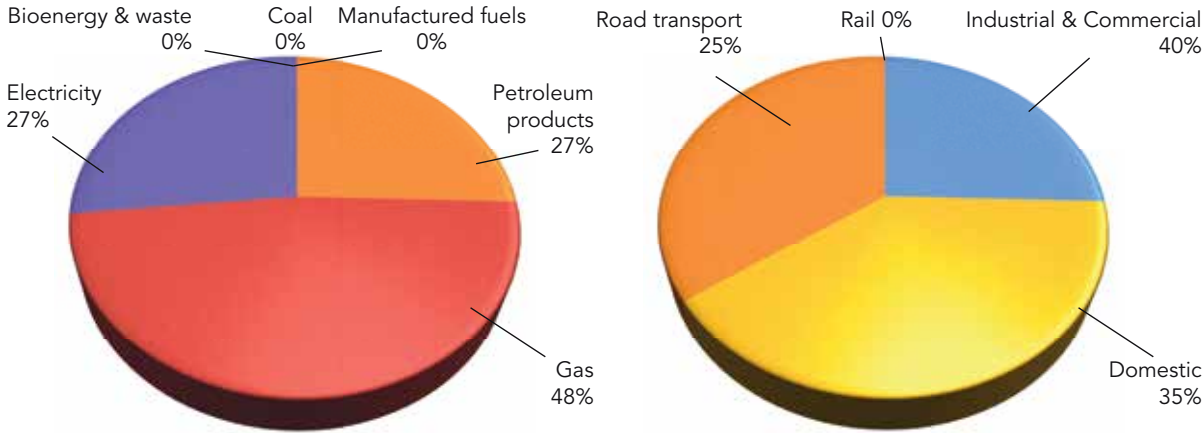
It can be seen that the main sources of energy consumption in Glasgow for 2012[23] are from natural gas (48%) followed by electricity (25%) and petroleum products (27%) (Figure 5). The main sectors using energy in Glasgow

Table 2. Energy Consumption in Glasgow 2006-2012

| Year | Coal (GWh/year) | Solid fuel (GWh/year) | Petroleum (GWh/year) | Gas (GWh/year) | Electricity (GWh/year) | Bioenergy (GWh/year) | TOTAL (GWh/year) |
|---|---|---|---|---|---|---|---|
| 2006 | 5.9 | 7.6 | 3,482.8 | 6,555.1 | 3,405.0 | 0.015 | 13,456.4 |
| 2007 | 6.0 | 7.1 | 3,495.7 | 6,438.0 | 3,318.8 | 0.017 | 13,265.6 |
| 2008 | 5.6 | 8.3 | 3,472.6 | 6,380.0 | 3,369.1 | 0.016 | 13,235.6 |
| 2009 | 6.5 | 7.4 | 3,325.5 | 5,909.2 | 2,956.1 | 0.017 | 12,204.7 |
| 2010 | 7.1 | 8.2 | 3,252.9 | 5,786.0 | 3,062.4 | 0.019 | 12,116.6 |
| 2011 | 6.8 | 7.4 | 3,167.4 | 5,603.6 | 3,063.1 | 0.021 | 11,848.5 |
| 2012 | 6.6 | 7.0 | 3,083.6 | 5,502.5 | 2,928.7 | 0.023 | 11,528.4 |

Source: DECC

Figure 5. Glasgow energy consumption (2012) by source and sector.




22 Department for Energy and Climate Change, Local Authority carbon dioxide emissions estimates 2012
23 Based on data from the Department of Energy and Climate Change (DECC)

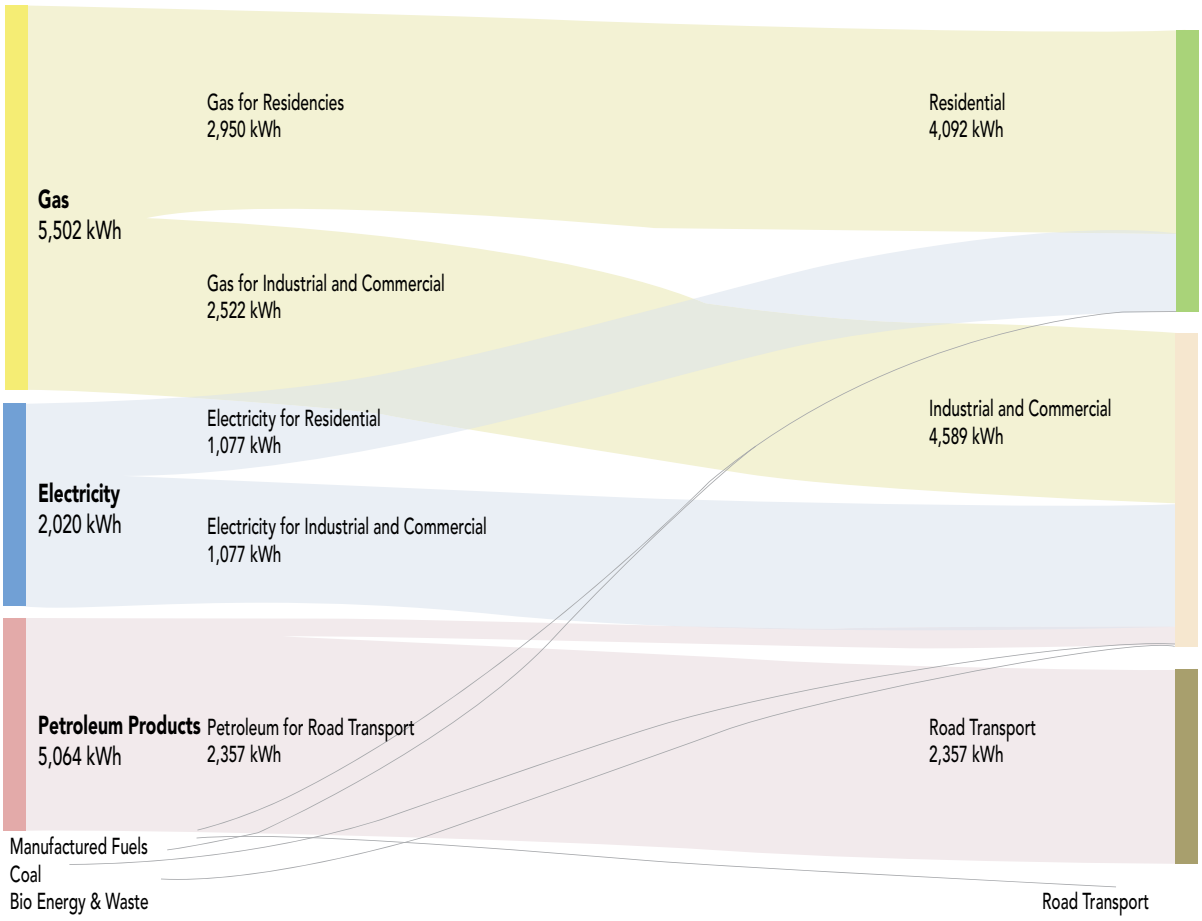
are the industrial and commercial sector (40%) and the domestic sector (35%). Road transport accounts for 25% of energy use.

The Sankey diagram (Figure 6) gives a visual overview of how energy is sourced and consumed in Glasgow. It illustrates – moving from left to right - the contribution that each energy source makes to Glasgow's total annual consumption and the amount of annual energy use which is attributed to each sector. In the data provided by DECC, there is no indication of the end use of the energy provided by bio-energy and waste, therefore, the diagram assumes that 100% of this energy is consumed by the industrial and commercial sector.

This diagram illustrates the significant contribution that buildings in the residential and commercial/industrial sectors make to Glasgow's overall energy consumption and the need for the action plan to focus on reducing energy use and $CO_2$ emissions in these sectors (see section 4). The road transport sector is almost exclusively reliant on petroleum products, forming a smaller but still significant proportion of the city's energy account which is also an area of focus for this plan.

The breakdown of energy sources used in Glasgow and trends in consumption since 2006 is given in Figure 7a and Figure 7b below. The overall levels of consumption have declined by 14% since 2006 but there were more marked changes in energy use in the period before this: In 2000 natural gas became the dominant fuel consumed in the UK owing to changes in electricity generation, following a switch from solid fuels, which dominated energy consumption, in 1970[24].

Figure 6. Energy supply and demand in Glasgow (2012)



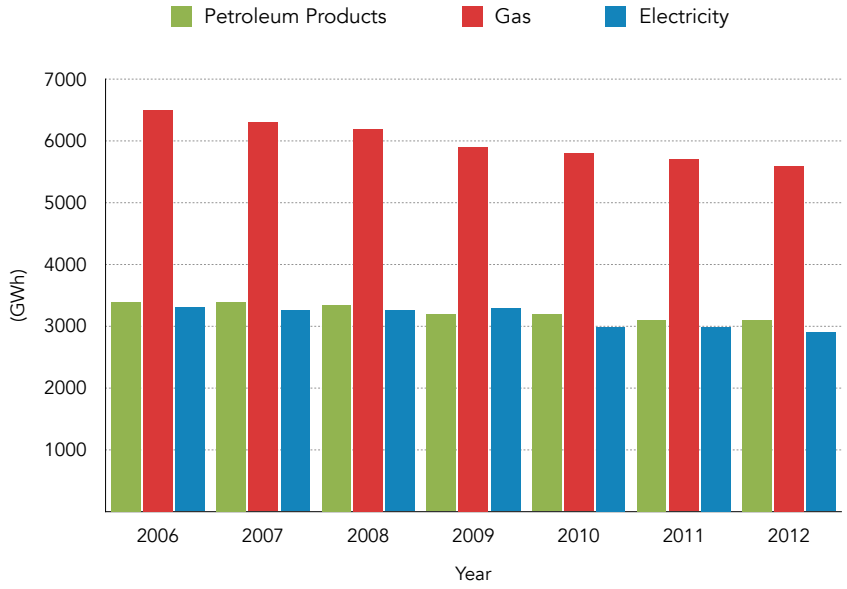

Source: DECC

[24] Energy Consumption in the UK. DECC. July 2014

As can be seen from Figure 7a and Figure 7b, there is a downward trend in all sources of energy consumed in the city between 2006 and 2012 but gas remains the dominant source. Gas consumption has declined in Glasgow since 2006 as more homes have adopted energy efficiency measures – including more efficient boilers – but still remains the main energy used in the city with implications for security of supply, price and the need to move to non-fossil fuel sources to meet climate targets.

Trends in energy consumption in Glasgow since 2006 and projections to 2020 are also shown in Figure 8 below. The graph shows that energy consumption is falling from all sources and will continue to decline to 2020 provided that past trends continue.

Figure 7a. Energy use in Glasgow by source (2006-2012)

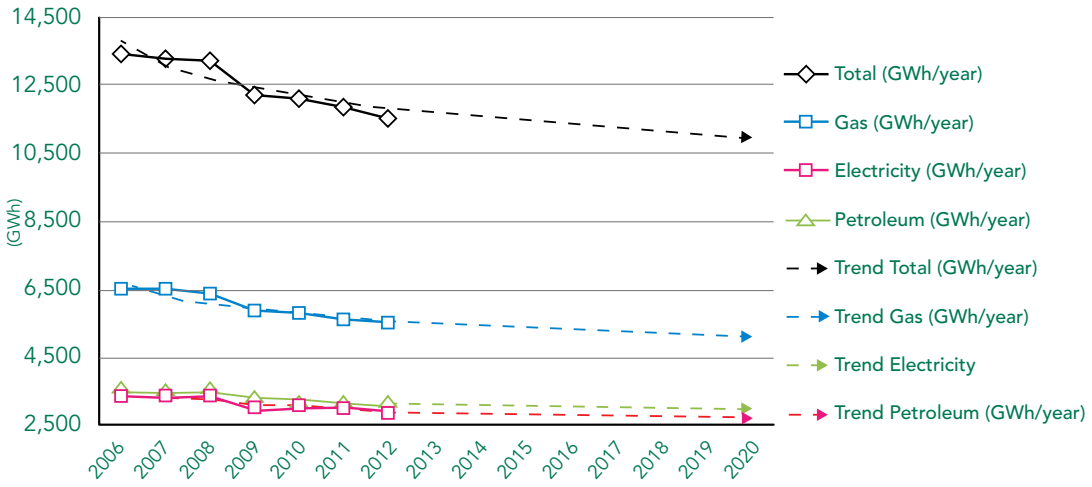



Source: DECC

Figure 7b. Energy use in Glasgow by sector (2006-2012)


Source: DECC

Figure 8. Trends in energy consumption in Glasgow to 2020




Source: DECC

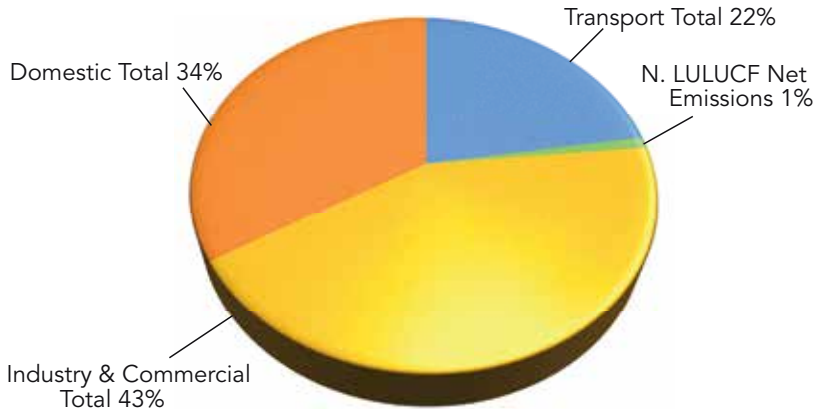
## Carbon dioxide emissions

The total $CO_2$ emissions produced in Glasgow (as given by DECC[25]) in 2006 were 4,094,327 $tCO_2$. This decreased to 3,563,624 $tCO_2$ in 2012, representing a 14% reduction. Figure 9 shows that the main sector accounting for carbon dioxide emissions is buildings, which in 2012 accounted for 77% of emissions, comprising industry/commercial sector emissions (43% of the total) and domestic emissions (34% of the total). The transport sector also accounts for around 22% of Glasgow's total $CO_2$ emissions. LULUCF[26] in an urbanised area such as Glasgow accounts for less than 1% of $CO_2$ emissions

These sectors consistently appear as high energy consumers and carbon emitters between 2006 and 2012 indicating little has changed in terms of the share of energy consumption and emissions by sector since 2006 – although there are variations from year to year.

Although the majority of energy consumed in Glasgow was natural gas, the main source of carbon emissions is electricity. This remains fairly constant over the period 2006-2012. This highlights the impact that electricity consumption has in terms of $CO_2$ emissions. Fossil fuelled electricity generation (which still dominates electricity generation in the UK) has significantly higher carbon intensity (up to 1,000g$CO_2$eq/kWh for some coal fired power

Figure 9. Glasgow carbon dioxide emissions by sector (2012)




Source: DECC

[25] There is a slight variance in the figures quoted in the SEAP and the DECC figures for 2006

[26] *Land use, land-use change and forestry* (LULUCF) is defined by the United Nations Climate Change Secretariat as "A greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities"

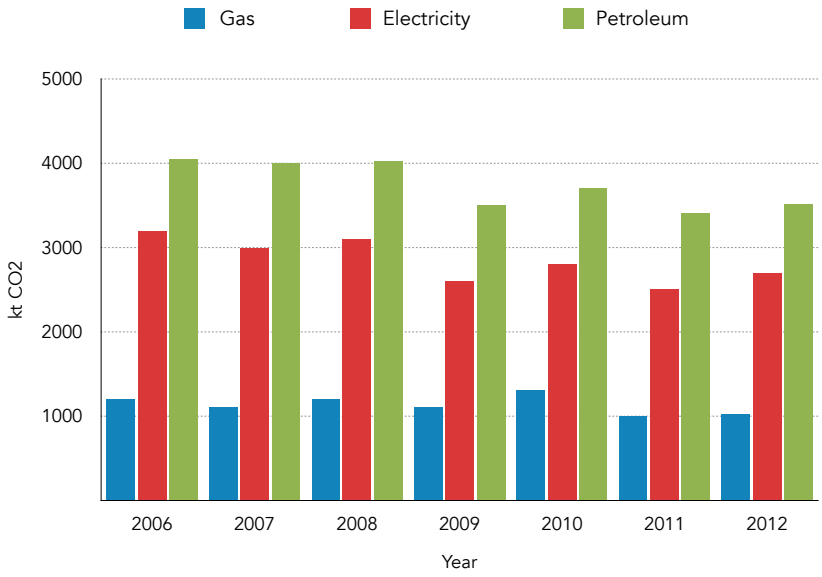
Figure 10. Glasgow carbon dioxide emissions by sector (2006-2012)


Source: DECC

stations) than other forms of generation and most emissions arise during plant operation[27].

The 2013 Digest of UK Energy Statistics report[28] states that the carbon intensity of the grid has been reducing as the proportion of wind generation is increasing. However, carbon intensity has also been influenced by gas prices leading to more use of coal for generation. Generally, however, the use of low carbon sources will continue to help decarbonise the grid. The Scottish Government, which is committed to a largely decarbonised electricity supply by 2030, called for a UK-wide decarbonisation target for 2030 but this has not been included in the UK Energy Act 2013.

Figure 11. Glasgow carbon dioxide emissions by main source (2006-2012)




Source: DECC

[27] Carbon footprint of electricity generation (October 2006) Parliamentary Office of Science and Technology Postnote number 268 p2

[28] Digest of UK Energy Statistics 2013. Office for National Statistics

# 2.2 Trends in carbon emissions and the 30% reduction target

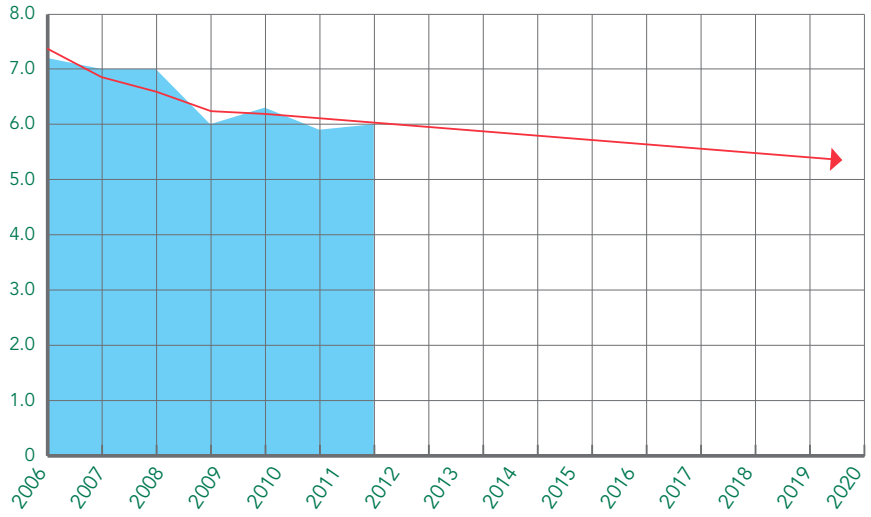
In Glasgow, the $CO_2$ emissions recorded in 2012 amounted to 3,563,624 tonnes, meaning a 14% reduction compared with 2006 levels of 4,094,327 $tCO_2$. Per capita $CO_2$ emissions have also reduced from 7.2 tonnes in 2006 to 6.0 tonnes in 2012 as shown in Figure 12. There were reductions in per capita emissions in the industrial/commercial and domestic sectors over this period, whilst road transport remained constant. However, overall there is clearly a downward trend, which may reach around 5.5 tonnes by 2020.

Glasgow is committed to reduce carbon dioxide emissions by 30% from 2006 to 2020, which is equivalent to 1,228,298 tonnes $CO_2$. Analysing the progress of this commitment, Glasgow has seen an overall reduction of 530,702 tonnes of carbon dioxide from 2006 to 2012 (the blue line on Figure 13), towards the target (shown as the green line).

During this period there has been an economic downturn, which has contributed to the large reduction in $CO_2$ emissions nationwide (the steep drop between 2008 and 2009 is an indication of this). However, actions and projects in Glasgow and greater energy efficiency in buildings and households have contributed to lower carbon emissions. In terms of current carbon emissions and the 2020 target, Glasgow still needs to reduce its carbon dioxide emissions by 697,596 tonnes to meet the 30% target, meaning there is a significant challenge for the forthcoming six years. Robust actions in the building sector (non-residential and residential) and transport sector are required to achieve the target.

The Sustainable Glasgow report and SEAP published in 2010 identified 30 key actions and outlined the carbon dioxide emissions savings for each action. Converting the actions in the SEAP into percentages of $CO_2$ reduction, the savings in carbon emissions were divided roughly equally between: 1) local electricity production (30%), 2) buildings & facilities/ equipment (28%), and 3) transport (26%), with a relatively small percentage in local district

Figure 12. Carbon dioxide emissions per capita from 2006 and predicted trends to 2020

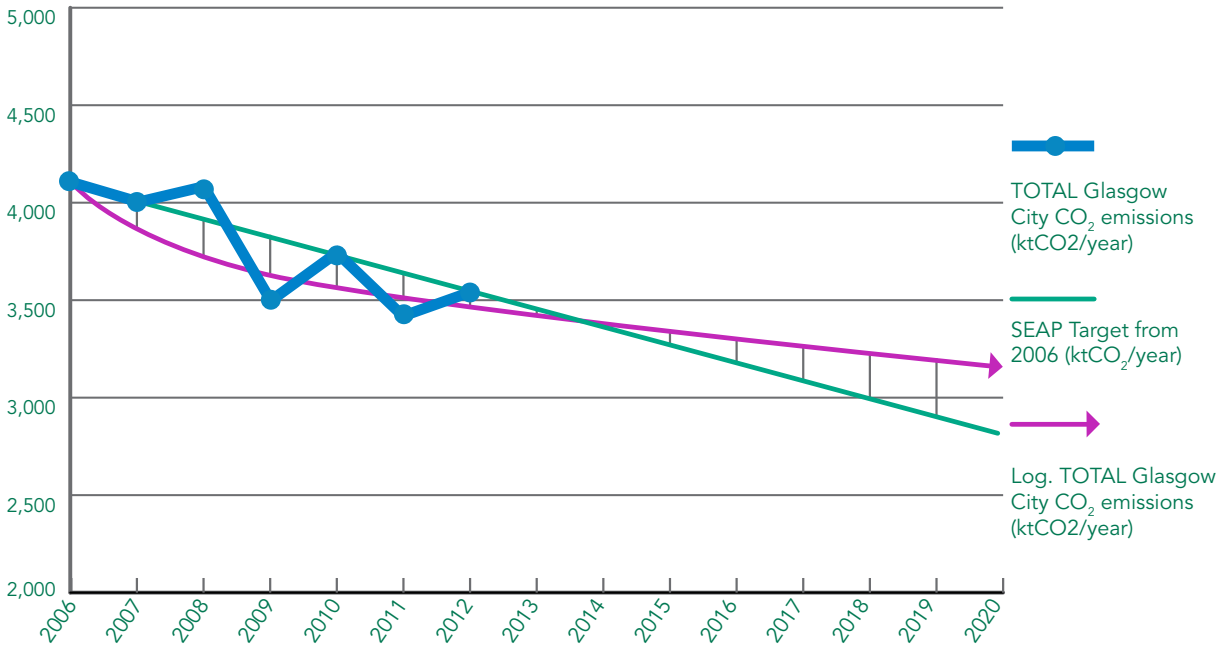



Source: DECC

heating/cooling (7%) and land use planning (9%). The ECM Action Plan (see section 4) has revised these actions and presents a new set of interventions including focusing on local district heating/cooling and use planning in terms of the location and implementation of low carbon developments including district heating schemes and renewable energy.

The UK Government's independent climate advisers – the Committee on Climate Change – have stressed in recent reports[29] that deep decarbonisation of the power sector by 2030 is central to carbon emissions reduction across the economy and meeting the UK's commitments at the lowest cost. It is important therefore that Glasgow makes its contribution by focusing on both reducing overall energy consumption and providing low and zero carbon heating and electricity to achieve its $CO_2$ reduction target and help meet the Scottish and UK Government commitments to decarbonise the electricity supply.

Figure 13. Glasgow carbon dioxide emissions and targets from 2006 up to 2020




Source: DECC

## 2.3 Local electricity and local heat/cold production and carbon emissions

Glasgow's energy is supplied almost entirely from national energy distribution and transmission systems and it generates only a small percentage of its energy within its local boundary. It is almost impossible for Glasgow to become energy independent but it can reduce energy consumption and improve energy efficiency whilst increasing local generation whenever and wherever feasible.

In the future, Glasgow has the potential to increase the proportion of locally generated

[29] Meeting Carbon Budgets – 2014 Progress Report to Parliament. Committee on Climate Change. July 2014

energy and heat, as result of current initiatives and projects: Installation of solar photo-voltaic (PV) arrays on the council's education estate and on social housing; the prospect of solar PV on vacant land in the city; a 3MW wind turbine on Cathkin Braes with the prospect of more at further sites; the installation of biomass Combined heat power (CHP) boilers on council premises together with more extensive CHP district heating. As far as local electricity and local heat/cold production are concerned the BEI showed that in 2006 the renewable energy produced in Glasgow accounted for 2,385 MWh in total (843 MWh in CHP and 1,542 MWh District Heating). This is a relatively low quantity of renewable energy production (0.01%) compared with the total energy consumption of 13,456,432 MWh for 2006 in the city.

The total figures for renewable energy produced in the city are difficult to estimate due to the number of different projects in the city today and the lack of a body to collate the generation output from these projects.

Notre Dame Primary School – eco building

The one project that there is data and can be verified is Cathkin wind turbine, which is operative and estimated to produce 7,300 MWh of renewable electricity every year. The improvement of data collection on renewable energy production in the city is one of the issues that will be addressed in the new monitoring arrangements for the plan set out in section 5.

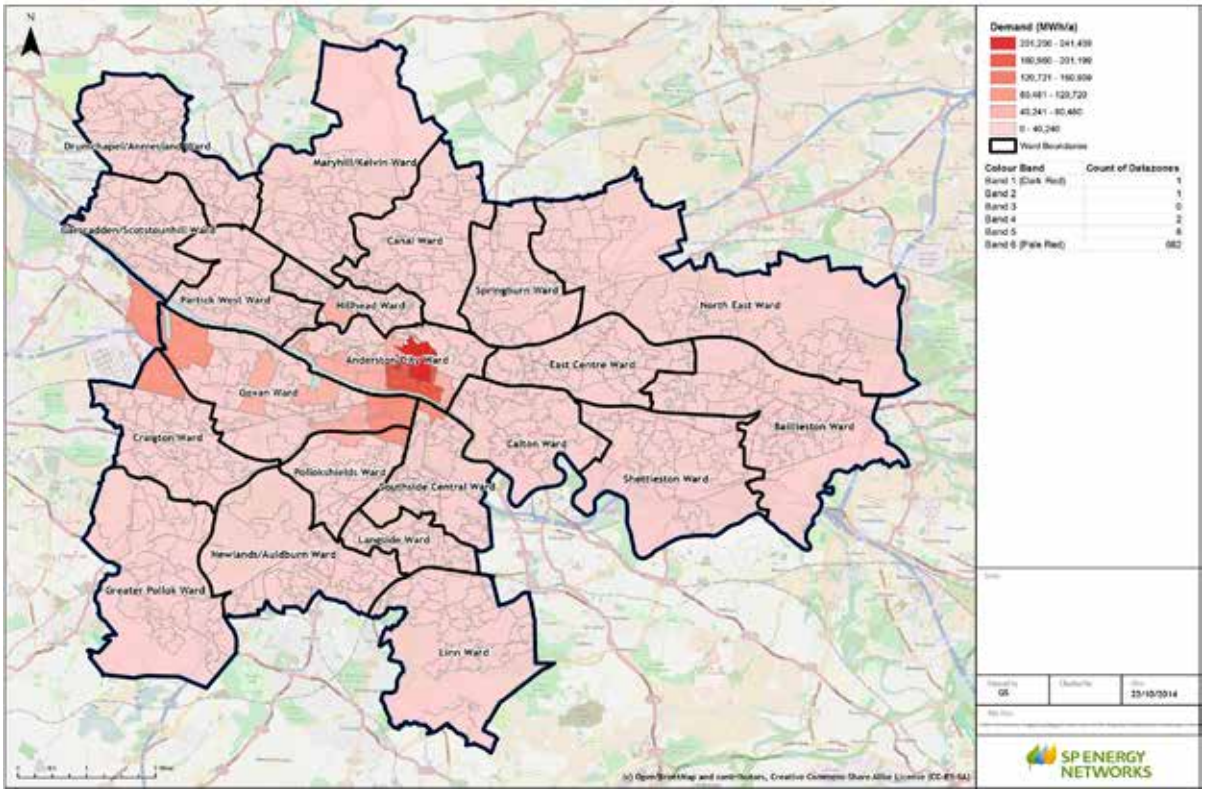
## 2.4 Distribution of energy consumption in Glasgow

Two separate sets of heat maps have been developed for Glasgow – one set by the Scottish Government as part of their effort to provide heat maps for the entirety of Scotland, and the other set developed by SPEN specifically for Glasgow under the STEP UP project. Both Scottish Government and SPEN developed heat maps use energy consumption benchmark and building use data to model the distribution of energy consumption in Glasgow. The maps show the spatial distribution of energy consumption across the city and can be used for the analysis of energy use in Glasgow overall as well as within individual wards. The SPEN heat maps were generated by combining data inputs including:

- Location and building footprint of every address within Glasgow
- Anonymised use class data , occupancy rate, gross internal floor area ($m^2$), and building age
- Use class based energy usage benchmarks that sets the typical annual energy consumption per unit floor area (in kWh/yr.$m^2$) associated with each type of building function based on historical data relating to buildings in the UK.

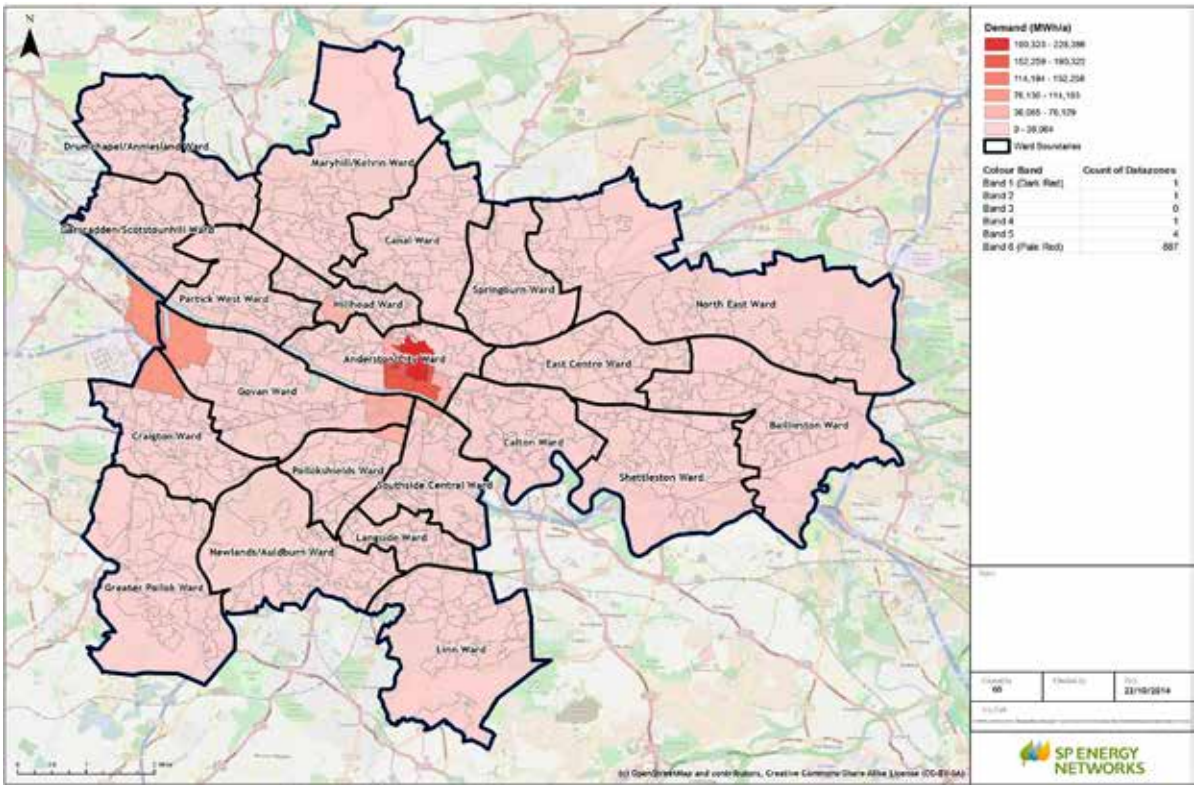
By combining these data sets and using various algorithms, an estimation of the total annual energy consumption (kWh/yr) attributable to every known address in Glasgow was carried out. From this, GIS maps showing the distribution of annual energy consumption across the city were produced. These are shown in Maps 3-6.

Map 3 Total energy demand in Glasgow



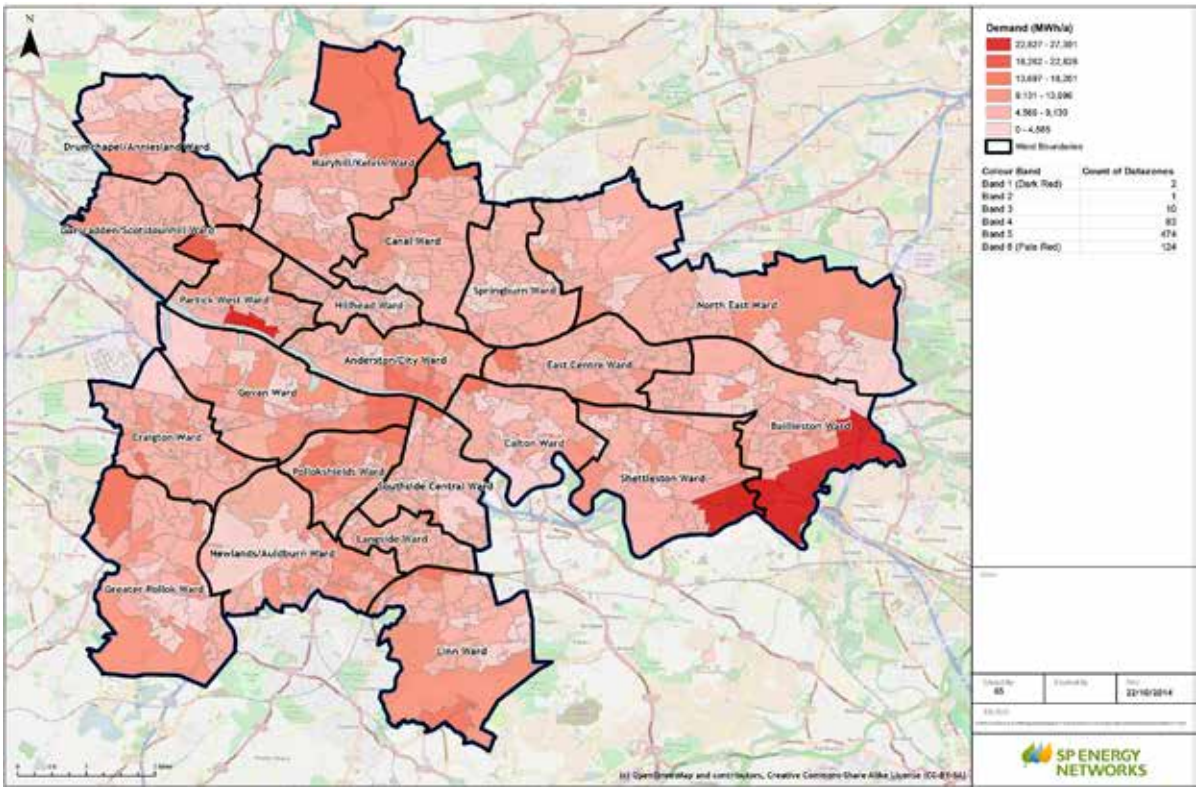

Source: SPEN

Map 4 Glasgow – Total non-residential energy demand in Glasgow (Source SPEN)



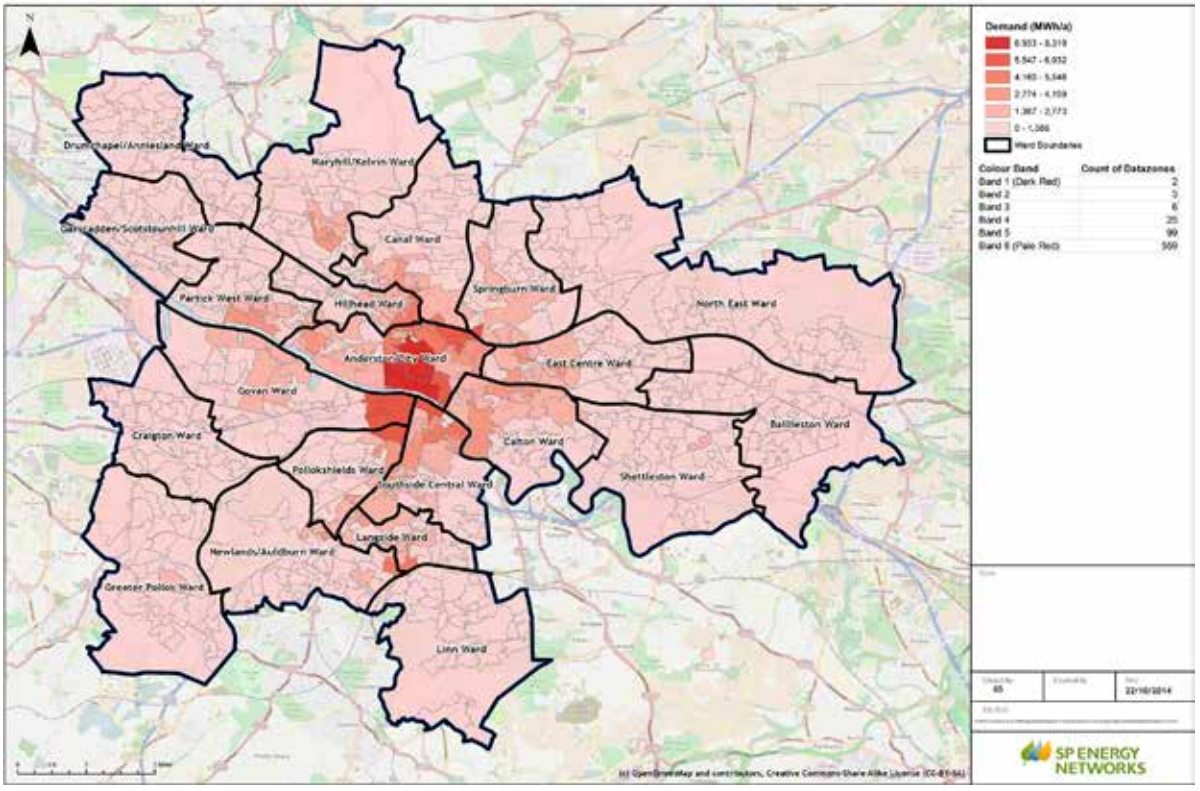

Source: SPEN

Map 5 Total residential energy demand in Glasgow (Source SPEN)




Source: SPEN

Map 6 Glasgow – Total electricity demand in residential buildings for heating and hot water




Source: SPEN

### Total energy consumption

Total energy demand in Glasgow is shown in Map 3. High concentrations of energy consumption are most prevalent in those areas of the city with high-density built development. The highest concentration of energy consumption (both electricity and gas) in Glasgow occurs in the city centre, due to the high-density of predominantly non-residential premises (both commercial and public buildings) along with considerable high density residential development. The highest demand is centred on Anderston/City Centre and Govan wards.

Non-residential demand, (Map 4), is also concentrated in the city centre, along major arterial roads and also in the commercial areas adjacent to the River Clyde (the Clyde Waterfront). Some discrete clusters of non-residential energy consumption are also observable around University of Glasgow.

In general the more affluent residential areas including the West End tend to a reliance on gas for heating, with less affluent areas (especially where there is social housing) having a somewhat higher reliance on electric heating.

The highest concentrations of residential energy demand (Map 5) appear to occur in the three clusters already identified to the west, south, and east of the city. Energy consumption in these areas is predominantly attributable to high-density residential accommodation and the associated space-heating and hot water use in these buildings.

Map 5 shows the distribution of annual electrical energy consumption associated with heating and hot water in residential buildings. This is a particularly important map in that it highlights possible areas to target actions and project that seek to reduce high carbon electricity use for heating. In the more affluent areas of Hyndland and Hillhead, which are predominantly populated with traditional tenement flats, residences are seen to be reliant primarily on gas for their heat and hot water. In contrast, the high-density flats situated along Maryhill Road and around the southern extent of Partick appear to be more reliant on electric heaters. In the high-density clusters identified in the southside and east end the majority of residences are reliant primarily on electricity for their heat and hot water.

## 2.5 Energy use in buildings

### Residential buildings

Glasgow currently has 297,000 homes in total[30] – and estimates suggest that this will increase by 56,000 homes to 2025[31]. While it is considered that a return to economic growth will boost household formation[32] rates, it is not expected that these will reach the levels seen in the 1990s. In fact, the 2011 census showed slower growth in household formation than the 2008 Housing Needs and Demand Assessment (HNDA), which arrived at the 56,000 figure, predicted.

The tenure and stock profile of Glasgow significantly differs from the Scottish average with a considerable social rented sector (108,000 dwellings), a large and important private rented sector (57,000 dwellings), and a lower than average owner occupied sector (132,000 dwellings). The national trend towards investment in 'buy to let', and more recently, the housing market situation, where many would-be first time buyers are unable to buy due to house prices and reduced access to credit, have led to a large expansion of the private rented sector in Glasgow, from a low of 14,900 in 1991 to the 57,000 dwellings now.

The housing stock in Glasgow is predominately flats, which contributes to over 74% of the total housing stock. In terms of size, the majority of the stock is 3-bed apartment (42%). 15% of

[30] Estimates of Glasgow's housing stock by tenure www.glasgow.gov.uk/CHttpHandler.ashx?id=17786&p=0
[31] Glasgow Proposed City Development Plan: Meeting Housing Needs. Glasgow City Council 2014
[32] A household can be made up of an individual, a couple, or either one of these with children, how the child functions generally mirrors growth, aging, and divorce/separation patterns of the general population

Traditional Glasgow tenements in Milnbank

Source: John Gilbert Architects

the stock is 2-bed apartment and 23% of the stock is 4-bed apartment. Glasgow's housing stock is also older than average for Scotland with nearly half of the stock constructed before 1945, and only 12% constructed in the last 25 years. Due to a progressive tightening of building regulations new houses are more energy efficient than older properties – however the slow rate of replacement of buildings means that older, less energy efficient properties will provide the majority of housing for many years to come. This means that measures that can be retro-fitted at reasonable cost to older properties are particularly valuable in reducing carbon emissions.

One interesting recent project looking at the potential for energy efficiency in Glasgow's tenements is the PassivTEN project[33] conducted by John Gilbert Architects for Milnbank Housing Association. Based in the Milnbank area in the east of Glasgow and in the tenement properties of Haghill area, the study identified ways of reducing the cost of tenants' fuel bills through physical refurbishment such as insulation, improving heating systems, window replacement and draught proofing.

The council's proposed Local Development Plan takes account of the current market circumstances and focuses on the amount of housing that can be delivered in the short term through the removal of obstacles to development of mainly brownfield sites. In terms of greenfield locations, progress in the current LDP in the three Community Growth Areas[34], at Robroyston, at Baillieston/Broomhouse/Carmyle (where construction is underway in a small part of the area) and at Gartloch/Easterhouse (where three masterplan locations have been identified), is anticipated. New housing is also anticipated on those sites emerged from the Green Belt Review[35] conducted in 2009 at Carmunnock, Darnley and Summerston.

More fundamental change is planned in the city's eight Transformational Regeneration Areas[36], where surplus multi-storey social rented stock

[33] www.johngilbert.co.uk/?q=node/474&image_id=645

[34] The current Local Development Plan (City Plan 2) includes provision for the development of a number of Community Growth Areas utilising sustainable development principles along transport corridors.

[35] City Development Plan. Background Paper 13. Green Belt Review

[36] Transformational Regeneration Areas were identified in 2009 and supported by Scottish Government, Glasgow City Council and Glasgow Housing Association

PassivTen retrofit

Source: John Gilbert Architects

has been demolished, and is in the process of being replaced by new mixed tenure housing.

Much social housing stock has been improved in the past decade thanks to a significant investment from the past Carbon Reduction Emissions Target (CERT) and the Community Energy Saving Programme (CESP)[37] that has included the fitting of new heating systems, windows, improved heating controls, and both internal and external insulation. Emissions from Glasgow Housing Association (GHA) stock – the largest landlord in the city – are estimated to have fallen by 55% in the period 1997 to 2007. This very significant reduction is due in part to the relatively poor energy efficiency of much of this stock when monitoring started in 1997.

This serves to emphasise the importance of continuing to upgrade – through retrofitting and removing electrical heating – the existing stock of homes in Glasgow, whether social or privately owned, whilst at the same time creating more energy efficient homes in different locations in the city.

## Energy Use in Municipal Buildings

The Glasgow City Council Carbon Management Plan (2014) covers the carbon emissions from the activities of the Council Services and Arms Length External Organisations (ALEO's) within the Glasgow City Council Family. There are in total 746 operational properties that fall under the responsibility of the Council and ALEOs and the Council spends around £40m[38] annually on heating and powering Council buildings, transport fuels and paying carbon tax (the Carbon Reduction Commitment or CRC) annually.

Energy use and carbon emissions from council and ALEO buildings are given in Table 3. The buildings energy costs are £28.6m and the $CO_2$ emissions are 152,406 tonnes.

The cost of electricity and gas are predicted to continue to rise annually on a national basis. If this were mirrored in Glasgow the council's energy bill would rise to £47 million by 2020 as a consequence of energy price

Table 3. Energy consumption during 2013/14 within Council properties (GCC and ALEOs)

| Energy Type | Usage 2013/14 | Cost to Council Family | CO2 emissions (tCO2) |
|---|---|---|---|
| Electricity - buildings | 132 GWh | £12.9m | 65,478 |
| Electricity – street lighting | 41 GWh | £4.2m | 22,513 |
| Gas | 283 GWh | £8.5m | 50,146 |
| Coal | 2.3 GWh | £0.015m | 924 |
| Gas oil | 50.4 GWh | £3.0m | 13,345 |
| **Total** | **508.7 GWh** | **£28.6m** | **152,406** |

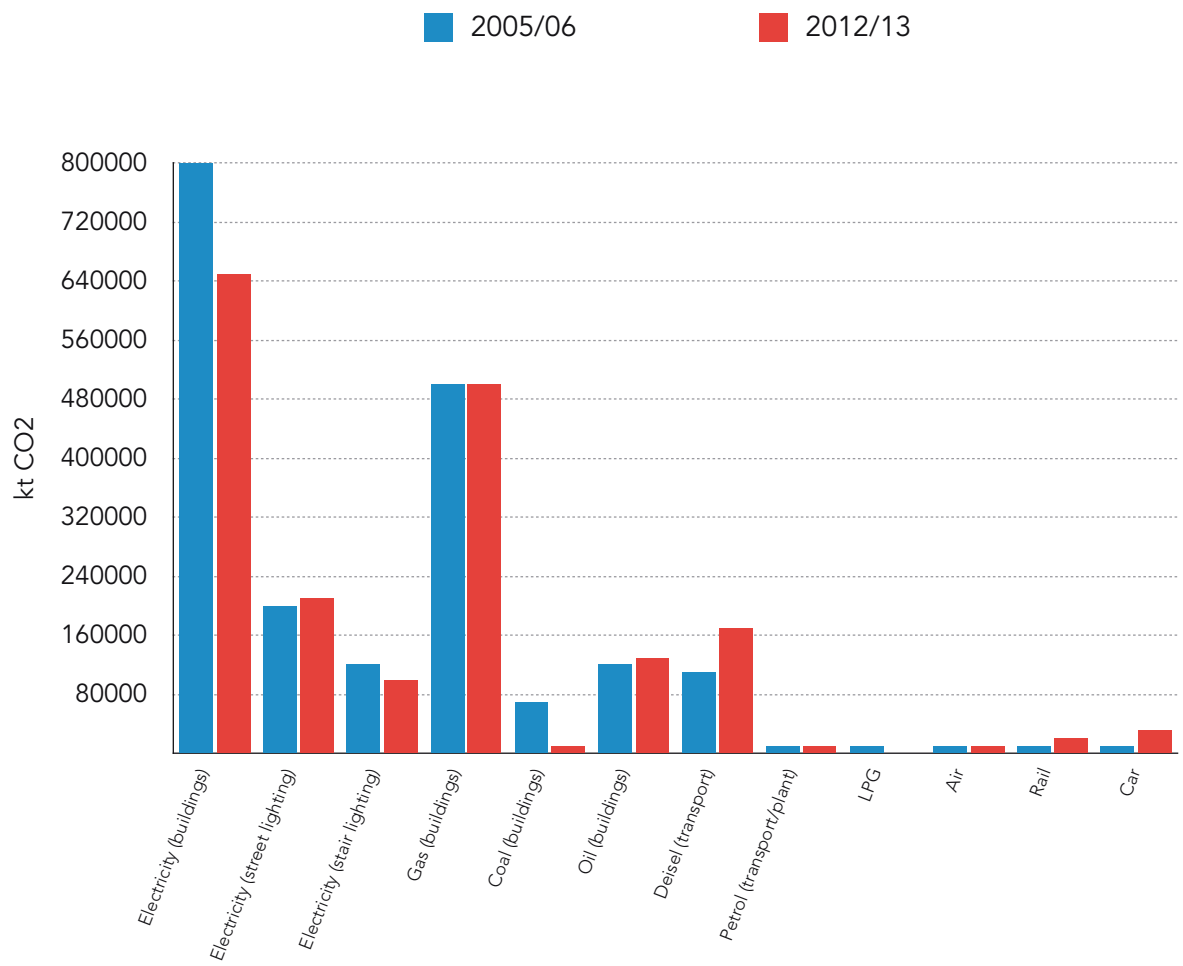
Source: Glasgow City Council.

[37] The past CERT and CESP programmes were replaced in October 2012 by the Green Deal and the Energy Company Obligation (ECO).

[38] Cost of Electricity, Gas, Gas Oil, Coal, Water, Petrol and Diesel in 2012/13

increase and CRC payments). In addition to the financial implications of non-action the city must consider the impacts of increased emissions from the consumption of fossil fuels on the environment and its $CO_2$ targets. Though carbon emissions from buildings and lighting have fallen between 2006 and 2012 (Figure 14) diesel transport emissions have risen. Coal emissions from building heating have fallen dramatically (Table 4).

Figure 14. $CO_2$ emissions in Glasgow City Council buildings and lighting 2005/6 – 20012/13




Source: Glasgow City Council

## 2.6 Large commercial energy consumers in Glasgow

Identification of large energy consumers in Glasgow is difficult because within the privatised energy market in the UK the amount and mix of energy consumed by a dwelling or enterprise is commercially sensitive information. The private energy companies do not voluntarily disclose any customer energy consumption information and Distribution Network Operators (DNO's) are precluded from publishing any information which could lead to the discernment or inference of the actual energy consumption data associated with specific customers on their networks.

Map 4 presented for energy consumption in non-residential buildings earlier in the report therefore provides the best indication of the location of high energy consumers in the commercial or industrial sectors (or indeed the residential sector) in Glasgow. Whilst it is not possible to publicly identify larger energy consumers within the city, such consumers are key stakeholders. The council will seek to identify and engage larger commercial and industrial consumers of energy on the basis of qualitative assessment based on commercial activity types and apparent relative scale of the commercial venture. The Sustainable Glasgow Board will be an important forum in which such action can be discussed.

## 2.7 Energy use in public lighting

### Street lighting

Glasgow has 72,000 sodium street lamps. This includes street lighting in residential areas and highways, traffic signs, bollards and lighting in residential common areas. It currently costs around £8.5million a year to power and repair Glasgow's network of public lighting[39]. $CO_2$ emissions from street lighting rose by 3% between 2006 and 2013 (thought largely to be due to improved reporting of consumption rather than consumption increasing per se).

Glasgow has launched a major programme to replace the majority of the old sodium lamps by 2018 with LED lamps. The new lamps are expected to use at least 50% less energy than the old ones and over 20 years they will cut the council's carbon emissions by 52,329 tonnes[40]. In a complementary initiative under the Future Cities Intelligent Street Lighting Demonstrator, energy efficient LED lamps are also being installed which will demonstrate how the city could use them to reduce carbon emissions,

increase safety and cut power consumption. Sensors will also be installed on lighting columns which will collect data such as footfall, air and noise pollution levels. This real time information will feed into the Open Data Platform which, in turn, will make it available to the public.

[39] Source – Glasgow City Council Lighting www.glasgow.gov.uk
[40] Source – Glasgow City Council Carbon Management Plan

## 2.8 Energy use in industry

Glasgow has the largest economy in Scotland, with an annual GVA of £35.4 billion[41]. In the past Glasgow was known for its strong shipbuilding, engineering and textiles industry. Although some major companies still operate in the city, these traditional industries have been in decline for some time. Glasgow is now overwhelmingly a service sector economy - only one in every 10 jobs is now based in production[42]. Around 13,000 companies are located in Glasgow – the main employment sectors include retail, tourism, food & drink and communications. Over the last few decades the city's financial services sector has also grown considerably.

A significant proportion of Glasgow's non-domestic carbon emissions are related to retail, finance, commercial and public sector activity however there are sectors where a small number of organisations can have high energy consumption and high emissions due to the type of activity. Particularly relevant in Glasgow are the food and drink sector; the leisure sector; data processing and storage; distribution warehouses; and certain types of public sector facilities (such as hospitals). There are also a few large manufacturing facilities with high energy profiles.

Electrical energy consumption used for all purposes (heating, cooling, hot water, lighting, other) in non-residential buildings across Glasgow is heavily concentrated in the city centre due to the physical density of non-residential premises. There is a concentration of electrical heating and hot water demand in the retail areas immediately surrounding Sauchiehall Street, Buchanan Street, Argyle Street, and the St Enoch Shopping Centre.

Arterial roads and the developments running alongside the River Clyde, which accommodate commercial/industrial/retail premises show as corridors of relatively high density electricity consumption on the maps above. Gas energy consumption in non-residential buildings for all purposes (heating, cooling, hot water, lighting, other) is heavily concentrated where the density of non-residential buildings is most prevalent in the city centre.

A key issue is the production of waste heat from industrial premises such as breweries or through energy generation. If such premises can be identified then waste heat can be potentially be tapped for use in distinct heating schemes.

## 2.9 Energy use in Transport

Energy use in transport is largely reliant on the mode of transport used. The modal split for transport (all journeys) in Glasgow in 2009 was as follows[43]:

- Personal motorised transport: 44%,
- Public transport: 33%,
- Bicycle: 2%,
- Walking: 14%,
- Other (passenger, taxi): 8%

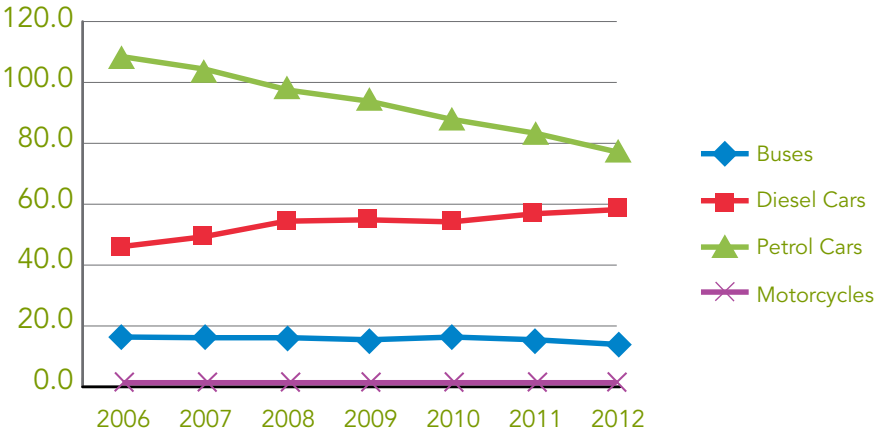
DECC figures for energy consumption show that there has been a decline in petrol consumption from 2006-2012 (see Figure 15). This may be due to a combination of factors including increasing fuel efficiency of vehicles, as well as decreases in vehicle use.

41 Glasgow Economic Commission Final Report June 2011
42 Ibid
43 http://sootfreecities.eu/measure/traffic-mobility

In contrast, diesel use in cars has increased and in buses it has remained constant. This has implications for local air quality in the city. Glasgow now has Air Quality Management Areas (AQMAs) located in the city centre, Byres Rd/Dumbarton Rd and Parkhead Cross areas. All of these have been declared for the pollutant nitrogen dioxide ($NO_2$). The AQMA covering the whole of the city has been declared for pollutant particles ($PM_{10}$) which arise from diesel emissions, often from buses.

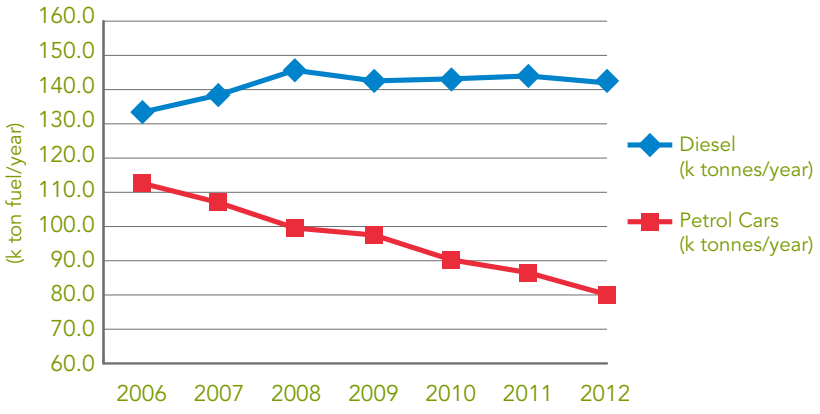
Cities such as Glasgow rely on effective transport systems for their economy and communities but transport is a significant user of energy and has a major impact on the quality of life in a city and its environment. Forecast increases in population and continuing regeneration of the city – including events of the scale of the recent Glasgow 2014 Commonwealth Games – may increase demand for transport in the future. The challenge for Glasgow is to implement initiatives that will result in significant modal shift towards public transport, walking and cycling and away from private motorised transport – as was achieved with some success during the Games.

Figure 15: Glasgow road transport energy use (personal) 2006-2012




Source: DECC

Figure 16: Glasgow road transport energy use (petrol and diesel) 2006-2012




Source: DECC

## Road and private transport

The city has an extensive road network consisting of some 40 km of motorway and 1700 km of other public roads. The backbone of the road system is the M8 motorway that runs through the city from Greenock in the west and continues to Edinburgh in the east. On the eastern outskirts of the city the M8 joins with the M73 which links with the M74 route to Carlisle and the south, and with the M80 route to Stirling and the north. A recent extension of the M74 provides direct access from the south to connect with the M8 near Glasgow city centre and with the M77 for southbound journeys.

A large proportion of journeys along these routes are by commuters in private cars travelling into the city. As a result there is frequent congestion on routes leading to the city – including the motorways - during peak periods. Glasgow also has around 1,400 licensed taxis, and a further 2,800 licensed hire cars. Glasgow has however, on average, a relatively low car ownership level compared with the rest of Scotland, with approximately half of all households (47%) not owning a car[44].

## Rail transport

In addition to the road system, Glasgow has an underground railway system and the largest suburban commuter rail network in the United Kingdom outside London. Each day the rail network is used to make 100,000 daily passenger trips in or out of the six central area stations, with almost 20% of this figure accounted for by morning peak hour movements alone[45]. Two major railway stations (Queen Street and Glasgow Central) are located within Glasgow city centre and link to a further 60 railway stations throughout the city, five of which have park and ride facilities.

The Strathclyde Partnership for Transport (SPT) Subway (Glasgow Underground) operates on a circular route around the city on 10.4 km of double track with 15 stations. It handles more than 40,000 passengers a day and is estimated to be used by about 10% of city centre travellers[46]. Together the rail and underground network account for 30% of peak trips to the city centre.

## Air transport

Glasgow International Airport lies 10 km west of the city centre, outside the city boundary and so emissions from the airport are not included in this Energy & Carbon Masterplan.

## Cycling

Glasgow has low rates of bicycle usage compared to other UK cities[47] but in the past few years the number of cycle lanes in Glasgow has been increased by 212km and the new cycle hire scheme Mass Automated Cycle Hire (MACH) has been introduced in the city from June 2014 onwards. So far the scheme has been used 20,000 times since the launch with an average usage of 250 times/day and a peak of 700 times/day during the Games.

## Air Quality

Transport systems in Glasgow are responsible for 24.7% of the city's GHG emissions (DECC, 2013) and 18% of the city's carbon emissions – as well as 80% of a range of other pollutants such as nitrogen oxides and particulates. These pollutants ($PM_{10}$ & $PM_{2.5}$) have a damaging effect on respiratory health and have resulted in some busy roads in the city being consistently ranked amongst the poorest for air quality in Scotland.

The city has both a Local Transport Strategy 2007-2009 (due for revision) and an Air Quality Management Strategy. These documents combined with the potential designation

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44 http://www.spt.co.uk/wmslib/Documents–RTS/TORs/glasgow.pdf

45 Air Quality Action Plan 2009. Glasgow City Council http://www.glasgow.gov.uk/CHttpHandler.ashx?id=8373&p=0

46 Ibid

47 Rates of bicycle use in the UK are around 2% in terms of proportions of trip cycled www.ecoroute.co.uk/info/huge-scope-for-cycling/

of Low Emission Zones[48] in the city in the future will contribute to improving air quality and reducing carbon emissions.

### Municipal fleet, public transport, private transport

Municipal fleet transport includes all Glasgow City Council (GCC) fleet vehicles - cars, vans, refuse vehicles - and the vehicle mileage covered by these in the course of council business. It includes the use of personal vehicles, hire cars and taxis. Diesel fuel energy usage in GCC's municipal fleet in 2012/13 was 17,301 tonnes of $CO_2$, which accounts for approximately 10% of total council $CO_2$ emissions[49]. There has been a rise in diesel fuel consumption over last period of monitoring in the council's Carbon Management Plan and a minor fall in petrol consumption. This increase is due to a significant increase in social work service provision by Cordia and associated use of their vehicles.

### Electric vehicles

The council has a fleet of 16 electric vehicles including Nissan Leafs, a 100% electric vehicle which can travel up to 124 miles on each charge. In addition to several electric vehicle charging points at council premises there has been a roll out of installed charging points across the city as part of the Plugged in Places programme[50]. There are currently 56 charging outlets operated by the council with plans for further installations by the end of 2015. GCC offers free charging and parking (whilst charging) at a network of charging points around the city. There is also a network of over 20 charging points operated by other private and public sector stakeholders such as the NHS and SSE. These are available for use by the public through a simple registration process.

## 2.10 Energy and waste management


Artist's impression of the Glasgow Recycling and Recycling Centre at Polmadie

Glasgow City Council disposes of 350,000 tonnes of waste every year[51]. Of this, Glasgow sends the vast majority (74%) to landfill. However, with Scotland's zero waste targets focusing on waste reduction, re-use, enhanced recycling and recovering renewable energy from what remains, a new, state-of-the-art recycling and sustainable waste management facility is being constructed at Polmadie, to be operational from 2016.

The Glasgow Recycling and Renewable Energy Centre (GRREC) will handle 200,000 tonnes of

[48] How Emission Zones are established to encourage the most polluting heavy diesel vehicles driving in the city to become cleaner
[49] Glasgow City Council Carbon Management Plan 2013-2021
[50] The Plugged in Places programme aims to expand the UK's electric vehicle infrastructure www.gov.uk/government/publications/plugged-in-places
[51] Glasgow City Council Waste Strategy 2010

council general waste (green bin) every year. The plant, working in combination with city-wide blue, brown and purple bin recycling, will divert 90% of green bin residual waste away from landfill, releasing recyclable resources from household waste and producing heat and power from what will be one of the most advanced waste management facilities in Europe.

The facility will produce enough energy to power the equivalent of 22,000 households and heat the equivalent of 8,000 homes, delivering a potential saving to Glasgow of 90,000 tonnes of $CO_2$ every year.

Waste to energy, and biogas from waste represent major low carbon energy opportunities for the city – potentially an estimated carbon reduction of around 6% annually. However, with the aim of maximising reuse and recycling, the Scottish Government has set a national limit that no more than 25% of waste should be used in waste to energy systems.

Much of Glasgow's waste (such as sewage and food waste) could be treated using anaerobic digestion to produce biogas which is then used to produce heat and power for homes, businesses and public buildings – or to fuel public transport. Anaerobic digestion treats waste organic matter (e.g. sewage, farm slurry or factory and kitchen food waste) in a sealed container using microbes to produce biogas and a residual compost like material. Sewage treatment plants at Dalmarnock and Shieldhall (also large consumers of energy) are potential locations for anaerobic digestion facilities, and the waste to energy plant at Polmadie could take more food waste for anaerobic digestion from other facilities and households in the city. Biogas could then be used to fuel combined heat and power and district heating schemes in Glasgow.

## 2.11 Energy consumption in water treatment

Water treatment in Glasgow is the responsibility of Scottish Water. The energy consumed in water treatment and waste water treatment makes Scottish Water one of the highest energy consumers and carbon emitters in the city (and the highest ranked on the Carbon Reduction Commitment payment list). Treating water and wastewater and their distribution is an energy intensive activity. Efficiencies could be achieved through waste minimisation by industry, reduced water demand, leakage reduction, recycling, and point-of-use treatment.

Reducing leakage is a top priority, a benefit of which is that there is a reduction in the amount of water that has to be produced by Milngavie and Balmore water treatment works, which serve most of Greater Glasgow, and so this reduces Scottish Water's operating costs and carbon emissions. Scottish Water has invested in a programme of District Metered Areas (DMA) which helps to identify any localised leakage by the installation of online flow monitors. For each DMA, the flows going into the network are recorded and compared against the expected consumption based upon actual meter readings for non-domestic properties and a calculated per household consumption rate. This allows early diagnosis and investigation of potential water loss through leakage.

Recent investment by Scottish Water on the Glasgow city centre mains rehabilitation programme to replace water mains across some key streets in the city centre, along with trunk main replacement serving the city centre, also helps to make the network more energy efficient. Further investment is under way to install Pressure Control Valves (PCV's) which reduce the demand placed upon the water infrastructure and further reduce the potential for interruptions to supply and leakage.

There is also a role for behaviour change in water use (as with energy consumption) so the company has also been working with its assets,

customers and stakeholders to reduce the demand for water through asset assessment, education and influencing new development and Building Standards Regulations. This could potentially be linked to the Integrated Energy Management (see section 4) and investment in energy infrastructure being made by Scottish Power Energy Networks.

### Waste water treatment

Scottish Water collects and treats the waste water from households, businesses and industry in Glasgow every day. The city population is served by four waste water treatment works – Dalmuir, Dalmarnock, Daldowie and Shieldhall - which comply with Scottish Environment Protection Agency (SEPA) regulations. However, the waste water treatment system is complex and the drainage infrastructure ageing and so in-depth analysis and investment is required to create a system to help promote the vision of a greener Glasgow. The Metropolitan Glasgow Strategic Drainage Partnership (MGSDP)[52] was set up in 2002 to bring an integrated and sustainable approach to sewerage and drainage master-planning for the metropolitan Glasgow area.

MGSDP has so far progressed a range of measures to reduce the risk of flooding, including: fast action Scottish Water choke squads to clear sewers; council hit squads to clear watercourses; multi-million pound investment in sewerage improvements; and the removal of almost 500 properties from the At Risk flood register. These measures, taken since 2002, are a start, but further major investment and effort will be required over the next 25 years to ensure that metropolitan Glasgow's drainage network can cope with a changing climate, improve the environment and support modern development requirements. There is a great opportunity to ensure that energy requirements are integrated into the MGSDP approach with further integration also with the LDP and Integrated Energy Planning Approach.

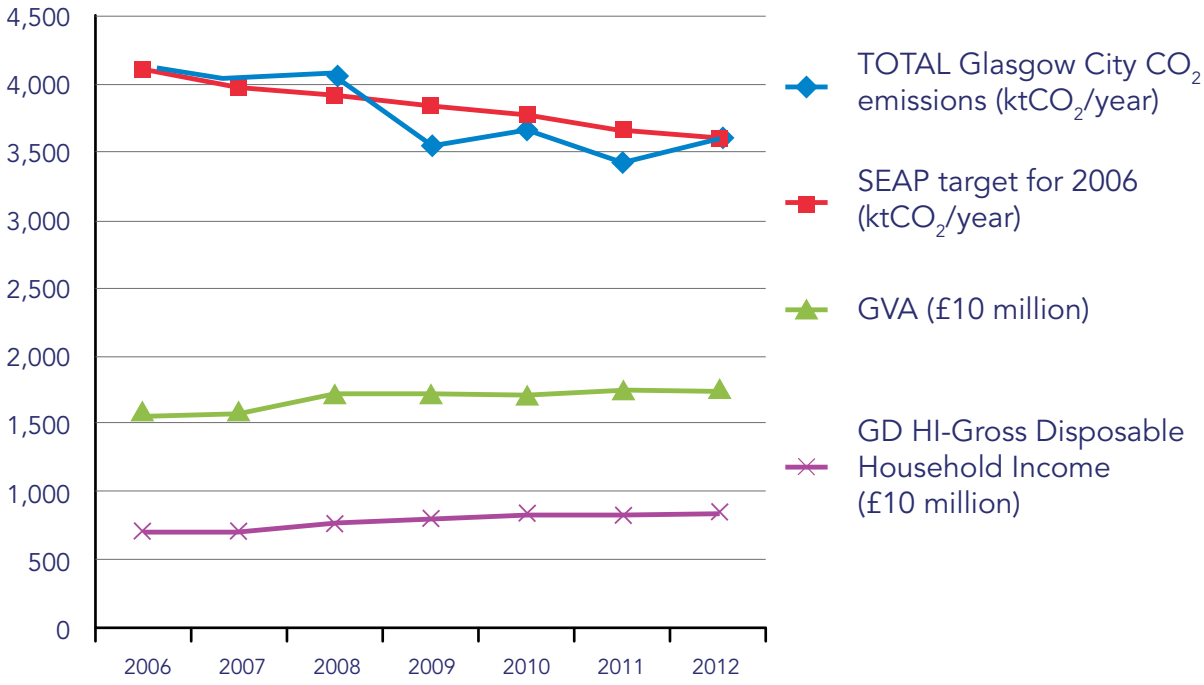
[52] www.mgsdp.org/

# 3 Future Trends in Energy and $CO_2$ Emissions

# 3.1 Introduction

This chapter looks at possible future trends in energy consumption and $CO_2$ emissions, looking at scenarios developed at both national and local level for Glasgow. One key issue discussed in this chapter is whether Glasgow can decouple economic growth and rising $CO_2$ emissions and create an enduring low carbon economic growth scenario.

Figure 17. Energy, $CO_2$ and GVA growth in Glasgow




Source: DECC, Glasgow City Council

# 3.2 The Economy, Energy and $CO_2$ Emissions

The relationship between economic growth and $CO_2$ emissions is complex and this ECM does not attempt to begin to resolve some of the issues associated with measuring this relationship, or projecting how the two factors will interact in the future.

Historically, there has been a correlation between global economic growth and carbon dioxide emissions. This is shown by the fact that higher income countries tend to emit more emissions than low income countries and within a country, $CO_2$ emissions tend to rise during a boom and fall during a recession. Some Scandinavian countries, such as Sweden, Denmark and Norway, claim to have achieved economic growth alongside reductions in $CO_2$ emissions. This is known as 'de-coupling' economic growth and $CO_2$ emissions[53].

[53] De-coupling can take two forms: Relative decoupling refers to a situation where resource impacts decline relative to the Gross Domestic Product (GDP); impacts may still rise but more slowly than GDP. Absolute decoupling is where resource impacts decline as GDP rises. The measurement similar to GDP used at the local level is Gross Value Added (GVA).

It is possible that without action, Glasgow's carbon emissions would continue to rise or at least would not fall enough to meet the 30% target. The gap analysis on the existing SEAP showed that this is likely to be the case (see section 1) and with the additional impact that a reviving economy might bring this means that Glasgow needs additional actions to compensate for a rise in energy use and $CO_2$ emissions caused by economic growth. However, the trend in energy consumption and $CO_2$ emissions since 2006 has been downwards overall, though in certain years increases may be recorded (see Figure 17) generally coinciding with periods of economic growth.

Economic growth in Glasgow should not necessarily result in an increase in $CO_2$ emissions because, for example:

- Productivity could increase by improving skill levels, for example, which could make businesses more innovative and competitive, increasing GVA with no resultant impact on $CO_2$ levels
- An increase in consumption may not result in increased emissions in Glasgow. Although as people earn more money (the Gross Disposable Household Income on the graph) they may tend to spend it on more goods, however these could be more efficient goods (e.g. a more energy efficient fridge) or low carbon technologies (e.g. solar panel or insulation) and therefore there may not be increased energy consumption
- Growth in the renewable and low carbon energy sector as opposed to conventional or more polluting industries would still be growth but 'greener growth' instead.

As introduced in section 1, rising energy costs due to diminishing fossil fuel sources and international and national financial mechanisms could mean that businesses' competitiveness is affected by their ability to reduce their energy use and/or obtain energy from renewable and low carbon sources.

## 3.3 Scenarios for energy consumption in Glasgow

### National Grid 'UK Future Energy Scenarios' to 2035

The development of scenarios for energy consumption and $CO_2$ emissions in Glasgow has been based on two locally developed scenarios relating to demographic growth and two of four scenarios developed at the national level by National Grid. These national scenarios were applied to the local energy model developed by SPEN described in section 2.

The National Grid annual UK Future Energy Scenarios report[54] describes the National Grids analysis of credible future energy scenarios out to 2035 and 2050. They are accessible, detailed scenarios based on robust evidence and trends in electricity generation and demand, gas supply and demand, new technologies and social and economic developments and progress against EU energy and carbon targets. The 2014 version presents four core scenarios to 2035. Previous versions have presented only two scenarios – Gone Green and Slow Progression, but the 2014 report has now added Low Carbon Life and No Progression scenarios. These were added at the request of stakeholders who said they wanted to see a broader range of scenarios and a stronger narrative underpinning the energy 'trilemma' of affordability, sustainability and security of supply.

Each scenario model considers the affordability of pursuing energy efficiency measures coupled with attitudes towards sustainability. All four scenarios have similarities regarding the overall make-up of the generation mix until 2018/19,

[54] UK Future Energy Scenarios 2014. National Grid. July 2014. Source: http://www2.nationalgrid.com/uk/industry-information/future-of-energy/future-energy-scenarios/

with subtle changes between strategies due to slightly different technology emphasis. For even the two most ambitious low carbon scenarios, (Low Carbon Life and Gone Green) National Grid anticipate that directed policies will not change the energy landscape until 2020.

A consistent message across all four scenarios, is that clear, coordinated, long-term policy at the UK level (or even at the Scotland level) is crucial in achieving a low carbon and renewable energy future. Below is a brief outline of each scenario with the headline figures and key assumptions for the UK as a whole. The key features of each scenario are shown in Figure 18.

### Gone Green

This scenario envisages a strong economy which leads to more emphasis on sustainability.

- The UK will meet its EU target of 15% (41.5GW) renewable energy by 2020 and 80% reduction of $CO_2$ emissions by 2050 set out in the Climate Change Act (2008).
- There is an increased reliance on renewables, to 28% (77.8GW) by 2030.
- An estimated 5.6 million residential heat pumps will be installed by 2030 and electrical vehicles will number 3.2 million by the same date.
- There is also a high up take of insulation with solid wall insulation installations sharply increasing
- To achieve this ambitious plan there should be consistent and joined-up policy across key sectors such as transport, heat and power.
- Economic and political harmonisation between Europe and the UK is crucial in order for this model to materialise.

### Low Carbon Life

This scenario focuses on future economic prosperity with long-term commitment to decarbonisation. The Renewable Energy Directive (2009) and the Climate Change Act (2008) targets are likely to be met but no new targets will be set. In the short term, there is political volatility with less emphasis on large scale renewable energy and more on nuclear power, district heating and carbon capture and storage.

- By 2030, there is a high up take of electrical vehicles (3.2 million) but a low level of heat pumps (0.6 million) installed. Cavity wall and loft insulation uptake is high but solid wall insulation will remain an unattractive option given the high cost.
- It is assumed consumers are not focused on energy efficiency and 'going green' is a by-product of purchasing desirable items.

To achieve this scenario it is assumed that the economy will recover at a pre-recession level. The UK Government's focus will be solely reinvigorating the economy rather than overtly pursuing a green agenda.

### Slow Progression

Whilst there is strong policy and regulation in Slow Progression, the poor economic climate hampers their implementation. This creates investor uncertainty and low level innovation in the technology sector.

- The EU 2020 target for renewables is missed - falling 2% short of the 15% target - but will be achieved later. New long term targets will be set after 2020 and will be missed but achieved at a later date.
- Renewable generation is mainly made up of wind (41.8GW) and solar (9.6GW) by 2030. Nuclear new build progresses and decommissioning of the existing stations is expected to remain in line with public announcements.
- There is a sharp focus on energy efficiency measures such as insulation, smart meters and time of use tariffs with behaviour mainly driven by price.
- Reduced affordability affects the residential sector with low uptake of heat pumps (0.6

million by 2030), and disruptions in the roll-out of smart meters and lower electrical vehicle numbers (1 million by 2030).

## No Progression

Inconsistent political statements and a poor economic recovery are key assumptions in the No Progression scenario. This leads to investor uncertainty, the pursuit of short term energy policies centred round gas and failure to hit EU 2020 targets. The inability to meet the carbon reduction targets may result in public scepticism and the conclusion that our carbon emission targets are too optimistic.

- As there is less disposable income, energy consumption is constrained and consumers replace appliances when they fail on a like for like basis.
- There is a lower drive for energy efficiency, compared to Slow Progression, so that replacement efficiency benefits are less, particularly in residential lighting and appliances.
- A shift of focus away from long-term decarbonisation and limited financial support available for low carbon technologies in No Progression results in a restricted new build programme for nuclear and no deployment of carbon capture and storage.
- Because this scenario focuses on short-term solutions, there is a heavy reliance on gas with renewable energy generation being hampered.

## Glasgow Scenarios up to 2020

The STEP UP project designed two scenarios based on demographic growth and decline and conducted workshops with stakeholder involvement to discuss these scenarios and how they might impact upon a sustainable energy

Figure 18. Summary of the National Grid UK Future Energy Scenarios 2014


Source: http://www2.nationalgrid.com/uk/industry-information/future-of-energy/future-energy-scenarios/

future for Glasgow. These scenarios – which were projected to 2020 (to align with the city's 30% $CO_2$ emissions reduction target) rather than 2035 as in the National Grid scenarios – described changes to Glasgow's socio-economic structure and assessed the impact on the city's carbon emissions target and planned energy actions as a consequence of this. The scenarios were:

- **Major boost**: this scenario presented a potential large population increase in the city larger than the 4.4% forecast to occur in population estimates to 2020[55]. This potentially would bring with it new economic opportunities, improved quality of life, strong economic growth, high housing demand but also increased electricity consumption and carbon emissions.

- **London calling:** this scenario presents a potential large population decrease in the city caused by better job opportunities being available in other Scottish cities or in England, out-migration growing as a consequence, an older population (as younger people leave the city), fewer workers and taxpayers and lower energy demand with lower carbon emissions.

Workshops with stakeholders were conducted to assess the impacts of these scenarios. This included time spent understanding the impacts of the scenario on political, economic, socio-cultural and technological factors in Glasgow and then assessing the effects on the city's climate and energy targets, and the impact on specific SEAP sectors (municipal buildings, tertiary buildings, residential buildings, public lighting, industry, transport, local electricity production, local heat/cold production). The impact on broad areas of intervention as identified by the Covenant of Mayors was also assessed. The objective of the exercise was to assess the robustness of the actions set out in this Plan to meet Glasgow's $CO_2$ reduction target in the light of external and internal factors not currently in the city's projections or covered by the National Grid scenarios.

The findings of the exercise were that a significantly larger than expected population increase would make it more challenging to meet the city's 2020 carbon emissions reduction target compared to the business as usual case, with significant impacts on all sectors except public lighting and others. A significant population decrease is expected to make it less challenging to meet the target, except for two sectors – public lighting and transport, for which the impact is expected to be neutral. In both scenarios, it is believed that the city would succeed in meeting its 30% reduction target, but depending on what factor, or factors, drives the population change, it could be the case that targets are not met.

### Impact of the National Grid Slow Progression and Gone Green Scenarios on Glasgow's energy model

The National Grid Slow Progression and Gone Green scenarios were applied to the Glasgow energy model described in section 2. But they were adapted to the 2020 timeline, instead of 2035. This work was carried out by SPEN as part of the energy mapping exercise.

Under both future scenarios, when superimposed upon the energy consumption model, energy demand in residential and non-residential sectors appears to increase. The magnitude and spatial distribution of this projected growth in demand is similar in both scenarios considered (see Table 5). However,

[55] People and Households in Glasgow: Current Estimates and Projected Changes 2010-2035 Glasgow City Council 2012

the total energy demand growth does not appear to be influenced by the assumptions inherent within each scenario regarding projections for economic growth and uptake of energy efficiency improvements. One possible explanation for this observation is that energy efficiency improvements assumed in the Gone Green scenario may be offset by increased total demand associated with stronger economic growth assumptions.

Both scenarios show growth in electricity demand, occurring primarily in the city centre and attributable to non-commercial buildings. There is noticeably greater growth in electricity demand in the Gone Green scenario due to the uptake of technology such as heat pumps and electric vehicles. Both scenarios also showed growth in gas demand, occurring primarily in the city centre, but there is marginally greater growth in gas demand in the Gone Green scenario, and there is a significant increase in residential gas consumption under both scenarios. Gas consumption is projected to increase more markedly than electricity consumption under the Slow Progression scenario. This reflects the assumption of a slower uptake of electric heat-pumps under the Slow Progression scenario.

The results from the analysis under the four scenarios are presented in Table 5 below. The Slow Progression scenario for Glasgow aligns with the general trends of the National Grid scenarios. The Gone Green scenario includes an element of economic growth (this is likely to provide the funds for the implementation of green measures). Gas consumption goes up accordingly, but carbon emissions drop due to the drop in carbon intensity of electricity in 2020.

In summary, scenarios are an important part of energy planning and monitoring both of the challenges and opportunities associated with major socio-economic changes and population growth. Ongoing utilisation of indicators and data used in these scenarios can help develop a broader understanding of potential scenarios that the city could face in the future. Using the outcomes from these exercises, Glasgow can better develop its resilience against such challenges and identify opportunities that may result in significant emissions reductions across key sectors.

### Table 5: Glasgow scenarios analysis of the impact on energy consumption and CO2 emissions up to 2020

| Indicator | Source | a) Estimated Consumption (2013) | b) Scenarios | | | |
|---|---|---|---|---|---|---|
| | | | National Grid Slow Progression (2020) | National Grid Gone Green (2020) | London Calling (2020) | Major Boost (2020) |
| Energy Consumption | Electricity (GWh/year) | 2368 | 2255 | 2296 | 2151 | 2526 |
| | Gas (GWh/ year) | 3994 | 3916 | 4421 | 3744 | 4863 |
| $CO_2$ Emissions (Gas + Electricity) | CO2 (kt/ year) | 2396 | 1910 | 1699 | 1826 | 1869 |

*a) The estimated consumption for Glasgow presented in the table refers to the energy consumption by buildings (residential and non-residential) in 2013 based on the energy model produced by SPEN. The model is a representation of energy consumption by buildings, however there may be buildings which the model did not capture.*
*b) The data presented in the analysis is for the four scenarios taken up to 2020 is based on the energy model consumption produced by SPEN in 2013.*

# 4 Actions

# 4.1 Introduction

The Energy and Carbon Masterplan provides a new strategic energy framework for Glasgow and is the new Sustainable Energy Action Plan for the city as far as the Covenant of Mayors commitment by the council is concerned. It takes a holistic view of the issues and opportunities and sets out how Glasgow can develop an energy system that promotes energy efficiency, develops low carbon energy generation and integrates and co-ordinates development within a wider framework for sustainable energy.

The actions outlined in this section and in the accompanying SEAP template (to be submitted separately to the Covenant of Mayors) are based on the key elements of this plan:

- A quantitative analysis of the city's energy demand – by source, sector and geographical area, as set out in section 2 – showing the areas of the city where energy demand is high and the reasons for this, depending on the type of building and type of energy used for power or heating
- An examination of existing approaches to energy management, energy efficiency and generation of renewable energy and heat in the city and how these could be improved
- Identification of low carbon energy resources in and around the city by size and availability – for example, the existing wind turbine at Cathkin Braes, current and potential solar photovoltaic usage, geothermal energy potential; and the development of waste to energy for example the new Glasgow Recycling and Renewable Energy Centre (GRREC) plant at Polmadie
- Implementing best practice approaches that are working well in other cities across Europe and the world as part of the STEP UP project and TSB Future Cities Demonstrator
- Tackling the key challenges of climate change, fuel poverty, energy security and regeneration by assessing the benefits that low carbon energy projects can have in supporting the key social and economic challenges facing Glasgow.

Delivering city-wide large scale carbon emission reductions in Glasgow (to the extent of the 697,596 tonnes required to meet the 30% reduction target) also requires changes at a national level to the way the energy market works in the UK so that decarbonisation of power generation through renewable energy generation is promoted[56] in the way that the Committee on Climate Change have suggested in their recent report to Government[57].

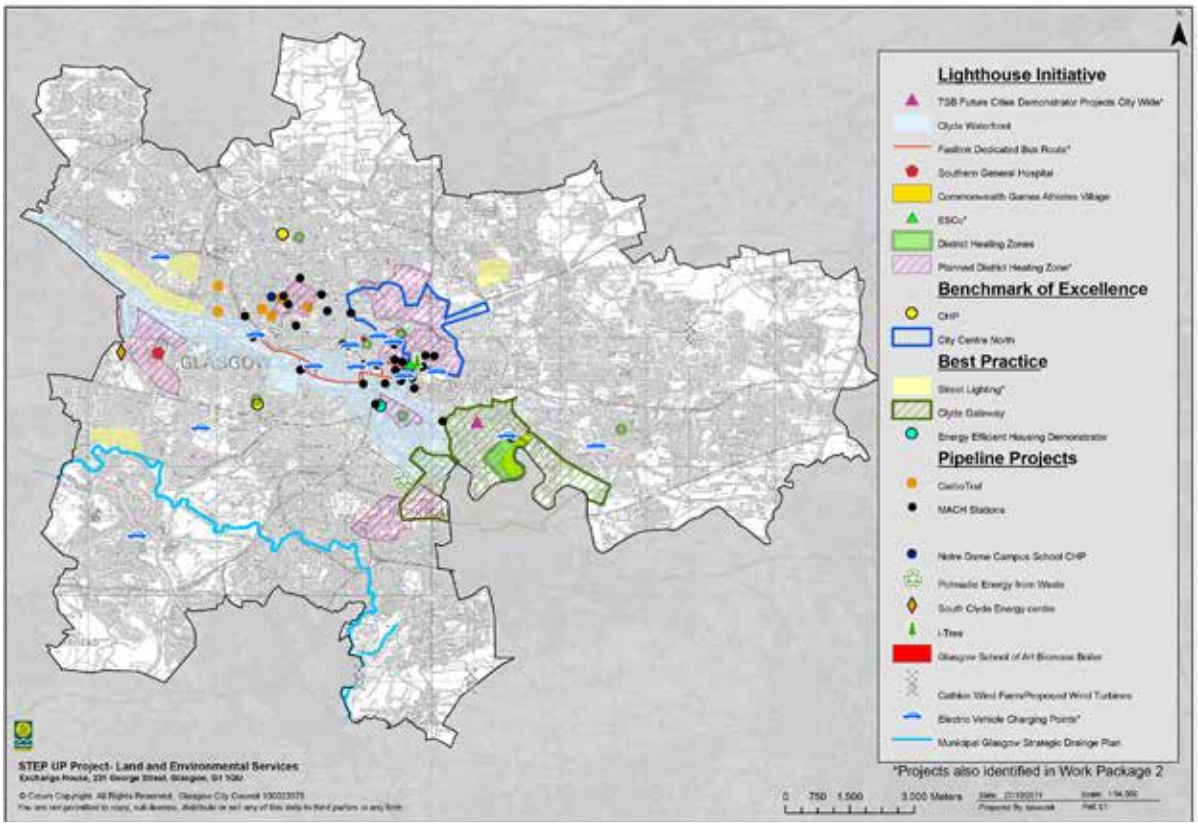
However, Glasgow can start a process of bottom-up change where Glasgow develops a robust and significant local decentralised energy system through a mixture of small and large scale projects and investment. As part of this effort there is the potential for many small scale community-based renewable energy technologies to flourish across the city making a contribution to carbon emissions reduction and generating other local social and economic benefits.

Map 7 shows the range of existing and potential energy projects that are already transforming Glasgow's existing energy system into a decentralised and low carbon energy system. The projects on this map will be added to over the next few years as more renewable energy, district heating and similar schemes are added.

[56] To an extent this process has started with Electricity Market Reform which aims to encourage investment in a range of low carbon technologies so that they generate an increasing proportion of our electricity. However, reliance on fossil fuels (including shale gas) remains a strong driver of energy policy and the energy market in the UK.

[57] Meeting Carbon Budgets – 2014 Progress Report to Parliament. Committee on Climate Change July 2014

Map 7. Installed and proposed energy projects in Glasgow




Source: Glasgow City Council

## 4.2 Sectoral contributions to the 30% $CO_2$ reduction target

The main sectoral contributions key to achieving the 30% $CO_2$ reduction target opportunities lie in developing comprehensive building energy efficiency in both domestic and non-domestic properties; developing low carbon energy and utilising energy more efficiently. The estimated contribution each sector would make within six years to Glasgow's 30% carbon dioxide emissions reduction is estimated in Table 6 below.

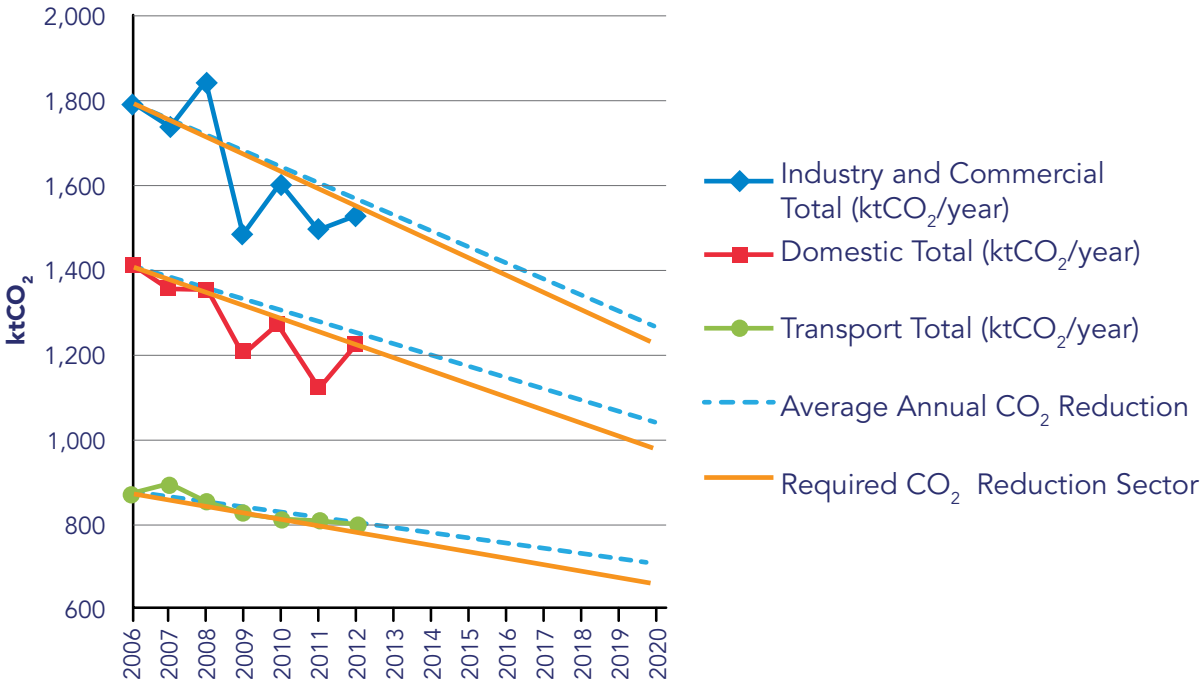
The Glasgow commitment to the Covenant of Mayors to reduce by 30% carbon dioxide from the 2006 baseline year, represents a total of 1,228,298t $CO_2$. Between 2006 and 2012 Glasgow managed to reduce its emissions by 530,700t $CO_2$; therefore, there remains 697,596 t$CO_2$ that Glasgow has to reduce in order to accomplish its 30% reduction target. Working on the basis of the overall contribution of each sector to $CO_2$ emissions remaining fairly constant and knowing the annual average reduction achieved since 2006 in each sector – Figure 19 shows the required $CO_2$ reduction for each sector. The opportunities identified in the actions below below are expected to produce significant carbon dioxide savings and ensure the achievement of the target.

Table 6. Current and expected $CO_2$ savings to meet the 30% $CO_2$ reduction target

| Sector | Total $CO_2$ Savings (2006-2020) | Current $CO_2$ Savings (2006-2012) | | Required $CO_2$ Savings (2013-2020) | |
|---|---|---|---|---|---|
| | 30% reduction from 2006 - 2020 (kt $CO_2$) | Current $CO_2$ reduction 2006 - 2012 (kt $CO_2$) | Current percentage achieved from 2006 - 2012 (%) | Target for 2013 - 2020 (kt $CO_2$) | Percentage reduction required for 2013 - 2020 (%) |
| Buildings (municipal, tertiary, residential, public lighting and industry) | 960.11 | 446.39 | 36.34 | 348.80 | 27.7 |
| Transport (municipal, private, public) | 262.18 | 78.36 | 6.38 | 69.76 | 8.9 |
| Local Energy Production | n/a | n/a | n/a | 104.64 | n/a |
| Local Heat/Cold Production | n/a | n/a | n/a | 104.64 | n/a |
| Others (forestry, landuse, efw) | 6.00 | 5.96 | 0.48 | 69.76 | n/a |
| Subtotal $CO_2$ reduction | | 530.70 | | 697.60 | |
| Target 30% $CO_2$ reduction from 2006 by 2020 | 1228.30 | | | | |

Source: Glasgow City Council

Figure 19. Annual Average and Required $CO_2$ reduction by sector (2006-2020)



# 4.3 Policy priorities

The creation of a supportive and integrated framework of policy measures from the national to the local level is vital in ensuring that the ECM can achieve its full potential for Glasgow. This means ensuring that the vision of a low carbon, energy secure city is translated into a wider range of policy objectives – such as how it contributes to tackling many of the challenges identified in section 1, including reducing fuel poverty, delivering jobs, regenerating communities, and building a more energy secure city.

## Fuel Poverty/Affordable Warmth

Fuel poverty remains a major problem in Glasgow, predominantly due to high energy prices (Map 1). At the end of 2012, 24% of homes[58] in Glasgow were estimated to suffer from fuel poverty[59] – with 57,000 as fuel poor and 10,000 as extreme fuel poor (a household that has to spend over 20% of its income on energy). Both Glasgow and the Scottish Government have strategies in place aimed at tackling fuel poverty – and investment in improving Glasgow's housing stock has acted to moderate the impacts of higher energy prices to some extent. However, more radical and targeted interventions are needed.

Targeting those homes that are in more deprived communities, heated using inefficient electrical resistance heating, or solid fuels, and which are therefore more likely to suffer from fuel poverty[60] is a priority for this plan. Replacement of electrical resistance heating is seen as a key action to address this issue. This form of heating has a lower capital cost and lower maintenance burden, and was therefore favoured by some social landlords in the city, but a programme of replacement now needs to be developed.

## District Heating

District heating is one of the key ways to tackle fuel poverty. Heat in Glasgow is delivered largely from fossil fuels either directly (e.g. gas heating) or indirectly (electrical heating). The most carbon intense forms of heating are coal fired heating, oil fired heating, and electrical resistance heating. Not only do these forms of heating emit more carbon but they are also far more expensive to operate. They are often found in lower income households, in some multi-storey and low rise social housing developments, and thus play a significant role in the high rates of fuel poverty in some parts of Glasgow.

This plan presents proposals for more extensive district heating networks in key areas of the city. This technology uses insulated hot water pipes to provide heat to communities. This policy is supported by the Local Development Plan (due to be published in 2015) which outlines the areas that district heating is expected to be deployed and also by the new ESCo that is being established to support the roll out of district heating. The LDP has supportive policies for district heating (as does the National Planning Framework and Scottish Planning Policy) including a rule that all proposed new developments in an operational district heating zone must obtain their heat from the district heating system or be capable of easy future connection to the district heating system when district heating is available.

## Regeneration

Glasgow's approach to energy has the potential to attract significant new investment into the city – and contribute to the ongoing regeneration and renewal of many areas. The integration of many of the projects listed below into mainstream regeneration programmes for areas of the city, both large and small, is crucial. Opportunities exist such as in the Sighthill Transformational Regeneration Area, for example, to install district heating as part of the proposed City Centre North scheme as part of the comprehensive housing regeneration in the area. In this way the people of Glasgow

58 Scottish Household Condition Survey (2010- 2012)
59 Fuel poverty - defined as a household that has to spend over 10% of its income to maintain a reasonable heating regime
60 Electrically heated homes are two to three times as expensive to heat and are responsible for emitting twice as much carbon per unit of heat delivered.

will be able to derive significant economic and social benefits from the investment in low carbon energy infrastructure.

There will be areas of the city and technologies where new jobs are expected to be generated making Glasgow a desirable location to set up innovative green businesses. Both in the long and short term, the impacts of this are likely to include: enhancing skills in the local workforce (in for example district heating installation); developing supply chains for particular skills and technologies in the city whether heat pumps, wind turbines or solar panels; ensuring that local companies are aware of the future opportunities that will be available; giving financial support and guidance to green entrepreneurs.
This is an issue the Low Carbon Industries workstream of Glasgow's Economic Leadership[61] emphasised in calling for greater recognition of the economic value of current low carbon investment in Glasgow and its growth potential.

The demand for skills, particularly engineering skills at all levels, was noted by Low Carbon Industries workstream. Glasgow is Scotland's largest source supply of engineering skills – something that has helped companies in the Low Carbon Industries space to grow and develop in the city already. In a world in which the city's competitive advantage will depend increasingly on innovation and high-value products and services, it is essential that the level of Science, Technology, Engineering and Maths (STEM) skills in the workforce is raised. The supply of creative young scientists and engineers coming out of Glasgow's universities and colleges will greatly enhance the attractiveness of the city to employers.

### Energy Efficiency

Energy efficiency measures and energy management systems are implemented in homes, public buildings, and businesses to reduce demand and improve the efficiency of energy use. If the energy is supplied from fossil fuels – such as petrol in a car or electricity from a coal-fired plant – then improved efficiency will cut emissions. The scope of the savings – and the techniques required – depend on the situation and location. For homes in Glasgow, the most effective measures include increasing insulation, draught proofing, installing good-quality double-glazed windows and switching to more efficient appliances and light bulbs. The Committee on Climate Change estimates that these improvements could reduce annual $CO_2$ emissions from British homes by around 17 million tonnes by 2020. By contrast, increasing efficiency in non-domestic buildings often means focusing on ventilation and air-conditioning, in addition to lighting, heating and appliances. Many such buildings have achieved savings of around 25% after undergoing a refit to increase efficiency.

Vehicles have also become more energy efficient over the decades thanks improved engines and lighter, more aerodynamic designs. The potential exists for further improvements and in EU the emissions of the average new car is set to decrease from 150 to 95 grams of $CO_2$ per km by 2020.

## 4.4 Integrated Energy Planning (IEP) and Infrastructure

As the city moves towards a low carbon and decentralised energy system for Glasgow, increasingly generating its own energy for local consumption, Glasgow needs to develop an infrastructure that supports this. Glasgow City Council and ScottishPower Energy Networks, the electricity Distribution Network Operator (DNO) in Southern Scotland, are working together to see how the existing electricity network can be made more efficient and where

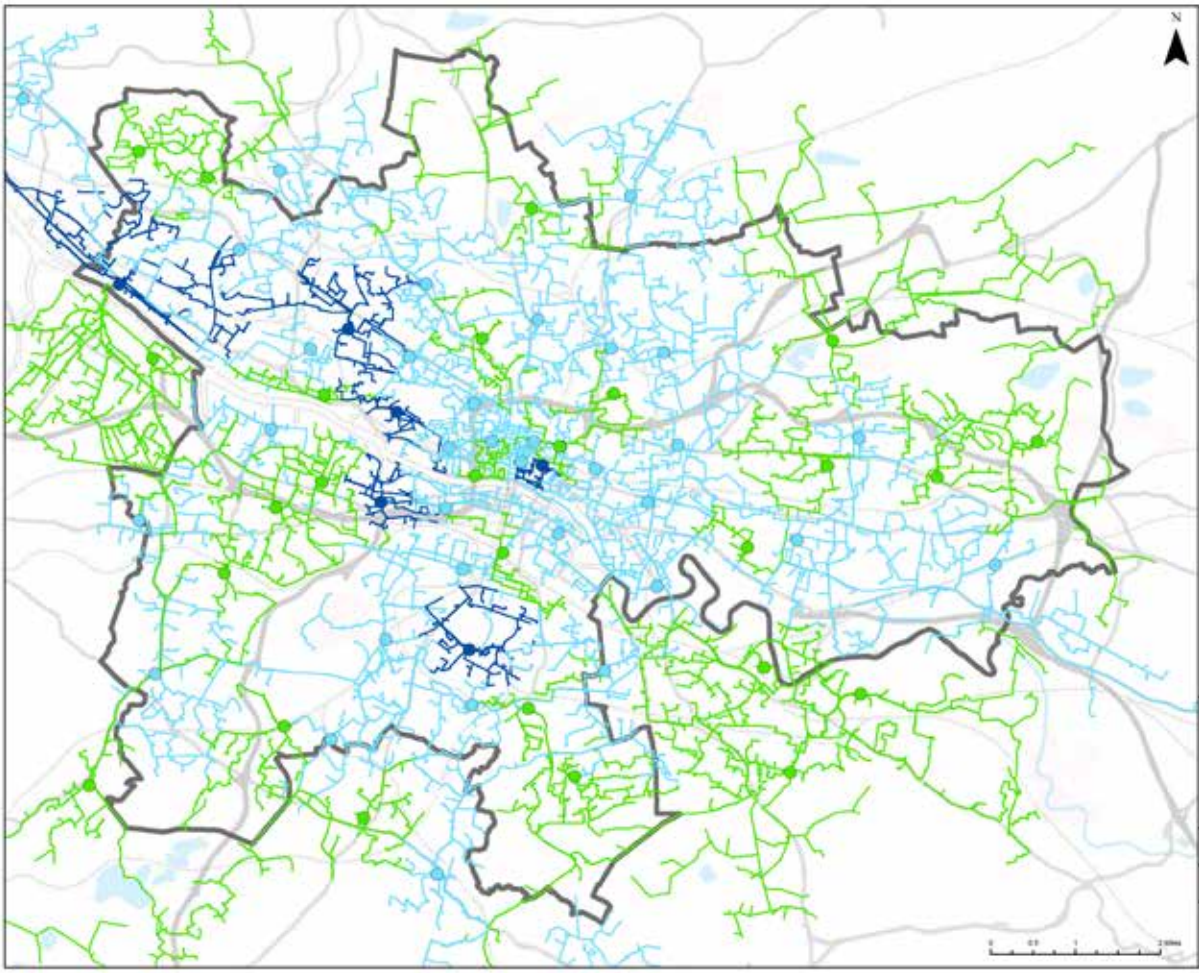
[61] Glasgow Economic Leadership. Low Carbon Industries Draft Action Plan. June 2012.

new development (including new renewable energy generation) might take place in order to predict and plan for new infrastructure.

The electricity distribution system in Glasgow comprises a system of primary substations and subsidiary secondary substations and cables. A primary substation and its subsidiary network is typically designed and constructed such that it has a rated capacity in megawatts (MW), and is able to deliver this level of electrical power continuously[62]. In instances where peak power demand on a substation has grown to the extent where it is regularly approaching the rated power level of a substation, the DNO must either undertake to 'reinforce' the substation, increasing its rated power to re establish a satisfactory margin of spare capacity, or constructing an additional substation to meet any new demand.

DNOs typically fund reinforcement projects that are required to meet changing patterns of power use and system wide growth in power demand. However, reinforcement of substations required due to significant increases in demand due to new customer connections may require that funding be provided by the connecting customer. Depending on the required scale of the reinforcement, this cost could

Map 8. Glasgow Electricity Network Available Capacity 2013




Source: Scottish Power Energy Networks (SPEN)

[62] While 24 MW is a typical capacity value of an urban substation, there is a limited 'standard' component design capacity for primary substations. Each substation's rated capacity is a reflection of the demand load and forecast load growth that is expected at the time of the substations construction. It should be noted that substations are able to reliably deliver power levels significantly in excess of their rated power for periods of days to weeks if required.

represent a significant cost to the connecting customer and may hamper development.

In order to anticipate potential network reinforcement costs SPEN and Glasgow city Council (GCC) have agreed an integrated energy planning approach that combines council planning and development data with SPEN network data. This will allow SPEN to model the impact of the likely demand associated with approved and proposed developments over coming years, and present this as a series of capacity forecast maps. These maps will provide an indication of the spare capacity availability across the Glasgow electricity network in future years.

A draft forecast network capacity map (Map 8) utilising SPEN modelled data from a 2013 scenario provides an indication of spare capacity across the various primary substations and their subsidiary cable networks in Glasgow. Substations and cable networks shown in green are those portions of the network where peak demand is significantly below the rated capacity of the local network. Sections of the network shown as dark blue have less spare capacity available. While any significant new connection may incur some level of reinforcement cost, new connections to sections of the network shown as having limited spare capacity will be more likely to require some level of network reinforcement activity.

Integrated Energy Planning will allow an improved understanding of the probable size and distribution of future electricity demands in the city (as discussed in section 3). This knowledge in turn will support more efficient infrastructure investment planning by Scottish Power Energy Networks in Glasgow's electricity distribution infrastructure. GCC will also, via a network capacity mapping process, gain improved insight into the energy network's spare capacity and its ability or otherwise to support new connections in a given area. This will allow improved identification of opportunities for development through better understanding of likely network connection costs associated with proposed developments.

The speed of connections into the network can also be improved with this approach. By identifying connection opportunities and constraints, developers are encouraged to engage with energy utilities early in their development planning process. Early engagement, combined with an improved understanding of network capacity opportunities and constraints, and utilising other energy mapping products, will facilitate a more strategic approach to identifying how best to utilise energy infrastructure in future. This approach will be particularly important as the demands on the electricity network evolve to include the connection of significant amounts of decentralised generation within the Glasgow city boundaries.

## 4.5 Energy supply

**Transforming Glasgow's Energy Supply System**

Transforming Glasgow's energy system involves the use of new technologies under a strategic framework of planning and infrastructure development. Glasgow can harness cleaner energy sources and use more efficient systems to deliver carbon emission reductions.

The council and its partners on the Sustainable Glasgow Board can help transform Glasgow's energy system by providing the right structures, stakeholders and business models that can deliver low carbon projects. The council and partners can use assets to create investment whether through use of buildings for retrofit and refurbishment or providing land for renewable energy projects (such as the solar photovoltaics on vacant land).

GCC can provide enabling finance to attract other public or private finance and create an income stream for the council from savings made from energy efficiency and from the revenues generated from renewable energy. The emerging energy system sees low carbon as potentially a net revenue generator for Glasgow, generating returns to deliver a surplus that can then be re-invested in further projects (see Glasgow Green Fund in section 5).

There are a range of technologies that can be deployed as part of the new Energy System:

- **District heating systems** using underground insulated hot water pipes to take the heat from low carbon energy sources to businesses and communities for heating buildings and providing hot water. Waste heat and other waste materials from industrial and commercial premises can be captured and used to provide low carbon energy for the city. A good example of this is the scheme at the Glasgow 2014 Commonwealth Games Athletes Village.

- **Heat pumps** - Heat pumps can be either air, water or ground-sourced which absorb heat from the medium around them. This is usually used to heat radiators, underfloor heating systems, or provide hot water in the home. One disadvantage of using heat pumps is that they need electricity to run; however, heat pumps are a very efficient form of electric heating, that use approximately a third of the electricity as a traditional resistive electric heater for the same heating effect. By using heat pumps electricity use is reduced and as electricity carbon intensity drops, heat pump heating options become low or even zero carbon options.

- **Combined Heat and Power** (CHP) generation, unlike conventional forms of power generation, captures the by-product heat from the generation process. In a conventional power plant this heat is released to the atmosphere. CHP on the other hand enables the waste heat to be used in industrial process and in district heating schemes. CHP is a recognised way of substantially decreasing $CO_2$ emissions associated with heat generation. The district heating schemes proposed in this Plan can potentially provide a significant proportion of the 30% $CO_2$ reduction target needed.

- **Waste to Energy**. Generating energy from waste is a proven, reliable technology that has been used for many years in Denmark, Sweden and the Netherlands. The energy from waste facility for Glasgow now being built at Polmadie will reduce the volume of residual waste going to landfill by 90% and will generate heat that can be used in local district heating schemes. It is also possible to process the city's sewage and municipal waste using anaerobic digestion to produce biogas which can fuel buses and generate heat and power for the city. The byproducts from the anaerobic digestion process can also be used to make the city's vacant land more fertile to help grow urban woodlands.

- **Biomass** from the new urban woodlands and from forests around Glasgow can be used to generate heat and power for the city in biomass energy centres. The installation of biomass boilers reduces the energy costs, helps to meet carbon dioxide reduction targets and (where local chip is used) also benefits the local economy, as money is spent on a local fuel source and not on imports of oil and gas.

- **Solar energy** is a growing potential energy source for Glasgow. Solar photovoltaic panels have already been installed on council-owned buildings and schools and many have been fitted on social housing across the city amounting to approximately 3MW of installed capacity. A project looking at the feasibility of installing solar panels on vacant land in Glasgow is being carried out as part of the Future Cities Energy Efficiency Demonstrator. Solar panels generate income from the Feed in Tariff (though are subject to variations in this scheme) which can be used for investment in further schemes.

- **Wind turbines** – a wind turbine is now operating at Cathkin Braes with a capacity of up to 3 MW. The Local Development Plan is identifying further sites for wind turbines

that can be operated by the council and benefit from Feed in Tariffs for the electricity generated. There are also smaller turbines erected on schools and at the Clyde Tunnel.

- **Hydroelectric power (HEP)** – comes from the process of using water's energy as it flows from higher to lower elevation, rotating hydraulic turbines to create electricity. It is considered to be a clean, renewable source of energy, emitting a very low level of greenhouse gases when compared to fossil fuels. It has a low operating cost once installed and can be highly automated. There is potential for small scale HEP schemes in Glasgow both on rivers or streams and canals and some pilot sites are being investigated.

- **Geothermal** energy utilises the natural heat that exists within the earth. Glasgow has a significant potential for the use of geothermal energy thanks to stored heat in rock formations and in flooded mine workings. Heat pumps can be used to concentrate heat energy from rock formations or minewaters, making the water hot enough to heat buildings. A small scheme using mine water to heat 17 houses in Shettleston has been running for more than 10 years. This new source of energy could help Glasgow to meet government targets to ensure 11%of heat demand comes from renewable sources by 2020.

- **Smart grids** are modernised electricity grids that efficiently manage electricity supply and demand. Smart grids have the potential to transform the way Glasgow uses energy in our homes and businesses, and allow for greater use of renewable energy in the electricity network. A smart grid can identify and resolve faults on the electricity grid, automatically self-heal, manage voltage and identify infrastructure that requires maintenance. Smart grids can also help consumers manage their individual electricity consumption and enable the use of energy efficient smart appliances that can be programmed to run on off-peak power. Ofgem has agreed that smart meters will be installed in every home by 2020 – however the measures proposed below may help to accelerate their deployment in Glasgow.

- **Energy Storage** is linked to smart grids in that it not only allows energy to be stored during periods of low demand for use during periods of high demand but also allows electricity grids to operate more efficiently so that they can run at average rather than peak load. Where there is uneven supply from renewable sources – such as wind – energy storage is one option to consider alongside inter-connectivity so that power can be exported or imported according to supply an demand. As electricity demand increases in the future (see section 3) the demand for storage solutions may increase and number of technologies for energy storage are being developed across the world from pumped hydro (water pumped uphill and released when needed to produce electricity) to batteries (lithium ion being the most popular). The potential for energy storage in Glasgow, linked to district heating, smart grids and demand side management is significant.

## 4.6 Key Actions by Sector

### Municipal Buildings

The Glasgow City Council family of organisations is responsible for approximately 5% of the city total emissions (building only). Reducing carbon emissions from municipal buildings will therefore have a direct benefit on the city's overall carbon reduction target and also reduce the council's operational costs allowing these finances to be directed into further energy efficiency measures.

The overall target for carbon savings from municipal buildings in the council's Carbon Management Plan[63] is also a 30% reduction by 2020, from a 2005/06 baseline. Annual targets are set against the previous year's performance, allowing the council to ensure its remains on track to meet the target in 2020. The target for 2014-15 is a 3% reduction from 2013-14. This will largely be met through building-related interventions; however there are targets and actions for transport, waste and water management too. Carbon reductions will usually result in revenue savings and any efficiency achieved help ease pressures on service energy budgets.

In addition to carbon management, reporting and review activities for council and Glasgow family facilities, the Carbon Management Team also carries out a utility management function which co-ordinates and ensures the delivery of electricity, natural gas and water to the council and ALEO buildings. There is a programme of energy audits of all municipal buildings which is identifying a number of actions and projects to be undertaken including:

- **Building Management Systems** (BMS): Energy used in council buildings is by far the largest source of carbon emissions from the Council's operations. Buildings include schools, care homes, day care centres, offices and depots. Glasgow Life and City Building Glasgow (LLP) buildings - libraries, sports facilities, manufacturing facility and museums - are also included with other council buildings. The largest contribution (aside from building rationalisation) to reduce energy use in council buildings is the implementation of building management systems into all buildings of a suitable size. BMS is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as heating, ventilation, lighting, power systems, fire systems, and security systems.

- **Demand Side Management** (DSM): The Council is taking part in a DSM demonstrator project, developed through the TSB Future Cities Demonstrator. Two council offices and a primary school have been included in the project with more to be included in future. This will involve Scottish Power exploring opportunities to reduce pressure on the supply grid by identifying opportunities to reduce load in these buildings. Simultaneously, this will provide the buildings involved with information as to where they can reduce their buildings base load on a more permanent basis.

- **Smart Metering**: There is a programme of installing smart metering in all of the council's buildings. The smart meters send half-hourly energy consumption data to a central system monitored by the council. This allows the council to identify any anomalous energy consumption patterns and identify opportunities to make buildings more energy efficient.

- **PC shutdown**: The council is seeking to improve the energy efficiency (electricity) of Glasgow schools IT equipment by implementing PC Shutdown. Computers on the network can be loaded with software and organised into groups

[63] Carbon Management Plan Phase Two. 2013-2020

comprising departments, floors or buildings. The scheduling software then allows PCs in a group to be switched off and on again as required.

- **Voltage Optimisation**: The majority of the buildings in the UK are supplied with a voltage that is higher than that which is required, this is largely due to movement towards using European equipment that was built to operate on lower voltage networks, leading to unnecessary consumption of electricity, increased failure rates of equipment, and over demand on the supply network. The installation of voltage optimisation equipment improves the supply to the building, reduces electricity consumption, enhances the lifespan of equipment, and reduces demand on the supply network.

- **Boiler Replacement and Optimisation**: There are a number of coal and gas-oil fired boilers that still exist in the education estate. A programme of replacement of these boilers with gas-fired boilers to reduce carbon emissions is in place. Where there is oil heating fuel being used then the possibility of replacing these with biomass boilers is being actively pursued. Wood chip is being sourced locally to feed these boilers. Furthermore, to ensure that the boilers used in the Glasgow City Council (GCC) estate are operating at as high an efficiency level as possible, optimisation units are being installed which inhibit unnecessary firing of boilers unless there is demand for heat in a building. This minimises any wasted heat generation and relieves unnecessary pressure on the supply network caused by standing losses in heating systems.

### Key Actions – Municipal Buildings

**Action 1:** Conduct internal energy audits of municipal properties and identify those that will benefit most from energy efficiency measures actions and projects.

**Action 2:** Decrease energy consumption in public buildings by developing Demand Side Management technology and procedures.

**Action 3:** Conversion of remaining coal-fired boilers and oil boilers into gas boilers (or biomass where appropriate) in GCC buildings.

**Action 4:** Implement PC Shutdown software in the Education estate and examine the feasibility to extend it to the entire council estate.

**Action 5:** Reduce electricity consumption associated with the GCC data centre using RES Data Centre Project.

**Action 6:** Reduce energy consumption of the Council estate through the council's Asset Management Strategy, including potential replacement of inefficient heating for more efficient heating in GCC temporary structures.

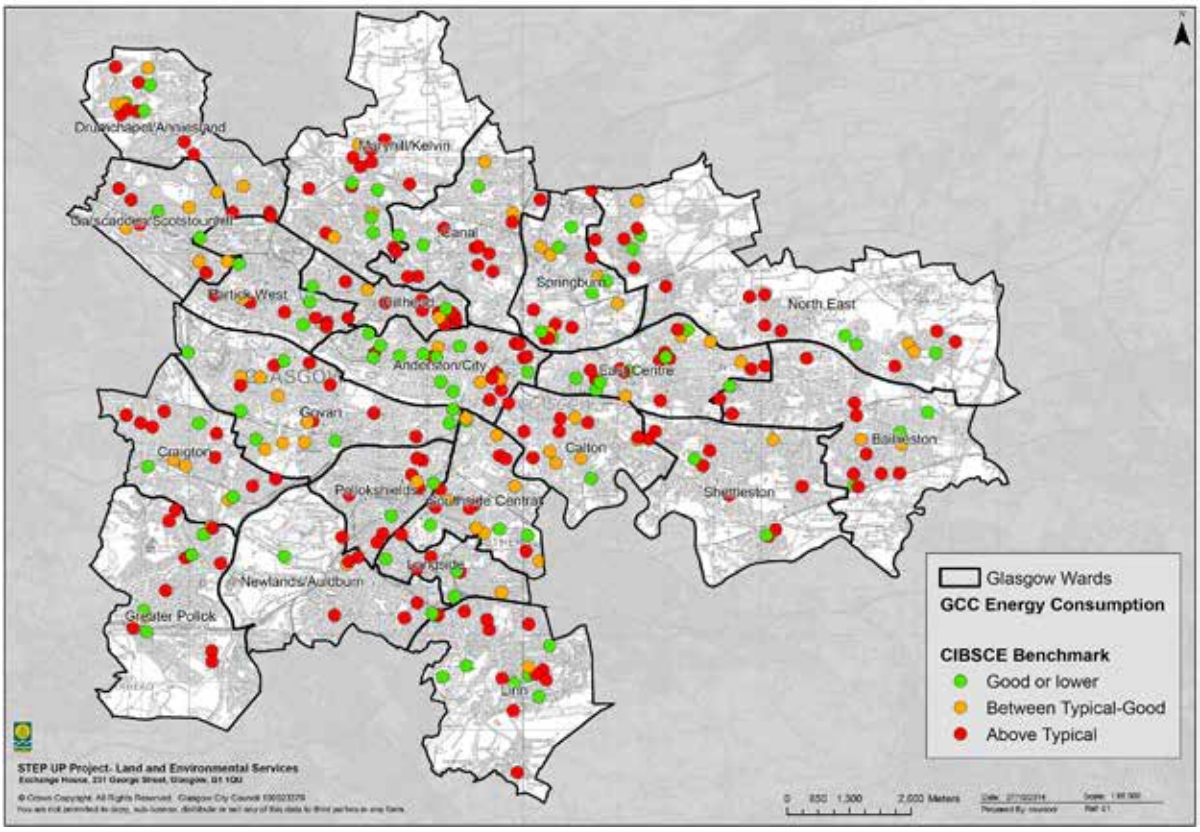
**Action 7:** Reduce energy consumption in Council premises via activities of green wardens and the staff behavioural change programme.

**Action 8:** Installation of LED lights as standard on all new builds and refurbishments.

**Action 9:** Installation of managed, centralised BMS control. Where possible this will integrate heating, lighting and alarms.

**Action 10:** All new (from 2014) GCC buildings to achieve Bronze Active standard by 2014; Silver Active standard by 2016 and Gold Active standard by 2018 (LDP, Resource Management Policy)

## Map 9. Glasgow City Council Buildings' Energy Consumption




Source: Glasgow City Council

## Non-municipal buildings and Industry

Tackling energy use in non-municipal buildings in Glasgow represents a significant opportunity to help meet the $CO_2$ reduction target, reduce energy costs and could also help create economic opportunities that could contribute to growth in Glasgow.

As seen in section 2 the highest energy consumption in Glasgow occurs in the city centre in high-density non-residential premises in this area, which consume significant levels of electricity and gas. There is potential for cost-effective improvements to the energy performance of the buildings here potentially linked to the area proposed for the City Centre North and North Glasgow district heating scheme. Potential opportunities for improving energy efficiency in city centre buildings are:

- Identification of worst-performing buildings comparing the actual energy usage of city centre buildings to national Energy Usage Indices (EUI's) and making these buildings the focus for energy performance improvement measures.
- Supporting this data with information from the Technology Strategy Board (TSB) Future Cities online energy model for the city (supplemented by energy use data contributed by city centre businesses) which will graphically illustrate energy usage in Glasgow and help target buildings with high energy consumption.
- Energy audits carried out for the worst performing buildings in order to identify the causes of their poor performance and suggest appropriate solutions for each specific case.
- Instituting energy management for all city centre premises to ensure they have an appropriate individual responsible for energy and carbon reduction.

Measures that can be undertaken in buildings include:

- Smart controls and systems diagnostics, predictive, intelligent user-oriented building management systems and diagnostic applications that optimise performance of building services;
- Carbon management services, integrating landlord-tenant building management to overcome split responsibility;
- Behavioural change for building users by providing clear information and incentives for energy reduction;
- Various design measures including:
  - Improving the functional performance of façades to provide light, insulation, shading and ventilation whilst reducing the need for cooling;
  - Advanced daylight technologies, harvesting daylight from roofs and façades through skylights, fibre optics or other means and reducing the need for artificial lighting; and
  - Advanced natural ventilation systems, using ventilation stacks, atria and automatic openings combined with automatic control systems, passive cooling such as breathable walls, and the effective thermal mass of buildings to reduce cooling and ventilation energy.

Underpinning all these suggested interventions is a need for more data regarding building performance. There is currently a lack of knowledge surrounding the energy consumption and energy performance of commercial buildings in the city, hindering knowledge of successful improvement measures and sharing of best practice. This is something the online building energy model from the TSB Future Cities Demonstrator seeks to address. To supplement this, gathering data on actual building performance is vital, and will support efficiency savings in all areas. Investment is required from building owners to implement smart building management controls and new technologies.

Bodies such as the Glasgow Chamber of Commerce (members of the Sustainable Glasgow Board) will be important partners

in developing initiatives with private companies including commercial landlords.

### Key Actions – Tertiary Buildings

**Action 11:** Target tertiary buildings where there is high energy usage and encourage owners and tenants to take a pro-active approach to energy efficiency and reduce $CO_2$ emissions.

**Action 12:** Develop and maintain a heat mapping model for non-residential sector by source (gas and electricity) for Glasgow and combine datasets with the city energy modelling tool.

**Action 13:** All new (from 2014) non-residential buildings to achieve Bronze Active standard by 2014; Silver Active standard by 2016 and Gold Active standard by 2018 (LDP, Resource Management Policy)

### Key Actions – Industry

**Action 14:** Identify areas with heat recovery potential to reduce waste and make productive use of excess heat.

## Residential Buildings

The Sustainable Glasgow report in 2010 made a conservative estimate of overall potential carbon savings from improved energy efficiency and management giving a 6% reduction in Glasgow's carbon emissions in this sector over the next 10 years. Given increased regulatory pressures, and that it is normally easier to trigger change in a small number of large organisations rather than thousands of individual households, the report concluded that carbon savings are likely to be greater within the commercial, industrial, and public sectors than the domestic sector.

However, a key issue for Glasgow is the core of housing with a poor standard of thermal efficiency concentrated in poorer quality pre-1919 private rented or owner occupied stock and this is an area that could be addressed with significant potential gains. These are often properties without any form of additional insulation. There are also un-insulated multi-storey and other developments where heating is provided by electric storage heating systems. By targeting these types of properties on an area wide basis, progress on residential building energy savings can be made.

In relation to good standard stock, the most promising measures for carbon reductions relate to micro-generation on site, such as solar hot water heating, generating electricity via photo-voltaic panels and the new generation of micro-CHP boilers.

An Affordable Warmth Action Plan[64] guides Glasgow City Council's work on housing energy efficiency. The main actions in the plan are to:

- Provide information and advice on energy related issues to householders across the city.
- Increase the energy efficiency of housing stock to reduce the amount of energy that is needed to heat the home adequately.
- Work with partners to support the installation of gas networks where there is no access to the gas grid and where this is the best solution for an area.
- Explore the feasibility of renewable energy measures in residential stock across tenures
- Explore the delivery of the district heating network including residential properties across tenures

Advice and information is seen by the council as a key way of tackling energy efficiency in residential building and tackling fuel poverty. A fuel poverty advice team, branded as G-HEAT (Glasgow Home Energy Advice Team), works in partnership with the Scottish Federation of Housing Associations (SFHA), Glasgow and West of Scotland Forum of Housing Associations and Glasgow Advice and Information Network. This service is available to householders

[64] Affordable Warmth Action Plan produced in 2009 by Development and Regeneration Services(DRS), Housing. Glasgow City Council.

regardless of whether they are tenants or owner occupiers. It focuses particularly on those who may be in fuel poverty and provides advice on the use of energy in the home, energy efficiency and ensuring that householders are able to access the best energy company tariffs available. Glasgow Housing Association (GHA) also has its own energy advice team.

One of the main issues on domestic energy is the rising cost of energy leading potentially to fuel poverty. A contributory factor is the private energy market in the UK which is dominated by six major utility companies, with energy tariff structures which are not seen to actively encourage households to reduce energy consumption. In fact, households with higher energy consumption pay a lower average price per unit of energy consumed[65]. Results of the STEP UP citizen survey also show that most households have not changed their energy supplier in the past six months. The reasons for this may include inertia, lack of transparency in tariffs or other factors.

Another of the issues (highlighted in the Sustainable Glasgow 2010 report) is a lack of sufficiently detailed information to allow strategic targeting of energy efficiency measures in residential properties. Utility companies sharing energy consumption data with local energy planners to help target future investment and activity could help overcome this, although this is currently prevented by data protection.

Improving the energy efficiency of Glasgow's housing stock is another key action in reducing fuel poverty. A number of housing associations successfully gained funding from the Community Energy Savings Programme (CESP). This was used to carry out insulation measures, double glazing, new heating systems and to give energy advice to residents. A number were also successful in getting CERT (Carbon Emission Reduction Target) which provided a similar range of interventions to CESP but at a lower funding level. It was mainly used for lower cost insulation measures.

Both the CERT and CESP schemes are now replaced by the Green Deal and the Energy Company Obligation (ECO) as from December 2012. The Scottish Government's Universal Home Insulation Scheme (UHIS) has now become the Home Energy Efficiency Programme for Scotland – Area Based Schemes (HEEPS-ABS). This programme provides grant funding for homeowners in areas of multiple deprivation to carry out a range of energy efficiency measures. In addition ECO can supplement this grant, owners' contributions and Housing Association contributions where projects are being delivered in mixed tenure areas.

Glasgow City Council has been awarded £8.6m (13/14) and over £4.5m (14/15) for local HEEPS-ABS programme of projects. The Green Deal, the government's initiative to increase the energy efficiency of the UK's housing stock, is supported by the Energy Company Obligation (ECO). The ECO is aimed at specific types of housing stock and offers funding for heating or insulation upgrades in hard to treat properties or those which may not fall within the Green Deal's reach.

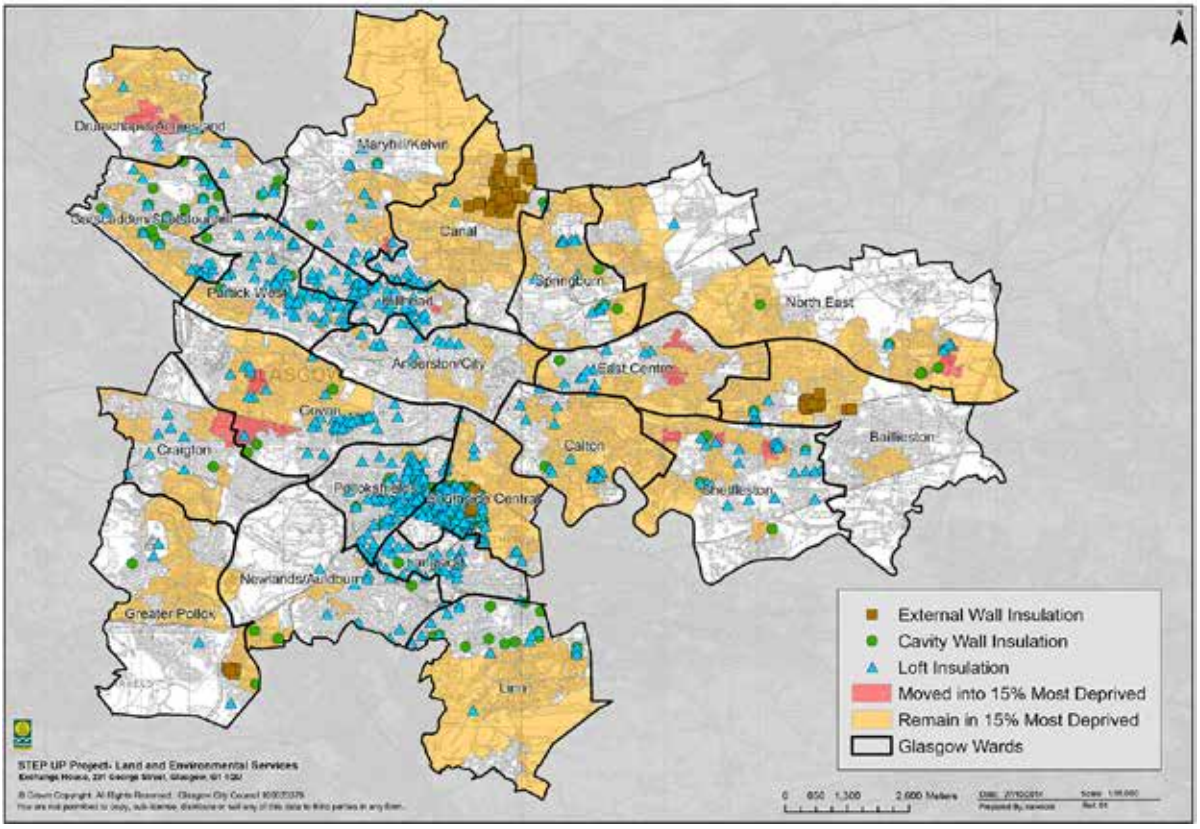
The Energy Companies Obligation (ECO) places legal obligations on the larger energy suppliers to deliver energy efficiency measures to domestic energy users. It operates alongside the Green Deal to provide additional support in the domestic sector, with a particular focus on vulnerable consumer groups and hard-to-treat homes. Energy suppliers are obliged to help improve the energy efficiency of their domestic customers' buildings in three areas:

- Carbon Savings Obligation – energy companies must concentrate efforts on hard-to-treat homes and measures that cannot be fully funded through the Green Deal. Solid wall insulation and hard-to-treat cavity wall insulation are the primary areas for focus. Other insulation measures and connections to district heating systems are also eligible if they are promoted as part of a package that includes solid wall insulation or hard-to-treat cavity wall insulation.

- Carbon Saving Communities Obligation – energy companies must focus on the provision of insulation measures and connections to domestic district heating systems supplying areas of low income especially social living.

[65] Survey by Which? [on line] http://www.theguardian.com/money/2012/sep/19/low-users-pay-more-energy

Map 10. Installed Insulation in Glasgow Residents' Homes 2011-2012




Source: Glasgow City Council

- Affordable Warmth Obligation - energy suppliers are required to provide measures which improve the ability of low income and vulnerable households (the 'Affordable Warmth Group') to heat their homes. This includes actions that result in heating savings, such as the replacement or repair of a boiler for example.

In autumn 2013 the government outlined proposed changes to ECO, and announced that £540 million will be made available over the next three years (to 2017) to boost energy efficiency. The changes to ECO have created substantial uncertainty within the energy efficiency sector in Glasgow and elsewhere. Funding dropped from April 2014, and job cuts in contractor companies have been made. ECO contracts were being put on hold while new, shorter-term contracts were agreed. Alongside this, the Green Deal is also being changed to make it more attractive for consumers. However, the take-up of the green deal in Scotland and across the UK has been very poor.

There is a need in Glasgow to examine how the Green Deal and ECO are operating and how these schemes can be better promoted and co-ordinated with schemes such as district heating schemes in areas of fuel poverty.

**Key Actions – Residential Buildings**

**Action 15:** Improve energy efficiency, reduce energy consumption and fuel poverty in social housing through the coordination and enhancement of existing schemes.

**Action 16:** Improve energy efficiency and promote renewable energy projects in private housing sector.

**Action 17:** Promote behavioural change in citizens in households to promote energy savings (through smart meters, online energy model, behavioural change).

**Action 18:** All new residential buildings to achieve Bronze Active standard by 2014; Silver Active standard by 2016 and Gold Active standard by 2018 (LDP, Resource Management Policy).

**Action 19:** Develop and maintain a heat mapping model for the residential sector.

## Public Lighting

Glasgow City Council approved a Lighting Strategy in 2003 which adopted the use of white light sources (from LED lamps) for road lighting. Research has shown that with 'white light' there is a perception of better visual conditions for motorists and improved visibility when compared to existing low/high pressure sodium lighting of an equivalent standard. An upgrade of the city's network of 72,000 ageing sodium lamps is now in progress and could cut the cost of street lighting (currently around £8.5m) by two-thirds and cut greenhouse gas emissions by more than 45,387 tonnes.

Currently a £2m pilot demonstration project is being delivered partnership with Scottish and Southern Energy (SSE). This project will replace 1000 lighting columns and introduce sustainable lighting infrastructure at four areas across the city. The project is funded by Glasgow City Council, with SSE contributing design, technology and market expertise to the project. This sustainable lighting infrastructure includes provision of control systems to allow dimming configurations to be introduced, thus reducing energy usage and resultant expenditure. To date energy savings of up to 40% have been achieved, when compared to energy demands from conventional lighting. The aim of the pilot is to test the technology and validate the resultant energy and carbon savings achieved from use of modern, sustainable lighting systems with a view to replicating this across the city.

**Key Actions – Public Lighting**

**Action 20:** Implement energy efficient street lighting across the city.

## Transport

Transport accounts for approximately 25% of Glasgow's total annual energy usage and petroleum is the predominant source of energy used in this sector. In general Glasgow needs to encourage a reduction in personal motorised transport and an increase in the use of public transport, walking, and cycling. This modal shift is the key to Glasgow becoming a more sustainable city in transport terms.

In other European cities (for example Zurich) the city is moving away from motorised individual transport which in 2005 was at about 35%. The target in Zurich is to reduce it to 27%. The city also aims at tripling its share cycling in the future (12% from 4% in 2005). Public transport is expected to stay at the current 34% level. Over 70% of the households are without a car and an inner city modal share of cars is only 20%. Meanwhile, in Stockholm the modal split shows that between 2004 and 2010, 14% of Stockholm inhabitants moved away from motorised individual transport to public transport and cycling. Those two latter modes of transport have increased by 9% and 3% respectively.

Glasgow City Council has developed a City Centre Transport Strategy and has a Local Transport Strategy 2007-2009 (LTS). The

LTS contains a balanced strategy, which concentrates on promoting and enhancing sustainable transport modes such as walking, cycling and public transport, with limited investment in road infrastructure to tackle key congestion points, provision of essential links to development areas and to enable public transport to provide effective services. While the LTS is due for revision, its recommendations are consistent with current transport policies in the LDP and the Regional Transport Strategy.

Many transport matters in Scotland are devolved to Regional Transport Partnerships (RTPs), with which the local authorities work in partnership. The RTP for the west of Scotland Glasgow is SPT (Strathclyde Partnership for Transport), a partnership of 12 local authorities of which Glasgow is the biggest, accounting for approximately one quarter of the whole partnership area's population. The RTS – A Catalyst for Change – The Regional Transport Strategy for the West of Scotland 2008-2021 was approved in 2008.

## Bus and Subway

The formation of Quality Partnerships between SPT and bus operators in the region has been one way of improving upon the deregulated bus system operated by commercial firms, the largest of which is the company First. SPT and Glasgow City Council have introduced a Statutory Quality Partnership scheme for all firms operating bus services on the major routes within the Glasgow city boundary. The partnership aims to provide high quality, low emission buses, measures giving buses priority (bus lanes, bus gates amongst others) over private cars and high quality waiting areas and infrastructure to encourage modal shift from private vehicles to public transport.

Another strategic priority in the RTS is the £288 million modernisation of the Glasgow Subway which is owned and operated by SPT. The modernisation programme includes refurbishing stations with improved accessibility, the introduction of smart card ticketing leading to wider integrated ticketing across all forms of public transport in the city, new trains and signalling automation.

Another major transformative transport project for Glasgow is Fastlink. The project will deliver a regional bus rapid transit (BRT) system to serve key sites along the development areas of the northern and southern banks of the River Clyde. It will include major employers located along the waterfront and connections to the new hospital which will have thousands of visitors every year, along with 10,000 staff commuting for work.

## Cycling

Glasgow's Strategic Plan for Cycling 2010-2020[66] is designed to increase the proportion of cycling journeys made within the city, especially in and out of the city centre. Trips into and out of the city centre are in excess of 5,000 per day which represents an approximate increase of over 50% since the start of the plan. The plan for cycling seeks to build on this public interest and work towards the vision of making cycling the largest participation activity in the city by 2020.

Glasgow City Council is increasing provision of cycling infrastructure to encourage active travel. In 2012/13, completed works included enhancements to the cycle route linking National Cycle Route 7 to Scotstoun Sports Campus in the west of the city. Planned works include completion of a cycle route linking Glasgow city centre and National Cycle Route 75 to Hampden Stadium and Cathkin Braes Country Park in the south of the city[67]. SPT and GCC have implemented route maintenance work programmes and enhancements in partnership with the UK Cycling charity Sustrans.

In June 2014 a Mass Automated Cycle Hire (MACH) scheme was launched in Glasgow. 400 bicycles are now available for public hire at 31 locations across the city. This scheme has proved to be very successful with 20,000 hires since it started and an average of 250 hires a day, with a peak of 700 hires in a day achieved during the Commonwealth Games.

Infrastructure improvements including the completion of the Connect 2 route, upgrade of the colleges cycle route projects and new cycle routes to the east of the city and southside Commonwealth Games clusters aim to increase

[66] https://glasgow.gov.uk/CHttpHandler.ashx?id=3521&p=0
[67] http://www.spt.co.uk/wmslib/Documents_RTS/TORs/glasgow.pdf

the modal share of journeys by cycle, which will have some effect on reducing emissions from private cars in the city. Another key project is the Future Cities Demonstrator Active Travel project which aims to provide information and support to citizens to take an increasing number of journeys by foot, bicycle or public transport.

Recently a City Centre Transport Strategy has also been developed by Glasgow City Council. The strategy is based on:

- Restriction of non-essential through traffic from the city centre to allow priority for buses, cyclists and pedestrians through the introduction of selected bus gates at key locations.
- Introduction of Avenues/segregated cycle routes. The concept of Avenues was developed through the districts strategy element of the overall City Centre Strategy. They are streets where the balance is shifted towards sustainable transport and placemaking with a people oriented approach.
- Potential bus hubs at Union Street and Dunlop Street. The desire for a southern bus hub in the city centre emerged through consultation and may help reduce number of through buses in the city centre.
- Reduction in on-street parking on Avenues to provide cycling facilities and on main bus corridors and to allow widening of footways at key locations.
- Introduction of enhanced pedestrian facilities.
- Introduction of mandatory 20mph zones across the city centre.
- Support for Subway enhancements, Crossrail, rail link to Glasgow Airport and a High Speed Rail link between Glasgow and Edinburgh.

A rail link to Glasgow airport (GARL) is now included in the new Glasgow City Deal[68]. SPT and Glasgow City Council are also the main partners in the Fastlink project, a dedicated bus route serving key locations on the Clyde Waterfront (designated as a STEP UP Lighthouse Initiative) including the new Southern General Hospital. The main bus station (Buchanan Bus Station) is also situated within the city centre which has an estimated annual footfall of 14 million people and 35,000 passengers/day. Around 1,000 buses are operational in Glasgow – with First Bus being the biggest of a number of operators in the city.

**Key Actions – Municipal Fleet**

**Action 21:** Procurement and deployment of a further 20 electric vehicles for the council fleet and further electric vehicles for Community Planning Partnership (CPP) partners.

**Action 22:** Reduce usage and maximise efficiency of council fleet, including Fuel efficient driver training.

**Key Actions – Public Transport and Active Travel**

**Action 23:** Work with bus, train operators and SPT to encourage modal shift from private to public transport.

**Action 24:** Promote and enable the use of active travel modes, such us walking and cycling across the city.

**Key Actions – Private and Commercial Transport**

**Action 25:** Promote the use of electric cars by continued installation free electric charging points across the city.

**Action 26:** Improve traffic management in congested areas of Glasgow and using measures such as Air Quality Management Areas.

[68] Glasgow City Deal plans to create a £1.1 billion infrastructure fund that will support projects such as the city centre-airport rail link, major improvements to the region's roads and bus network, and the development of new employment sites

## Local Electricity Production

There is a small but growing amount of local electricity generation from local generators in Glasgow. This is often called de-centralised generation but is also called Distributed Generation (DG) by the energy companies. There are a number of local schemes in the city (Table 7). Many more schemes are planned to be connected to the SPEN electricity distribution network across Glasgow. Map 11 also shows the distribution of solar PV currently installed on GHA (Glasgow Housing Association) properties.

The four most significant generators currently operational in and around the Glasgow city boundary[69] are at three landfill sites and the wind turbine at Cathkin.

Summerston 2 Landfill closed in 2002. The original capacity of electricity generation was 2.1 MW, but in 2013 only a 0.5MW engine is operating with a rated output of 0.2MW. All other local generation projects identified as operational either have a rated power output of less than 1MW or are far outside of the city boundary.

Decentralised energy will have a significant role to play in encouraging efficient delivery of energy to new and existing developments and the council is actively promoting these solutions through the Local Development Plan. Developers are being encouraged to look beyond the boundary of their own sites in order to develop shared energy and heat resources with neighbouring developments. The council is also setting further requirements for the consideration of microgeneration on a small scale for all developments. This could make a significant contribution to tackling climate change by ensuring a reliable low and/or zero carbon energy supply, which not only helps to reduce $CO_2$ emissions, but will also help to increase awareness and engage the public in projects locally. Over time the generation of local electricity in the city will grow and the council could assist small electricity producers to sell power to the market as other councils are doing.

### Wind turbines

There is currently only one significant wind turbine in the city at Cathkin Braes. This project was undertaken as a 25 year co-venture pilot project between Glasgow City Council (GCC) and SSE which is intended to inform future wind farm development across Glasgow. The cost of the project was just under £5m and was jointly funded by GCC and SSE. There are also other smaller wind turbines installed in the city on the Clyde Tunnel and at Merrylee Primary School in Shawlands (Table 8).

The Cathkin wind turbine has been operational since March 2013 and since this date has been generating renewable energy which is exported to the national electricity grid. It is projected that this project will generate 7.3 GWh of renewable energy per annum. This is enough energy to power 19% of the street lighting columns across the city.

The LDP Main Issues Report[70] highlighted the potential for a small number of large wind turbines at nine potential locations in the city and that further assessment of these locations was required. Following an assessment the Local Development Plan now identifies three locations for further wind turbine development (subject to further more detailed investigation) at Cathkin, Netherton Braes and Queenslie. Further turbines could be erected at Cathkin Braes, subject to satisfactory compliance with British Airport Authority air safety requirements. If a further five turbines, in addition to the turbine at Cathkin, were introduced it would generate renewable electricity to power all of the city's street lighting. This could cost approximately £25m[71] but the investment would be repaid in 9.5 years though the sale of electricity to the grid.

### Solar photovoltaics

The Sustainable Glasgow report (2010) identified that solar thermal and photovoltaic (PV) panels could provide domestic hot water and electricity generating potential from suitable building roofs. GHA has fitted solar panels in 500 homes across the city (Map 11) which provide free electricity during the day for residents saving them around £100 a year on their bills. Each GHA house fitted with solar panels could potentially remove 24 tonnes of $CO_2$ emissions over a 25-year period.

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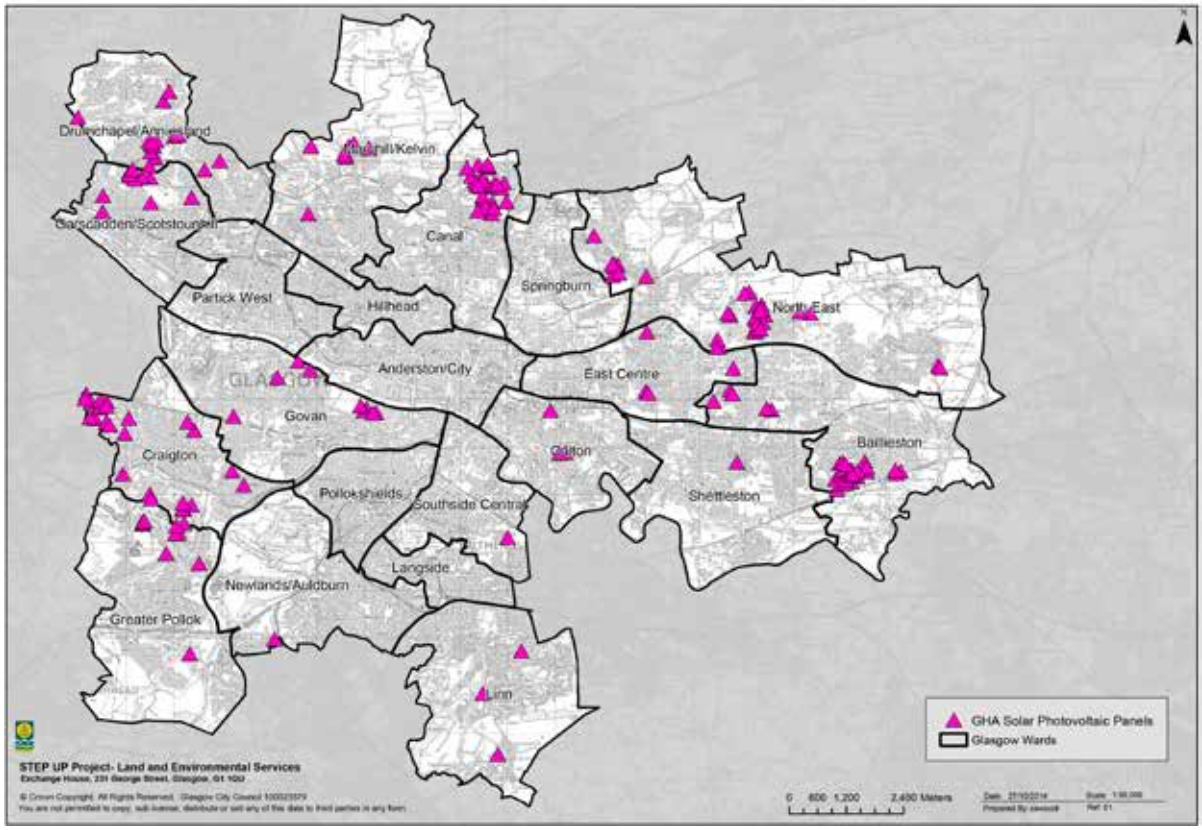
[69] Two significant landfill gas sites have been identified in the figure above, which are situated just outside of the Glasgow City boundary. It is understood the landfill gas harnessed by these facilities is piped back in to Glasgow for consumption within the city. They have, therefore, been included above as relevant sources of low carbon energy to Glasgow.

[70] https://www.glasgow.gov.uk/CHttpHandler.ashx?id=13033&p=0

Table 7: Local energy generation in Glasgow – potential future projects

| **Project Name** | **Technology** | **Rated Output** (MW) | **Location** |
|---|---|---|---|
| Cathkin 2 Landfill Site | Landfill gas | 7.4 MW | South Lanarkshire |
| Cathkin Braes Wind Farm | Single wind turbine | 3 MW | South Glasgow |
| Summerston 2 Landfill Power Project | Landfill gas | 2.1 MW | North Glasgow |
| Greenoakhill Landfill site | Landfill gas | 8.3 MW | East Glasgow |

## Map 11. Glasgow Housing Association Solar Photovoltaic installations




Source: Glasgow Housing Association

Table 8: Renewable Energy Installations on Glasgow City Council land and buildings

| Type of Technology | Fuel | Energy/heat produced | Facility | Service |
|---|---|---|---|---|
| Biomass boiler | Wood chip | Heat | Drumry Care Home | Social Work Services |
| Biomass boiler | Wood chip | Heat | Fergusson and Anderson Care Home | Social Work Services |
| Biomass boiler | Wood chip | Heat | Queens Park, Glasshouse, Depot | Land and Environmental Services |
| Solar photovoltaic panels | Solar, Heat/Light | Electricity | The Chara Centre | Social Work Services |
| Solar photovoltaic panels | Solar, Heat/Light | Electricity | St Benedict's Primary School | Education Services |
| Solar photo voltaic panels | Solar, Heat/Light | Electricity | Eastgate | Community Safety Glasgow |
| Solar photovoltaic panels | Solar, Heat/Light | Electricity | Bardowie Care Home | Social Work Services |
| Solar photovoltaic panels | Solar, Heat/Light | Electricity | Glenwood Care Home | Social Work Services |
| Solar photovoltaic panels | Solar, Heat/Light | Electricity | King's Park Secondary School | Education Services |
| Wind turbine | Wind | Electricity | Cathkin Windfarm | Land and Environmental Services |
| Wind turbine | Wind | Electricity | MerryLee Primary School | Education Services |
| Wind turbine | Wind | Electricity | Clyde Tunnel | Land and Environmental Services |
| Geothermal heat pumps | Ground Heat/ Electricity | Heat | Crookston Early Learning Centre | Education Services |
| Geothermal heat pumps | Ground Heat/ Electricity | Heat | NotreDame High School | Education Services |
| Waste to Energy | Waste | Heat/electricity | Polmadie Waste Transfer station | Land and Environmental Services |
| Hydro Electric Power | Water | Electricity | Pollock Park | Land and Environmental Services |
| Combined Heat and Power | Natural Gas | Heat/Electricity | St Paul's High School | Education Services |
| Combined Heat and Power | Natural Gas | Heat/Electricity | NotreDame High School | Education Services |
| Combined Heat and Power | Natural Gas | Heat/Electricity | Maryhill Leisure Centre | Glasgow Life |
| Combined Heat and Power | Natural Gas | Heat/Electricity | Glasgow Museum Resource Centre | Glasgow Life |
| Combined Heat and Power | Natural Gas | Heat/Electricity | Athletes Village | Development and Regeneration Services |
| Combined Heat and Power | Natural Gas | Heat/Electricity | Tollcross Leisure Centre | Glasgow Life |
| Combined Heat and Power | Natural Gas | Heat/Electricity | Bardowie Care Home | Social Work Services |
| Combined Heat and Power | Natural Gas | Heat/Electricity | Glenwood Care Home | Social Work Services |

Glasgow City Council (GCC) is currently analysing the potential use of vacant & derelict land to site ground mounted PV arrays. Glasgow has 5.5km$^2$ of vacant and derelict land and some of this land could be suitable to house ground mounted solar photovoltaic panels. A project to develop 550,000m$^2$ of this vacant and derelict land would generate electricity equivalent to 39% of the council family's annual energy consumption requirements. Sites are being assessed for technical, planning, and policy constraints to assess the proportion of each site deemed suitable to site arrays of PV panels installed on the ground. One hectare of panels can potentially produce enough electricity to power up to 150 homes.

## Hydro-Electric Power (HEP)

Despite Glasgow having the Clyde and other rivers and canals, the energy available from these for hydro-electric power is not large as neither the height drop or speed of flow is high making them unsuitable for most turbine systems. However, some of the Clyde tributaries and canals may offer potential for some small hydro-electric systems. Although this is unlikely to make a large contribution to Glasgow's overall energy needs there may be locations suitable for community based energy schemes. Water bodies can also provide a good source of heat for heat pump based systems.

A recent study[72] identified six viable sites within the city for development with small scale hydro. One of the identified sites is Pollock Sawmill. The council is in dialogue with South Glasgow Heritage & Environment Trust (SGHET) regarding development of the site, including the hydro scheme. The installation of six hydro schemes would cost approximately £9m. Two hydro schemes could be installed at each of the following sites: Whitecart, River Clyde and River Kelvin respectively. It is anticipated that this would generate 7 MWh of renewable energy, securing income of just under £800,000 per annum, or £16m over a 20 year period. Potential local electricity generation projects in Glasgow are summarised in Table 9 below.

Table 9: Opportunities for local electricity generation in Glasgow

| Local Electricity Generation Project | Description |
|---|---|
| Solar Photovoltaic Panels in 'solar farms' | Ground and building mounted solar panels on vacant and derelict land in the city. |
| Wind Turbines | Wind turbines within the council estate at Netherton Braes, Cathkin and Queenslie (subject to further appraisal). Other sites on council land and buildings are also being appraised. |
| Hydro Electric Power | Small scale hydro electric power technology deployed on watercourses in the city – subject to a pilot study of six potential sites on the Whitecart, Kelvin and Clyde. |
| Geothermal/Heat Pumps | Potential deployment of heat pumps to exploit the deep and shallow geothermal sources of water under Glasgow for district heating. |
| Biomass boilers | Biomass boilers are being installed at three sites in the city with another six being planned. The wood chip fuel is being sourced locally. |
| Energy from waste | Renewable energy will be generated at the council owned site at Polmadie to be known as the Glasgow Recycling and Renewable Energy Centre (GRREC). |

[72] Hydro power scoping study, City of Glasgow Weirs – BabyHydro September 2013

## Energy from Waste

Waste to energy facilities can help Glasgow meet its environmental targets. However there is a need for care in the design and capacity of waste to energy systems given the objective of reducing waste volumes over the longer term. With the aim of maximising reuse and recycling the Scottish Government has set a limit that no more than 25% of waste should be used in waste to energy systems.

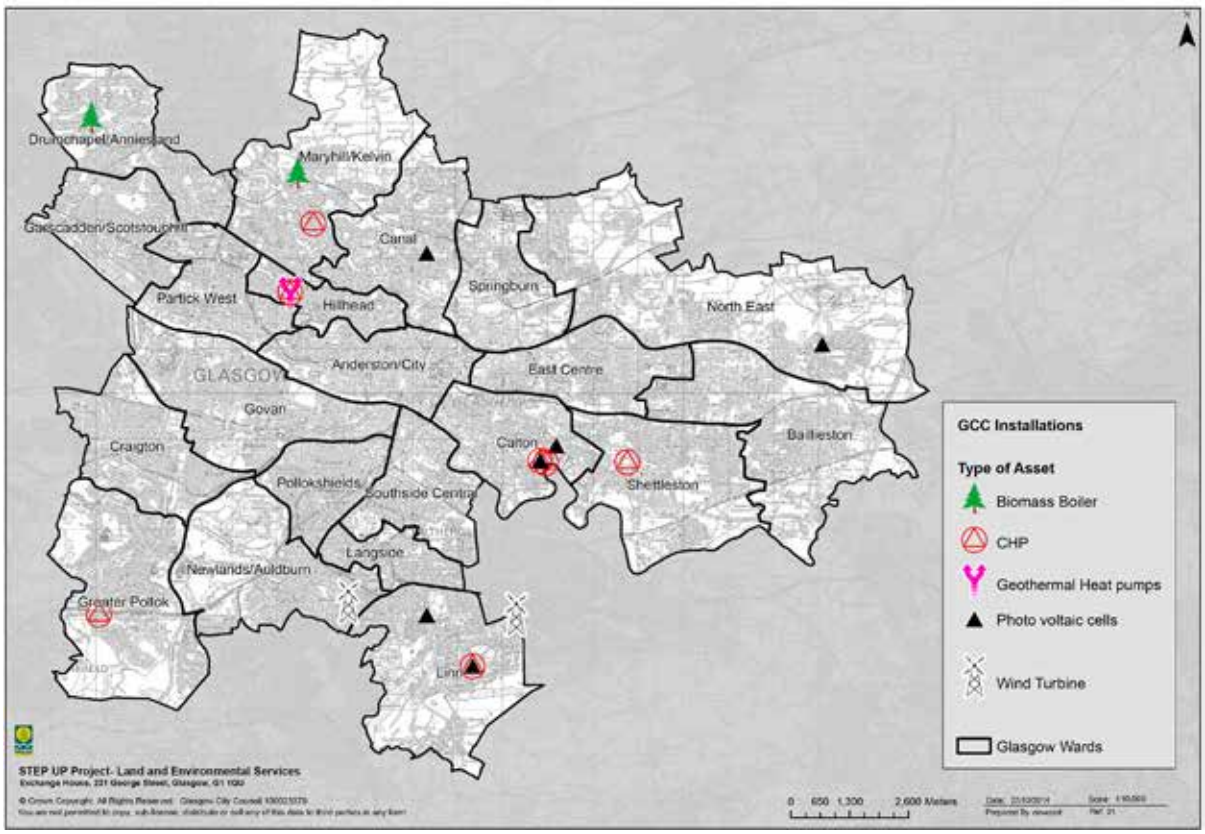
The Glasgow Recycling and Renewable Energy Centre (GRREC) development is a £154m recycling and renewable energy project being delivered by Glasgow City Council in partnership with Viridor Waste Management Limited. The development is located at the Polmadie site in the south of the city and will treat 200,000 tonnes of domestic green bin waste per annum. The process will maximise the recovery of recycling and natural resources from the waste stream, thus diverting waste from landfill. The treatment process will produce renewable energy that is capable of supporting district heating networks in the city.

Construction of the new facility is underway and is on track to be operational in early 2016. The GRREC will include processing food and organic waste to produce biogas for energy generation through anaerobic digestion (AD).

Peel Energy received planning consent in 2012 to build a waste to energy plant in the Shieldhall area of the city on the south bank of the Clyde. The plant is expected to handle 250,000 tonnes of waste per year. There is an opportunity for heat produced from the treatment of waste to be utilised locally including by the new Southern General Hospital, the Braehead Shopping Centre, and Hillington Industrial Estate.

Much of the city's sewage and food waste could be treated using anaerobic digestion to produce biogas which is then used to produce heat and power for homes, businesses and public buildings – or to fuel public transport. Anaerobic digestion treats waste organic matter (e.g. sewage, farm slurry or factory and kitchen food waste) in a sealed container using microbes to produce biogas and a residual compost like material.

Map 12. Renewable Energy Installations on Glasgow City Council land and properties




Source: Glasgow City Council

The University of Strathclyde, in collaboration with Zorg Biogas, is already conducting preliminary investigations into the potential for developing an AD EfW plant on the site of Dalmarnock sewage works.[73] The published findings of this study suggest a proposal to develop an AD plant on the site of the existing sewage works to harness the biogass for on-site combustion in a CHP engine would be feasible.[74] The resulting sludge from the process would then be pumped through an existing pipe to a sewage drying and pelletisation plant at Daldowie.

Even if all of the energy produced by the process were to be consumed on-site by the sewage works, it could still make a significant impact to reducing Glasgow's overall $CO_2$ emissions by substituting the consumption carbon-intensive energy that the waste water plant currently consumes from the grid, with locally generated heat and power. This could also potentially free-up spare capacity on the local network.

### Community energy projects

There is great potential for community led projects for renewable energy using new technologies to provide the heat and power for homes and businesses. A high level of community ownership and control of local energy generation and use can be encouraged in the city. Combining energy efficiency and new technology in renewable generation will help improve energy security, tackle fuel poverty and promote local employment.

The recent publication of the Community Energy Policy Statement for Scotland and associated CARES[75] grants made available for community projects provides a potential boost for such schemes. Glasgow City Council (GCC) could also support the local generation and distribution of electricity from these schemes by becoming an electricity supplier. It can apply for an electricity supply licence, sometimes known as Licence Lite, which would enable the council to sell electricity produced by community projects and other public sector owners of systems producing heat and power locally (decentralised energy systems). The schemes that can be included are small scale CHP units that generate electricity. These types of schemes primarily heat local buildings through gas engines but also produce electricity.

**Key Actions – Local Electricity Generation**

Action 27: Promote local production of renewable electricity through GCC-led projects that bring a return on investment

Action 28: Promote local production of renewable electricity through community based projects.

## Local Heat/Cold Production

### District Heating

GCC will support the delivery of affordable heat and power in partnership with stakeholders in the city allowing it to protect the citizens of Glasgow from the uncertainties around energy security and rising energy prices.

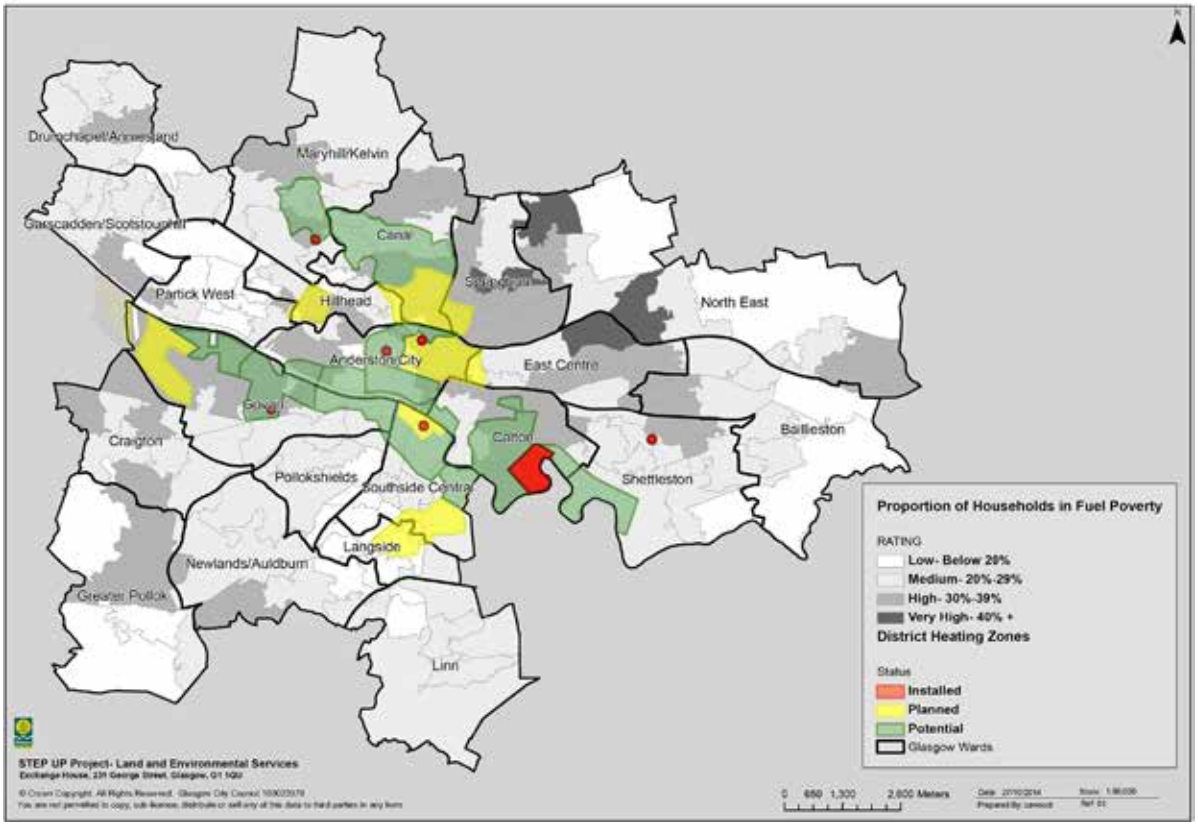
The provision of district heating is a key policy issue for the Scottish Government, which is committed to decarbonising heat supply systems by 2050 and reducing carbon emissions by 80% by the same timeframe. Currently, heat accounts for almost half of Scotland's carbon emissions. Scottish Government is doubling funding available for district heating from £4M to £8M and aims to have at least 40,000 homes connected to district heating by 2020[76].

The installation of district heating infrastructure can be targeted at areas of fuel poverty (Map 13) and can be carried out in tandem with building renovations allowing for improvements in energy efficiency to be achieved at the same time.

District heating can be fuelled from a number of different low carbon and renewable sources. In an optimised scenario, a district heating network should make use of any, and all, sources of heat that are available and can be feasibly connected to the network. For example, a network could make use of heat from gas fired CHP heat derived from waste disposal, through anaerobic digestion, at a waste to energy plant

[73] www.esru.strath.ac.uk/EandE/Web_sites/09-10/ZeroCarbonCommunities/wastemethodology.html
[74] The proposed plant occupies an area of 5600m2 and an inspection of the sewage works indicated this system could be accommodated on site
[75] CARES is the Community and Renewable Energy Scheme for Scotland established by the Scottish Government in 2011
[76] http://www.scotland.gov.uk/Publications/2014/03/2778/0

Map 13. District Heating Zones and Fuel Poverty in Glasgow




Source: Glasgow City Council

such as Polmadie; or through heat captured from trapped water in flooded mine workings via heat pumps; or heat captured from industrial processes within the vicinity of the network.

The benefits of district heating are maximised when a variety of customers connect to the scheme. Heat consumers such as homes, offices, academic institutions, industrial operations, and hospitals all have different profiles of heat consumption and consume heat at different times across the day. When combined these profiles create a near constant baseload, allowing near constant operation of the heating plant contained within an energy centre. The highest efficiencies are gained when plant is allowed to run constantly with minimum ramping up and down.

There are a number of schemes currently in operation in the city and further schemes currently at different stages of development.

The following are some of the schemes currently in place or in development in the city:

## Commonwealth Games Athletes Village

The Glasgow 2014 Commonwealth Games Athletes Village is heated by a district heating network providing heat to over 700 homes, a 120 bed care home and the Emirates Arena and Velodrome. The energy centre on the village site contains two large 750kW gas fired CHP engines, supported by three back-up conventional gas boilers. The combination of the two CHP engines offers a surplus capacity of 3MW of heat which could supply heat into neighbouring areas such as the Glasgow Housing Association owned Helenvale flats which are currently heated by very expensive and carbon intensive electrical heating.

The ownership of the energy centre and distribution network at the village now lies with

Glasgow City Council. The council will provide operations and maintenance, customer billing, and expansion of the network via the new ESCo.

## City Centre North and North Glasgow

The city centre and Glasgow North area has been subject to many studies into the implementation of district heating, the most recent of which was commissioned by Glasgow City Council, Scottish Government, Scottish Enterprise, Luddon Construction and Scottish Canals, and completed by Craighall Energy Ltd.

The study[77] covers the low carbon energy infrastructure solutions and business case for the City Centre North and North Glasgow areas. Specific areas include: Port Dundas, North Woodside, Sighthill, Townhead, Roystonhill, Wellpark and key sites within the city centre including the Glasgow Royal Infirmary, University of Strathclyde and Tennents Caledonian Brewery.

Successful implementation of the North Glasgow and City Centre North district heating strategy would take 4,500 homes out of fuel poverty and save the city approximately 54,000 $tCO_2$ p.a. This particular project also has the potential to create 500 jobs in Glasgow[78] in the construction phase and a number of permanent jobs to operate and maintain the system once established.

Work has also begun on the University of Strathclyde (UoS) district heating network funded through a £8 million capital contribution by the University and £8 million of match funding from the Scottish Funding Council (SFC). The University of Strathclyde wish to ensure that surplus heat generated is transported off their campus to neighbouring customers. The most immediate customer, geographically, is the Glasgow Housing Association (GHA) owned housing in the Townhead area of the city. The University of Strathclyde and GHA have begun discussions, facilitated by GCC, into connecting Townhead to the University of Strathclyde network.

In addition to the immediate opportunity for connecting Townhead to the University of Strathclyde, there is also an opportunity to have the Glasgow City Chambers complex connect to the University of Strathclyde district heating system.

## Ibroxholm Oval

Ibroxholm Oval is a housing estate owned by GHA in the south of the City. The area contains two high-rise blocks of flats which were heated by electrical heating. In partnership with Scottish Power Energy Networks (SPEN) and Integrated Energy Utilities (IEU), GHA designed and built a district heating solution for one of the blocks, containing 98 homes. Upon the formation of a city ESCo ScottishPower will donate the Ibroxholm DH network to the ESCo. This scheme provides an indication of the way DH networks can be developed in the city and then adopted by the city ESCo.

## Wyndford Housing Estate

The Wyndford housing estate has the largest (1700 homes connected) district heating network in Glasgow. The Wyndford housing estate is owned by Cube Housing Association (CHA) who are members of the Wheatley Group. SSE has a 30-year contract to deliver low carbon heat at an affordable level to the residents of the estate. It is possible that Wyndford could be connected to a wider city network subject to discussion as to how the SSE business model would fit into a city ESCo business model.

## University of Glasgow

The University of Glasgow is proceeding with a campus development programme which will involve a major redesign of its heating system. It is intending to replace its old steam heating system with a new district heating system fed from gas fired CHP. The scheme will cover the entire campus and will connect the newly acquired Western Hospital buildings. The viability of connecting nearby schools and museums to the network is being examined. Should the scheme connect to customers outside of its campus, it is likely that they would seek to engage with an ESCo to provide services.

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77 North Glasgow and City Centre North: Low Carbon Energy Infrastructure Solutions, 7 November 2013, Craighall Energy Limited in Partnership with IEU.

78 Based on Scottish Government estimates of 1 job/£140,000 construction spend.

## Glasgow Recycling and Renewable Energy Centre

Glasgow City Council (GCC) have engaged Parsons Brinkerhoff to deliver an outline business case for the development of two kick starter district heating schemes to aid in the promotion of heat off take from the GRREC. The two areas outlined are Polmadie, which will take a direct feed from the GRREC to homes and businesses in the surrounding Polmadie area and the Ballater Street area, which will initially be developed as a stand alone network for homes and businesses in that area in anticipation of connecting to the GRREC at a later date. These schemes have the potential to provide affordable heat to over 1000 residential customers and around 30 business premises.

### Key Actions – Local Heat/ Cold Production

**Action 29:** Develop a Glasgow Recycling and Renewable Energy Centre to produce energy from waste to supply heat locally.

**Action 30:** Establish a city-wide Energy Services Company (ESCo) to facilitate, coordinate, maintain and develop a district heating network in Glasgow.

## Heat Pumps and Geothermal Energy

Heat energy from the ground can be used to help to warm Glasgow's homes and communities. Geological studies are helping to identify which parts of the city would offer the best prospects of supplying this kind of energy; looking at the potential heat within minewaters, superficial deposits and bedrock aquifers beneath Glasgow. One small housing estate – Glenalmond Street[79] in the East End – already uses geothermal energy from underground mine workings and residents have heating bills of around £160 per year, as compared to £660 for an average Scottish family.[80] These sources of energy could help Glasgow meet Government targets to ensure 11% of heat demand comes from renewable sources by 2020.

British Geological Survey estimate that potentially up to 40% of the city's heat could be provided in this way either from abandoned mines or bedrock aquifers[81]. The sandstones of Devonian and lowermost-Carboniferous age constitute a deep geothermal aquifer at a depth of around 2km below the city stretching from the west end to the east end. Investigations by University of Glasgow suggest that there is a very good possibility of finding water in the strata at a temperature of 75 – 80°C, which is good enough for district heating without needing a heat-pump. The existence of geological faults in these strata would add permeability to the target sandstones and could then be intercepted by deep boreholes.

Heat pumps can be used to concentrate heat energy from lower temperature waters in the mines to make water hot enough to heat buildings. The heat can then be removed and used to warm the city's houses and offices. During summer, when buildings like hospitals need to be kept cool, the system can be reversed; the excess heat is stored underground for use in the winter.

Map 14 predicts those areas of the city where ground source heat pumps could be deployed to tap into geothermal heat.

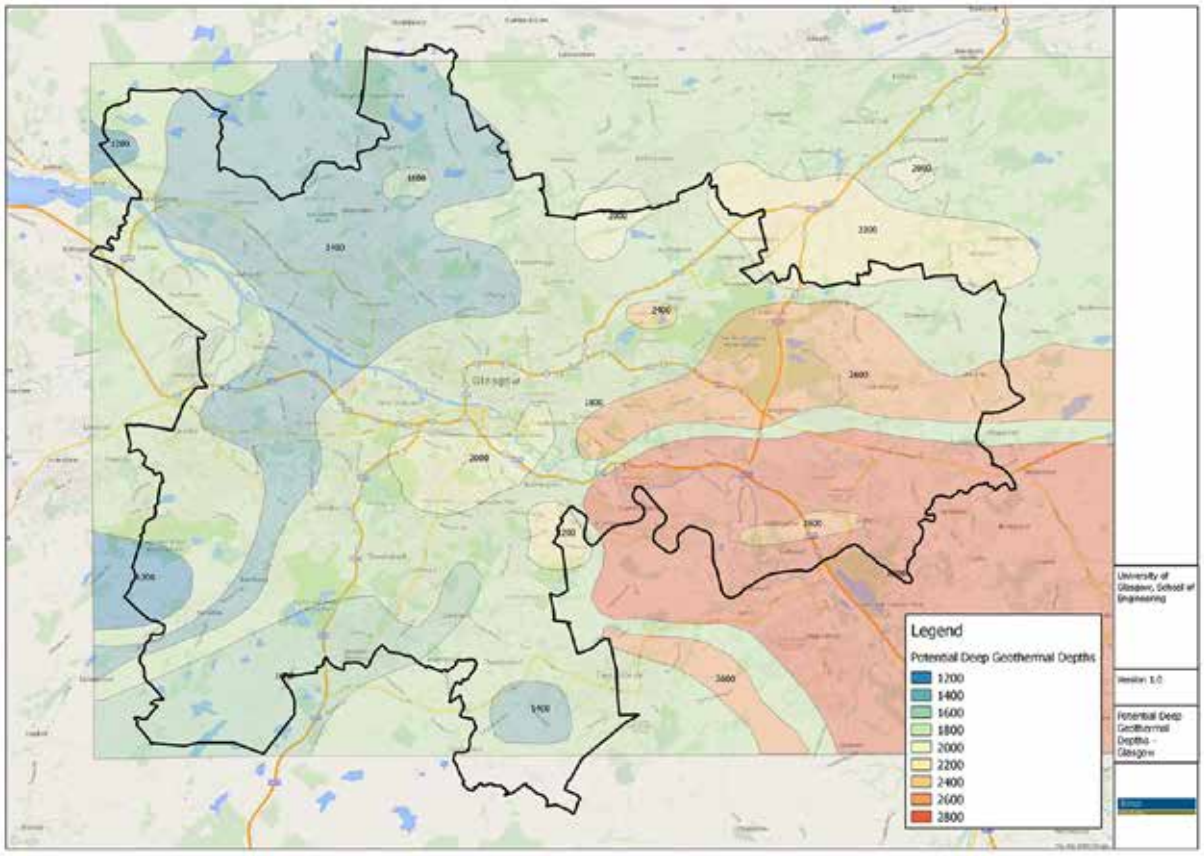
## Woodlands and Biomass

Glasgow has a large extent of woodlands and trees which have been catalogued as part of the iTree project. This project has catalogued the tree stock of Glasgow and also estimated the value of this in both monetary terms and contribution to pollution and carbon reduction. The value of trees and woodlands is primarily aesthetic but the iTree project helps identify the key role trees play in carbon sequestration. There is also value of trees and woodlands in terms of the production of biomass and other woodland products.

Glasgow's existing parks and woodlands are capable of producing 1,800 tonnes of timber per annum in a sustainable manner. In addition there are around 1,300 hectares of vacant and

[79] www.sust.org/pdf/glenalmond.pdf
[80] www.gcu.ac.uk/newsevents/news/article.php?id=53804
[81] British Geological Survey, http://www.bgs.ac.uk/research/energy/geothermal/heatEnergyGlasgow.html

Map 14. Geothermal Potential in Glasgow




Source: University of Glasgow

derelict land throughout the city – around 7.5% of the city's area. Much of this land has been vacant for over 20 years and this can create a negative impression of the city.

Glasgow's production of biomass could be increased through the planting of vacant ground with trees to create urban woodland for short rotation coppicing that would start producing timber for energy after 5 or 6 years. The estimated average yield is around 10 tonnes of timber per hectare per annum (approximately 13,000 tonnes of timber could be sustainably produced if all the vacant land is available for urban woodland).

Significant additional timber resources are available from the 121,000 hectares of forest within a 30 mile radius of the city boundary; an estimated total of up to 723,000 tonnes per annum could be theoretically available – however it is not clear how much of this resource would be available in practice as it may be contractually committed to other purposes. It may be possible to grow other biomass crops both within the city and the surrounding metropolitan area in addition to woodland, giving a mosaic of landscapes.

**Key Actions – Others are:Woodland and Waste**

**Action 31:** Roll out for households in the city the local collection of food waste and enable anaerobic digestion/ energy generation from this waste

**Action 32:** Develop anaerobic digestion of sewage waste at a sewage treatment works (potentially Dalmarnock) to generate energy for the plant.

**Action 33:** Promote further urban forestry for capture of carbon dioxide.

# 4.7 City Centre and district-wide opportunities

## City Centre

Section 2 of this report showed that the highest concentration of energy consumption in Glasgow occurs in the city centre and is attributed primarily to the abundance of high-density non-residential premises in this area, which consume significant levels of both electricity and gas. This high-concentration of load makes the city centre an attractive location for the consideration of an area-wide district heating scheme and this is being considered in part through the City Centre North and North Glasgow DH scheme. This can also be combined with a range of other improvements to transport, infrastructure and public realm making the city centre a more attractive place for business, leisure and accommodation. This is being progressed through the City Centre Transport Strategy. In tandem with opportunities for district heating, the potential for cost-effective improvements to the energy performance of the buildings to be served by any district heating scheme needs to be progressed, together with opportunities for Demand Side Management.

## Districts

Outside of the city centre, the three most pronounced areas of high-density energy consumption occur in the following zones:

- West End: the area surrounding Kelvingrove Park,
- Southside: the area surrounding Queen's Park and the Gorbals, and
- East End: the Dennistoun area and surroundings (also in Merchant City).

The primary driver for energy consumption in these buildings is the provision of space-heating and hot water. The high concentration of thermal loads in these areas makes them an attractive opportunity for local district heating schemes combined with further energy efficiency in the existing buildings and associated improvements to transport and other infrastructure.

## The West End

In the more affluent areas of Hyndland and Hillhead, which are predominantly occupied by traditional tenement flats, residences are seen to be reliant primarily on gas for their heat and hot water. Case studies of successful energy refurbishments of traditional tenement buildings in Glasgow's west end have been published[82]. One case study for a tenement house in Hyndland recommends that a new boiler was the cheapest measure and the best value for money in terms of carbon saved, and the most carbon is saved by the full insulation of the walls which was also second best value for money[83].

In contrast to the gas-heated areas of Hyndland and Hillhead, the high-density Broomhill flats and maisonettes and high rises at Whiteinch are reliant on electric storage heaters[84]. Because of the inefficiencies associated with the generation and transmission of electricity, heat provided by electric resistance heaters consuming national grid electricity is currently around 2-3 times more $CO_2$ intensive than heat provided using gas boilers. The high concentration of electric heating in these areas presents a potential opportunity to reduce $CO_2$ emissions by replacing electric storage heaters with an alternative source of heating.

Various alternative technologies are available for consideration, including: solar hot water systems, condensing gas boilers, biomass boilers, heat-pumps, and potentially even Combined Heat and Power (CHP) engines as part of a district heating scheme.

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82 www.2020climategroup.org.uk/news/retrofit-scotland-launched-at-the-lighthouse/
83 Tenement Flat Carbon Reduction Shopping List – Sustainability Research Project. Homes Architects. 2010
84 http://www.cubehousing.co.uk/LookingForAHome/Whereareourproperties/Glasgow/GlasgowArea.asp

## Other residential areas

Corridors of relatively high-density energy consumption radiate out from the city centre, tracing the main arterial roads which accommodate commercial premises and shop fronts. Whilst these areas do not appear to exhibit sufficient thermal demand density to warrant consideration of a DH scheme, the high concentration of retail premises present opportunities and constraints similar to those identified for the city centre. Consequently, the energy efficiency measures suggested for the city centre may also be applicable here. Table 10 gives a summary of issues and opportunities that exist in different parts of the city and for large energy consumers and small energy generators.

Table 10: Issues and opportunities for energy in Glasgow

| Area of Interest | Issues | Opportunity |
|---|---|---|
| City Centre | High Density Energy Demand | Demand side management / energy efficiency |
| | Building, planning, land use constraints | Align LDP, Policy needs of target areas |
| | High utilisation of existing infrastructure | Engage with key stakeholders |
| | High cost of new infrastructure | Integrated planning approach |
| Residential | Fuel poverty and high energy costs | Lower cost fuel sources |
| | Poor building fabric | Improve insulation |
| | Inefficient heating/ hot water systems | Replace with more efficient systems - DH |
| Large Energy Consumers | Large energy consumption | Demand side management/energy efficiency |
| | Individual energy systems | Integrated planning approach |
| | Large grid connections | Localised generation - anchor loads for DH |
| Distribution Generated | Grid network constraints | Integrated planning approach |
| | High initial investment | Engage with key stakeholders - funding sources |
| | Availability of renewable resources | Explore technology that fit urban areas - PV |
| | Location and size of energy centres | Align with other stakeholder requirements |
| | Technical and commercial constraints | Develop ESCo model to standardise approach |
| | | Distribution system operator |

Source: SPEN

- North west edge of Kelvingrove Park in the West End (around University Avenue),
- The commercial areas of Laurieston on the southside.

The area around the north-west corner of Kelvingrove Park accommodates a mix of university facilities, a swimming pool, shops, and eateries. Cost effective energy efficiency improvements in these types of buildings should initially focus on the following energy-intensive end-loads:

- Swimming pool: air conditioning and ventilation,
- University buildings: space heating and lighting,
- Retail: space heating and lighting,
- Eateries: space heating and lighting.

The consistent thermal loads presented by the swimming pool could potentially make a case for the use of CHP. The university buildings (including the pool), schools, and the clusters of high-density student accommodation in the area could also potentially provide anchor loads for the development of a local community heating scheme in the area. The university currently has an existing steam generator and has recently released a tender to replace this system with a new extended DH network including CHP. The Laurieston area on the south-side accommodates a significant number of low-rise commercial premises, warehouses and light industrial units.

In terms of the business and industrial parks around the city, further investigation would be required for the specific functions and operations conducted in these premises to develop an accurate idea of their energy consumption, and therefore, the most appropriate course of action for reducing $CO_2$ emissions. Improvements could focus on:

- Improvement of operational energy management, through training and behavioural change
- Optimisation of energy efficiency through:
  - improving BAU energy-intensive processes to reduce energy consumption)
  - substitution of inefficient plant (e.g. replacing inefficient lighting/boilers)
  - adoption of appropriate technology.

Table 10 above summarises the issues and opportunities for energy efficiency and local energy generation in different parts of Glasgow.

## 4.8 Cross-sectoral projects

The STEP UP project has highlighted the benefits of cross-sectoral opportunities for enhanced SEAPs, which go beyond traditional stand-alone energy actions to deliver multiple benefits. Cross-sector opportunities are based on the convergence of transport, energy and ICT sectors, as set out by the EC in its criteria for lighthouse projects[85], or on a combination of more than one Covenant of Mayors' sectors (key sectors mentioned, plus industry, public lighting, local electricity production or local heat/cold production). These projects also ideally provide environmental, social and economic benefits in an integrated way. Energy actions across various spatial levels are also of interest, from the micro-level (for example, individual buildings), to district or city-wide scale projects (for example, area wide energy efficiency, district heating and sustainable transport). A number of district-wide approaches have been highighted in this plan, indicating that there is the opportunity to take district-wide approaches to actions and to replicate these in areas across the city, or indeed in other cities

[85] Lighthouse projects are defined by the EC as projects which combine ICT, transported energy outcomes.

across Europe. Glasgow has identified six cross-sector opportunities that it has highlighted through the STEP UP project. These are:

- **Housing refurbishment** (energy efficiency and district heating), building on the district heating stand-alone actions. This will help residents across the city to make their homes more efficient and reduce fuel bills through insulation and other efficiency measures, district heating and renewable energy opportunities, and has the potential to result in greater impacts at lower costs if entire blocks of flats or streets are retrofitted at the same time.

- **Online building energy modelling tool**, which enables citizens to assess the energy performance of their buildings and suggests cost-effective measures for improving them. The model will provide a repository of intelligence on the condition and energy performance of Glasgow's building stock, which can be combined with other information that is being fed into the Glasgow city observatory[86]. There is scope to expand this model to identify district heating opportunities, and energy use from transport to create a real-time model of how the city is functioning overall.

- **Intelligent street lighting** is a project developing a dynamic street lighting network that can be controlled automatically and manually to reflect road usage and users. It is also linked to the roll out of energy efficient street lighting across the city. The intention is to extend the intelligent lighting beyond pilot sites across the city, and by combining it with existing initiatives to encourage active travel, it will help to reduce emissions from both lighting and transport.

- **Behavioural change project** engages citizens to understand their perceptions and motivations around energy issues and then helps them change their behaviours to reduce their energy demand. The project has been focused on energy use in buildings to date, but going forward the scope could be expanded to also cover transport, and other issues.

- **Energy Services Company (ESCo)**, this being established predominantly to support the roll out of district heating schemes in the city although these will be integrated with transport and other initiatives on the ground. Linked to this, the council is also working to encourage developers to look beyond the boundary of their own sites to develop shared energy and heat resources with neighbouring developments.

- **Industrial waste heat recovery and CHP**, is a project which could potentially link to the district heating stand-alone actions and is about developing waste heat recovery in the city simultaneously helping to reduce energy costs and $CO_2$ emissions. In the future it could be used to ensure that district heating schemes have a sustainable, efficient and low cost supply of heat.

[86] The Glasgow city observatory has been established under the Future City Demonstrator and hosted by the University of Strathclyde to provide public access to city data.

# 5 Implementation and Monitoring

# 5.1 Introduction

Implementation of the Energy and Carbon Masterplan will be co-ordinated through existing officer and member structures in Glasgow City Council (GCC) and the Sustainable Glasgow Board. The Environment and Sustainability Policy Development Committee will be the primary co-ordinating body as far as the council is concerned and the Sustainable Glasgow Board will co-ordinate stakeholder involvement as far as the partnership in Glasgow is concerned.

Covenant of Mayors progress and implementation of SEAP actions will be incorporated into the work of the City Energy and Carbon Management teams of the council which will monitor future progress and ensure that the council and partners are working together to deliver comprehensively on the SEAP. The council is putting in place a dedicated City Energy and Carbon team that will co-ordinate the delivery of this plan.

The council's performance management arrangements – existing arrangements involving service managers, departmental managers and Executive Directors – will help monitor implementation. The council's Performance Management System, will be used to help monitor performance against actions during the course of the plan's lifetime. However, the issue of time-lagged carbon emissions data will need to be addressed.

**Risk management**

The approach to the management of risk in the plan covers the three parts of the SEAP: the strategic approach (this document); the Baseline Emissions Inventory (BEI); and the action plan itself. Meeting the requirements of the CoM guidance both in terms of the Baseline Emissions Inventory (BEI) and the robustness of the action plan and the ongoing monitoring and reporting requirements of the CoM with regards to implementation of actions within it is a risk that needs to be managed.

A current risk is the lack of consistency of data and evidence to set accurate and realistic baselines, targets and intervention measures across all the sectors. There are inconsistencies in baselines and monitoring data required for some sectors – particularly transport, waste and wastewater treatment and gaps in the information required to estimate the impact of actions on energy and $CO_2$ emissions. The city needs to develop an enhanced capability to collect and assimilate information to support the implementation of the SEAP in the future.

Further issues on data exist on the baseline with regards to Life Cycle Assessment which is where the total carbon emissions associated with a product or service are included rather than just the emissions produced where energy is used. For example, the emissions associated with a refrigerator used in Glasgow but manufactured in China would need to include the energy and emissions associated with manufacture in China. $CO_2$ from sources such as aviation and shipping are also excluded from Glasgow's BEI.

There is a strong case for developing the Glasgow baseline to cover other greenhouse gases (GHGs) covered by the Kyoto Protocol. These are carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), sulphur hexafluoride,

hydrofluorocarbons and perfluorocarbons. These GHGs can be measured in carbon equivalents ($CO_{2e}$) and weighted (e.g. methane is over 20 times stronger than $CO_2$, nitrous oxide is 310 times stronger than $CO_2$ and chlorofluorocarbons several thousand times stronger than $CO_2$).

There are also gaps in the information available to measure the contribution that each action makes in terms of energy and $CO_2$ reduction for 2020 targets, in addition to other benefits such as job creation and economic growth. An issue for monitoring is therefore developing the ability to measure the impact of actions consistently.

A risk register will be compiled which will allow for analysis of risks, as well as a comprehensive list of all the risks that can be identified. This register will be a live document, kept up to date on an annual basis so that risks can be managed. This will be accompanied by regular review meetings allowing a comprehensive approach to analysis of risks and balancing responsibility between all stakeholders involved. The overall governance structure of Glasgow City Council (GCC) will support the appropriate designation of risk.

## 5.2 Co-ordination

**Responsibility for co-ordination of the plan and specific actions in Glasgow**

Responsibility for co-ordination of the implementation of the Energy and Carbon Masterplan will rest with Glasgow City Council. The action plan details the responsibility for implementing specific actions that are listed. The council will ensure that actions in its own area of responsibility are implemented and will – though the Sustainable Glasgow Board – seek to ensure that other partners implement their actions also.

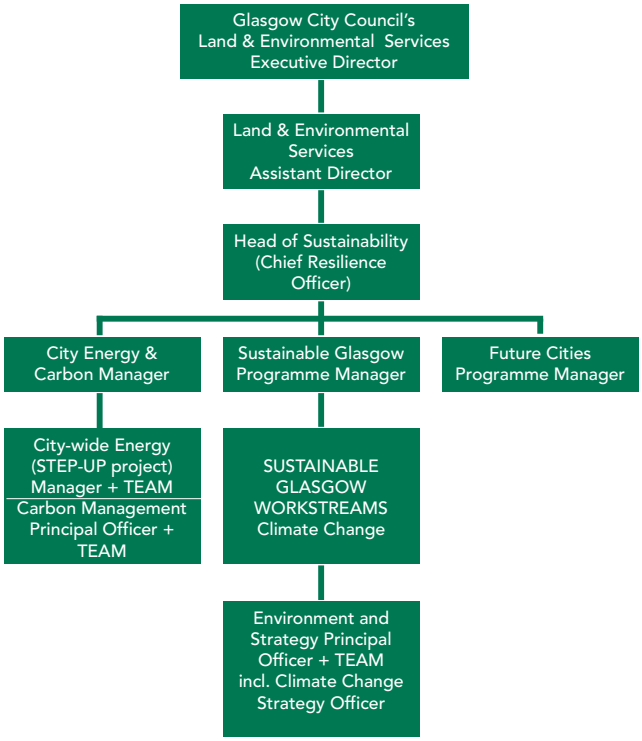
The development of the ESCo and other delivery vehicles will help ensure that certain actions (such as district heating schemes) are delivered and the council will continue to look at ways that the financing and implementation of projects can be taken forward.

# 5.3 Staffing

The council staffing structure to support the delivery of the ECMP is shown in Figure 20 below. Some of the staff presently work on city-wide carbon reduction (from the STEP UP project) and some on the council's carbon management programme. There will be an increasingly collaborative and co-operative approach across these work areas within the context of the Sustainable Glasgow initiative.

The TSB Future Cities Demonstrator Programme and STEP-UP are short term projects; the former concluding in January 2015 and the latter in June 2015. The legacy of these projects will be carried forward by a newly formed City Energy and Carbon team and by the existing Carbon Management team focusing on the Council's own activities.

Figure 20: Staffing for the implementation of the ECM




# 5.4 Stakeholders and Citizens

Sustainable Glasgow is a city-wide partnership formed in 2009 to help Glasgow become one of the most sustainable cities in Europe - and one of the best places to live and work. It brings together partners from higher education, the public and private sectors to work with local people, communities and businesses. It is focused on sustainable development broadly and part of its role is to help the city reduce its carbon emissions by 30% within 10 years and build a greener and more sustainable future for Glaswegians.

Its co-ordination role includes looking at the economic, social and environmental opportunities across Glasgow and presenting them in an integrated way. There is both a huge challenge and a huge opportunity for regeneration and new investment in Glasgow over the next decade as the low carbon economy develops.

One of Sustainable Glasgow's roles is looking an integrated approach to sustainability and energy infrastructure across Glasgow and identifying opportunities for implementing the range of city-wide projects contained in the action plan. These projects will be environmental but will also bring about economic growth and help tackle social issues.

## Citizen involvement and Behaviour change

Delivering significant and meaningful behavioural change in Glasgow amongst the general population will be a challenge. However, results of the stakeholder and citizens surveys carried out by STEP UP show wide support for the energy and sustainability agenda.

Investment in a programme of change – such as this action plan - and adoption of a group of policy actions that work together to deliver integrated benefits (e.g. energy saving and money saving) that reinforce and support behaviour change is likely to be more successful than one-off publicity campaigns. People need to be reminded to continue with new behaviours, and may need help that enables them to adopt the new behaviours in the first place. One of the projects of the TSB Future Cities Energy Efficiency Demonstrator was a project with University of Glasgow to look at the barriers and opportunities for energy behavior change in Glasgow. One of the results of this project is an online game – Glasgow's Energy Challenge – that encourages people to play a game that gives points for various energy efficient behaviours.

Glasgow's Green Year 2015 is also an opportunity to engage an entire city in a programme of events that will give residents practical information and resources, and reminders, on how to change their behaviour in ways that reduces their energy consumption in all aspects of their lives.

## Working with communities

Individual behaviour change is important but to achieve significant change there has to be large scale adoption. There is the potential for very wide scale community take-up of energy projects. For example, district heating systems and more sustainable transport require large uptake and collective behavioural change. The economic and environmental benefits of these schemes will increase when they are used by groups of people. Certain projects can be designed to engage community support through delivering direct benefits and involvement to communities:

- creation of a fund (potentially as part of the Glasgow Green Fund) to facilitate local smaller scale community based renewable energy projects
- training and jobs linked to projects
- giving communities direct involvement in local projects – such as the creation of urban woodlands
- improving the local environment as an integral part of implementing projects.

Community involvement in the implementation of the Sustainable Glasgow initiative has been limited to date and there is an opportunity to take advantage of the new Community Energy Policy Statement for Scotland, and encourage community involvement in renewable energy.

## 5.5 Budget

The existing revenue budgets available to support the implementation of the Energy and Carbon Masterplan are listed in table 11. These will be supported by the council's capital programme spending on projects and externally funded projects. These projects are listed in the SEAP action plan template.

Table 11: Budget to support the implementation of the Energy and Carbon Masterplan

| Budget | Amount allocated (£) |
|---|---|
| City Energy/ESCO | 150,000 |
| Carbon Management | 308,250 |
| Sustainable Glasgow | 62,000 |
| DRS Housing (Affordable Warmth) | 4,569,973. |
| Waste Management | 35,000,000 |
| Sustainable Transport | 434,500 |
| Environmental Strategy | 480,000 |

Source: Glasgow City Council

## 5.6 Financing the low carbon sector and de-centralised energy

One of the challenges identified earlier (see section 1) is the financing of low carbon projects in a world where public finances are constrained. In such a context we need to find innovative financial solutions and develop new business models.

Innovative financial mechanisms can encourage private investment supporting both large and small-scale energy projects. In this context, there are opportunities for Glasgow to drive investment in smart technologies and Low Carbon and Environmental Goods and Services (LCEGS) sector through public procurement. Possible opportunities for the use of public investment to spur follow on private investment include:

- retrofitting of social housing sector building stock
- developing smart energy grids and broadband access
- increasing electric vehicle charging infrastructure
- installing district heating networks

- developing further renewable energy generation
- promoting climate change adaptation and mitigation initiatives.

By investing in the LCEGS sector, Glasgow can help develop a market advantage in new technologies and build new skills and expertise as suggested in the Glasgow Economic Commission report. There are several aspects of financing the delivery of the SEAP that need to be considered:

- The total costs of the projects
- The sources of funding (both individually and in the form of a potential Glasgow Revolving Energy Fund)
- The delivery vehicles used for implementation of projects.

Some projects will generate significant revenues and offer good rates of return on capital investments. In current economic circumstances it is no longer realistic to expect this level of funding to be delivered entirely by the public sector. However, there are a range of financial opportunities available to help fund such projects if assembled in the way that the London Green Fund has been assembled.

Public sector money can be used for pump-priming and kick-starting schemes in a way that reduces overall project risk and helps to encourage private sector investment. Potential public sector sources of funding include local authority borrowing, European funding, the Scottish Government's Joint European Support for Sustainable Investment in City Areas (JESSICA) fund and other schemes such as the District Heating Loan Fund. The European Investment Bank and Green Investment Bank (GIB) funding priorities in relation to tackling climate change through renewable energy and energy efficiency are also potential sources of funding.

Organisational assistance is available from The Low Carbon Infrastructure Transition Programme (LCITP), operational from 5 January 2015, will provide a Scotland-wide low carbon Project Development Unit operating across the public, private and community sectors where there exists significant potential for decarbonisation and enterprise growth.

The focus will include low carbon and renewable electricity and heat generation, energy efficiency, resource efficiency and materials recycling and re-use. The programme brings together the current individual work streams that the Scottish Government, Scottish Enterprise, Highlands and Islands Enterprise and the Scottish Futures Trust have in place, including the Scottish Green Investment Portfolio, to deliver a single collaborative integrated programme of project support activity. The collective aim of this new approach is scaling up and accelerating the delivery of low carbon infrastructure projects across Scotland, by bringing a greater number of projects to investor readiness stage and helping to secure the appropriate capital investment to build projects on the ground.

Business models to finance renewable electricity projects are well understood. With an existing incentive system and grid infrastructure available for connection, viable projects should not struggle to raise finance. However in urban areas there may be additional merit in employing business models which include community involvement and or community benefit – as community based projects are likely to experience lower levels of public opposition. Community based projects also more clearly represent the interests and views of citizens directly as they can be designed to pursue and deliver on citizens' objectives. Projects such as these also generate a sense of autonomy for participating groups which only serves to increase public participation in the decision making process and better reflect stakeholders' views.

## Sources of funding

Funding may be raised through Council financing (capital or prudential borrowing), shared financing and equity between the Council and a third party, or through third

party funding and equity. The Council could also raise finance through third parties such as the Green Investment Bank (GIB) or Salix Finance. In addition incentives such as the Renewables Obligation, Renewable Heat Initiatives, Feed in Tariffs, Contract for Difference, may be available for renewables. This revenue stream can accelerate payback and thus assist with business case development to attract funding. Financing sources for implementation of the ECMP that could potentially be accessed include the following:

- **Revenue budgets** - annual expenditure and income from annual budgets designed to deliver benefits and services within the year of expenditure can be used to support some projects for example staff awareness and behavioural change.

- **Capital Programme** is expenditure on capital projects which deliver benefits over future years and can be used to support some major schemes such as building refurbishment or renewable energy projects.

- **Prudential Borrowing** – The Local Government Act 2003 allows an individual authority to borrow money to fund capital spending subject to plans being prudent, affordable and sustainable in line with the Chartered Institute of Public Finance and Accountancy (CIPFA) prudential code for capital finance.

- **Central Energy Efficiency Fund (CEEF)** is an allocation which the Scottish Government's Central Energy Efficiency Fund makes to local authorities and is a key vehicle for delivering energy efficiency and small-scale renewable energy measures across the public sector in Scotland. This fund is self financing in that it is paid back through the financial savings generated from the energy efficiency projects. The funding has been used to set up locally administered revolving funds. Energy efficiency projects generate savings which can then be used to invest in further energy efficiency measures and to help improve frontline services.

- **The Green Deal and Energy Company Obligation (ECO)** works alongside the Green Deal. The Green Deal provides funding to allow a householder to make up front investment in energy efficiency measures or renewable energy projects to be paid off over time as part of their energy bills. Under the ECO, energy companies with over 250,000 customers have an obligation (placed on them by Ofgem) to provide additional financial help for energy efficiency measures. For example, hard to treat cavity wall insulation may be the best energy efficiency option for a particular property - but may be cost prohibitive for the property's owners. In these situations, the ECO can help homeowners achieve these energy efficiency measures.

- **Feed in tariff (FIT)** is a scheme that guarantees a minimum payment for all electricity generated by the renewable system, as well as a separate payment for the electricity exported to grid. These payments are in addition to the bill savings made by using the electricity generated on-site. The payments vary depending on the type and size of installation. Viable projects will be identified to take advantage of this incentive in both the housing and non-housing stock. Energy sources that can benefit from FITs include solar PV, wind, anaerobic digestion, hydro and micro CHP.

- **The renewable heat incentive (RHI)** scheme provides long term support for renewable heat technologies, from household solar thermal panels to industrial wood pellet boilers. It can be used to install biomass boilers at schools or other Council facilities for instance.

- **Salix Finance** – Salix Finance is an independent company funded by the Carbon Trust. Its remit is to work with the public sector to reduce carbon emissions by investing in energy efficiency measures. Salix provides interest free loans that can be used to fund known energy saving projects. The savings from projects are used to pay off the loan, which is then recycled to support new projects where carbon reduction is the key driver.

- **Green Investment Bank** – is a relatively new public financial institution established to unlock the investment needed in supply chains and infrastructure in order to meet UK climate change and renewable energy targets between now and 2020. The GIB has three areas of focus: offshore wind, energy from waste and energy efficiency. The energy efficiency strand is broad, encompassing retrofitting and district heating network development which could be particularly relevant for Glasgow. The GIB is being utilised to fund street lighting replacement in the city.

- **Local Energy Challenge Fund:** is a new £20m fund established by the Scottish Government. Local partnerships including community groups, charities, local authorities, housing associations, universities and businesses can apply to set up low carbon energy pilot projects in their areas, through the Community and Renewable Energy Scheme (CARES) Local Energy Challenge Fund.

- **Renewable Energy Investment Fund (REIF)** provides financial assistance for projects that will deliver energy from a renewable source, reduce the cost of renewable energy or provide key solutions for renewable energy generation. Examples of areas that REIF can support includes: marine energy, community owned renewables, and renewable district heating. REIF is delivered by the Scottish Investment Bank on behalf of the Scottish Government and its enterprise agencies.

- **European Investment Bank** provides lending for renewable energy projects, most of which go to wind and solar power generation. By investing in renewable energy the EIB aims to support the European Union's climate policy and will help to achieve our target of 20% of overall EU energy consumption being met from renewable energy sources.

- **European Union (EU) funding**. There is a range of EU funding available to support energy projects including ELENA (the European Local Energy Assistance Fund); LIFE+ and the European Regional Development Fund (ERDF). Horizon 2020 is the successor to the Framework Programme 7, the European Commission's research and development funding programme (which funds the STEP UP project) and incorporates actions previously funded under the Intelligent Energy Europe Programme. It will combine much of the research and innovation funding currently provided through different mechanisms and aims to move closer to market with greater emphasis on innovation.

- **JESSICA** (Joint European Support for Sustainable Investment in City Areas) is an initiative developed by the European Commission (EC) and the European Investment Bank (EIB) in collaboration with the Council of Europe Development Bank, to enable sustainable regeneration activity to be delivered in Europe's urban areas. JESSICA works by allowing EU Member States to make contributions from their Structural Fund Programmes, along with funding from other public and/or private sources, to urban development funds (UDFs). The UDFs then invest these monies, in the form of equity, loan and/or guarantee - not grants - in urban development projects. This is a strategically important delivery mechanism as any return on investments can be reinvested in other urban development projects. The Scottish Partnership for Regeneration in Urban Areas (SPRUCE) is a £50m fund established for support projects in 13 local authority areas in Scotland including Glasgow.

## Developing a Glasgow Revolving Fund

Glasgow City Council (GCC) could potentially establish a revolving fund similar to the London Green Fund to fund low carbon projects in the city. The essence of a revolving fund is that the initial investment in a local energy project is repaid by returns, freeing up cash to invest in further carbon reduction schemes. Revenues from reduced energy bills, selling energy, and feed-in tariffs can fund activities for decades on a steady, predictable basis. By reinvesting returns, or spending them on other carbon saving projects, the community can multiply

projects, the community can multiply the impact of its investment and avoid the need for continual injections of grant funding.

London Green Fund (LGF) amounts to £100 million and is used to invest in schemes that will cut London's carbon emissions. The fund was launched in October 2009. It is made up of £50 million from the London ERDF Programme, £32 million from the Greater London Authority (GLA), and £18 million from the London Waste and Recycling Board (LWARB). The European Investment Bank manages the London Green Fund on behalf of the GLA and LWARB. The LGF provides funding for three UDFs that invest directly in waste, energy efficiency, decentralised energy and social housing projects. They are 'revolving' investment funds, where monies invested in one project are repaid and then reinvested in other projects. It aims to bring in private capital to match the public investment, and to make investments (loans and equity) that allow the funds to revolve so that the returns can be reinvested in urban regeneration. The London Green Fund is an innovative tool for financing infrastructure that brings commercial discipline and expertise into public sector financial decisions.

This not only enables more low carbon activity to be financed but additionally allows an initial restriction on project types to be financed. However, funds are only available to re-invest as they are repaid. This may mean that funds are slow to recoup and reinvest in other projects. This mechanism is not necessarily suitable for some investment programmes looking for shorter payback periods or a higher level of return on investment. The initial investment will not be recovered unless the fund is closed.

## 5.7 Delivery Structures

A wide range of delivery structures exist which can be used to deliver public sector energy projects. The type of structure adopted can be defined by the level of council involvement, investment and ownership in the project. The type of structure is also determined by the level of risk the council wishes to carry. There are commonly three main types of delivery structure:

- Public sector funded, developed, operated and owned. Within this option the council would retain 100% ownership of all aspects of the project or initiative. Development of renewable projects will generate revenue which can be used to support initiatives such as the Glasgow Revolving Energy Fund or be reinvested to expand ESCo district heat networks to tackle fuel poverty.

- Joint Venture initiative. Within this structure funding provision and project risk would be shared by parties to the contract. An example of this would be the GCC/SSE design build finance and operate - equal finance and profit share for Cathkin wind turbine. Within this model the community could also finance (through community grants or crowd sourcing) small projects that the council make a contribution to in the form of land or buildings for instance. RSLs would also fall into this category of partner joint ventures.

- Private sector funded, developed, operated and owned. Within this option the council would not have any ownership of the project or initiative.

There are a range of delivery structures that fit between options 1 and 3, whereby the project ownership, funding and risk would vary. The decision in relation to the council's role and delivery structure adopted would be decided by the council on a project by project basis.

# 5.8 Monitoring Process

The plan must be kept under review to ensure that it delivers on the actions and projects that will deliver a low carbon economy for Glasgow. This means monitoring to meet the requirements of the Covenant of Mayors but also a wider set of parameters concerning the future of the city as follows:

- Progress on the actions and projects that are delivering energy and carbon reductions;
- The changing nature of the city's economy, society and environment so we can ensure that the city is becoming more sustainable;
- Proposed new developments in terms of planning applications for housing and commercial or industrial development that are exerted new energy demands so that these can be identified and infrastructure planned for early on through the Integrated Energy Planning process;
- New opportunities for funding projects through European, UK or national public sources are identified together with private funding and inward investment as part of the Green Glasgow Fund;
- New technologies and low carbon energy opportunities are monitored as part of the GCC Economic Development function so that Glasgow can be first-mover on the implementation of new initiatives;
- Changes to the legislative and regulatory environment are monitored and assessed as part of the legal teams functions.

The publication of an annual report reviewing progress on implementation of the Energy and Carbon Masterplan and the overall vision for a greener Glasgow would be an appropriate frequency of monitoring in terms of maintaining momentum.

### The Monitoring Emissions Inventory and Monitoring Synthesis report

Monitoring is a very important part of the SEAP process. Regular monitoring, followed by adequate adaptations of the plan, allows the SEAP to be continuously improved and updated. Covenant of Mayors signatories are committed to submit regular reports following the submission of the SEAP 'for evaluation, monitoring and verification purposes'. Some indicators are also needed in order to assess the progress and performance of the SEAP.

Every two years after submission of the SEAP, Covenant signatories are required to submit an implementation report. This report will provide a summary of the results achieved, both in terms of measures implemented and $CO_2$ emission reductions. Monitoring and evaluating these results is important for following up on achievements made, and for developing future actions and measures. Glasgow City Council will assess the potential emission reductions of the implemented measures to continuously develop and improve the SEAP.

In order to monitor the energy consumption and $CO_2$ emissions data effectively and adapt the action plan accordingly if necessary, Covenant signatories are encouraged to compile Monitoring Emission Inventories on a regular basis. The CoM recommendation is to do this on a yearly basis, and the minimal requirement in the context of the Covenant of Mayors is to do it at least every 4 years. In Glasgow monitoring will be done on an annual basis and a report produced for internal and external use. In this way, annual inventories will be compared with the Baseline Emission Inventory, and progress towards the emission reduction target of 30% tracked.

# Glossary

# Glossary

**Bioenergy**
Bioenergy is renewable energy that is produced from materials that come from living organisms often from by-products of plants or animals. Biomass and biofuels are the main types of bioenergy.

**Biodiesel**
Biodiesel is a form of biofuel produced from renewable resources such as plant oils, animal fats, used cooking oil, and new sources such as algae. Biodiesel contains no petroleum, but can be combined in any quantity with petroleum diesel to create a biodiesel blend. Biodiesel blends can be used in most "compression-ignition" (diesel) engines with little or no modifications.

**Biomass**
Biomass means natural material, and refers to biological materials that were alive or created during our lifetimes. Biomass specifically excludes coal and petroleum. When burned, biomass materials release heat – just like wood logs in a campfire. Examples of biomass include grass clippings, wood chips, animal manure, and non-toxic rubbish. Methane gas from landfills can also be captured and burned. Energy from biomass is most often used in CHP schemes to generate electricity and heat.

**$CO_2$/kWh**
This is the annotation for carbon dioxide per kilowatt hour. This is used to represent the potential carbon emissions per hourly unit of energy supplied/produced.

**Carbon Budgets**
The UK Climate Change Act (2008) requires the Government to set legally binding carbon budgets; a cap on the amount of greenhouse gases emitted in the UK over a five-year period. The first four carbon budgets have been put into legislation and run up to 2027. The Scottish Government has also set annual emissions reduction targets for the period to 2027 and set out proposals for how it would meet these targets in 2013.

**Combined Heat and Power (CHP)**
Combined heat and power (CHP) integrates the production of usable heat and power (electricity), in one single, highly efficient process. CHP generates electricity whilst also capturing usable heat that is produced in this process. This contrasts with conventional ways of generating electricity where large amounts of heat are wasted often seen as a cloud of steam rising from cooling towers.

**Compact Fluorescent Light (CFL)**
Fluorescent light manufactured to occupy a very small area and able to be installed in an ordinary light fixture. CFL bulbs use a fraction of the electricity used by incandescent light bulbs.

**Conservation**
The reduction of energy usage through increased efficiency and/or reduced waste.

**Covenant of Mayors (CoM)**
The Covenant of Mayors is the mainstream European movement involving local and regional authorities who voluntarily commit to increase energy efficiency and use of renewable energy sources on their territories. One year after joining the Covenant of Mayors, signatory cities pledge to adopt a SEAP and report every two years on its implementation

**Department of Energy and Climate Change (DECC)**
This is the department in the UK Government that deals with energy supply, efficiency and provision; as well as supporting action towards climate and environmental change. DECC provides official statistics on energy, climate change, energy efficiency, fuel poverty and related areas. It produces annual and sub national data on greenhouse gas emissions as well as quarterly data based on changes in CO2 emissions, and links to other Climate Change data

**District Heating (DH)**
District Heating (or Cooling) is where heat that is produced centrally, or from many large commercial or municipal buildings is utilized to provide heat and hot water to residential properties. It utilizes an otherwise wasted by-product and helps to reduce fuel costs for residents and businesses who use it.

**Energy Efficient Appliances**
This refers to electrical devices or appliances that perform their task, and use less electricity than lower-efficient devices. Electrical inefficiency in many devices is directly related to the heat they produce. For example, energy efficient light bulbs use most of the incoming electrical energy to produce light, not heat.

**EV**
Abbreviation for Electric Vehicle, a vehicle that derives all of its ability to move from energy stored in batteries, and does not have an internal combustion engine of any type.

**Energy Services Company (ESCo)**
An Energy Services Company is either a commercial or not-for-profit company that provides a range of energy services from retrofitting (see retrofit), energy solutions, energy supply, energy production and efficiency/savings projects.

**European Commission (EC)**
The European Commission (EC) is the executive arm of the European Union (see European Union) that manage the governance and administrative work of the European Union.

**European Union (EU)**
The European Union (EU) is a political and economic union of 28 European countries.

**Feed-in-Tariff (FIT)**
Money paid to a customer by a power company for electricity generated by from renewable energy that is surplus to local needs. The renewable energy source is most frequently either solar or wind generated electricity. Feed-in-tariffs are implemented to encourage end users to install renewable energy equipment and sell excess renewable energy back to the utility company.

**Fossil Fuels**
Fossil Fuels are refined from matter that has been produced from the bodies of dead organisms through anaerobic digestion over millions of years. These are a finite resource and also produce greenhouse gases when they are used as fuel. The three main types of fossil fuel are: coal; gas; and oil.

**Geothermal**
Heat from the earth is often thought of as energy from geysers and hot springs. More recently, this term is applied to any heat stored in earth and available as a renewable energy resource. In Glasgow this applies to geological formations under the city and also disused mine-workings, both of which can be utilized as a potential source of heat.

**Gigawatt**
From giga, meaning billion, and watt, a unit of energy (see watt). A gigawatt is one billion watts of electrical energy. One gigawatt is equivalent to the energy consumed by 10 million 100 watt light bulbs illuminated at the same time.

**Glasgow Housing Association (GHA)**
GHA is one of the largest providers of social housing in the Glasgow area.

**Global Warming**
The Earth's gradual warming due to the greenhouse effect.

**Greenhouse Effect**
The rise in temperature the Earth experiences because certain gases in the atmosphere (such as water vapor, carbon dioxide, nitrous oxide, and methane) trap energy from the sun. Without these gases, heat would escape back into space and Earth's average temperature would be about 60°F/15.5°C colder. Because of how they warm our world, these gases are referred to as greenhouse gases.

**Greenhouse Gases**
Some gases in the Earth's atmosphere are responsible for producing the greenhouse effect. Changes in the concentration of certain greenhouse gases, due to human activity such as fossil fuel burning, increase the risk of global climate change. Greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, ozone, and various forms of fluorocarbon gas (used in air conditioners and refrigerators).

**Grid**
This refers to the network of wires and cables that transport electricity from a power plant to the home.

**HEEPs**
HEEPs is an abbreviation for the Home Energy Efficiency Programme.

**Intergovernmental Panel on Climate Change (IPCC)**
The IPCC is the leading body that scientifically assesses the effects of climate change. It looks at a range of research and reports to determine the many parameters that effect and are affecting climate change. The IPCC falls under the sovereignty of the United Nations.

**Incandescent Bulb**
An incandescent bulb is a source that produces light by heating a wire filament to a very high temperature.

**Insulation**
Materials that keep energy from crossing from one place to another: on electrical wire, it is the plastic or rubber that covers the conductor; in a building, insulation makes the walls, floor, and roof more resistant to the outside (ambient) temperature.

**Kilowatt (kW)**
This means one thousand watts of electricity (see Watt).

**Kilowatt-hour (kW-h)**
As above, this means one thousand watt-hours. This is calculated by multiplying the number of watts being used times the length of time in hours that amount of electricity is used. A refrigerator that uses 250 watts will consume one kilowatt-hour of energy in four hours (250 watts x 4 hours = 1,000 watt-hours or one kilowatt-hour). Utility bills are based on the number of kilowatt-hours consumed each month.

**Light Emitting Diode (LED)**
An extremely efficient source of light, LED lamps convert from 65% to 95% of the electric energy to light energy (depending on the colour of the light). LEDs also typically last from 50,000 to 100,000 hours. Light emitting diodes are made from the same material as transistors and give off light when electricity is passed through them.

**Low Carbon**
Low carbon indicates any business, economy or type of energy production that uses or produces energy that is either renewable or low in carbon dioxide emissions. Typically high carbon fuels are fossil fuels.

**Megawatt**
From mega, meaning million, and watt, a unit of energy (see watt). A megawatt is one million watts of electrical energy. To give an idea how large one megawatt is, it is the energy consumed by 10 thousand 100 watt light bulbs illuminated at the same time.

**Nuclear Energy**
Nuclear energy or power is produced through exothermic nuclear processes. This usually involves reactions where nuclear binding energy is produced through nuclear, fission, fusion or decay. It is low carbon solution but is highly controversial due to the potential for large scale and long term risks to people and the environment.

**Off-the-grid (Off-grid)**
Not connected to the national electricity grid network.

**OFGEM**
This is the independent government regulating body for electricity and gas markets in the United Kingdom. It stands for Office of Gas and Electricity Markets.

**Photovoltaic**
This means light-generated voltage. (Photo means light. Voltaic means voltage. This is often shortened to PV (see below).

**Photovoltaic (PV) Cell**
A photovoltaic cell is an electronic device consisting of layers of special materials capable of converting light directly into electricity.

**Renewable Electricity**
Renewable electricity is electricity generated without the use of fossil fuels.

**Renewable Energy (RE)**
This is an energy source that renews itself without effort. Fossil fuels, once consumed, are gone forever, while solar energy is renewable in that the sun energy we harvest today has no effect on the sun energy we can harvest tomorrow.

**Renewables**
Shorthand for renewable energy or material sources.

**Retrofit**
Retrofitting refers to the targeted approach of home energy retrofitting where old or existing buildings are fitted with energy efficient technologies to make them greener and more efficient.

**Scottish Power Energy Networks (SPEN)**
SPEN is a partner in the STEP UP project and are a member of the Scottish Power group of companies. SPEN is the electricity Distribution Network Operator providing power connections across the southern Scotland. SSE is the DNO for the north of Scotland.

**Smart City**
The European Union (EU) advocates the development smart cities. Smart cities incorporate improved and streamlined infrastructure, skills and social capital and the use of modern technologies and innovation to take metropolitan areas into the future and improve the functioning of cities in many aspects.

**Smart Grid**
A smart grid is a modernized power supply grid that uses digital information and demographic/behavioural information to maximize energy efficiency and help provide energy supply that meets the demand of those using it.

**Solar Energy**
This refers to the radiant energy of the sun; which can be converted into other forms of energy such as heat or electricity.

**Solar Modules**
Also more commonly referred to as a solar panel. This refers to a set of either solar thermal cells or solar photovoltaic cells that are connected up together to form a panel.

**Solar Thermal**
Solar thermal energy is derived from the heat that comes from sunlight. Examples of derived heat are: home heating, solar cooking, clothes drying, solar heated water, and so forth. Concentrated solar thermal heat is often used to create steam, from which electric power is generated.

**Strategies Towards Energy Performance and Urban Planning (STEP UP)**
The STEP UP Project is a collaboration between four cities across local government, higher education and private sector institutions. The four participating cities are Glasgow, Ghent, Gothenburg and Riga.

**Sustainability**
Sustainability relates to the quality of life in a community, and is frequently used as meaning not taking more from a resource than is replenished naturally. In a broader sense, sustainability pertains to the economic, social and environmental systems that make up a community as a whole, and whether all three are working in concert to provide a healthy, productive, meaningful life for all community residents, present and future.

**$tCO_2$**
This is the annotation for tonnes of carbon dioxide.

**Technology Strategy Board (TSB) Future Cities Demonstrator**
The TSB (formerly TSB; it is now called Innovate UK) Future Cities Demonstrator is a large scale project in Glasgow that aims to show how technologies for the city can make life for residents smarter, safer and more sustainable.

**United Nations (UN)**
The United Nations is an intergovernmental organisation set up to promote international cooperation. Today the UN carries out social, economic, charitable and legal practices and duties.

**Watt**
A watt is a unit of electrical power. Watts are calculated by multiplying the electrical pressure in a circuit (volts) by the amount of electricity moving in the circuit (amps). For example, 120 volts times 2 amps equals 240 watts.

**Watt-hour (W-h)**
The electrical energy unit of measure equal to one watt of power supplied to, or taken from, an electric circuit steadily for one hour. For instance, a 60 watt incandescent light will consume 600 watt-hours of energy when used for ten hours (60 watts x 10 hours = 600 watt-hours.). Our electric bills are based on the number of watt-hours of energy consumed each month.