Job creation from a Sustainable Transition for
Sheffield City Region

How delivering a climate change compatible sub-regional economy will create new enterprises and employment
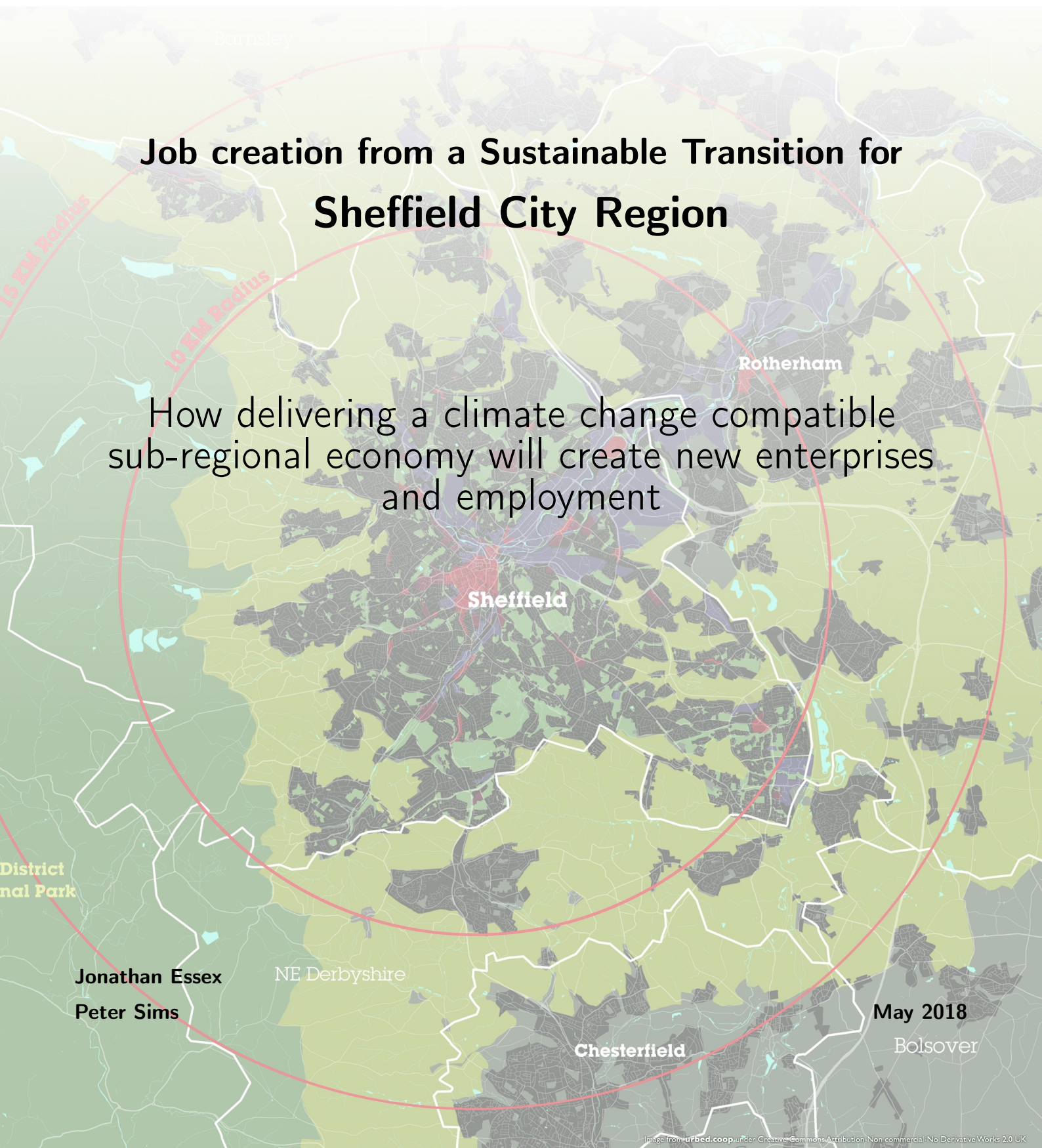
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Executive Summary

This report asks the question, **How many jobs would be created in the Sheffield City Region by a transition to a zero-carbon economy?**

In contrast to the 'Better Future Together' and 'State of Sheffield' reports [1, 2], this project has not assumed that long-term economic growth is tenable or that adding financial value should be the primary goal. Rather than the financial size of the economy, we should focus on the things that we want the economy to deliver: employment, meeting our targets for reductions in emissions of greenhouse gases, and a good quality of life for the population. This report finds that a focus on activities that reduce greenhouse gas emissions would create more jobs in the region than would be lost by the reduction in fossil-fuel use. By focusing on the creation and maintenance of social and environmental capital it is possible to better utilise Sheffield's workforce and improve its citizens' quality of life, while reducing greenhouse gas emissions.

The transition this report proposes is ambitious and transformative; in terms of the changes to resource, energy and land-use and in strengthening local communities, their resilience and quality of life. Although we do not claim that the proposals set out would on their own reduce greenhouse gas emissions to net zero by 2030, they would provide the foundation that enables this goal to be achievable by then or shortly thereafter.

The jobs creation estimates in this report have been based on a set of Job Metrics (published information on the number of jobs created per ton of waste recycled, homes insulated, bus mile or MW of solar photovoltaic panels installed, the details of which are in- Annex - Base Job Metrics) which have then been scaled to SCR on a sector by sector basis, using available data on the SCR. Jobs which would be lost as a result of the transition, where they can be quantified (for example in coal-fired power stations, or repairing internal combustion engine cars), have been subtracted from the number of jobs created, to give the net number of jobs created.

The net number of full-time equivalent (FTE) jobs would be about 21,600, in a transition phase and 17,600 FTE in the longer term (post 2030). The break down in each of the sectors we have considered, are set out in Figure 1. Support jobs are those jobs associated with retraining, re-skilling and supporting those currently out of work (including those under-employed, seasonally employed, with mental or physical health issues or with disabilities) to allow them to take on these new jobs. With the exception of support jobs we have not estimated the 'induced jobs' created in the wider economy by the spending of those employed in the above sectors. The estimates are therefore conservative.

It is encouraging to see reports such as 'Sheffield Green Commitment' which highlight the need for a substantial amount of investment in sectors such as transport infrastructure and state that active and public transport to facilitate every day journeys has to be prioritised. The evidence is now clear that additional

Figure 1: Breakdown of new jobs in full-time equivalents (FTE)
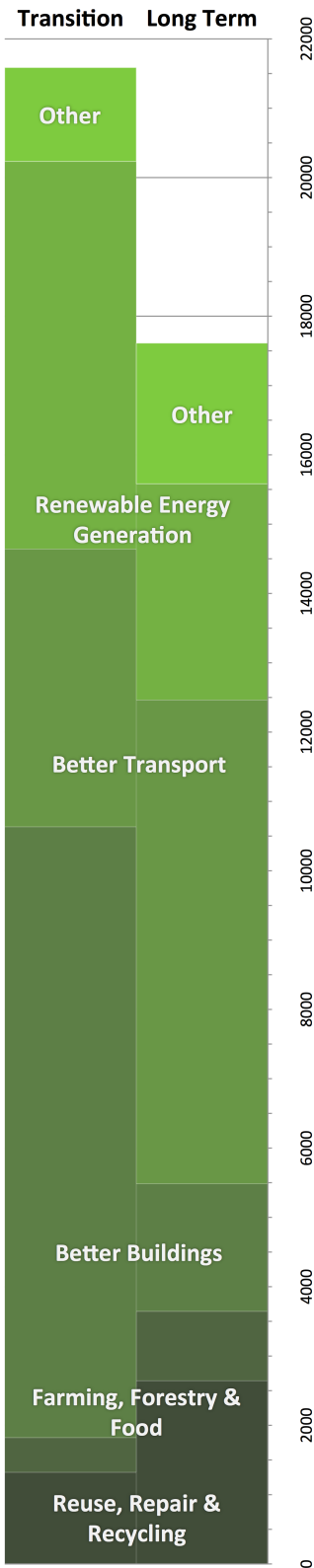
road and high speed rail projects to facilitate ever longer commutes are both incompatible with SCR meeting its climate obligations, and undesirable for it's population's quality of life. The focus must be to allow quality of life to be maximised in the longer term.

The report outlines the changes required in each sector for the proposed transition before analysing how achievable these changes are. By delivering the proposed transformational carbon emissions cuts at the local and sub-regional level over the next decade or so, the proposed transition would leave some remaining carbon budget, enabling more difficult and potentially harder to avoid emissions to be addressed nationally, culturally, and within key sectors.

This report recommends:

- Funding is allocated on the basis of jobs created to address the key climate and environmental challenges present locally (*e.g.* by the Local Enterprise Partnership). That this funding is structured as part of an overall spatial strategy, employment and skills plan and strategic investment strategy that delivers the climate transition locally, as quickly as possible.

- This should be underpinned by a zero carbon energy strategy for the Sheffield City Region / LEP area.

- Local authorities and other key stakeholders identify support, incentives and regulations at the local, SCR, county or national level that will enhance the scale and rate of the transition, and work through the different levels of government to realise and implement them.

- The transition is prioritised at the local and regional level, but in a way which integrates social and environmental issues so that there is a single holistic process that transitions the SCR to become socially and environmentally sustainable.

- Target investment to generate momentum and maximise organic replication within communities, drawing on areas where there is already a high level of buy-in, so these become replicable hubs for green employment, and those with employment needs.

- Investment and support should be available at the community and household/individual level as well as the strategic level. For example, investment in the 'final mile' of affordable public transport access into the most deprived communities, not just regional infrastructure.

- Investment should be locally embedded, so that the transition supports, empowers and amplifies existing local leadership.

The Green European Foundation (GEF) is a European-level political foundation whose mission is to contribute to a lively European sphere of debate and to foster greater involvement by citizens in European politics. GEF strives to mainstream discussions on European policies and politics both within and beyond the Green political family. The foundation acts as a laboratory for new ideas, offers cross-border political education and a platform for cooperation and exchange at the European level.

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The **Green House think tank** was founded in 2011. It aims to lead the development of green thinking in the UK. Green House produces reports and pamphlets on different subjects. We do not have a party line, but aim to stimulate debate and discussion.

Politics, they say, is the art of the possible. But the possible is not fixed. What we believe is possible depends on our knowledge and beliefs about the world. Ideas can change the world, and Green House is about challenging the ideas that have created the world we live in now, and offering positive alternatives.

The problems we face are systemic, and so the changes we need to make are complex and interconnected. Many of the critical analyses and policy prescriptions that will be part of the new paradigm are already out there. Our aim is to communicate them more clearly, and more widely.

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Peter Sims is an Electronic Engineer who specialises in systems engineering. He particularly focuses on the overlap and interfaces between human and non-human systems. For example, the relationship between energy or transport systems and human behaviour in the context of climate change. This work has included a multi disciplinary design project to propose a 2℃ compatible energy system for Europe [3], as well as work on employment consequences of the transition to become sustainable. Peter also campaigned to get the University of Surrey to sell its stocks and shares in the fossil fuel industry. Peter co-authored with Jonathan Essex "A Green Transition for the Isle of Wight - A Sustainable Local Economic Strategy realised through more Green Enterprises and Employment."

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"[There is] no certainty that adaptation to a 4°C world is possible. A 4°C world is likely to be one in which communities, cities and countries would experience severe disruptions, damage and dislocation, with many of these risks spread unequally. It is likely that the poor will suffer most and the global community could become more fractured and unequal than today. The projected 4°C warming simply must not be allowed to occur—the heat must be turned down." - **World Bank** *[4].*

"The only way to avoid the pessimistic scenarios will be radical transformations in the ways the global economy currently functions... This suggests a need for much more ambition and urgency on climate policy, at both the national and international level. Either way, business-as-usual is not an option." - **Pricewaterhouse Coopers** *[5].*

Acknowledgements

Foreword

Our climate is changing in drastic ways and the future will be dramatically different either because we take radical action or because we fail to do so. People feel unsettled by change and so there is a temptation either to ignore or to resist it. We in Sheffield Climate Alliance have been trying to promote the case for engaging at the necessary pace with the challenge of climate change and we have come to recognise that people need to be given a clearer vision of what this might entail.

This report builds on national and regional studies, notably the Mini-Stern Report and the work on Zero Carbon Britain, to quantify the number of extra jobs that could be created in Sheffield City Region as a concomitant of transitioning to zero carbon. While this report does not cover the changes necessary to the heavy industry for which the region is renowned, it does address in some detail other sections of the economy.

The report should prove a useful tool for the Local Enterprise Partnership, employers and local authorities in Sheffield City Region in facing up to the urgent investment decisions that need to be taken. There are good examples in the region of enterprises such as MAGTEC, Sheffield Renewables and Regather which are leading the way.

Green House think tank has done Sheffield and its region a service by demonstrating how, by facing up to climate change and embarking on drastic reduction of climate emissions, new jobs can be created and the quality of life across the board be enhanced.

Jenny Carpenter & Aaron Thierry – Co-Chairs of Sheffield Climate Alliance

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1   Introduction

This report investigates how a focus on reducing greenhouse gas emissions and increasing sustainability and resilience could create good quality local jobs in the Sheffield City Region (SCR), taken to be the area considered in the original SCR devolution deal comprising South Yorkshire, Chesterfield, North East Derbyshire, Bassetlaw and Bolsover. It builds on work carried out on the Isle of Wight in 2016 [6] and uses available information about the number of jobs created by the activities that need to be scaled up if we are to move to a zero-carbon economy (see Appendix A for our sources of information). These activities fall into five key sectors:

- Reuse, repair and recycling

- Farming, forestry and food

- Buildings

- Transport

- Renewable energy

In addition we estimate the number of jobs that would be needed to up-skill, train and support people to do the jobs created in the above sectors and discuss other areas where jobs would be created, such as in management of electricity demand, improving the urban and rural environment and adapting to climate change. The estimates are net numbers of jobs: jobs that would be lost (for example in coal fired power stations) have been subtracted from the number of new jobs created.

The transition to a zero-carbon economy is an urgent task. We do not have time to wait for new technologies to become available but need to employ those that we have now at our disposal. Fortunately, reports such as the Centre for Alternative Technology's, Zero Carbon Britain [7] suggest the main technologies we need are available now, though further technological progress in areas such as energy storage and demand shifting, to manage the electricity grid, will help considerably. These need to be developed alongside the deployment of renewable energy generation and the other measures outlined here.

Section 2 of this report gives the background to this project: the challenge of reducing our greenhouse gas emissions, current emissions in the SCR and the demography of the region. Section 3 summarises the main findings of the study in terms of the net number of jobs created in each sector and compares these estimates with those from other studies. Section 4 discusses each of the sectors in turn and section 5 how these jobs could actually be realised.

By focusing on creating jobs **now**, to enable planned and locally led greenhouse gas emissions reductions between 2018 and 2030, not only can new (decentralised) employment be created across the SCR, but more money be retained to circulate in the SCR's local economies and the foundation provided on which the myriad of other social and environmental issues faced by local communities can be addressed.

Allocating funding, organising events and setting targets doesn't necessarily make anything happen: creating new enterprises, and the associated employment opportunities does. The programme set out here would help to revitalise local economies (and through this, communities) and together with similar activities in local areas elsewhere could build on the existing momentum to kickstart the economic transition. Such a transition is needed nationally and globally to take sufficient action to move away from our high-carbon, fossil fuel dependent economy, towards one which instead values the strength of local communities, environmental sustainability and local economic activity.

2 Context

There are many pressing issues facing communities in the UK today which local councils, charities, local enterprise partnerships (LEPs), campaign groups, media outlets, national government, private companies, social enterprises and more have decided to act on. These include local councils and housing associations retrofitting social housing to reduce energy bills, charities trying to tackle the growing number of people with mental health issues, LEPs trying to encourage companies and start-up enterprises to create more employment, private companies installing solar PV and charging points, as well as housing developers aiming to build more houses in response to pressure on the availability of affordable homes. There are lots of groups of people doing things to address 'their issue', but as the below table highlights, on many of these issues current progress is either slow, or non existent. This report explores what an overarching strategy to address these issues together might look like in the context of the climate challenge.

Table 1: Some challenges facing local communities and current progress in addressing them.

Challenges facing local communities	Current progress to address them
Access to decent housing	House price inflation is still exceeding wage inflation for most of the UK population, making housing less affordable [13, 14]. A large percentage of rented accommodation is of poor quality [15, 16].
High Energy Bills & Fuel Poverty	Some progress being made to improve energy efficiency measures in homes, but government support is limited to those in particular target groups. Many people are either in fuel poverty or spending money they don't need to on energy which is wasted. Almost 10,000 deaths each year are attributable to the avoidable circumstances of living in a cold home [17].
Lack of well paid, secure jobs with career progression prospects	Increasing numbers of people are employed in insecure, short term, flexible jobs in Sheffield [1].While there is increasing demand for high skilled, specialised employees, significant numbers of people under-employed or under-utilised. There is also an increasing number of low skilled jobs with few long-term career progression prospects [18, 19].
Increasing prevalence of mental health issues[1]	Insufficient preventative actions, greater support needed [20].
Ageing population putting a strain on the NHS	Current funding gap for the NHS. Current prioritisation (at least in terms of funding) on treatment as opposed to preventative measures, including public health aspects [21, 22, 23].
Lack of skilled employees to do key jobs	Increasing number of nursing job vacancies in the NHS. Shortage of teachers, including for STEM subjects, and a problem of teacher retention [24].
Pollution	Serious levels of air pollution in many urban areas. Scale of actions being taken is not resolving underlying problem [25, 26].

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[1]Getting by as a citizen in the UK may be less physically hard work (due to labour saving technology, cars, central heating . . .) than was the case in the past, but is significantly more mentally demanding in many cases. Fifty years ago, the vast majority of people didn't have a bank account let along a credit card, mortgage, phone contract, insurance . . . Families often live further apart and neighbours are more isolated, which has affected the reach and depth of local support networks.

Challenges facing local communities	Current progress to address them
Child care and education/training	Class sizes are increasing [8], University fees are increasing [9], Government funding for colleges is not increasing [10]. The education system has been criticised for over testing children, and not providing a sufficiently rounded education [11, 12].
Waste	Still significant issue with plastic pollution, and fly tipping. England does not have a waste plan (unlike Wales and Scotland) and is still constructing energy-from-waste plants which is constraining recycling potential [27, 28].
Degrading soil quality in many areas.	Strategy set out in 2009 [29]. Situation doesn't appear to be improving [30].

2.1   The Climate Challenge

There is currently a climate investment and action gap - between the action needed to meet (let alone exceed) our climate targets and what is currently happening (changes in our physical economy). Globally, the remaining carbon budget for an 80% chance of avoiding a 2℃ rise is about 628 Giga tonnes carbon emissions (including other greenhouse gas emissions). Meanwhile global emissions continue to rise, and currently stand at around 40 billions tonnes each year [31, 32, 3]. This means the objective, both in national plans and locally planned actions, should be to limit the **total cumulative** carbon emissions, as opposed to just getting carbon emissions down to a certain level, by a certain date.

The UK's total domestic greenhouse gas emissions were 497 millions tonnes CO_2e in 2015 [33] with an additional estimated 350 $MtCO_2$e imported through our trade deficit in goods (2010 data) [34]. An estimated 23% of this total is non-CO_2 greenhouse gas emissions, based on 2014 figures. Overall, this amounts to around 13 tonnes CO_2e for each UK resident, each year. Figure 2 shows a breakdown of UK carbon emissions by sector, and how they have changed since 1990.

The UK is committed to reducing this total to 160 MtCO2e/year by 2050. This alone requires a greater than five-fold reduction from current greenhouse gas emission levels to 1.5-2tCO_2e/person, based on the government's predicted 77 million future population and current 2050 greenhouse gas emissions allowance.

However, following the Paris Climate Agreement, the Government's Committee on Climate Change considered what would be the effect of meeting the commitment to pursue efforts to limit global warming to 1.5℃. They concluded that what is required is a reduction to net zero emissions of CO_2 (and other long-lived greenhouse gases) in the 2030s, or a decade later if technologies to remove CO_2 at scale from the atmosphere are realised [35]. A precautionary approach is therefore for a target of zero net emissions of CO_2 and other long-lived greenhouse gases by 2030, as set out in this report. For SCR to make its contribution, this will need to occur both for emissions emitted within SCR (the focus of this report) and emissions in the wider UK and global economy as a consequence of consumption patterns and wider economic decisions made within SCR (*e.g.* carbon embedded in imports).

There is also a compelling argument that the UK and Western Europe should increase their leadership in this area, as the UK was one of the first nations to industrialise, and therefore has amongst the highest per capita historic emissions (dating back to the start of the industrial revolution) of any country. Therefore, we should aim to decarbonise sooner. Currently many countries with lower per capita historic emissions

Figure 2: Infographic of UK Carbon Emissions in 2014 [36]
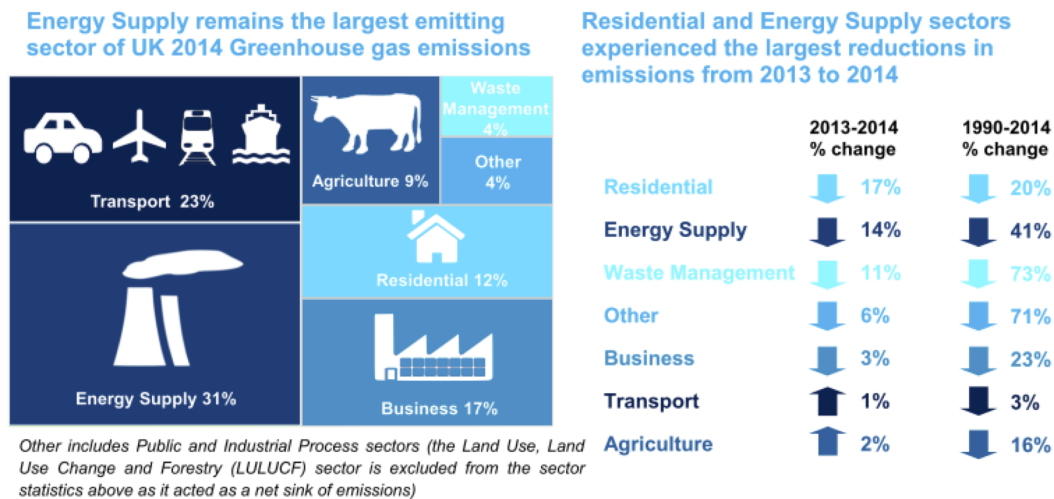
are making significantly more progress in decarbonising than the UK, which also gives them an advantage in the development, deployment and export of low and zero-carbon technologies.

Box 1. Gulf between Global Targets and National Pledges

The global emission reduction pledges made at the time of the Paris Climate Agreement in 2015 do not add up to limiting global temperature rise to 2 degrees. The UK does not currently have a realistic plan to meet its own emission reduction pledges as set out in the Climate Change Act 2008 and some of its policies, such as plans to expand runway capacity at Heathrow, and therefore potentially its wider industrial strategy to which this is linked, are not accounted for in our Carbon (reduction) Plan. The majority of UK citizens do not fully understand the gulf between what is currently happening and what would need to happen for us to meet these targets. Neither do most citizens have any understanding of the scale or speed of the transition, and resulting changes in our economy and lifestyles that are required.

2.2 Sheffield City Region's Current Emissions

Figure 3 shows how the direct CO_2 emissions (around 1/3 of the total noted above) are broken down by sector for the Sheffield City Region. This figure does not include non-CO2 greenhouse gas emissions, which make up around 20% of UK emissions. It also shows that about a third of the emissions are from transport, a third the domestic sector and almost all the remaining from industrial and commercial activity. Agriculture represents only a small part of the CO_2 emissions, but is still significant as it is a major contributor to non CO_2 greenhouse gas emissions (including methane). However, these are not quantified for SCR as this data is not available at the local or regional level. Imported food, consumer goods and building materials are all likely to be significant contributors to the indirect emissions of the region.

Figure 3: Carbon dioxide emissions within Sheffield City Region broken down by sector (2014 - ktCO$_2$) [37]
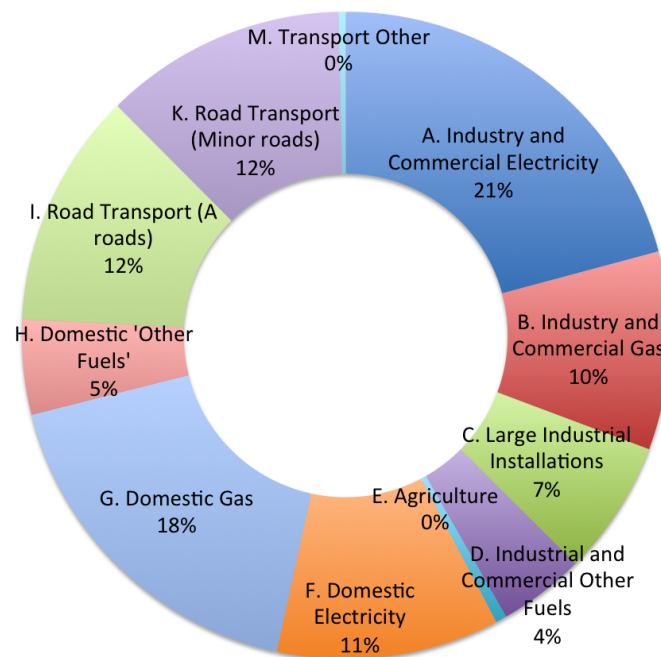
Note: The data show emissions allocated on an "end-user" basis where emissions are distributed according to the point of energy consumption (or point of emission if not energy related). Except for the electricity generation, emissions from the production of goods are assigned to where the production takes place. Therefore, emissions from the production of goods which are exported will be included, and emissions from the production of goods which are imported are excluded.

Box 2. The Shift to More Indirect (Imports) Emissions in our Carbon Footprints

Over the last 20 years the UK has been largely assisted in reducing its emissions through in effect relocating significant emissions (and jobs) overseas. As a result the UK is increasingly reliant on imports for many of our goods, which means that the impacts of our consumption, both in terms of resource use and carbon emissions, occur outside of our borders. In 2010 this was around 24% of the UK carbon footprint (contrast data from national statistics 590.4 MtCO$_2$e [36] and the Government's Committee on Climate Change 775 MtCO$_2$e [38].) The UK's manufacturing sector, and heavy industry in particular, has shrunk massively over this period such that we now import the majority of the goods we buy in the shops as well as significant quantities of commercial products, vehicles and building materials. The emissions linked to this consumption are still produced, but count in other countries' carbon emissions. Also not included are the additional emissions from transporting goods around the world [39].

2.3   Geographic and Demographic context

For the purpose of this report we have considered the SCR area as comprising South Yorkshire, Chesterfield, North East Derbyshire, Bassetlaw and Bolsover. This is the area that was considered in the original SCR devolution deal. The SCR Local Enterprise Partnership also includes the Derbyshire Dales. Therefore the jobs potential considered here is likely to be an under-estimate for the overall Sheffield City Region LEP area.

Figure 4: Map of Sheffield City Region [40]
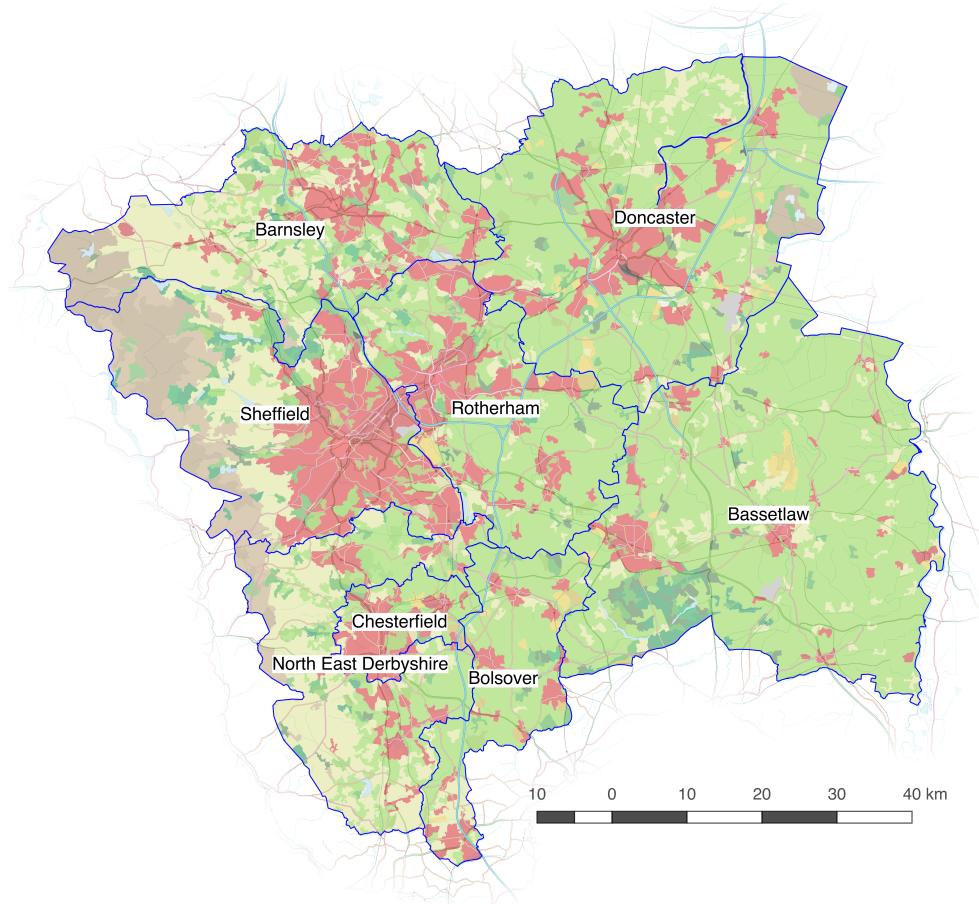
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Table 2 shows the current and predicted population of the SCR, including the number of households, and statistics on the likely demand for additional employment.

Table 2: Statistics on the people of Sheffield City Region

SCR population 2016	**1,782,761**	Table:SAPE19DT12 [41]
Predicted population 2030	**1,853,000**	Table:426 2014-based [42]
Job seekers allowance claimants - June 2017	**17,720**	NOMIS [43]
Looking for work 2016-7	**49,700**	NOMIS [43]
Economically inactive but wants a job 2016-7	**73,200**	NOMIS [43]
Total number of households 2016	**755,000**	Table:406 [42]
Predicted number of households 2030	**828,000**	Table:406 [42]
Number of workless households 2016	**111,500**	NOMIS [43]
Number of children in workless households 2016	**55,000**	NOMIS [43]

3   Jobs Summary

A summary of the estimated number of jobs that could be created in each sector through a move to a zero-carbon economy is given in Table 3. These are net jobs: the number of jobs that would be lost has been subtracted from the number created, where they could be identified and quantified. The estimates are based on the metrics set out in- Annex - Base Job Metrics along with available data on land, population, energy and consumption levels for the SCR. The table shows jobs associated with the transition to address climate change and other environmental challenges (assumed to take place as a linear process from 2018 to 2030) and those post transition (longer-term).

Table 3: Summary of transition and long-term jobs estimates by sector for the Sheffield City Region in full-time equivalents (FTE).

Total additional jobs by sector	Transition (2024)	Long-Term (2030)
Reuse, Repair & Recycling	1,323	2,645
Farming, Forestry & Food	500	999
Better Buildings	8,810	1,839
Better Transport	4,009	6,982
Renewable Energy Generation	5,590	3,117
Other Jobs	1,355	2,028
Total	**21,586**	**17,611**

None of the metrics used include multipliers for 'induced jobs' in the wider economy, or supply chain jobs outside of the SCR area. The exception to this is Support Jobs, which have been scaled from the core job creation estimates across the different sectors to reflect the additional employment associated with retraining, re-skilling and supporting those currently out of work (including those under-employed, seasonally employed or with mental health needs) to allow them to take on these new jobs. In addition, for some activities there is as yet no reliable labour intensity or scaling data, so no estimates have been made The estimated employment potential is therefore conservative . The estimates here can be compared with those of the One Million Climate Jobs report [44] and the Mini-Stern Review for Sheffield City Region produced by the Centre for Low Carbon Futures [45]. Assuming the population of the UK is around 65 million, then the One Million Climate Jobs report implies an additional 15.4 jobs per 1000 people across the UK. If these jobs were equally distributed between regions based on population (which is unlikely), this would imply around 27,000 additional jobs in Sheffield City Region. The Centre for Low Carbon Futures report estimates that 6,189 job years could be created over a ten year period. This corresponds to an average of 620 additional jobs p.a. over the transition period. The difference between these estimates and those of this report is probably due to three factors:

- A significant number of the One Million Climate Jobs report's proposed new jobs are related to increasing offshore wind generation. Most of these will be in coastal areas, although some of the supply chain jobs could be in the SCR (but are not estimated in this report). Excluding these jobs the estimate for the SCR is comparable with this report's estimate. However, this report's jobs estimates are probably more conservative than those of the One Million Climate Jobs as this report makes fewer generalisations, and jobs lost have been subtracted where identified.

- The mini-Stern review's measure only aims to achieve a 15% CO_2 reduction relative to 1990 levels. This lesser ambition is reflected in its employment estimates.

- The jobs estimates in this report (with the exception of support jobs) only include additional direct employment whereas both of the other reports include supply chain multipliers.

The next section details the breakdown of the jobs in each sector in turn, and provides an illustration of the type of enterprises and work areas that these jobs could represent.

4   A Climate Jobs Transition for the Sheffield City Region

This section highlights what the transition of the Sheffield City Region's economy might look like, and provides further information on the details and metrics used to estimate employment potential in each sector. This report does not specify how these changes should be brought about, either in terms of the initial investment or ownership structures of the enterprises which are created or expanded to take on this work. However, it is anticipated that the jobs created across the different sector areas will vary in the scale of enterprises, nature of up-front investment, and whether they are most likely to grow out of the public sector, private sector, or through social enterprises, charities or community based organisations.

The proposals made here are bold, and implementing them completely by 2030 will be a real challenge, not least because of the rate of change required to shift from planning to implementation. The level of ambition set out here is that demanded by the climate science and reflects the ambition of the 2015 Paris Agreement [46]. Deciding how quickly to act on climate change is also, in part, a question of risk management. While it is impossible at this stage to prove that not acting in this time frame with this level of ambition will make the 2°C target unattainable, this would be a prudent and conservative approach to take (and even so, could still fall short of what is needed to avert some dangerous climate change). Thus, this approach is proactive: the only way of being confident that we will avoid the worst case scenarios is to take such actions as quickly as possible. The targets therefore are not cautious, but provide opportunities to creatively devise and engineer a better future, from the bottom up. To start now requires us to base these proposals solely on currently commercially available technology, although other actions could be embedded into a flexible and adaptive process of change, as new technologies and other opportunities arise.

4.1   Reuse, Repair & Recycling

The transition proposed for what is traditionally referred to as 'the waste management sector' is away from a linear economy where raw materials are extracted, processed, made into products and then discarded (often after a very short time and before products have reached the end of their usable life) to a circular process. This means reducing the amount of material throughput by:

- not making things we don't need

- extending the life of products by reusing and repairing them until they finally reach the end of their usable life,

- and only then recycling the material contained in products.

Generally reducing, reusing and repairing are the least energy intensive (but often more labour intensive) options and making new products is the most energy intensive. Firstly, the extraction, transportation and processing of new materials can require a high energy input which is provided by fossil fuels and therefore produces high carbon emissions. Secondly, use of new materials may be unsustainable if our use exceeds the sustainable replacement rate (*e.g.* timber) or the amount that exists (*e.g.* rare earth metals). Thirdly, manufacturing products involves significant carbon emissions, often much more than will be emitted during the average lifetime of a product [39].

Currently over 1000 hectares across SCR are used as landfill sites [47]. In 2015, 464 thousand tonnes of waste (60% of the total) was landfilled or incinerated [48].

4.1.1   Visualising the Transition

Communities elsewhere in Europe have managed to significantly cut the amount of municipal waste going to landfill, so that now, in Austria, Belgium, Denmark, Germany, the Netherlands, Norway, Sweden and Switzerland, virtually no waste is landfilled [49]. This could be achieved in the SCR by increasing reuse and recycling and through reducing the total amount of material wasted in the first place. The paper and cardboard category is likely to change little (but could be processed more locally). Food waste could be used in small scale agriculture as well as used to produce compost and energy in anaerobic digestion plants.[2] More of the items currently dropped off to community recycling centres could be reused in their current form, repurposed back into use or recycled. Scaling up reuse and recycling could be in part through community enterprises (such as the Storeroom 2010 furniture reuse charity). New initiatives could increase 'recycling on the go' such as through setting up an exchange for a deposit refund as proposed by the Campaign for the Protection of Rural England [51]).

In the future a lot of what is currently 'recycling' should be reused or even eliminated entirely from the waste stream. Recycling should be viewed as the last option (after waste reduction and reuse), not the main target for improvement in 'waste management'. Many items that are currently collected from residents' doorsteps could be minimised as we shift away from single-use packaging towards reusable boxes (*e.g.* for cereal) or bottles (*e.g.* for milk).

New enterprises could extend the life of the wide range of household appliances (*e.g.* cookers, fridge, phones, laptops, televisions *etc.*) as well as furniture and many other things we use. This would reduce waste and create jobs locally, while saving the resources, carbon emissions and the workmanship embodied in making these products in the first place. In the past we used to invest time and money to repair, repurpose and maintain items from clocks and socks to tables and telephones. Whilst most people might not want to return to darning their socks, a transition to once again getting things repaired and modified, passing more of our unwanted items on to people who can utilise them is anticipated[3]. There could be an associated shift from buying to renting appliances, putting the onus on manufacturers to design in repairability and build products that last much longer.

The building industry notion of what constitutes good waste management could also shift to revive the concepts of salvage and reclamation, rather than low value material recovery (which generally means crushing and chipping waste), to achieve much higher value recycling and reuse (thus supporting more jobs

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[2]This requires separation of meat contaminated food waste from vegetable matter only food waste, which would require changes in the law to be done on a farm scale (see The Pig Idea)[50].
[3]Sheffield already has a repair cafe and active freecycle group.

and less energy consumption). This means existing buildings being refurbished or carefully deconstructed rather than being demolished. Construction should focus on sustainability and reuse in a wider sense as it focuses on improving the energy performance of existing buildings and repurposing empty buildings, rather than on demolition and new-build.

This shift would benefit from wider incentives, such as to shift VAT relief from new-build housing to refurbishment to make better use of existing buildings. Design and construction practices could also better utilise low carbon, local building materials and be designed for flexible repurposing and deconstruction at the end of their life.

The existing RDF (refuse-derived fuel) energy from waste plants[4] should be converted to run off different sustainable fuel sources rather than constraining the above transformation towards a circular economy. Possible alternative fuels are bio methane derived from sewage, or synthetic methane. The existing district heat networks which is currently fed from combined heat and power plants [52, 53] could instead source heat from industrial scale ground source heat pumps (see4.3) [54]. No new incinerators (often called energy from waste plants) should be required.

4.1.2   New Employment Potential

The jobs modelling for this sector is based on reuse and high quality recycling for the majority of the waste produced in the SCR, instead of co-mingling waste collections, maximising low quality material recovery, incineration or other burning and landfill. This overall estimate is an average figure, because reuse and repair jobs vary significantly in their labour intensity, including between different processes, products and materials. There is also a lack of data about the make up of commercial, industrial and construction waste streams in SCR (and across the UK) which further adds to the difficulty in modelling the likely labour intensity of these activities. Despite the difficulties in quantification, reuse and repair activities should be encouraged, as any transition from recycling to reuse and repair will generally be more labour intensive, save resources and carbon emissions, and provide more local employment options than recycling. Reuse and repair create more skilled and interesting jobs than recycling activities, and thus make an increased social contribution.

4.2   Farming, Forestry & Food

Currently just over 50% of UK food is imported [55]. SCR has quite a high average population density at 6.6 people per hectare, particularly relative to agricultural land (~10 people per ha), meaning only a fraction of food consumed in the SCR area is currently produced locally. Although there are notable exceptions[5] there is no evidence that farming in SCR today isn't predominately highly specialised, large scale and reliant on fossil fuel energy including for its fertiliser inputs like the rest of the UK [60]. UK farming generally competes in a national/EU/global market place rather than first supplying to local communities. Below are some challenges this presents if SCR's rural economy is to make its contribution to addressing the climate challenge whilst also improving lives of the local communities and those employed in the sector.

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[4]Sheffield, Templeborough & Blackburn Meadows
[5]Sheffield Organic Growers, Whirlow Hall Farm Trust, Heeley City Farm, Loxley Valley Community Farm [56, 57, 58, 59].

Table 4: Reuse, Repair and Recycling Jobs Breakdown in full-time equivalents (FTE)

	Transition	Long-Term	
Municipal solid waste (MSW)	573	1147	Assuming recycling rate increases from 38% to 90% [48]
Commercial and industrial waste (C&I)	506	1011	Assuming increase in recycling rate is the same as for MSW
Construction and demolition waste (D&C)	503	1005	Assuming increase in recycling rate is the same as for MSW
Waste disposal (landfill and incineration jobs)	-259	-518	Based on total waste diverted.
Net:	**1323**	**2645**	

- The current food system has very long supply chains which are reliant on fossil fuels for transportation [61].

- Much of the current food system is heavily reliant on fossil fuel derived fertilisers, herbicides and pesticides [62, 63].

- Top soil is being lost and degraded at a dangerous rate, both in the UK and across the world, which means agriculture is becoming more heavily reliant on the above fossil fuel inputs [64, 60]

- The biodiversity of the rural landscape is also important for both agriculture and the quality of our countryside; for nature and our quality of life. In SCR there has been a decline in biodiversity which could affect the important ecosystem services provided by the natural environment [65].

- Agriculture, forestry and land use changes are responsible for the majority of non-CO_2 greenhouse gas emissions, with animal agriculture being the most significant contributor [66].

- Current farming practices do not produce enough food within the land available in SCR to feed the local population [67].

- Across the UK, we consume far more food than we actually eat as a significant proportion is wasted from farm to plate - in distribution and retail, as well as in homes, canteens and restaurants [61].

- Assuming the average diet in SCR is comparable to the rest of the UK, there is an opportunity for more healthy diets to improve our nutritional balance [61].

- There is growing concern that the younger generation are becoming more and more disconnected from sources of the food they consume and lack the skills or experience needed to produce or gather their own food and combine it into healthy meals [68, 69].

- In the UK the age of those working in farming is still increasing and there is concern that not enough younger people are gaining the skills and experience needed to support even the current labour intensities in the rural economy [60].[6]

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[6]Land ownership in SCR is likely to follow national trend of becoming concentrated in the older generation, and agricultural land in particular into large blocks making it hard for a new generation of farmers to gain access to land.

- There are significant issues across the UK in relation to pollution from farming activities [70, 60, 63].

To address these issues requires a change in attitudes with respect to land and food. This report proposes that SCR should try and maximise the proportion of food produced that is consumed locally, whilst also taking steps to minimise food waste. This should be done in a way that maintains and enhances biodiversity, soil quality and landscape resilience, to ensure that essential ecosystem services are sustained.[7]

This report proposes a shift to smaller scale mixed farms based on organic and permaculture practices [72]. This would mean reduced pastoral agriculture (nationally), and a much closer integration of livestock farming with arable farming and horticulture. A large increase in horticulture is also proposed, particularly in urban and suburban areas, both domestically, at the community level and commercially.[8] There is lots of land within many cities which could be used very productively, as has been highlighted by the Incredible Edible initiative in Todmorden and further afield [74, 75]. It would also be important to strengthen local supply chains to enable more locally produced food to be distributed locally, which would also create diverse and interesting jobs.

As the demand grows for building materials and fuels that have lower levels of embodied carbon, wood and other biomass such as straw will become more important as resources. Wood is a good building material, and as it stores carbon for the life of the building its use in buildings can sequestercarbon, whilst in rural areas it can be utilised as a carbon neutral heat source. This should increase the potential for local use of timber and other biomass materials, which could be supplied through more active management of existing woodlands as well as new planting. If done carefully, this could also improve biodiversity [76].

4.2.1 Land Use & Diet Modelling

Table 5 on page 13 shows the land use and diet proposals. Under these proposals the SCR could produce about 50% of its food within its land area. Currently SCR has very little pasture (1/3 of arable land) when compared to the UK average (approximately the same pasture as arable land). This has meant that our modelling suggests that with the transition to more mixed farming there would be some conversion of arable land to permanent pasture (see Figure 5 on page 15).

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[7]Ecosystem services are services which natures provides free of charge to humans exploiting the earth for resources through activities like farming and forestry [71]. Improving soil quality can also sequester carbon into soils, which reduces the risk of runaway climate change [66].

[8]Sheffield already has over 3000 allotments across 70 sites and an active Allotment Federation [73].

Table 5: Modelling of land use for food production.

	Consumption	Calories in diet	Production	Yield	Grain	Arable land	Perm: pasture	Notes
	g/p/day	kcal/p/day	tons/year	tons/ha	(tons/ton)	ha	ha	(p->person)
Cereals for people	448	1,526	291,517	4.3		67,795		
Potatoes	453	300	294,771	25		11,791		
Sugar	32	100	20,823	7.5		2,776		
Vegetables & fruit	500	150	325,354			2,942	1,471	
Hemp & flax	13.7		8,914	3		2,971		5 kg/year
Horse or biofuel						13,639		(energy crops)
Green Manure						17,516		As part of crop rotation
Milk	568	330	369,602	3.7 (3.26 net)		83,530	52,188	(incl butter, cheese)
Beef	33	86	21,473	0.4			53,683	(grass reared)
Cereals for pigs	36	180	23,425		4.52	8,210		(bacon)
Cereals for hens	30	50	19,521		2.51	11,403		(egg/chicken)

						Non Farm Land:		
Sheep	9	24	5,856	0.084		69,719		[rough grazing]
Wild meat	5	10	3,254	0.031		93,402		[forest, moors, rough grazing]
Leather & sheepskin	4.0		2,603					1.46 kg/year
Wool	2055		1,337,071					750 kg/ year
Fish	11	11	7,158					

Total Calories:	2767		**Farm Land Needed:**			222,572	107,342	
			Farm Land available:			136,069	39,440	

Note: This is based on calculations done by Simon Fairlie [67], using his 'permaculture' scenario: an integrated approach to food production done on a farm scale. It assumed, for instance that pigs are used to convert organic matter not fit for human consumption into food by feeding them mostly on crop residues and food waste. Cattle are grazed on land in rotation with arable crops to help restore vital nutrients such as nitrogen to the soil. The hunting of common wild animals, such as deer and rabbits, for meat, enables us to obtain nutrients and calories from land which is not suitable for agriculture and prevents those animals (in the absence of large predators such as wolves) from becoming so numerous that they reduce the biodiversity of the land they graze. The approach also relies on a shift in the crops grown and the varieties used.

Box 3. Exploring Different Diet Options

Different diets have different land use requirements as well as different associated greenhouse gas emissions, energy inputs and import requirements [61]. SCR's current diet requires around a third of an hectare per person.[a] This report proposes this could be reduced by around 50% to 0.22 ha per person as it has considered diet, not just from land use, agriculture emissions or nutrition perspectives, but also in terms of how food and land use align with the demand for other resources in a potentially very different energy landscape. The change shown here is mostly a result of modelling a reduced level of meat and dairy consumption - although these still form a significant part of a typical diet and the associated land use.

There have rightly been concerns raised recently about the negative consequences that animal agriculture has, both in terms of nutrition, land and energy use, as well as in terms of greenhouse gas emissions [66]. Some argue that vegetarian or vegan diets are the way forward, which, like this report's proposals (although arguably to a greater extent) present a behavioural change challenge. Vegetarian or vegan diets also present other issues in the UK. Although they have much smaller per person land requirements (0.12 ha and 0.11 ha) respectively, in order to maintain good nutritional balance they currently require a much greater percentage of this land being overseas (more that 50% in the case of a typical vegan diet) [61]. Given that globally many people are now suffering from lack of calorific or nutritional intake, and we have an increasing population (not to mention the embodied carbon emissions in food imports), reducing the amount of land and water that other countries use to produce food for the UK arguably should also be an important aspect to consider in UK policy.

Vegan diets could make areas of the UK countryside that are not suited to arable agriculture redundant (which could allow more re-wilding), and also require ploughing up lots of existing pasture for arable production. Over the last 50 years, animal agriculture practices have changed significantly. Changing how animal agriculture typically takes place could also significantly reduce its impact[b][c]. Without a balance of animal and arable farming other fertiliser sources such as sewage may be required (or continued reliance on artificial fertilisers). Animal Agriculture, if done in an permaculture way with high animal welfare standards, could also be a significant increased source of rural employment, which if removed, would need compensating for.

In modelling the jobs created in agriculture, this report has chosen to prioritise removing dependency on food imports (nationally) and reducing the need for external chemical, and therefore energy inputs, as the long-term viability of both of these in a carbon constrained world is questionable [77, 63]. Although some of the job increases (see 6 on page 16) are due to changes in land use, the majority are due to how existing farmed land is managed, so may still be applicable as diets evolve in future.[d]

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[a]Assuming the SCR average is the same as UK average [61].

[b]**Example 1:** Milk yields of dairy cows have increased as they are fed on grain/supplements as well as just grass. This means dairy cows, which used to add nitrogen into arable land by rotating crops with grazing, now overall result in nitrogen being taken out of the land which needs to be replaced in other ways (e.g. artificial fertilisers).

[c]**Example 2:** Increased beef production has increased the land intensity per beef cow because there are now dedicated suckler herds, as opposed to beef animals being solely the surplus from dairy herds.

[d]Annex A can be used to model employment from different diet and land use proposals.

4.2.2 Visualising the Transition

In the future the connections both between the urban and rural economy, and within the rural economy itself, should be stronger. More children would grow up having seen where food comes from. This could

Figure 5: Change in SCR land use proposed by transition
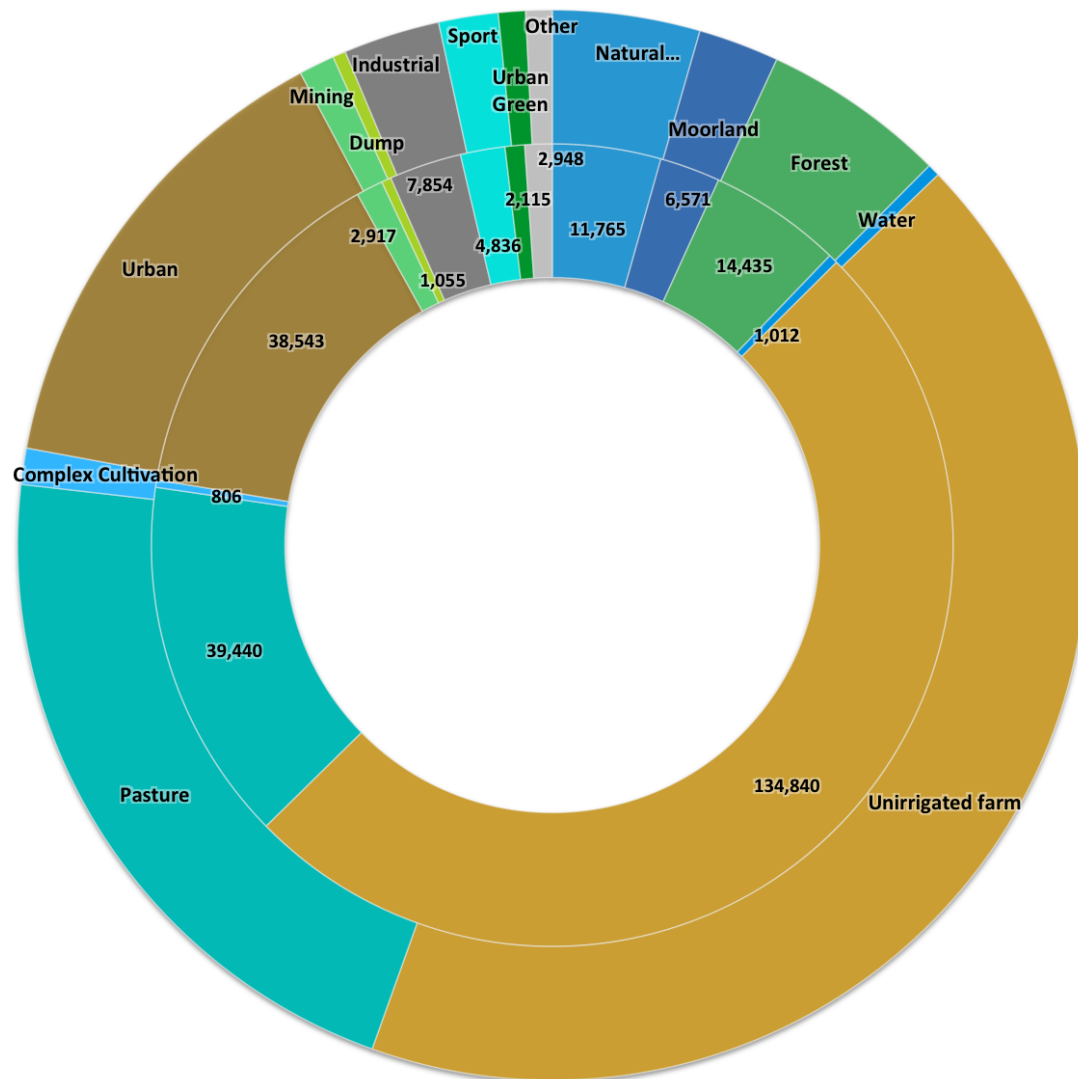
Inside: Corine 2012 land use (hectares) [47]   **Outside:** 2030 Proposed

be through an increase in urban gardening, through engagement in community agriculture projects, but also because more communities support local employment in managing woodland and producing food (and probably energy too), and because more households choose to have allotments and grow vegetables. More people are likely to be employed seasonally in agriculture, supplementing their income from other livelihoods at other times of the year.

Such an increased connection to the local environment could result in healthier eating, with more local seasonal fruit and vegetable consumption, and potentially a reduced level of meat consumption [78, 79]. Local cold storage could increase, powered by intermittent wind and/or solar power. There might also be changes in farming and land management practices. For example, meat could come more from surplus dairy herd animals, and as more fields rely on organic fertiliser there would be increased crop rotation, co-cropping and probably an increase in the range and varieties of crops grown in the region.

More diversification as well as local consumption should lead to increased profitability (and viability) of the

rural economy as well as more money circulating in local economies. These changes would be encouraged through better incentives and regulations at the national level. With more of SCR's production being consumed locally, and increased productivity in general, the scale of imports would reduce, cutting food miles and associated transport greenhouse gas emissions.[9]

Some of this additional work may be done through involvement across communities as well as additional people being paid on a full-time basis. In addition (although not modelled in the employment estimates) there would probably also be an increase in the amount of food grown in gardens, allotments and on currently unused urban land.

Agricultural vehicles and machines will probably remain internal combustion engine-driven, at least in the short term, but in the longer term should shift to using bio fuels grown onsite and hydrogen as a fuel source.

4.2.3 New Employment Potential

The jobs modelling for Farming, Forestry and Food is based on labour intensity data for a range of activities set out in the table below under organic management practices. Data was not available for permaculture practice at an appropriate scale but it is believed that this would also be more rather than less labour intensive on average. These labour intensities were then scaled to land use areas proposed in 4.2.1.

Table 6: Farming, Forestry & Food Jobs Breakdown in full-time equivalents (FTE)

	Transition	Long-Term	
Farming - Cereal Crops	548	1096	Assuming 83,296 ha
Farming - Potatoes	239	479	Assuming 5,746 ha
Farming - Sugar	16	33	Assuming 1,353 ha
Horticulture (Fruit & Veg)	170	339	Assuming 4,413 ha
Farming - Dairy Cattle	558	1115	Assuming 37,915 head of cattle
Farming - Beef Cattle	184	368	Assuming 40,443 head of cattle
Farming - Pigs	327	654	Assuming 277,457 head of pigs
Farming - Sheep	20	41	Assuming 14,928 head of sheep
Farming Chickens	148	296	Assuming 1,032,011 head of chickens
Existing Farm Jobs	-1730	-3460	Assuming part time is 0.5 FTE and Casual is 0.25 FTE [80]
Woodland Management	19	38	Assuming additional 14,435 ha managed
Net:	**500**	**999**	

4.3 Better Buildings

We have two main proposals in this sector. Firstly, we need to improve the energy efficiency of existing buildings. To achieve this we set out a massive retrofit programme, to bring both domestic and commercial/industrial buildings as close as possible to best practice energy efficiency standards, whilst

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[9]This could be supported by a 'buy local' campaign and/or a 'Made in Sheffield' brand to encourage more agricultural produce to be sold locally.

adding renewable energy generation to buildings. Secondly, we propose that all new buildings are built to zero-carbon standards, of high energy efficiency and with renewable energy designed in from the outset. Building construction should use materials and construction methods which maximise reusability and are designed for deconstruction, whilst minimising carbon emissions from the materials and from the construction phase.

4.3.1 Visualising the Transition

Street-by-street retrofit programmes[10] would be a main feature of the transition. These programmes would improve the thermal insulation and airtightness of properties, as well as adding cost-effective renewable energy generation technologies such as heat pumps, solar photovoltaic panels and solar thermal water heating systems (see Box 4. Street-wide Energy Efficient Retrofit of Homes).

Box 4. Street-wide Energy Efficient Retrofit of Homes

The first stage for any street is a street survey of each house to assess the energy efficiency options and whether renewable energy options are appropriate. Residents and building owners would be contacted to choose measures, and confirm the time frame for installation. Different arrangements may be made for owner-occupied and privately rented homes. Socially rented properties may be delivered separately. Many more of these properties have already been improved to some degree, and currently the least energy-efficient properties are often in the private-rented sector. The New Green Deal was the coalition government's policy which provided loan funding for home energy efficiency improvements [81]. However, the high rates of interest charged meant that there was very little take up and it was discontinued by the Conservative government in 2015. There has since been no new major programme to improve energy efficiency of the housing stock. However, there is a great deal of experience of street-by-street home insulation programmes in the UK, such as the Kirklees Warm Zone which could be drawn on, with schemes providing whole-house retrofits, not just insulation measures [82].

This program will reduce remove the SCR dependancies on fossil fuel for heating as well as minimising the electrical energy required to keep SCR's population adequately warm. However these measure will not be effective in facilitating SCR reducing it's dependance on fossil fuels and energy imports unless they primarily lead to less energy use rather than warmer homes as the previous trend as been[11]. Although there will be some increase in individual home temperature, particularly for those currently in fuel poverty, demand management measure will be needed to ensure that total energy used for heating falls over the transition [12].

A similar retrofit programme should be undertaken for offices and commercial buildings, retail premises, schools, hospitals, community buildings, public houses, hotels and restaurants and for other non-residential buildings. Higher building standards would mean all new buildings are built to meet a net zero carbon standard.[13]

In addition to retrofitting buildings, there is an opportunity to reduce the energy used to maintain buildings and infrastructure. This starts by investing in early interventions to keep these in better repair. For

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[10]This was trialled over the last decade prior to the attempt to incentivise this on a house-by-house basis by big companies and commercial interest rates, through the 2010-2015 government's Green Deal programme.

[11]Over the past 40 years in the UK increasing building performance and central heating has led to the average temperature in each UK home increasing by 7°C[83].

[12]e.g. ensuring gas prices rise rather than fall as gas consumption reduces

[13]This was previously proposed for all new build housing by 2016.

Table 7: Better Buildings Jobs Breakdown in full-time equivalents (FTE)

	Transition	Long-Term	
Improving energy efficiency of dwellings	3977	-	Assuming 75% of dwellings require retrofit [84]
Solar Thermal - Domestic Installation	1682	-	Assuming 75% of dwellings require retrofit [84]
Solar PV - Domestic Installation	476	-	Assuming 25% of dwellings require retrofit [84]
Ground Source Heat pumps - Domestic Installation	1756	-	Middle scenario suggests heat pumps and heat networks from low-carbon sources provide heat for around 13% of homes [85]
Retrofitting Commercial buildings	Data not available		
Retrofitting Public Buildings	Data not available		
Improved Housing Maintenance	920	1839	Assuming 75% of dwellings will require some additional maintenance to maintain energy Efficiency standards [84]
Net:	8810	1839	

example, fixing a pothole early could prevent the condition of the road deteriorating so much that far more carbon (and cost) intensive road reconstruction or resurfacing is required. Better stewardship of the built environment, as well as of the natural environment (noted under Food and Farming above), would increase employment as well as saving on future capital expenditure.

4.3.2 New Employment Potential

The number of new jobs in this sector are based on the labour intensities of the above activities, which have been estimated using data from existing projects and case studies (see Annex A).

4.4 Better Transport

While emissions of other sectors have fallen substantially since 1990 UK transport emissions have hardly changed since 1990 (see Figure 2 on page 4 in Section 2).

To meet the scale of reduction of greenhouse gas emissions required globally (as well as that legislated already by the UK Government) we propose a shift from private to public and active transport and changing the overall focus of transport investment from increasing mobility, to enhancing accessibility. This means shifting the focus of transport provision from maximising how far each person can travel easily, to maximising their access, particularly within neighbourhoods and local communities, of key services and destinations (such as the location of friends, relatives and workplaces). Such a change in how transport is viewed and how its quality is measured would delink improvements from increasing energy demand, while improving quality of life.

This report's transport proposal are based on the passenger modal shift outlined in Figure 7 on the

Figure 6: Sheffield City Region Proposed Transport Modal Shift
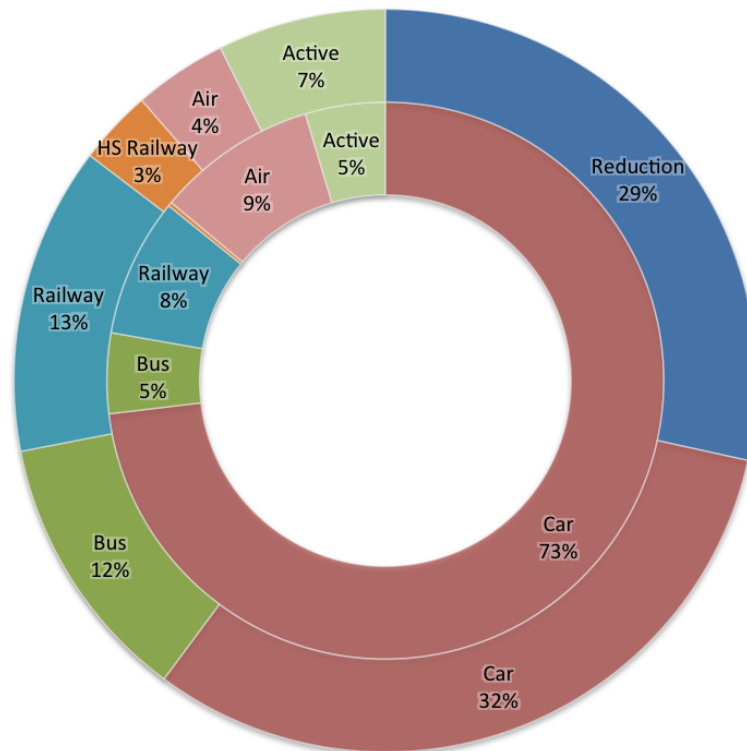
Inside: Modelled based on 2015 Nation Transport Survey [7, 86, 87]
Outside: Proposed 2030 based on Modelling [7, 3, 88, 89]

following page which in turn is based on the modal shift used in the Zero Carbon Britain 2 report as illustrated in Figure 7 on the next page [7].

4.4.1   Visualising the Transition

One noticeable change would be the expansion of public transport provision, both between and within communities across the SCR – both increased service frequency on existing routes, and new routes.[14] Digital maps data could be used to optimise and extend these routes. Every community should have a regular service to key amenities (shops, work places, hospital, bank, pub/bar), including at off-peak times. The powers in the Devolution Deal for SCR to introduce franchised bus networks need to be made full use of to reverse recent declines in bus services [90]. Access to these public transport connections, and sustainable travel within neighbourhoods would be encouraged through safer and dedicated cycle routes (for bicycles and e-bikes). Some routes (including in rural areas) may use a "bus-taxi" or similar alternative, to avoid low occupancy of large vehicles.[15] An increase in car share or similar schemes would also add flexibility. Taxis (including shared taxis) may also play an increased role, especially outside peak times. Some rural communities would still rely on private vehicles, but possibly in a more communal way, that increases vehicle utilisation.

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[14]Public transport is a much more attractive option if it is integrated (e.g. train to bus) and is both reliable (punctual) and runs frequently, at regular intervals, throughout the day and into the evening.

[15]Bus-taxis are common in many other countries. These could be mini-buses that pick up people anywhere along their route, and often vary their routes (slightly) depending on where the people on the bus-taxi already wish to go. More direct and stopping services may operate on the same route (much like a rail replacement bus service in the UK).

Figure 7: Modelled Transport Model Shift, Source: Zero Carbon Britain 2 [7]
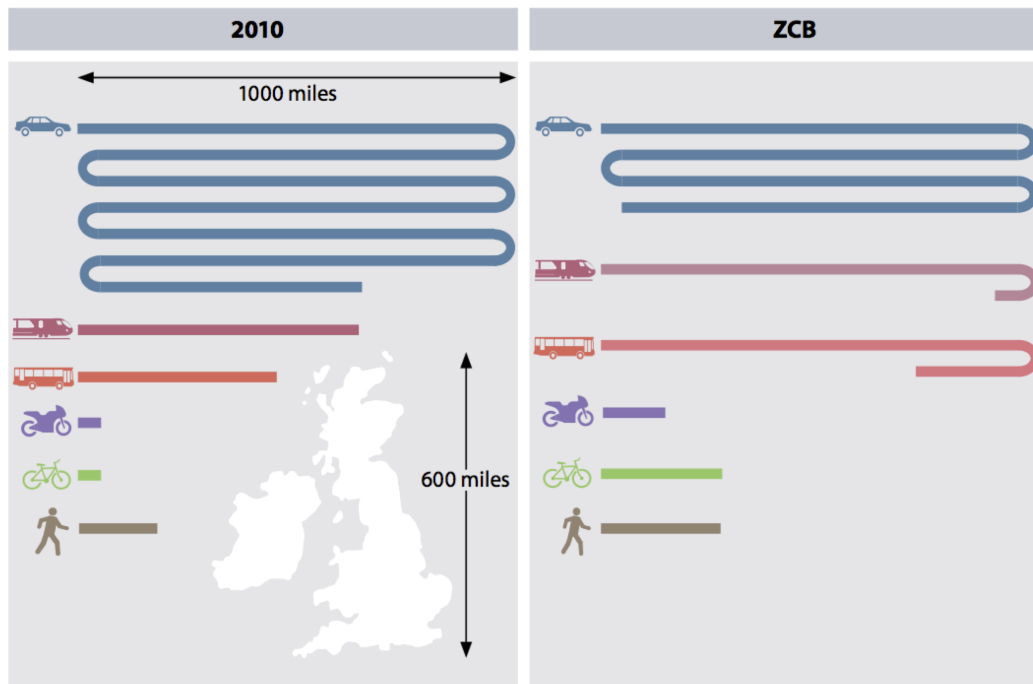
Average distance travelled per person per year by various modes of transport in 2010 (DfT, 2012) and our scenario.

In addition, there would be significant changes to the vehicles used. In some areas (*e.g.* Sheffield) existing tram systems could be extended, or supplemented with trolley bus systems to replace buses on busier routes so they can run directly off the electricity grid.[16] Where this is not viable (*e.g.* more rural areas), buses could still be electrically powered, but would store energy on-board, such as using batteries, capacitors or hydrogen. Private vehicles, vans and minibuses are likely also to be a mix of electric vehicles (EVs) and hydrogen vehicles in the future. Smaller buses and 'bus-taxis' might provide a more flexible model than large vehicles, for some routes. There could be a network of electric cars for an extensive car-share (for residents) and rental (for visitors) scheme.

The modal shift from private transport to public transport and active transport (walking and cycling) would reduce the energy used in fuel per passenger-km and the shift to electric vehicles will increase energy efficiency, particularly in urban settings.[17] These transitions in type of vehicles and from private car to increased public transport are likely to occur together. Initially, this could be through promoting the idea of 'our second car is now an electric second car - or electric bicycle' alongside promoting improved provision and use of public transport.

For those put off by the hills, e-bikes could provide a good way to increase cycling. They can progress at a steady speed of up to 15mph[18] (including up hills).

There would be a very **visible transition** in Sheffield's road networks, particularly in urban areas: fewer lines of parked cars, more pedestrianised roads and segregated cycle lanes. Less land would have to be given over to car parking, but the remaining car parks would have electric vehicle charging points. Petrol stations would eventually be made redundant. These changes would make walking and cycling safer.

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[16]The Nottingham tramway extension was funded using a workplace car parking space levy [91].

[17]The efficiency of electric vehicles (relative to using internal combustion engines) is higher due to their use of regenerative braking. This is particularly the case in urban driving due to its stop-start nature.

[18]Manufacturers are currently required to restrict the top speed to 15mph by law.

More roads (especially in urban areas) might be prioritised for buses and bikes only. This should allow wider pavements and, with few non-electric vehicles passing by, streets should be quieter with significantly reduced air pollution. Overall the transport changes would lead to cleaner air, improved health and quality-of-life of residents.

Reducing transport needs would also mean more community needs are met locally, thus increasing the viability of enterprises such as the 'local' pub, corner/village shop, and community centre (which could host different local enterprises).[19] Increasing the utilisation of these 'final mile' neighbourhood level services would increase community wellbeing.

4.4.2 New Employment Potential

Table 8: Better Transport jobs breakdown in full-time equivalents (FTE)

	Transition	Long-Term	
Driving buses	2061	4121	68 million addition bus miles modelled[92, 93, 94, 95]
Maintaining buses	540	1081	Averaged over the transition period & assuming no change in labour intensity of maintenances with traction type changes [92, 93, 94, 95]
Jobs maintaining private vehicles (ICE)	-1614	-3228	4.4 billion fewer internal combustion engine vehicle miles modelled after transition [94, 96]
Jobs maintaining private vehicles (EV)	658	1315	Additional 2.4 billion electric vehicle miles modelled after transition [94, 96]
Installing Electric vehicle charging infrastructure	68	-	Car park not domestic chargers - Assuming num of parking spaces half's and 50% have chargers[20]
Railway operations & maintenance	1596	3191	54% increase in train km Modelled [86, 89, 97, 98]
Electrifying & upgrading railway lines	Not estimated		
Building new railway infrastructure	Not estimated		
Building new tramway	450	-	Additional 46 km tramway proposed [99, 100]
Operation of additional tramway	250	501	Six fold increase in tram km modelled [99, 100]
Net:	4009	6982	

Transport employment potential has been modelled in four categories: buses, private vehicles, railways and trams. For buses this considers driving and maintaining buses separately. For private vehicles this includes maintaining internal combustion engine (IC) vehicles, maintaining electric vehicles (EVs) and installing electric vehicle charging infrastructure. Additional railway employment is split between operation

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[19]Like Indycube shared workspaces

and maintenance, network improvements and electrification and construction of new routes. Additional tramway employment will include both operation and construction.

Employment metrics for each category (detailed in Annex A) have been scaled for the SCR region - see Table 8. The additional amount of each of these quantities (km of tramway or bus v-km/y) in the proposed SCR scenario has been based on modelling of the potential changes in fuel source, utilisation, utilisation levels, demand reduction, vehicle life spans, as well as the total energy demand from different options. The current situation was modelled based on published current modal splits, occupancies, fuel consumption and vehicle-km. This has allowed the post-transition (2030) scenario to be modelled based on modal shifts proposed in Figure 7.

4.5   Renewable Electricity Generation

There are currently two coal-fired power stations,[21] one combined cycle gas turbine (CCGT) power station[22] and various energy from waste or biomass plants[23] operating in the Sheffield City Region. In addition to this there is some distributed renewable generation in SCR including Royd Moor Wind Farm [107]. We have estimated that around 0.35TWh of renewable electricity is currently generated within SCR,[24] a fraction of the 7.2 TWh of electricity that SCR currently uses [109].[25] Only about a third of the energy consumed currently is distributed in the form of electricity. This means that the SCR is currently a net importer of both energy and electricity.

Due to transition proposals outlined across the other sectors, it is predicted that the proportion of energy delivered via electricity would rise significantly, although total energy demand would fall. This would be met through a massive and rapid increase in renewable electricity generation capacity, both within and beyond the SCR. In addition, we have modelled that coal fired power stations will be phased out over the transition period, and gas and waste power stations shifted to run off different fuels with reduced load factors (as they will primarily be used as standby generation to fill gaps in renewable energy generation). The district heating systems which currently use heat generated from biomass or energy from waste plants should be switched to using ground source heat pumps as their primary source of heat, with the electricity-generation switched to provide back up power when this is needed by the grid.

This report estimates that post transition the electricity demand will almost double, to around 15.7 TWh per year. This reflects a change in how we heat buildings (*e.g.* using heat pumps), as well as a switch from internal combustion engine to electric vehicles (including for increased public transport). This corresponds to an average power demand of around 1.8GW, although depending on the amount of distributed demand response (DR) and storage added, the peak demand is likely to be much higher than this. The intermittent nature of renewable electricity generation means that installed capacity will need to be significantly greater than this, although the increase can be minimised by diversity in generation type and spatial location. This report therefore predicts that even with inter-regional electricity balancing, the renewable generation

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[21]Cottam (2,005 MW) and West Burton A (2,000 MW) in Nottinghamshire [EDF] [101]
[22]Cottam Development Centre (395MW) [Uniper UK Limited] [102], West Burton B (1,332 MW) [EDF] [103] Combined Cycle Gas Turbine (CCGT) Power Station.
[23]Blackburn meadows biomass plant (33MW) [E.On UK] [104] and Templeborough biomass plant (44MW) [Copenhagen Infrastructure Partners][105] both burn waste wood. Waste heat from the Blackburn meadows plant is used in a district heating system. The Sheffield incinerator burns domestic waste [106].
[24]0.94 GWh Hydro, 74 GWh Wind & 28 GWh from sewage Gas & 246 GWh from Landfill gas [108].
[25]TWh = 10^9 watt hours — 1Wh = unit of energy (1 watt of power being transfer for 1 hour)

capacity[26] needed to power SCR could be around 9.1GW.

Recent reports have estimated the potential renewable energy resource that can be utilised in South Yorkshire [108], Derbyshire [110] and in the East Midlands [111], from which the potential renewable electricity generation capacity of the SCR is estimated as approximately 7GW peak production, to generate around 10 TWh of electricity annually. This is approximately 65% of the above estimated electricity demand meaning SCR would not be self sufficient in electricity, (or energy generation). However, other areas along England's north east coast could have a surplus generation of land based renewables (*e.g.* Northumberland [112]) meaning that together with increased North Sea offshore wind generation capacity the overall supply needs for land-locked city regions such as Leeds and Sheffield could still be met from renewables alone. This report therefore proposes that an additional 2TW of offshore wind generation capacity is needed to meet Sheffield City Region's needs, the majority of which would probably be located in the North Sea.

Box 5. Community Energy in SCR

Sheffield Renewables is a community benefit society which owns a number of solar photovoltaic systems, funded through community share offers, including:

- 50 kWp at Paces Campus

- 50 kWp at Swinton Fitzwilliam School

- 50 kWp at Attercliffe police station

- 26 kWp at Lembas Wholefood wholesalers

They have also investigated the possibility of hydro power at two locations but neither have been found to be viable. See www.sheffieldrenewables.org.uk.

4.5.1 Visualising the Transition

For the SCR to become zero carbon it must phase out its reliance on fossil fuels, both those used locally and those used to generate the electricity and other energy imported from outside the SCR. Visible changes would include a significant expansion of roof-mounted and ground-mounted solar PV panels. In more rural areas there would be a significant number of wind turbines distributed across the landscape, particularly concentrated on higher ground[27] (but we do not think they need to be in the Peak District National Park). There is the potential to install micro hydroelectricity plants in some rivers across the region, especially on sheffield's fast flowing rivers from the pennines feeding into the Don.

In addition, there is likely to be an increase in the heat generated from biomass produced in rural areas and anaerobic digesters (AD) at both sewage plants and (at a smaller scale) on farms. Some of the bio-

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[26]The maximum output is when all generation is operating at 100% (i.e. a 1MW turbine producing 1 MW) as opposed to only some of the wind power operating. The derated capacity (i.e. capacity x load factor) takes into account the amount of time that the turbine are operating below this capacity, including when the wind does not blow.

[27]Although there is significant potential in the Pennines, the area designated a national park has been excluded from calculations in this report.

methane produced could be fed into the gas network, used locally or combined with synthetic methane[28] to power the combined cycle gas turbine (CCGT) power station, which can be used when there is insufficient supply of electricity from wind, solar and hydro generators. It may be possible for the existing incinerators to be converted to use synthetic/biogas so that they could also provide standby electricity generation capacity to ensure worst case scenarios are met. Small amounts of synthetic fuels could also be used to power rural buses and emergency service vehicles (where they cannot be adapted to use other fuels types).

Additional energy storage could take the form of battery banks or flow batteries (in homes, industry, transport hubs and substations) to smooth out short-term differences between energy generation and demand. However, the most cost effective solutions would most likely also involve changing how energy is consumed. For example, by automatic controls on non-time-sensitive activities like charging electric vehicles, making hydrogen, heating home hot water tanks and storage heaters, washing clothes in washing machines and cooling of freezers, so that, where compatible with the needs of the use, they are turned on when there is excess electricity on the grid and turned off when renewable energy is not available. Over short timescales, this could shift the timing of electricity use to better balance demand with supply.

4.5.2   New Employment Potential

The energy jobs potential has been estimated by generation type with jobs lost from coal power stations subtracted. The employment figures for renewable generation potential are calculated from labour intensities in Annex A and renewable generation potential outlined in reports for Yorkshire, Derbyshire & East Midland Councils [108, 111, 113]. It has been assumed that all of the 'practical potential' or 'technical potential' is installed over the transition period, although we have excluded onshore wind in National Parks and some hydro with high environmental impacts.

4.6   Other Jobs

This section includes other changes to those quantified in the sections above including areas where the likely employment impact of changes has not yet been modelled. This is another reason why this report is likely to under-estimate the employment potential of proposed transition. However, as action in these areas is important they have still been described below.

4.6.1   Electricity Demand Management

It is often assumed that the best solution to the challenge that climate change poses to the UK energy system is to use less energy and replace fossil fuel use (including existing electricity generation) with an increase in renewable power (and perhaps to some extent some would say nuclear power). However, meeting total annual energy demand is only part of the challenge. Fossil fuels are highly controllable; they are the energy from the sun over millions of years stored in a condensed form that we can release by burning when and where we need it. In contrast, electricity from solar, wind and hydro is only available when the sun shines, the wind blows or the water flows. We need either to build enough renewable generation capacity to be able always to meet our demand for electricity (probably an impossible task for

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[28]Surplus renewable electricity can be used to electrolyse water to create hydrogen, which can then be converted to alkanes by adding biomass in the Sabatier process. This allows easy transportation and storage.

Table 9: Renewable Electricity Generation Jobs Breakdown in full-time equivalents (FTE)

	Transition	Long-Term	Capacity Installed[2]	
Onshore wind (construction)	3202	-[1]	4,269 MW	Assuming linear install over transition [108, 114, 113, 110]
Onshore wind (maintenances)	704	1409	4,269 MW	Assuming linear install over transition [108, 114, 113, 110]
Solar PV (I&D roof mounted)	201	401	204 MW	Total Roof Mounted Solar Potential - Roof PV Already assumed to be install on Dwellings [108, 114, 113, 110]
Solar PV (field mounted)	271	542	276 MW	Assuming 50% of 'dump site' area was cover in PV at 0.52MW per ha [40]
Hydro [run of river] (construction)	45	-	11 MW	Assuming linear Install over transition [108, 114, 113, 110]
Hydro [run of river] (maintenance)	7	15	11 MW	[108, 114, 113, 110]
Coal Power Stations	-410	-820	4,005 MW	Closure of Cottam and West Burton coal power stations [101]
Anaerobic digestion (sewage)	Data not available			
Smart grids and energy storage	1570	1570	15.7 TWh	Based on average modelled annual electricity demand [115]
Net:	**5590**	**3117**		

1 - Based on 25 year life span of turbine you could estimate average long term FTE from replacement at end of life, although this isn't currently included.

2 - MW = 1,000,000 Watts (power)   TWh = 1,000,000,000 Watts hours (energy)

cold, still winter nights), find ways to store electricity, or to shift the demand for electricity to times when renewables are providing surplus power. The optimal solution will be a combination of these approaches.[29]

The challenge is therefore not just one of using less energy but of developing better ways to store electricity, using less electricity when there is less generated, and making use of additional electricity when there is a surplus generated. This report therefore splits demand management into demand response measures and demand reduction measures, as discussed below.

Electricity Demand Response   Changing electricity demand to reflect (local) electricity availability,[30] alongside installation of energy storage capacity. This could include:

- Using thermal storage to maintain system temperatures to shift electricity demand, together with increased flexibility in room and water temperatures (domestic, commercial and retail).

- Flexible scheduling of some energy intensive industrial processes (*e.g.* smelting, particle accelerators, chemical processes etc.). This could include payments for short term reductions in demand, where more cost effective than energy storage, along with existing variable energy pricing.

- Flexibility in the timing and rate of charging of electric vehicles. Potential to meet short term peak demand through discharging these into the grid and thus using electric vehicle batteries as a dispersed short term battery back up for the grid.

- Using electrolysis plants to produce hydrogen when there is surplus electricity generation (see 4.5.1 on page 23).

Implementing some combination of the above will create jobs. However the potential impact in the SCR has not been estimated.

Electricity Demand Reduction   Increased energy efficiency of different appliances will reduce both the average and peak energy demand needed. This will reduce the amount of generation, storage and demand response needed [116]. Some aspects of this are included in this report, others are likely to involve more efficient technologies and processes, and different ways of working and living. Some examples could include:

- Enhancing thermal efficiency of residential, retail and commercial buildings to reduce energy demand (see 4.3 on page 16)

- Increasing the energy efficiency of products and appliances both domestic and commercial, including those used for heating and cooling.

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[29]Building large amounts of renewable electricity generation infrastructure takes energy, labour, machinery, creates CO_2 emissions and takes a long time. The same is true for large scale electricity storage, although to a different degree for different technologies. Building Infrastructure also takes up land and often with renewable energy there is a limited number of good sites. On the other hand shifting demand and increasing demand flexibility requires behavioural changes and in some cases can affect productivity or efficiency of industrial processes.

[30]Transmission infrastructure has limits to how much energy it can transport and there maybe a surplus or shortfall in renewable energy generation.

- Improved efficiency of electric traction on road and rail vehicles (e.g. power distribution and regenerative braking).

- Using LED lighting as standard, including for street lights, some of which could be dimmed or turned off at in the early morning hours.[31]

4.6.2   Better Environment

The SCR's urban environment and countryside could also be improved. This would enhance quality of life, both directly through less pollution, more green infrastructure (*e.g.* for walking and cycling), green spaces *etc.*, but also indirectly through measures to protect and restore natural areas in ways that enhance biodiversity and allow nature to thrive.

Box 6. Pollution Reduction

The World Health Organisation has named Sheffield as one of 9 UK towns and cities to breach air pollution standards [118, 119]. In 2015 Sheffield City Council launched its air pollution action plan which proposes 7 key actions [120]. These include the role out of EV charging infrastructure and promotion of active and public transport which this report also calls for. However, the action plan does not include urban greening, expanding public transport infrastructure and shifting to zero emission buses/taxis.

Rural Biodiversity   Maintaining and improving rural biodiversity will not only allow wildlife to flourish but also ensure ecosystem services (such as natural flood management and crop pollination) are sustained [121, 71].[32] Industrial agriculture has been described as creating 'green deserts': large areas of intensively farmed single crops with few hedgerows or trees which support very little wildlife. The farming proposals set out above (4.2), encouraging smaller and more diverse farming practices, could go some way to addressing this. Changing some practices, such as choosing to lay hedges instead of renewing fencing, as well as reducing field sizes could have soil retention and productivity benefits as well as increasing biodiversity. Some areas could be returned to a more natural state. More wetlands, peat bogs, mixed woodland planting and meadows could help reduce flood risk, support insect populations and increase the amount of carbon sequestered from the atmosphere [122, 123].

Urban Greening   Though not making a significant contribution to reducing carbon emissions, urban green spaces, street trees and green infrastructure have many other advantages. Urban greening can reduce the urban heat island effect, reduce air pollution, improve mental health, create habitats and wildlife corridors to enhance biodiversity within cities *etc [124, 125, 126, 127, 128].* This requires existing urban open land and green spaces to be protected, alongside enhancements to the built environment such as green walls, green roofs and gardens. Community based organisations and initiatives that empower and strengthen local communities could play a key role in creating and maintaining urban green spaces [129].

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[31]Colour temperature also matters (<3000K) to ensure that lighting does not have negative impacts on human and animal sleep patterns [117].

[32]Such improvements could be delivered in partnership with the Sheffield and Rotherham Wildlife Trust Derbyshire Wildlife Trust.

Figure 8: Socio-spatial flood venerability in Yorkshire and Humber & East Midland regions [131]
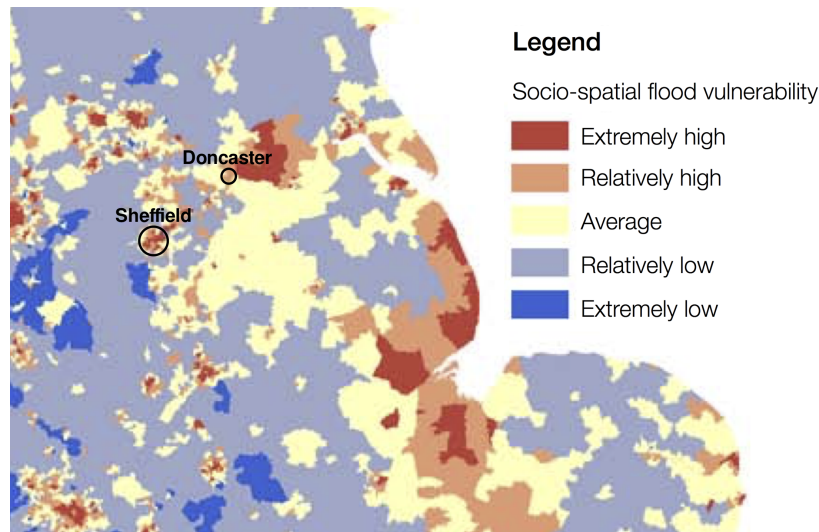
Sheffield has many street trees although, controversially, many are currently being felled as a result of a PFI contract the City Council has entered into [130]. From the perspective of the benefits that urban trees provide this seems a retrograde step.

4.6.3 Adaption to Climate Change

"The Yorkshire and The Humber region is estimated to have the highest average flood disadvantage of all English regions and also the largest proportion of its neighbourhoods classed as being extremely flood disadvantaged. The East Midlands shows a similar pattern." - Joseph Rowntree Foundation [131]

Improving flood resilience is likely to be the principal way in which SCR will need to adapt to the changing climate. Adaptation should focus on enhancing community resilience, and ensure that those with the greatest vulnerability to climate-related risks are able to cope, such as elderly residents, poorer neighbourhoods and areas most at risk from flooding.

As Figure 8 on page 28 shows, the area in the SCR which has the greatest flood risk is in and around Doncaster, followed by Sheffield itself. The SCR has a higher percentage of its area in the average (as opposed to low) vulnerability category than the UK as a whole. In the long-term, climate change may also pose a significant risk to the agricultural productivity of the SCR.

Box 7. Community Resilience

Definition: Communities' ability to reduce exposure to, prepare for, cope with, recover better from, adapt and transform as needed to the direct and indirect effects of climate change, where these can be both shocks and stresses [132].

The above definition highlights that the need for resilient communities is not just to minimise the impact of shock events like flooding but also to ensure they can better cope with slower-acting changes such as rising sea levels or price changes. The transition described in this report requires a significant shift in what is considered "normal" (culture change). A lot of these changes are likely to be induced through price signals like carbon taxes, but this report highlights that new organisations, enterprises and physical changes to the local environment will also play a part. These enterprises will need support to start-up, including through subsidies and grants. These initiatives are likely lead to many behaviour changes, particularly at the household and neighbourhood level. The way communities collectively respond, not only by recognising the need to adapt, but by transitioning lifestyles, could have strong positive impacts, enhancing community wellbeing, the strength of local economies, and overall quality of life. This will require investment beyond the new employment set out in this report, as enhancing the 'resilience' of communities will be determined by the extent to which they are included in the decision making processes, empowered to lead the transition, and to participate hands-on in making it happen. This must include support for excluded groups, vulnerable residents and more deprived areas, to ensure that social capital is strengthened both in local neighbourhoods and across the region. Enhancing resilience in neighbourhoods and communities and creating the transition will require:

- Institutional capacity (experience and confidence, planning and co-ordination within formal and informal organisations to create space for new opportunities)

- Economic capacity (start-up capital and support, skills/experience to access other resources needed)

- Local infrastructure (public spaces, community assets, access to space/work places to start-up and extend new and existing enterprises, meeting places and workshops, tools, support facilities)

- Human capacity (specialist skills and knowledge, time) supported by social networks, academic/innovation/business support, inclusion and community relationships.

4.6.4   Support Jobs

Matching the employment opportunities with those who want to work and are underemployed or unemployed in SCR will require support activities, including:

- **Training and Up-skilling.** There will be a significant amount of up-skilling and retraining required to support the creation of these new jobs, which will create new job opportunities in its own right.

- **Part-time and Flexible Working.** Not all of those seeking new work in SCR will want full-time positions.[33] However, the job estimates in this report are based on full-time jobs. Therefore, the total number of people employed will be higher than the 'fulltime equivalent' number of jobs proposed in this strategy.

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[33]For example due to having child care responsibilities, a disability, mental health issues, or a wish to work less prior to full retirement.

- **Supported Working and Coordination Roles.** Some of those able to work will need reasonable adjustment in the workplace or extending training and induction periods. Ensuring these employees can work to the best of their ability will therefore create additional supervision, personal support and facilities employment.

- **Community engagement support, especially to support vulnerable residents.** Supporting residents through guidance, assistance and information towards more sustainable living will also help move households out of fuel poverty. Similar assistance could be provided to support the shift to sustainable transport and to promote more local and sustainable food options.

These roles will increase the total number of jobs required. While some of these positions might mean lower productivity of some activities in terms of person hours required for some tasks, it will open up employment to many who cannot currently access employment, which will improve the self esteem and quality of life of many people, and create a stronger, more resilient society as a result.[34] This increase in employment may mean a reduced pressure on NHS or welfare services – which is not currently reflected in the employment estimate in this report. Not providing support for people to take the new jobs would not only represent a significant loss of wellbeing and productivity for some SCR residents, but also mean that fewer new positions would be filled by those already living within the SCR [133].

4.6.5 Coordinators, Managers and Administrators

Many of the jobs proposed require new enterprises and work streams to be created: they are not just 'more of the same' in existing workplaces. Therefore these jobs (and workplaces) will need to be planned, initiated, championed and innovated, coordinated, supported with facilities as well as legal and financial agreements for these varied projects in many different locations across the region to succeed. This will include new managers and volunteer support from within communities. This report has not included these jobs as it would be hard to quantify whether additional management and volunteering roles are needed, above that reflected in the overall job estimates. There may also be some positions involved in developing and sharing ownership of this strategy, and enabling stakeholders across communities to participate in how it is developed and realised.

4.6.6 New Employment Potential for Support Jobs

This report has not estimated the employment potential associated with electricity demand management, urban greening, climate change adaption or additional enterprise management or volunteer positions, due to insufficient data being available to produce reliable estimates. However as Table 10 on page 31 shows we have included an estimate for up-skilling and training as well as for the extra jobs needed to support volunteers and workers with support needs.

5 This is possible

The job metrics used in this report are all derived from existing projects and research estimates. This means the proposed jobs could be realised in practice. Technologies that are not yet proven at a commercial

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[34]State of Sheffield Reports highlight that there are significant numbers of people under employed or employed below their skills/education level [1].

Table 10: Other Jobs Breakdown in full-time equivalents (FTE)

	Transition	Long-Term	
Electricity demand management	Not Estimated		
Rural biodiversity	255	574	Based in increase in hedge laying by 10m per farmed ha over transition [134]
Urban greening	Data not available		
Pollution reduction	Data not available		
Adaption to climate change	Data not available		
Coordinators, managers and administrators	Data not available		
Up-skilling and training	615	485	3% addition Jobs assumed
Extra jobs need per volunteer or worker with support needs	485	969	30% addition FTE on 10% of transition jobs and 20% of long-term jobs assumed
Net:	**1355**	**2028**	

scale (*e.g.* carbon capture and storage) have not been considered. In some cases, employment estimates are quite conservative while in other cases they relate to transition proposals that are themselves quite ambitious,[35] but that does not mean the transition proposals are not possible between now and 2030.

Area	Comment
Labour	This report assumes a significant level of additional employment is needed for the transition. This is about 55% of those currently without a job but who want one in the SCR.
Skills	It is highly likely that not all of those currently unemployed in SCR will have the skills, training and experience needed to match the specific job opportunities set out in this transition. However the employment estimate includes additional jobs to facilitate their training. It is likely that many of the transition jobs will go to those already in employment creating other job vacancies that some of those without a job might find suitable.
Resources	Innovation and entrepreneurship could link to academic institutions across the SCR, including two universities (Sheffield University and Sheffield Hallam), a university technical college in Sheffield, the Barnsley College Think Low Carbon Centre and Siemens Wind Power Research Centre [136].

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[35]For example, the transition proposals are based a permaculture based approach to farming, which is a significantly bigger shift in farming practices than changing to organic farming which is what the labour intensities are based on [135, 72].

Area	Comment
Investment	There are 847,000 currently employed in the SCR of whom 81% are likely to have a non-state pension [137, 43]. The average value of a UK non-state pension is around £70,000 meaning there is approximately £48 billion of long-term investment potential as a result of SCR citizen's pensions alone [138, 139]. That is enough to fund the construction of 4000 miles of railway or over 2000 6MW offshore wind turbines [140, 141]. SCR currently spends an additional £3.4 bn on importing gas, electricity, petrol and diesel into the region each year [142, 143, 109]. If all this money could be harnessed it would go a long way toward funding the transition. In addition, there is the potential to allocate finances from the Sheffield City Region's LEP which has an existing infrastructure investment channels and, like all LEPs across the UK, is required to have an Energy Strategy in 2018. There is a clear economic case for many of the transition projects to be incentivised and delivered with LEP/public sector support - as well as being reflected in local planning frameworks. Establishing overall packages of individual projects or infrastructure delivery, such as installing renewable electricity generation capacity, installing EV chargers and purchasing of electric cars would help to secure investment funding [45]. Public sector borrowing for such projects, and to support new enterprise start-ups, would reduce the private risk and make the transition more likely to occur. It also makes sense as other parts of the public sector could have to pay for the consequence of not succeeding in this transition.[36]
Time	Investment can be secured, people trained, skills and resources gathered, workplaces established and machinery commissioned, but all these activities take time. To make the transition to net zero carbon over the next 20 years is a massive logistical challenge, although history shows us that it is possible to restructure the economy as a matter of urgency. [37] Even assuming we could mobilise and make substantial changes by 2020, sustaining a >10% annual emission reduction is a challenging target, not least because the upfront infrastructure investments required will also require upfront emissions. However, this should still represent a transition/shift rather than overall increase in construction sector emission in the short term. To achieve the transition will require planning, as it is not just a change in one sector (*e.g.* renewable energy) but changes across the major energy and resource utilising sectors of society.[38].

Table 11: Support needed to Implementing the transition

As Table 11 shows, the significant challenges to implementing the transition can be overcome, given sufficient resolve. Perhaps the biggest barrier is how to initiate a sufficient number of actions, at a speed required to enable the transition to match the scale of the challenge/opportunity presented to us. Society is currently quite change averse - and the risk of change is often overstated, while the risk of continuing business-as-usual is not taken into account. To embrace the opportunity to avoid runaway climate change and improve the lives of the communities in SCR requires leadership. The starting position should be not whether this **could** be done, but that it **must** be done. Then the challenge shifts from questioning if it is possible, to planning how it can be achieved, and getting to work.

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[36]E.g. for climate change adaption including rising flood risk, NHS costs associated with the health impacts of air pollution, lost employment (e.g. sick leave/benefit costs) and NHS costs associated with continuing mental health issues.

[37]Between 1939 and 1942 around 25% of the UK's working population changed industrial sector and 45% of net national expenditure was transferred to specific purpose, in this case for the war effort [144].

[38]Major offshore wind projects typically take around five years from the initial application to commissioning [145].

5.1 Approaches

People and organisations have to take the initiative for progress to happen. Progressing many of these initiatives will require up-front investment, skills, finance and /or premises to be secured. Only once human ingenuity and collective support have been applied can these barriers be overcome and the required jobs created to realise the transition. Thankfully, many of these are already in place and many initiatives already started, at least in some locations, even if at a relatively small scale. So the challenge is more about extending this, and having a bold enough plan with sufficient investment, resources and support for these to be replicated far and wide - to become the new normal. The impetus to make this happen is likely to depend on the sector and type of initiatives. It will certainly include:

- Community-led and private-led initiatives, which could be kickstarted by community share issues (*e.g.* by co-operative or community benefit societies). Community funded projects (including assets purchase) might benefit from public coordination to assist in allocation of sites to reduce start-up costs/risks (*e.g.* through the establishment of new green enterprise areas). These could be delivered jointly with communities and/or the public sector. Funding could be sought from existing and new green and social investors including Big Issue Invest, Key Fund and Triodos Bank.

- Public sector-led schemes, which could target local economic sustainability through extending council service provision. This should target specific infrastructure needs to underpin the green transition (*e.g.* electricity charging points) and coordinate activities that will be more efficient if planned and implemented collectively (*e.g.* rooftop solar PV, improved reuse and recycling collections). Such initiatives could be supported through schemes such as the SCR Local Enterprise Partnership (LEP) and government departments (*e.g.* Community and Local Government's current community economic development fund and Business Innovation and Skills's ambitions for clean energy in its new industrial strategy) and (currently) the EU. This may include opportunities associated with devolution plans.

- Different (procurement and enterprise) approaches and funding from councils, which could include:

  - Renegotiating waste management contracts to realise the employment potential associated with increased rates of reuse and recycling.

  - Splitting up procurement contracts to allow small, more local providers to compete[39].

  - Taxes/levies to encourage behaviour change and fund infrastructure improvements (*e.g.* income from parking charges used to fund cycling infrastructure)

  - Direct investment in sustainable income generation projects within the SCR (*e.g.* renewable energy) rather than investing in a property portfolio.

- Changes to local and national funding priorities, and regulations and incentives to help direct private sector investment, as set out in box 5.1

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[39]Smaller local providers may also buy from more local suppliers (e.g. farms) reducing transport emissions and potentially being more able to take advantage of new low carbon options (e.g. EVs, building retrofit, renewable energy, shared transport with other local business . . .)

Box 8. Changing incentives (and removing perverse incentives) to fund green jobs

Some of the biggest externalities are around fossil fuels and farming subsidies and the hidden costs of air pollution and climate change:

- **Fossil fuel subsidies** in the UK were estimated at over $800m in 2015 [146]. If this was redirected to fund a green transition across the UK this would be approximately £14.5m of additional funding each year for the SCR.

- Recent cuts to **Feed-in-Tariffs** and other support mechanisms for renewable energy have reduced the viability of new solar, wind and hydro projects [147].

- If **farming subsidies** encouraged sustainable farming practices (as set out here) rather than mainly accruing to landowners on the basis of how much agricultural land they owned, they could increase incentives for sustainable land-use and a stronger rural economy [148].

- If the principal producers of **air pollution** were taxed according to associated health impacts, this could improve public health, NHS finances and fund better transport solutions.

- Transport infrastructure funding reflects a **perverse incentive** towards large rather than local schemes. More funding goes to large schemes (with a lower ROI[a]) to make it easier to travel further, rather than local schemes that improve accessibility and road safety and have better sustainability, job and local economic outcomes [133].

This requires a change in approach to investment:

- **Making decisions that include all externalities** (*e.g.* the social cost of structural under/unemployment, mental health and exclusion, the environmental cost of waste, air pollution and climate change, wider social return on investment) will change what is the economically 'best' option in many cases. This may require different economic tools, or different overall strategies;

- **Making longer-term decisions.** Many of the opportunities presented in this plan tend to be longer-term, and are better value when viewed in that way; and

- **Different incentives, regulations and initiatives** to better utilise existing sites or buildings – including by local government and national government departments. This should better prioritise investment to improve social and environmental sustainability – these should be the options that deliver the highest financial return.

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[a]ROI = Return On Investment

6 Overall Conclusion and Recommendations

The analysis in this report estimates that the transition to an economy with zero net carbon emissions and sustainable resource and land-use across the Sheffield City Region will create a significant number of jobs. The report estimates that the transition will create at least 21,000 additional people in employment full-time up until 2030, after which timearound 18,000 additional jobs will remain across a whole range of sectors to maintain a more sustainable and more circular local economy.

The transition this report proposes is both ambitious in scale and would be transformative in nature - both in terms of the changes to resource, energy and land-use but also in terms of strengthening local communities, their resilience and quality of life. Although this report does not claim its proposals would entirely reduce greenhouse gas emissions to net zero by 2030 (in part because this is also dependent on the wider economy), it would provide the foundational economy across the SCR area that enables this goal to be achievable then or shortly thereafter. By delivering the proposed transformational carbon emissions cuts at the local and regional level over the next decade or so the proposed transition would leave some remaining carbon budget, enabling more difficult and potentially harder to avoid emissions to be addressed nationally, culturally, and within key sectors. The approach taken in delivering the changes set out in this report would be to take a precautionary approach to climate change: accelerating local actions will help achieve and exceed current commitments nationally, minimise the scale of adaptation needed globally, and enable the national leadership required to reduce the risk of runaway climate change.

This set of proposals will enable quality of life to be maximised across the SCR in the longer term, and if that transition is implemented in a fair and just way it could lead to more resilient local communities across the region. This would not only help protect communities from the increasing risk of climate-related disaster events and stresses, but also maximise the positive ways in which the transition will impact on household and wider (public) quality of life. The most deprived and vulnerable communities both within the region and globally could be negatively impacted by the transition to address and adapt to climate change, as well as by its long-term impacts, unless sufficient investment and action supports all communities across the world to transition and be more resilient [149].

For this and the other actions needed for the transition to happen, leadership is urgently needed. The broad range of current challenges including: access to decent housing, high energy bills, lack of well paid, secure jobs, increasing prevalence of mental health issues, an ageing population putting strain on NHS, lack of skilled employees for key jobs, pollution, waste, degrading soil quality and access to good quality education and child care all need to be addressed while the climate challenge is addressed. It is not acceptable to delay reducing our climate impact until after some of these have been addressed, or vice versa. A holistic, systemic approach has to be taken that sets the overall economic development of the UK, including the SCR, onto a different economic pathway which enables rapid progress in addressing climate change and also addresses these other issues facing the SCR. These solutions must not just be discussed, but put into action, delivered by more people working to make it happen.

That is why this report focuses on the creation of jobs, not the allocation of money or commissioning of projects per se. The Climate challenge requires sufficient people power to make it happen, and participation of the wider communities and key decision makers to magnify and accelerate the take-up of the changes we need to make. Strategic investments must be supported, planned and realised. The economic sectors we have covered in this report should provide an enabling infrastructure for wider societal changes -

enhanced community relations, wellbeing, ways of living, local environmental value, and a stronger local and regional economy. Investment in green jobs should not just lever multiplier effects in terms of economic development but bring about social changes that mean we care more for each other, as we share a much lower environmental footprint. This requires action to deliver the transition, and an active economy and society to then maximise its benefits. This report therefore recommends:

- Funding is allocated on the basis of jobs created to address the key climate and environmental challenges present locally (*e.g.* by the Local Enterprise Partnership). That this funding is structured as part of an overall spatial strategy, employment and skills plan and strategic investment strategy that delivers the climate transition locally, as quickly as possible.[40]

- This should be underpinned by a zero carbon energy strategy for the Sheffield City Region / LEP area to plan how the investment needed for the energy transition (and associated employment) will be structured, allocated and disbursed.

- Local authorities and other key stakeholders identify support, incentives and regulations at the local, SCR, county or national level that will enhance the scale and rate of the transition, and work through the different levels of government to realise and implement them.

- The transition is prioritised at the local and regional level with other issues considered as part of this overall investment pathway, as a single holistic process that transitions the SCR to become socially and environmentally sustainable.

- Investment is targeted to generate momentum and maximise organic replication within communities. This is likely to combine the prioritisation of employment generation and inward investment to where there are the highest employment deficits and regeneration needs, with a focus on areas where initiatives are already embedded so these become hubs for green employment that can be replicated across the region. In this way, the transition must both draw on areas already with the highest-levels of buy-in and those with the highest need for a transition in employment prospects as well as climate and environmental transformation.

- Investment and support should be available at the community and household/individual level as well as the strategic level. For example, not just regional infrastructure investment but investing in the 'final mile' of affordable public transport access into the most deprived communities; engagement for changes to be trusted, drive uptake and change demand patterns to match supply side investments; overall community development and participation to address barriers, strengthen social capital and buy-in, and to improve community resilience.

- Investment should aim to be locally embedded. Where there is a choice between a local or regional scale investment approach, the priority should go to the local approach, even if on face value it is more expensive, as this will embed the transition more deeply and inclusively into individual communities, and enable aspects to be (re)tailored to meet local needs. The transition should support, empower and amplify existing local leadership[41].

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[40]Alternative economic strategies in line with this have already been proposed [133]. NEF - People and Places First
[41]The New Economics Foundation has also highlighted the importance of local decision making [133].

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A - Annex - Base Job Metrics

The table below lists the job metrics used to estimate the potential employment change associated with a green transition across the Sheffield City Region

Reuse, Repair & Recycling Jobs	Source/Notes:	Quantiy	Units	FTE/Quanity
Municipal solid waste (MSW)	- Excluding Indirect & Induced.	1000	Tonnes of Recycling	2.9
Commercial and industrial waste (C&I)	Own Estimate Based on FOE, 'More Jobs, Less Waste' 2010. - Assuming 50% less jobs intensive than MSW recycling due to larger volumes.	1000	Tonnes of Recycling	1.5
Construction and demolition waste (C&D)	Own Estimate Based on FOE, 'More Jobs, Less Waste' 2010. - Assuming 50% less jobs intensive than MSW recycling due to larger volumes.	1000	Tonnes of Recycling	1.5
Waste disposal (landfill and incineration jobs)	- Reference States Waste deposal employees roughly a 10th of reuse and recycling.	1000	Tonnes of Recycling	0.3

Farming, Foresty & Food	Source/Notes:	Quantiy	Units	FTE/Quanity
Farming	(Assuming Permaculture compatible to Organic in terms of labour intensity) - James Morison, Rachel Hine and Jules Preety, 'Survey and Analysis of Labour on Organic Farms in the UK and Republic of Ireland', 2005.	100	ha	2.1
Cereal Crops	The Land's Calculation are based on Soil Association's 'Organic Works' report and DEFRA data - Ed Hamer - the Land Magazine, 'Can Britain Farm Itself?', 2012.	100	ha	1.3
Potatoes	The Land - Can Britain Farm itself? - Organic Estimate - Ed Hamer - the Land Magazine, 'Can Britain Farm Itself?', 2012.	100	ha	8.3

Sugar	The Land - Can Britain Farm itself? - Organic Estimate - Ed Hamer - the Land Magazine, 'Can Britain Farm Itself?', 2012.	100	ha	2.4
Fruit & veg	UK Typical - Sustain Report fig 3.3 - Labour days per Ha - Nix, J , 'Farm Management Pocket Book, Wye College, University of London. ', 1997.	100	ha	7.7
Dairy (excluding any labour to grow grain for feed)	The Land - Can Britain Farm itself? - Organic Estimate - Ed Hamer - the Land Magazine, 'Can Britain Farm Itself?', 2012.	100	head	2.9
Beef (excluding any labour to grow grain for feed)	The Land's Calculation are based on Soil Association's 'Organic Works' report and DEFRA data - Ed Hamer - the Land Magazine, 'Can Britain Farm Itself?', 2012.	100	head	0.9
Pigs (excluding any labour to grow grain for feed)	The Land's Calculation are based on Soil Association's 'Organic Works' report and DEFRA data - Ed Hamer - the Land Magazine, 'Can Britain Farm Itself?', 2012.	100	head	0.2
Sheep	Weighted average assuming 2:1 Sows:Finishing Pigs - Defra, 'defra-stats-foodfarm-landuselivestock-june-junemethodology', 2012.	100	head	0.3
Chickens - eggs (excluding any labour to grow grain for feed)	The Land's Calculation are based on Soil Association's 'Organic Works' report and DEFRA data - Ed Hamer - the Land Magazine, 'Can Britain Farm Itself?', 2012.	10000	head	2.9
Woodland management	Scaled from proposals for Britain from ref - Independent Panel on Forestry, '', 2012.	100	ha	0.3

Timber processing (indirect)	Multiplier 1.43 (from English Forestry Contribution to Rural Economies) - Public and Corporate Economic Consultants (PACEC) on behalf of the Forestry Commission, 'English Forestry Contribution to Rural Economies', 2000.	100	ha	0.1

Buildings - Energy Retrofit	Source/Notes:	Quantiy	Units	FTE/Quanity
Improving energy efficiency of dwellings	Direct Labour only - Using 134h on site per house + 3h survey from reference - Birmingham City council, 'Birmingham Green New Deal - business Plan', 2009.	1000	Dwelling/y	81.5
Adding Solar Thermal to dwellings	1 FTE (direct and indirect) per 100m2 installed. Then is scaled using 400 FTE direct out of 2900 FTE total to remove indirect jobs. Both from reference. Also assumed 4m2 per house as most installation are 2x 2m2 panels. - Riccardo Battisti, University Sapienza of Rome Thomas Pauschinger, Ambiente Italia Research Institute & SFI Solites Roberto Salustri, Reseda Luca Zingale, Solarexpo Research Centre, '"Solar Thermal Takes off in Italy - 1st Statistical Survey and Market Study" - Published by SOLAR EXPO Research Centre & European Solar Thermal Industry Federation', 2006.	1000	Dwelling/y	34.5
	30.75h install per KW of PV installed (number for dwellings) [Possibility too high due to scale change] Converted from KW to dwelling assuming 2KWp per dwelling - Birmingham City council, 'Birmingham Green New Deal - business Plan', 2009.	1000	Dwelling/y	36.6

Installing GSHPs into Houses (8KW 2 bed)	Assuming 26k average wage - 40% labour from Chirs Davidson (GSHP Association) estimate - Own Assumption about % of Capital Cost Labour - Rest is Ground Source Heat pump association & kensa heat pumps, 'Case Studios - See CALC Building Tabb', 2017.	1000	Dwelling/y	207.7

Facilities Management	Source/Notes:	Quantiy	Units	FTE/Quanity
Maintaining cycling Infrastructure	From Case studies - ekogen, 'Employment in Sustainable Transport', 2010.	100	km-path	8.50
Dwelling	Birmingham Green New Deal - Based on 8 hours maintenance as a result of retrofit per year and 1680h worked per employee per year in (see Birmingham Green New Deal - business Plan) Assumed 2/3 of this is additional paid as boiler servicing jobs maybe lost.	1000	dwellings	3.1

Better Transport	Source/Notes:	Quantiy	Units	FTE/Quanity
Railways [Op + maintainence)	Total UK Rail Industry staff divided by total v-km (Includes supply chain) - Rail Delivery Group & Officer for Rail & Road, 'Annual Report 2016 & Rail Statistics May 2017', 2016-17.	1000	V-km/y	0.41
Light Rail	Averaged across existing UK tramways - Employment data via employment in sustainable transport report - Department for Transport Statistics, 'Light rail and tram statistics ', 2009/2017.	10000	V-km/y	0.50
Building New Tramway	Based on NET Phase 2 (2015) - Nottingham City Council, 'Nottingham Express Transit Phase Two Full Business Case', 2011.	1	mile	189.0

Driving buses	Using bus Drivers employed in the UK to bus miles in the UK ratio from references. - ONS, 'Annual Bus Statistics 2011-2012 - BUS0208 & Table EMP04: ALL IN EMPLOYMENT BY STATUS, OCCUPATION & SEX: PEOPLE', 2012.	1000		0.1
Maintaining buses	No assumed change in maintenance intensity of Trolley/EV/Hydrogen buses. Using employed in the UK to bus miles in the UK ratio from references. - ONS, 'Annual Bus Statistics 2011-2012 - BUS0208 & Table EMP04: ALL IN EMPLOYMENT BY STATUS, OCCUPATION & SEX: PEOPLE', 2012.	1000	bus miles	0.0
Constructing cycling infrastructure	Based on National Cycle Network - Friends of the Earth, 'Less Traffic more Jobs', 1997.	100	km-route/y	40.6
Installing electric vehicle infrastructure	Assuming 1/3 labour and 26k average wage - , '', .	100	PublicEVChargers/y	11.1
Jobs maintaining private vehicles (internal combustion engine, ICE)	Based on 233,000 FTE supporting 316.7 billion vehicle miles - Office for National Statistics, 'Table TRA8901 & Table EMP04', 2016.	1000000	vehicle miles	0.74
Jobs maintaining private vehicles (electric)	Based on 2/3 of 5231 Vehicle technicians, mechanics and electricians - A cost- and benefit analysis of combustion cars, electric cars and hydrogen cars in the Netherlands, 'WAGENINGEN University', 2009.	1000000	vehicle miles	0.54

Renewable Energy Generation	Source/Notes:	Quantiy	Units	FTE/Quanity

Onshore wind construction	Estimate is based on a range of sources compiled in - Campaign against Climate Change Trade Union Group , 'One Million Climate Jobs - Online Companion', 2014.	1	MW/y	9.0
Onshore wind maintenance	Estimate is based on a range of sources compiled in - Campaign against Climate Change Trade Union Group , 'One Million Climate Jobs - Online Companion', 2014.	1	MW	0.3
Offshore wind construction	Scaled from Onshore relative to subsidies (1.8/0.9) - Campaign against Climate Change Trade Union Group , 'One Million Climate Jobs - Online Companion', 2014.	1	MW/y	18.0
Offshore wind maintenance	Scaled from Onshore relative to subsidies (1.8/0.9) - Campaign against Climate Change Trade Union Group , 'One Million Climate Jobs - Online Companion', 2014.	1	MW	0.7
Tidal Stream	Figures for Dorset from reference - The Resilience Centre (Molly Scot Cato), 'The Power to Transform the South West', 2015.	1	MW/y	2.1
Wave	Figures for Devon - 460 FTE for 250MW (from ref) - The Resilience Centre (Molly Scot Cato), 'The Power to Transform the South West', 2015.	1	MW	1.8
Solar PV - Commercial Installation	- The Resilience Centre (Molly Scot Cato), 'The Power to Transform the South West', 2015.	1	MW	2.0
	- Nick Forrest and Jamie Wallace (British Hydro Association), 'The Employment Potential of Scotland?s Hydro Resource', 2009.	1	MW/y	48.5

	- Nick Forrest and Jamie Wallace (British Hydro Association), 'The Employment Potential of Scotland?s Hydro Resource', 2009.	1	MW	1.3
Anaerobic digestion (of sewage)	Using data for Dorset - The Resilience Centre (Molly Scot Cato), 'The Power to Transform the South West', 2015.	1000	MWh/y	1.5
Smart grids and energy storage	Using data for Dorset - The Resilience Centre (Molly Scot Cato), 'The Power to Transform the South West', 2015.	1000	MWh	0.1

Better Environment	Source/Notes:	Quantiy	Units	FTE/Quanity
Hedge Laying	Sustain's Double Yield Report - Each FTE works 240 days/y, laying 10m/d where each hedge needs laying every 14years	10	km	1.7

B - Annex - Case Studies

The table below is for illustrative purposes, aiming to signpost the types of enterprises that could enable this green economic strategy to be realised.

Reuse, Repair & Recycling	**SCR:** Sheffield Repair Cafe **UK:** Bristol Bike Project, Deconstruction. **Worldwide:** Habitat for Humanity Restores (USA)
Food, Land Management & Forestry	**SCR:** Regather Coop **UK:** Community Farm (Southampton, Stroud and other case studies), Abundant Earth (Durham), Steward Community Woodland, Permaculture Association (various case studies), Foodshare, FoodforLife
The Built Environment	**SCR:** Reach Homes **UK:** Kirklees Warm Zone, Energy Retrofit (e.g. Wandsworth)
Better Transport	**SCR:** MAGTEC, Sheffield Supertram **UK:** NGT Leeds Rejected Trolley Buses, Bio-diesel and electric buses (Brighton – Community Owned, Milton Keynes, London), Brixton Cycle, Cycle Training UK. GO-OP (Public Transport Co-op), Bike Co-op (Oxford), Car Share Co-op (e.g. Cambridge Lift-Share), Electric Bike Share Co-op, Hydrogen Buses Aberdeen **Worldwide:** Trolley Buses (Trolley-project.eu, Seattle, Beijing, Mountreux, Schaffhausen), HyTrEc (Europe), Green City Ferries - Sweden (Electric Passenger Ferries)
Renewable Energy Generation	**SCR:** Sheffield Renewables **UK:** Hydro Coop (Scotland, Wales), Wind Power Support (Grimsby), Powerstar, Energy Coop (Brighton, Aberdeen, Somerset, Bath, Hackney, Scotland), Wind Farm Coop (Boyndie), Community Scale AD **Worldwide:** Evergreen Cooperatives (USA)
Community/ Other	**SCR:** University of Sheffield Biodiversity Action, ITM Power Plan **UK/Worldwide:** Green business and enterprise parks/zones - Working families – Case Studies, Transitions London – Case Studies, Local Currencies (various):

Table 13: Green Enterprise Case Studies

Other case studies will relate to the type of business models required, such as: skills and innovation hub linked to the SCR's universities, supported workplaces and initiatives to enable all those desiring employment a route back into work, community roles for architects, a variety of new stewardship and 'caretaker' roles, and wider programmes and strategies linking green employment to a more caring society.