Making the local economic case for low carbon – an Oxfordshire case study

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Abstract
The case for a low carbon economy is usually made in terms of the imperative of avoiding dangerous climate change, linked to an analysis showing that overall economic impacts are acceptable, nationally or globally. However, for local economic decision makers, the important factors are more likely to be employment and wealth creation within the local economy. This paper reports a study designed to address these questions for the County of Oxfordshire in the UK. The analysis considers the impacts of a low carbon transition in creating opportunities for local businesses and research organizations, and its links to the modernization of local infrastructure. It draws on both scenario modelling and case studies of existing initiatives. The results show that a shift to a low carbon economy is consistent with Oxfordshire's strengths as a knowledge economy and plans for economic growth, with key sectors for potentially positive impacts being building technologies, alternative fuels and vehicles, and renewable energy technologies, as well as related research and service sectors. These sectors correlate with needs for local infrastructure investment, potentially allowing local schemes to act as 'living laboratories' for innovation. The scale of investment required is large, across research, commercialization and deployment, and will require a coordinated approach from local political and economic decision-makers. In the last two sections of the paper we reflect on our experience of doing this work, engaging with local stakeholders, and trying to achieve shared understanding of terms which were vague or unclear at the outset. The final discussion considers how the approach taken for this report could apply to other city-regions, but that the context and economic reality of each new place would have to substantially shape the detailed findings of any such report.

Introduction
The case for a low carbon economy is usually made in terms of the imperative of avoiding dangerous climate change, and has been done for the world economy (Stern 2006), for individual nation states (e.g. UK Government 2011), and for sub-national entities such as city-regions (Gouldson et al. 2013). However, for local economic decision makers, the risks of global climate change can be too remote, too uncertain and too large-scale to have much immediacy at the level of local economies.

Presenting the economic case for shifting a local/regional economy towards low-carbon activities can arguably be more appealing to local policy-makers if the focus is on local political priorities, such as employment and wealth creation. This paper reports a study designed to address these questions for the County of Oxfordshire in the UK, which came about because of the work of the Low Carbon Hub, which is 'a social enterprise tackling the big issue of climate change in Oxfordshire' (www.lowcarbonhub.org), and its local stakeholder network, Low Carbon Oxford (http://lowcarbonoxford.org/). The analysis considers the impacts of a low carbon transition in creating opportunities for local businesses and research organizations, and its links to the modernization of local infrastructure.

The full report 'Oxfordshire's Low Carbon Economy' (Patrick et al. 2014) is available on the Environmental Change Institute website (www.eci.ox.ac.uk). The aim of this paper is not to repeat all the detail of that report, but rather to sum-

marise the work that we did, and how we did it, and to reflect on many of the issues which arose in the process. We include these reflections on the process in order to help others tackling similar tasks in different places. The first section of the paper summarises the report, leading to a description of three scenarios to 2030, which we developed for the report. A section entitled 'Knowledge Exchange' then discusses our interactions with stakeholders both during and after the process of writing the report, focusing on the need to discuss and clarify the purpose and some of the key concepts we used in this work. In the conclusions section, we address how we think the model of this report for Oxfordshire could apply more widely. By moving away from our usual primary focus on energy efficiency and emissions reduction, we have been able to engage with a new group of stakeholders and to begin to shift our perspective and theirs.

Summary of the report 'Oxfordshire's Low Carbon Economy'

THE LOCAL CONTEXT

Oxfordshire's geography and infrastructure

Oxfordshire, a county with a population of around 635,500**,** sits at the edge of two of the UK's most prosperous economic regions: the South East region and the South Midlands (Figure 1). The city of Oxford is one hour by train from London (~100 km), and has generally good transport links with the rest of the UK.

Figure 1. Oxfordshire's local government boundaries, showing the County (comprised of four District Councils) in relation to the City of Oxford.

The main A34 trunk road runs north-south through the county of Oxfordshire, and is one of the busiest non-motorway roads in Europe, linking the major south coast ports of Southampton and Portsmouth to the north of the country. In common with much of the rest of the UK, especially in the south-east of England, Oxfordshire has a chronic shortage of housing, following decades of under-provision. Housing has been described as 'the defining economic crisis of our times' in the UK, with an ever-increasing gap between those who can afford to buy or rent decent housing, and those who cannot (Dorling 2014). Oxfordshire's Strategic Housing Market Assessment (SHMA) estimates that the county needs an additional 100,000 homes in the period 2011–2031, which represents a 37 % increase on the existing stock of 273,000 homes. The estimate takes account of the backlog of unmet housing demand, in addition to the additional new pressures on housing which come from the county's economic growth plans (GL Hearn 2014).

Local politics and governance

Oxfordshire's local government is politically divided between, on the one hand, a City Council which has been controlled almost continuously since 1980 by the left-of-centre Labour party and – on the other hand – the surrounding County Council, which has largely been run by the right-of-centre Conservative Party for over a century. Proposals have been made for a so-called 'unitary' authority to overcome the political barriers, but no progress has been made for the simple reason that neither side wishes to lose the power and influence that it currently enjoys.

The UK government brought in an innovation in local governance in 2010 in the form of Local Enterprise Partnerships (LEPs). The LEPs are public-private partnerships of local councils with business leaders and other major institutions with a remit to 'decide what the priorities should be for investment in roads, buildings and facilities in the area' (UK Government 2012). The LEPs can apply to central government for funding to support strategic economic development at the local/regional level. The Oxfordshire LEP has a strategic economic plan for the period 2015–2030, which sets out how it would use £678 million (932 million euros) of central government funding to stimulate over £6.3 billion (8.7 billion euros) total investment and create over £6.6 billion (9.1 billion euros) of gross value added in the local economy (Oxfordshire LEP 2014a). The ratio of private to public investment ('leverage') in this plan is more than 9 to 1.

Despite having pockets of social deprivation, Oxfordshire's population is generally affluent and well-educated. The county is also home to a large number of voluntary groups, with a high concentration of place-based organisations interested in low carbon futures (Parag et al. 2013). Community-owned projects for renewable energy (where large numbers of local people each invest relatively small amounts of money) include a wind farm and large solar array at Westmill. A community share issue for investment in a micro hydro generator in the river Thames at Osney Lock was quickly over-subscribed in 2014.

Oxfordshire's knowledge economy and growth agenda

Oxfordshire has the third highest concentration of research and development workers in the country after Cambridgeshire and Hertfordshire. It is home to two leading universities (the University of Oxford and Oxford Brookes University), as well as a

group of large science and other research facilities. Its highly skilled labour force has a higher proportion of graduates than any other English county (47 % in 2012 compared to a UK average of 34 %). The relatively high prevalence of research and development and highly skilled workers is reflected in the make-up of Oxfordshire's economy which enjoys a high degree of specialisation in creative, knowledge intensive and high tech sectors.

Gross Value Added (GVA) per person is well above the national average. The number of unemployed in Oxfordshire has been consistently below national and regional averages. New enterprises in Oxfordshire have a higher survival rate than the average across the South East region and across England. Oxfordshire is ranked 7th in the country in terms of gross disposable household income.

In the context of this relatively wealthy knowledge economy, local organisations, strategies and plans emphasise a framework of "growth through innovation" (Oxfordshire LEP, 2014a).

In particular, the LEP's Strategic Economic Plan (SEP) identifies an investment need to 2030 of £6.3 billion (8.7 billion euros) in order to provide over £6.6 billion (9.1 billion euros) of additional gross value added (GVA) and 85,000 jobs, and three priority localities – Science Vale Oxford (Harwell–Milton Park–Didcot), Oxford and Bicester, which together make-up Oxfordshire's "knowledge spine" (Figure 2). The SEP also identifies tourism and leisure as a sector for growth potential. A commitment to improve broadband connectivity is made in the SEP, not only to support local businesses, but also to make more rural parts of the county (especially in the north and west) more attractive for business start-ups.

Local economic and development strategies and plans support this growth agenda. These include the Strategic Economic Plan, but also others: two plans for use of national government funding for economic development – the Oxfordshire Growth Deal (Oxfordshire LEP 2014c) and the City Deal (Oxford City Council et al. 2014); plans for use of EU investment, European Structural Investment Fund Plan (Oxfordshire LEP, 2014b); and plans for the development of key infrastructure, Oxfordshire's Local Transport Plan (Oxfordshire County Council 2012) and the nascent 'Smart City' strategy (Oxford City Council 2014). These consistently headline the roles of innovation and the 'knowledge economy', but with less emphasis on low carbon specifically and certainly no real sense of the scale of economic change implied by a low carbon transition.

More specifically, the City Deal sets out plans for investment in a network of innovation and incubation centres, building on the intellectual assets of Oxfordshire's universities and scientific research facilities; as well as investment in innovation business support, new housing, new transport schemes (the Enterprise Zone, the Northern Gateway and the first phase of the Science Transit scheme), and investment in 500 new apprenticeships (Oxford City Council et al. 2014).

Figure 2. Map of Oxfordshire highlighting the Knowledge Spine linking Harwell, Didcot, Oxford and Bicester (Oxfordshire LEP, 2014a). Map provided with kind permission of Oxfordshire County Council.

Oxfordshire's infrastructure: transport, housing and energy systems

Oxfordshire's long history in the automotive industry continues to this day, from early innovators and investors such as William Morris to current employers such as BMW Mini and a healthy and bourgeoning supply industry of innovators in low carbon technology. More than a third of local buses are hybrid electric vehicles. Oxfordshire is still in its infancy in terms of building a charging infrastructure for electric vehicles (EVs), but it has fostered a cross-sectoral network of stakeholders, following the successful trial of BMW's electric MINI E in the county in 2010–2011.

Oxford has a well-developed bus system, including a comprehensive park and ride (P&R) network, with benefits to jobs and the local economy. Oxford has a significantly higher cycling prevalence than the rest of the country, with around 10 % of adults usually travelling to work by bicycle (2 % in England) (ONS 2014). The Oxford Transport Strategy (OTS) has over the past two decades significantly reduced the number of car trips to the city centre, largely through a combination of demand management and accessibility measures.

Existing plans under an integrated transport 'living lab' (MobOx) aim to create know-how and technology that can be transferred to similar city centres in the UK, focused on innovative improvements to P&R bus services (including better integration with other modes; better ticketing and information systems; new P&R hubs closer to journey origins).

In relation to housing, the headline figure of Oxfordshire's need to provide 100,000 new homes by 2031 is regularly quoted in local news media. This figure is based on an estimate in the SHMA, which takes account of the backlog of unmet demand for housing as well as the new demands which would arise from increasing economic growth, leading to the arrival of more workers (and their families) seeking to move from outside Oxfordshire in order to take up the new jobs. The 100,000 figure

has been opposed by some local politicians, who argue that the method of the SHMA estimate is flawed. The town of Bicester is set to increase in size, with 6,000 new homes planned in two extensions to the existing town. Oxford Brookes University has strengths in post-occupancy evaluation of building energy use, and the principles of monitoring and evaluation are well integrated into many of the plans for Bicester through a partnership called the Bicester Living Lab (http://bicesterlivinglab.org/).

The combination of housing shortage and ambitious economic growth plans places significant new pressures on a housing system which is already under strain. Even more pressure is applied by the further requirements to overcome the design-performance gap and achieve market breakthrough for sustainable energy solutions. And yet, this is what is needed if the dual goals of economic growth and carbon emissions reductions are to be met. Most of the media and political focus on housing in Oxfordshire is around the provision of new homes, particularly the question of where new developments should take place. Despite the efforts of a few innovators, Oxfordshire's record on building renovation and energy efficiency is not particularly well developed.

The south of Oxfordshire has been a centre of excellence in energy research and technology since the 1940s, initially focussing on nuclear energy, but in recent decades with a stronger focus on renewable energy and energy efficiency. The area was also the home of two large conventional, fossil-fuelled power generation at Didcot – a 2,000 MW coal-fired power station (which closed in 2013), and a 1,360 MW gas-fired station (planned for part closure in 2023).

The resulting expertise and commitment to clean energy catalyzed a significant strength in civil society energy projects. There is also a very large energy research activity in the University of Oxford and significant energy-related research on buildings and planning at Oxford Brookes University. Further along the innovation chain, there are some ground-breaking developments in Oxfordshire, e.g. the University of Oxford spin-out company Oxford Photovoltaics, which has world leading expertise in perovskite PV technology, and research expertise in energy storage (e.g. batteries and hydrogen), synthetic fuels, control systems and data analysis.

THE ECONOMIC ANALYSIS

Analysis of national economic statistics was commissioned from economics consultants, Vivid Economics. As reported in the final report (Vivid Economics, 2014) this analysis used the concept of comparative advantage (CA), based on employment numbers obtained from the Office for National Statistics (ONS 2013). For any given economic sector, the proportion of the total workforce in Oxfordshire is compared with the proportion at a national level (statistics for the UK are not easily aggregated so employment data for England serves as the national comparison). If the proportions are the same, the CA value is 1, indicating that Oxfordshire is no different from the national average for that sector of the economy; a value below 1 indicates a sector where Oxfordshire employs relatively few people compared with national figures; and a CA value of more than 1 indicates a sector where Oxfordshire employs relatively more than the national average. Formally, CA is derived as:

Comparative advantage in sector i (CA_i)
= $Oxfordshire_i$ / $England_i$

Where $Oxfordshire_i$
= number of employees in sector i in Oxfordshire
/ total number of employees in Oxfordshire

And where $England_i$
= number of employees in sector i in England
/ total number of employees in England

Oxfordshire's economic strengths and low carbon potential

The analysis of CA was carried out for Oxfordshire's economy in general (all sectors), showing that the county's main strengths lie in tertiary education, health care, research, engineering, publishing, market research, motor vehicle manufacturing, and advertising (Figure 3). Within Oxfordshire's wider knowledge economy, Oxfordshire has significant and growing low carbon sectors. Low carbon sectors generated £1.15 billion (1.6 billion euros) worth of sales in Oxfordshire in 2013 and employed 8,800 workers, contributing 7 % of GVA in 2011. Between 2011 and 2013, sales and employment increased by 10 % and 5 %, respectively.

With a CA of over 10, tertiary education is the stand-out sector, where Oxfordshire has established strengths. In contrast, none of the sectors in the category of 'environmental goods and services' has a CA of more than 1.4 (Figure 4). However, within that classification, it is possible to discern sectors with some comparative advantage – including building technologies, nuclear power and wind (mainly systems and equipment manufacture and supply) alternative fuels, and alternative fuel vehicles. Together these four sectors employed 4,000 people in Oxfordshire in 2013 – nearly 2 % of the county's workforce.

This analysis throws up a problem which we have not yet managed to resolve: the categories used in compiling economic statistics do not map easily or well onto what we understand to be involved in 'low carbon'. To take the example of tertiary education, it seems intuitively obvious that not all of university-based education is focused on creating a low carbon future, but nor does it seem correct to discount completely the importance of education in preparing for a low carbon future. And yet, no estimate exists of the fraction of 'tertiary education' which could realistically be counted. The classification of the statistics does not match the task we have taken on very well, and yet we have used those statistics because nothing better exists.

SCENARIOS TO 2030

Moving on from the snapshot of Oxfordshire's economy using economic data, three scenarios of possible futures to 2030 for Oxfordshire's low carbon infrastructure were developed. These scenarios are intended to help us explore and quantify some of the strategic decisions which would need to be made to set Oxfordshire on a path to 2030 which is both 'high growth' and 'low carbon'. Because of time and budget constraints, these scenarios were developed using expert judgement by the report authors, rather than any more rigorous method. None of the scenarios should be seen as a forecast or prediction, but instead the scenarios allow different possible development and investment strategies to be communicated and compared. The scenarios focus on key development measures for the county, including low carbon vehicle deployment, sustainable transport provi-

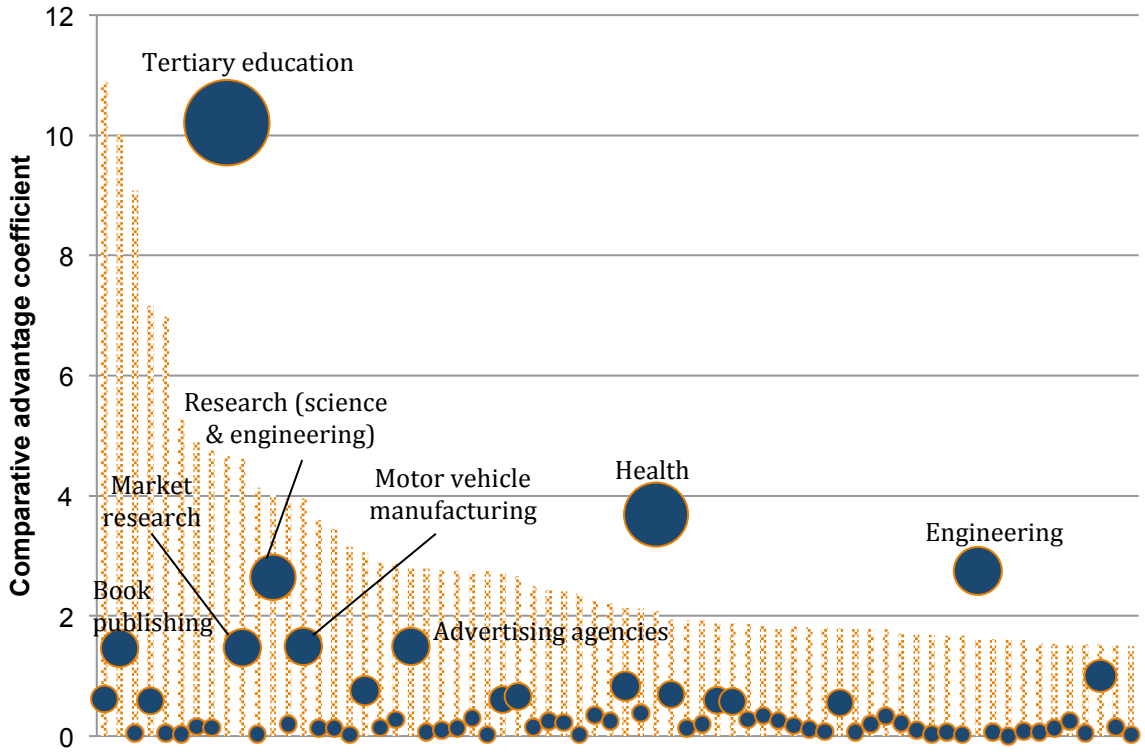

Figure 3. Economic strengths of Oxfordshire, based on comparative advantage and numbers employed in 2011. Note: The size of the bubbles indicates the relative size of employment for the sector. Employment data obtained from the Business Register Employment Survey (ONS, 2013).

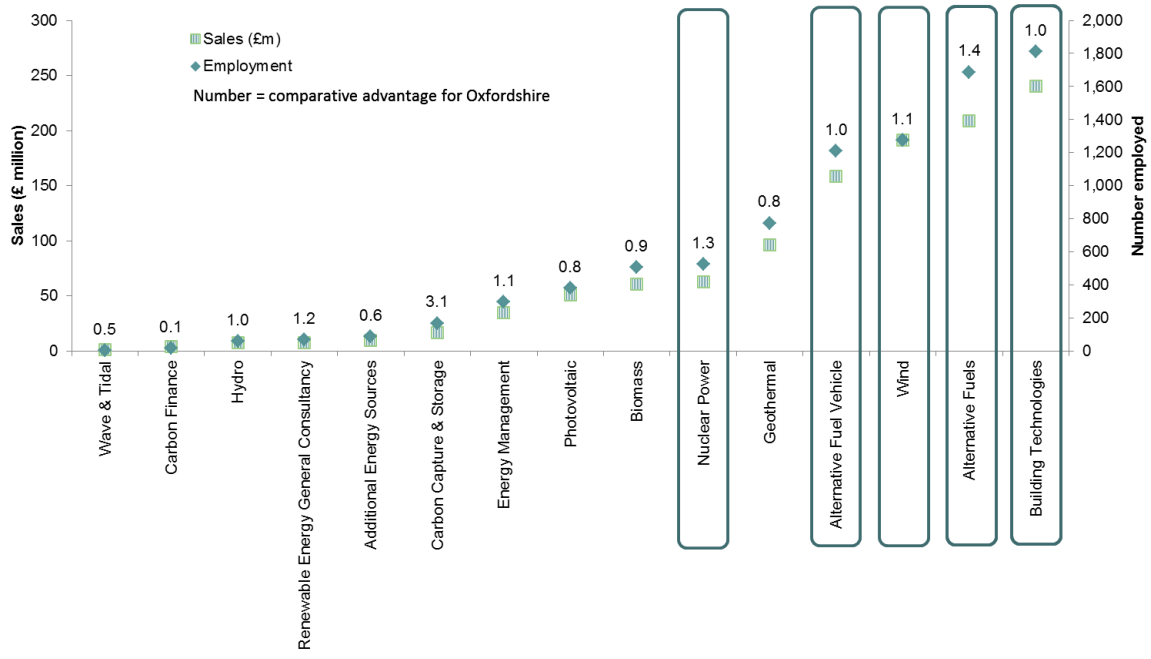

Figure 4. Top sectors for Oxfordshire within the category of 'environmental goods and services', based on comparative advantage and scale (sales and employment). Note: Circles indicate strength of the sector as a combination of high comparative advantage and/or higher existing level of activity in the low carbon economy. Source: Vivid Economic (2014).

sion, new low carbon housing, low carbon renovation of existing homes, and increased renewable energy deployment.

Scenario A represents 'business as usual', with broad continuation of recent trends and inclusion of *firmly* funded policies; scenario B includes all the new development plans which are not yet realised, but which have reached an advanced stage of planning (examples include: the upgraded rail line for future train services between Oxford, Bicester and London Marylebone; and plans published by the City and District Councils for new housing); scenario C is more ambitious than A or B, in terms of both economic growth and carbon emissions reduction. The scenario storylines, key modelling assumptions, data inputs and methods are described in detail in Patrick et al. (2014). Key input variables for the three scenarios are given in Table 1.

The results suggest that additional investment in low carbon business sectors and infrastructure can generate significant numbers of jobs and economic output. In the most ambitious investment and abatement scenario tested here (scenario C), additional investment of about £300 million (413 million euros) a year could generate an additional 11,100 jobs, adding economic value (GVA) of about £1.35 billion (1.9 billion euros) a year in 2030. The relative scale of the three scenarios is shown in Figure 5.

Knowledge Exchange

Collaboration has been a feature of this project, from its early inception as a joint piece of work between ECI and LCO, right through to the (ongoing) work to provide some of the coordination required to turn words on the page into action on the ground.

The report was published in October 2014 but officially launched in December 2014. The role of LCO in coordinating relevant stakeholder groups has been instrumental in making the report more than just a publication. The leader of Oxfordshire County Council gave a speech at the report launch at Oxford University's business school, and answered questions from the audience of about 60 people, who attended (from about 300 invitees). Other speakers at the launch included the university's Director of Energy Research (itself a recently-created post to better coordinate research activities which tend to operate in silos).

Coincidentally, the ECI has another initiative (called AgileOx), which aims to foster better links between local stakeholders and the research community working on environmental science (in the broadest sense). Funding from a university-administered start-up budget has allowed AgileOx to appoint a coordinator to help with this work.

Using expertise in the university's press office, the report attracted local media coverage (TV, radio and the local newspaper). We also produced a 5-minute video, which summarises the key messages of the 92-page report.

Two of the report authors presented key ideas from the report to Council officers in order to inform the specification of a call for proposal to a £2.5 m (3.4 million euro) fund strategic investment fund for low-carbon projects in the county.

The idea of a series of living laboratories to prove low-carbon initiatives in real-life settings has been welcomed by the Oxford Civic Society (a voluntary community organisation) and its consultants, Urbed, who wrote a report on the future of Oxfordshire in 2014 quite independently of our report. There has also been interest in the idea from other groups promoting Oxford as a 'smart city', with a possible overlap of interests in the use of communications technology for monitoring and demand side management.

The economic potential for the construction sector of investing in low-carbon infrastructure was emphasised in a presentation to the Oxfordshire Construction Training Group (http://www.theoctg.co.uk/). At the time of writing, similar strategic links are to be explored with the Oxford Strategic Partnership, a group of senior managers from local government and major employers seeking to help guide the city's future.

None of these points of contact have led to major projects, nor is that to be expected, given that the report is only three months old at the time of writing. However, this short account of knowledge exchange activities illustrates the efforts that have been made to engage different stakeholder groups to date. These activities are set to continue indefinitely, although such work is still dependent on securing ongoing funding.

KEY CONCEPTS

At several points in the project we encountered many words and meanings which were unclear or contested, or both. Although we suspected that certain key concepts would need to be defined in the writing of the report, we were not able to predict which terms would be the most important. The following emerged as the key concepts, and we found that a shared understanding (even imperfect) was needed for the interdependent tasks of explaining what we were trying to say and building support for the work among stakeholders.

Low carbon

We observed early on that many stakeholders talked about 'low carbon' as a specific (and separate) sector of the local economy to other sectors. This understanding of 'low carbon' focused mainly on technology firms whose products either increase energy efficiency or generate energy from renewable sources, and is supported by, for example, government departments, who emphasise low-carbon supply technologies in their definition of 'low carbon', with little or no account taken of energy demand reduction. Our research experience and our work on scenarios for the report led us to a very different view, in which 'low carbon' is not a sector at all, but a characteristic of the whole economy, implying changes in technology and society much more broadly. In this context, a 'low carbon transition' is not just the development of some new clean technology sectors (although these are certainly needed), but rather an outcome of the structure and priorities of all economic activity (and other activity that lies outside the exchange economy, such as management of the home, leisure and volunteering). The two different views of what counts as 'low carbon' emerged also in the debates about comparative advantage. Using government statistics allowed us to compare Oxfordshire with national data, but it also tied our analysis into a classification system for economic activity, which did not match our own understanding of what would be needed to achieve low-carbon outcomes. Partly, this problem is linked to the use of scenarios to imagine radically different futures. The standard classification of 'energy and environmental services' does not include many mainstream economic sectors (e.g. construction, transport), which are central to a low carbon future.

Table 1. Assumptions for the development of the three scenarios.

2030 scenarios	A	B	C	Key assumptions / rationales
HOUSING				
New homes				
No. of new homes by 2030	37,000	50,000	100,000	
Energy standard for new homes per unit floor area, kWh/m^2.year	50	40	30	NB many building technologies can contribute to achieving the standard
Renovation of existing homes				
No. of existing homes renovated per year	40	400	4,000	
Energy standard for renovations per unit floor area, kWh/m^2.year	100	80	60	NB many building technologies can contribute to achieving the standard
TRANSPORT				
Alternative vehicles & fuels				
Average No. new vehicles per year	33,450	34,417	38,133	Most are new cars; figures also include new vans, trucks & buses
Share of EVs in *new* fleets	1 %	10 %	25 %	Figures for buses are double: 2 %, 20 %, 50 %
Automotive cluster activity				
Automotive production growth in 2030 (compared with 2014)	150 %	150 %	200 %	
Proportion of new production that relates to low carbon vehicles	10 %	25 %	50 %	
	A	B	C	Key assumptions / rationales
INFRASTRUCTURE				
No. of EV home charging points installed by 2030	1,000	10,000	30,000	Up to 6,000 per district area, costing £700 (962 euros) each, spread over 15 years
No. of public DC fast and AC slow charging stations	10	100	300	Up to 5 DC and 55 AC per district area, spread over 15 years
Mass rapid transit (km)	–	–	50	Oxfordshire Busway modelled on Cambridgeshire Busway
Cycling infrastructure (km)	–	50	200	Includes cycle routes, bridges, tunnels, interchanges & a bike hire scheme.
Influencing travel behaviour				
No. of personalised travel plans for all homes (new and existing)	3,100	32,300	373,000	Rising to 100 % coverage in scenario C
ENERGY SUPPLY				
Renewable heat supply, GWh	63	258	2183	
Renewable heat as a percentage of total heat demand	1 %	5 %	40 %	
Renewable electricity supply	539	842	2052	A=committed projects + new buildings; B=A+20 % of other potential; C=full potential
Renewable electricity supply as a percentage of electricity demand	15 %	23 %	56 %	

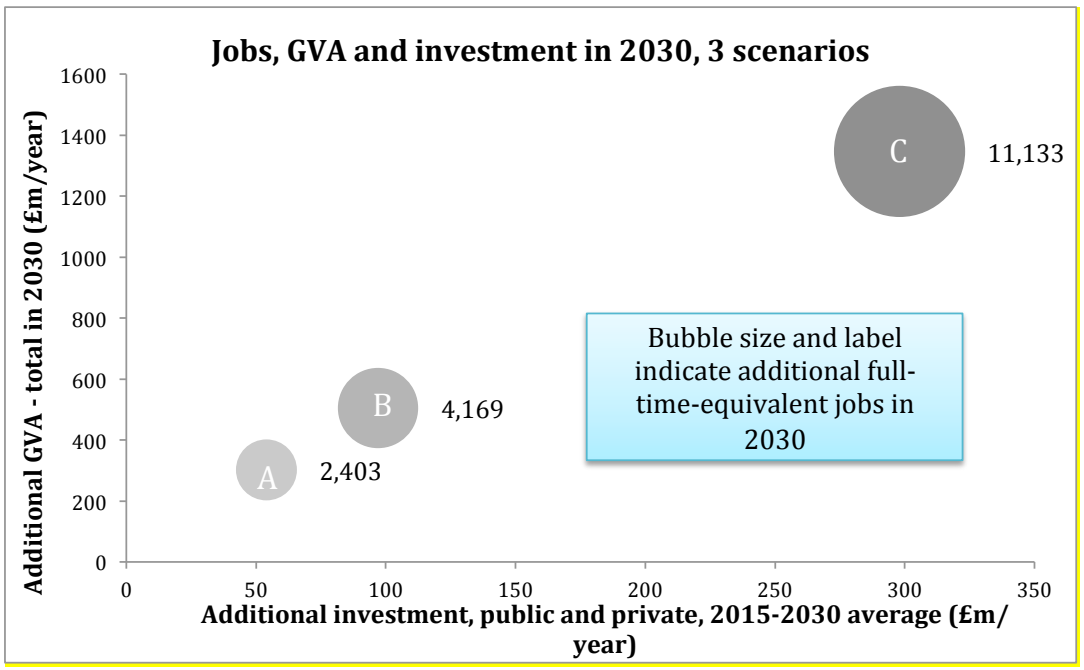

Figure 5. Additional GVA and jobs over additional investment in transport, housing and energy infrastructure – three scenarios.

Table 2. Types of collaborative partnerships in a low-carbon ecosystem.

Name	Types of members	Focal point
cluster	firms	technology development (how to create/improve a technology)
network	clusters, firms	market development (how to increase technology deployment)
living laboratory	networks, users, policy-makers	outcomes in real-life settings (e.g. how to enhance a particular town or place?)

Clusters, networks and living laboratories

Linked to the idea of 'low carbon' being a separate economic sector, we encountered many suggestions for greater coordination through clusters and networks. These terms were not narrowly defined, but rather captured the sense that economic sectors each have their own special interests and constituents, for whom coordination is generally beneficial. Given that our understanding of 'low carbon' was much broader, we found the need to define the vague uses of 'cluster' and 'network' which we came across, and to propose another term which reflected better what we saw as the pervasive nature of low carbon activity in a local economy. The term we used was 'living laboratory', borrowed from a movement of different real-life experiments around the world (Pallot et al. 2010). An original categorisation of coordinated groups was therefore proposed, defining the differences (and possible links) between clusters, networks and living laboratories (Table 2).

Innovation, investment and infrastructure

The 'three Is' (innovation, investment and infrastructure) were used early on in the framing of the project to summarise the approach that the project team wanted to take, and it proved useful throughout the process of writing the report and engaging with stakeholders. Innovation has proven to be a key term, because it fits very well with the economic growth agenda of the LEP, and it also resonates with Oxfordshire's strengths in high-tech and knowledge-intensive technology sectors. However, our understanding of 'innovation' encompasses more than new technology, and the term has been used to communicate the need for new business models and working practices in different industry sectors, just as much as the need for new technologies.

The question of investment also underpinned the work, leading us to quantify the amounts of money needed to bring about the low-carbon transition which the report described. The sum of £300 million (413 million euros) additional annual investment implied by Figure 5 is seen as worryingly large by some stakeholders, notably those dealing day-to-day with the implications of public sector budget reductions. In practice, it is a relatively small fraction of total annual investment expected in the County. This mismatch of perceptions led us to drawing up a long and quite varied list of sources of investment, ranging from venture capital for technology start-ups to funding by major infrastructure providers and productive investment by 'ordinary' businesses and households. Many of the stakeholders with whom we engaged were familiar with a subset of all the possible sources of finance, but relatively few had an overview of all the different possibilities, and how they could be combined for maximum effect. This reinforces the importance of thinking about the 'low carbon agenda' as

a challenge and goal for society as a whole rather than a new economic sector with a small number of beneficiaries. In our experience, local stakeholders tended to think of 'low carbon' as a stand-alone (and exclusively technological) sector. Nor did our engagement with stakeholders stimulate any concerted debate about the potential costs of inaction. The implicit assumption was that the future costs of climate adaptation did not count, did not matter, or were perhaps too difficult and uncertain to grasp.

Finally, infrastructure was a recurring theme in the report and also in debates about the future. This is perhaps unsurprising, given that Oxfordshire's transport networks are already operating at (or beyond) capacity, and given the fact that new housing development is such a prominent local issue. The report used the concept of infrastructure investment as a way of articulating the current (and growing) pressures on existing systems and as a way of envisaging a better future.

Discussion & conclusions

Our experience of this work is that developing low carbon strategies for local economies that are likely to be convincing is not a trivial exercise. Of course, it is simply possible to 'downscale' European or national strategies to determine the 'fair share' for a city or region. However, this is not likely to be convincing to local decision makers, as it fails to recognise the economic granularity with which decision-makers will be familiar and tends to underplay the local autonomy they have and want. Any effective strategy will need to start from the key priorities and challenges that these decision makers face day to day, not the remoter challenges of global climate change.

Any effective local strategy will need to build upon some aspects of current economic strategy and seek to develop some level of consensus among important local stakeholders. Of course, any low carbon strategy will have uncomfortable aspects for some stakeholders – that is implicit in the nature of change. A low carbon strategy cannot dissolve existing tensions, for example between opposing political parties or alternative visions of local development. However, at least for stakeholders who recognise that the low carbon challenge will need to be addressed, our experience is that it will be more effective to build on whatever elements of analysis and vision exist. Our strategy of building on issues of broad consensus means that more radical ideas (such as the pursuit of a new economics, in which growth is not assumed to be always desirable) do not feature in this work. The hegemony of neo-classical economics is unquestioned here, although we acknowledge that it can be, and is, questioned by others (e.g. Jackson, 2009).

In the case of Oxfordshire, our analysis starts from the existing economic agenda of developing a strong knowledge economy and showing how low carbon development can be integrated into this, and even enhance it. Our own analysis indicates that this is a convincing description of the strengths of the Oxfordshire economy, but, perhaps more importantly, key political and business stakeholders recognise the vision and discourse. That is not to say there is no opposition to the planned levels of economic growth and housing, the scale and patterns of development they might imply or to the emphasis on high-skilled jobs. But promoting a completely different strategy would be a much more difficult task.

Our most ambitious scenario showed that current levels of investment in low carbon in Oxfordshire are insufficient, and would need to grow by perhaps two orders of magnitude. At the same time, the economic analysis suggests that the leverage of public funding to private investment would be positive, with a ratio of approximately 1:4.5. The simple statement in economic terms says nothing about the quality of work needed to support that investment, and there is perhaps a danger in this kind of project that the reduction of complexity to a simple 'leverage' figure may be misleading. We note, however, that much economic analysis does seem to follow this model of distilling surprisingly simple numbers from complex reality. Our figures seem no more or less plausible than those of other studies, and the numbers are familiar and expected among the kinds of stakeholders with whom we sought to engage.

The type of study described in this paper about Oxfordshire might be broadly applicable to other regions of Europe with major universities, high technology research and knowledge based economies. In other cities and regions, there may need to be more emphasis on other types of economic activity (e.g. manufacturing, tourism, primary industries, energy-intensive industries), so strategies will need to be significantly different. However, we think it is likely that some of the same issues are likely to recur in most locations, notably the linked issues of investment needs and the breadth of economic transition required.

However, we suspect the process we have followed in developing the strategy is applicable more widely. In particular, two points of process have been critical to getting as far as we have in developing a shared low carbon strategy. The first is to ensure that the analysis is sound and adequately reflects the particularities of the local economy, so that the proposed ways forward are recognisable as reasonable. The second is to work with local stakeholders in the process of developing the analysis, so that the results have 'no surprises'. Indeed, the report for Oxfordshire would not have come about without the original initiative from the Low Carbon Hub and Low Carbon Oxford, whose role in stakeholder engagement has been instrumental in creating and supporting the broad base of support for the initiative.

One element of the strategy we suspect will be reflected quite widely is the inevitability of change and being prepared for it. In general, decision makers already understand that they need to respond to global changes. They already think about risks and opportunities: low carbon is just an additional dimension. So we have found them receptive to the idea that they need to prepare their city or region for change at least as well as other regions and cities, and that leading rather than lagging is a sensible strategy.

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