

Toward Low Carbon Cities: Madrid and London

Why choose Madrid and London to discuss low carbon cities?

Madrid and London are both big cities for European conditions. Their metropolitan character, building stock, airports and motorway networks, and status as international hubs add considerably to their ecological footprint. If they manage to curb their CO₂ emissions they will have a noticeable impact on climate change.

Could Madrid and London become low carbon cities?

Spain and the UK have set stringent targets to reduce CO₂ emissions and have taken concrete actions to implement them. They have allocated fundsⁱ, introduced changes to their own building and rolling stock and pledged to reduce their own wasteful energy use.ⁱⁱ Their campaigns have raised awareness among citizens and businesses to change their behaviour toward energy consumption,ⁱⁱⁱ and they have launched actions to mitigate and adapt to climate change in all key sectors.^{iv} Madrid and London have adopted similar targets and measures. Will they suffice though to transform them into genuine low carbon cities or 'eco-cities' in the long term.

1. The Critical Path toward 'Eco-Cities'

In answer to the questions of this paper, it is necessary to define first what is meant by 'low carbon' or 'zero carbon' city or, more generally, by an 'eco-city'.

1.1 Defining Eco-Cities

What is an 'eco-city' and where does the notion come from?^v Early settlements in Mesopotamia^{vi} may be their precursors as they serve the collective needs of their communities with local natural, renewable materials. Such vernacular architecture^{vii} remains an inspiration for 'eco-design'.^{viii} Is living in sustainable symbiosis with nature feasible in an urbanised world? In the developed world, Jane Jacobs^{ix} considered that cities which are integrated with their immediate hinterland are drivers of prosperity and capable of revitalising nature in overloaded rural areas. The American eco-city movement proposed alternative solutions for city planning.^x Richard Register^{xi} coined the term ecocity in 1987. His 'Ecocity Builders'^{xii} defined an ecocity as ecologically healthy: "an ecocity is a human settlement that enables its residents to live a good quality of life while using minimal natural resources". They perceive Paolo Soleri's Arcosanti in Arizona as the prototype of such an ideal ecocity. The European Union ecocity project on "urban development towards appropriate structures for sustainable transport" incorporated the sustainability visions of the participant cities, while the ecological cities movement produced international manifestos.^{xiii}

The ecocity concept is gathering momentum in the developing world. For Akhtar Chauhan^{xiv} a sustainable living environment is "based on climate responsiveness, appropriate use of technologies, and innovation of sustainable environmental design". China is committed to realising ecocities, the most publicised among them Dongtan in the Shanghai conurbation and Tianjin ecocity, planned in cooperation with Singapore on a salt pan near China's third largest city. Curitiba is Brazil's avant-garde ecological capital with its ecological public transport system and university of the environment. Porto Alegre follows participatory eco-principles from the bottom up. African countries are starting to adopt ecocity principles; and the Middle East is preparing an "eco-friendly future after oil" with ecocities like Masdar in Abu Dhabi.

At a more abstract level, the concept of eco-cities draws on analogies with biology and the notion that successful ecosystems are driven by innovation and shaped by human intervention. Ecocities constitute a context in which human beings can adapt and evolve. At a large scale, ecocities constitute whole Ecosystems of Innovation.^{xv} Their integrated design facilitates continuous and complex interactions and information flows, the key ingredients of innovation driven by intellectual exchanges and synergies which assist cities in their

transition to a knowledge society. In operational terms, ecocity design applies ecological technologies to the built fabric and combines high quality public spaces with sustainable mobility and nature. The biggest challenge is to transform existing cities into 'eco-cities'.

1.2 Eco-Deficit of Cities

Environment and energy are two sides of the same coin. Cities are the major consumers of fossil fuels which have risen from 4% of global energy consumption in the early 1900 to over 86% at present, notwithstanding indirect city related activities such as air travel, intercity road freight and passenger transport, logistics; food, goods and construction material production, import to, and distribution in cities; energy generation and transmission; commuter movements to jobs in and outside cities. Madrid, for example is 97% energy dependent, of which 62% petrol based products, 17% natural gas and the rest electricity.^{xvi}

For all these reasons cities play an inordinate role in greenhouse gas emissions. Mitigating CO₂ emissions and adapting to climate change are essential at city level, just as is preventing and reducing damages from potential climatic repercussions, such as flooding, water shortage, heat islands,^{xvii} heat waves, sudden cold spells or storms. It is essential that cities curb waste, manage their full water cycle and contribute to renewable energy generation. They have to become 'low carbon', 'zero carbon', 'eco-cities'.

City and related hinterland activities amount easily to two-thirds of total energy consumption, with corresponding contribution to environmental pollution and greenhouse gas emissions. It is imminently sensible to establish more ecologically sound principles for the construction of new urban settlements – 'eco-cities', 'eco-towns', low carbon or zero carbon cities, also 'eco-villages' and eco-neighbourhoods.

However, in relation to existing cities, new buildings, and even eco-towns represent a minute addition. Thus, introducing the principles which underpin low carbon cities to existing cities and sustainable urban regeneration is of the essence if greenhouse gas effects are to be stabilised or, better still, reduced. Efficient equitable use of energy^{xviii} and climatic design^{xix} were adopted by the international community.^{xx} Even the intergovernmental OECD has directed its attention to ecological city design and management in the light of climate change^{xxi} by embracing the notion of 'eco-city'.

1.3 Mitigation and Adaptation to Climate Change

In view of the urgency to stave CO₂ emissions all instruments are being mobilised to reduce emissions at source and to adapt existing emissions. How are mitigation and adaptation to climate change incorporated in policies?^{xxii}

Mitigation consists of reducing the rate of carbon emissions into the atmosphere to manageable sustainable levels. Measures include: promotion of lifestyles less dependent on fossil fuels and releasing less carbon into the atmosphere (less car use and air travel, lower indoor temperature to reduce space heating, switching off stand bys, lights, computers, etc.) more efficient use of energy and less waste (energy efficient appliances, less packaging, less food waste, local procurement, etc), widespread use of renewable energy as alternative to fossil fuels, in sum curbing energy and finite resources use at source.

Adaptation is the capacity to respond to the impacts of climate change. e.g. through design and construction of buildings (better foundations to resist subsidence and flooding, comfortable environments at higher temperatures without mechanical cooling and air conditioning, energy efficient appliances, better insulation, etc). Adaptation also includes carbon capture and sinking, as well as fiscal and economic measures, such as carbon trading.^{xxiii} The earlier these measures are taken the cheaper they are.^{xxiv}

1.4 *Measuring Environmental Qualities of Eco-Cities*

The effect of such methods of reducing ecological footprints are difficult to capture in quantitative terms. The contribution of cities to CO₂ emissions tends to rely on intuitive estimates as ‘global warming’ is a complex phenomenon with a myriad of compounding and contradictory effects. Lack of empirical data and knowledge about energy flows and consumption, adverse environmental effects and externalities impede on the conceptualisation of eco-cities.

Are eco-cities feasible on green field sites or do existing cities have to take the brunt of curbing adverse man-made effects on climate change?

Adopting the principles which underpin low carbon cities to existing cities and sustainable urban regeneration is imminently sensible to stabilise or reduce greenhouse gas effects. However, understanding how large existing cities function as ‘ecosystems of innovation’ is still rudimentary and limits remedial, preventative or palliative interventions. In this sense Madrid and London could operate as huge laboratories in identifying effective actions and discarding those with adverse side effects, including economic ones.

2. **The Climate Change Context of Madrid and London**

Both Madrid and London benefit from the political commitment of their respective national governments to international CO₂ emission reduction targets which they sometimes even exceed. Cities, and in particular the capitals Madrid and London are of the essence to achieve national goals, as they house 7.1% and 14.4% of national population, produce 8.3% and 21% of national GDP, and emit 2.2% and some 8% pollution (green house gases and particulates) respectively. Ambitiously, they have set higher than national targets for CO₂ emission reductions^{xxv} although their recent development evolved in the opposite direction.

Comparative Table: population and GDP Spain – UK, Madrid - London

'Is State'	Spain	UK	Madrid	London
Population	46,157,822 (2008)	60,975,000 (2007 est)	3.273.006 (2008)	7.56 million (2007) [13% UK]
% migrants ethnic population	5,268,762 (2008)	6.3 million (2004 est)	571,864 (2008)	162,000 [2.14%] [39% of E&W]
GVA (gross value added, workplace basis) GVA per capita	GDP PPP 1.378 trillion US\$ (2008 est.) GDP PPP per capita \$34,600 (2008 est.)	GDP PPP 2.231 trillion US\$ (2008) 1.358 trillion £ GDP PPP per capita 36,600 US\$ (2008)	114,906,801 (2006) 30,094 (2006)	£ 251 billion (2007) [21% of UK total] 66% above UK average But 3rd deprived region

Sources: Madrid: National Institute of Statistics, List of Inhabitants, Madrid City Town, CIA World Factbook, London: Government statistics and inventories.

2.1 *Unsustainable Physical Development*

The physical development of Madrid and London has exacerbated their environmental deficit over recent times. Decentralisation onto cheaper land of back offices, logistic interchanges relying on road freight transport, decentralised university campuses, techno-parks, other specialised compounds of large corporate enterprises (financial institutions, the media, the military, etc.) were major drivers of urbanisation at metropolitan and city-region scales. Waste stemming from their energy consumption tended to affect areas beyond their administrative boundaries, and should form part of their own energy and ecology equation.

When manufacturing moved out of Madrid and London it remained connected by logistics and required new neighbourhoods for workers or infrastructure for commuters. Such production nodes tended to develop into urban agglomerations in their own right. Housing sprawl occurred with increasing affluence. Airports, seaports, and other productive concentrations, such as ‘brain-ports’ are energy consumers indirectly related to city end

uses. Both Madrid and London have been growing rapidly, due to demographic expansion and immigration, compounded by a buoyant economy until recently.^{xxvi} All these changes have increased the ecological footprints of both cities.

Comparative Table. Ecological footprints: Spain Madrid – UK - London

Ecological footprint	Spain	UK	Madrid	London
World average: 2.8 gha/capita	6.4gha/capita for energy consumption (1) deficit = -4.4 gha/capita	321,621,000gha 5.45gha/capita (deficit = -3.7gha/capita) re world average (2007)	gha/capita is 46 times greater than its area (2)	48,868,000gha 6.63 gha/capita (2007) GLA estimate (2003) 6.3gha/capita 9% of the UK deficit = -3.8gha/capita

Sources: Madrid: (1) Ministry of Environment, Rural and Maritime Areas, 2007, (2) Observatory of the Sustainability in Spain, 2009. London: Defra Inventory. City Limits. Environment News.

2.2 Renewable Energy

Renewable energies are arguably the most effective means to curb CO₂ emissions. The share of urban renewable energy generation and consumption is well below average in Madrid and London compared to their respective countries and the EU. Yet they could lead the way by making innovative renewable energy technologies a new dynamic force of their economies.^{xxvii} Their concentration of knowledge and wealth, their institutional base for investment into experiments and business development, their large internal market are providing them with a competitive advantage for 'eco' R&D, to bring new 'green' products to market and to mobilise technology transfer at a trans-national scale. As an estimated 60-80% of man-made carbon dioxide and other green house gas emissions are generated in cities, they are the obvious place for comprehensive climate change mitigation and adaptation, and in particular or innovative methods of using renewable energy sources.

2.3 Constraints of Turning Existing Cities into Eco-Cities

When cities are preparing pre-emptive or retroactive instruments to curb adverse effects on climate change they find it difficult to cope with the full complexity of energy consumption, pollution and interdependence with urban activities. City leaders in Madrid and London are committed to the holistic principles of sustainability. Yet, they tend to focus on specific effects, thereby sub-optimising their interventions and intervene separately at different scales. In targeted local areas they aim at individual buildings, their uses and mobility. At a larger scale, they intervene by sector or by type of remedial action. Acting at the level of the city as a whole they focus on general targets and strategies. Their greatest challenge is to deal with the city region and its hinterland which is absorbing the city's environmental footprint. Fulfilling their aim to turn their cities into eco-cities may be a very long term undertaking and will require the cooperation of all the life forces they can master.

2.4 Protagonists of Low Carbon Strategies

Intervening effectively to reduce CO₂ emission presupposes a host of prerequisites. Developers, designers, builders and estate managers can no longer apply their routine solutions and have to invent new ways of producing and using sustainable buildings and neighbourhoods. Committed leadership is essential to overcome the plethora of obstacles.

The political leaders of Madrid and London have started by reducing CO₂ emissions in their own activities and institutions as an exemplar for others. They offer incentives to attract the participation of other actors in implementing CO₂ emission reductions. As their own powers and resources are limited, they have to rely on the private sector and on citizen behaviour, while taking care of the most vulnerable members of society. Madrid and London have set up partnerships with city-wide institutions. They have created specialist agencies to combat

adverse climate change.^{xxviii} They cooperate with the lower tier local governments (Madrid Districts and London Boroughs) and the private sector on strategies, implementation and funding streams. They are aware that a wide ranging culture change is needed to generate and sustain the necessary momentum of handling the environment and scarce resources with greater care.

**Comparative Table. Energy consumption and CO2 emissions:
Spain UK, Madrid - London, overall, and per main sectors**

Is State'	Spain	UK	Madrid	London
Energy consumption	146,779 ktep (1) industry: 34% transport: 38% residential: 16% others: 12% (2007)	240 mt oil equivalent (2001) (1)	3.688 ktp (2) transport: 40% residential/commerce, institutional, agriculture: 51% industry: 9% (2006)	14,000 kt oil equivalent (1) Housing: [39% London total] Commerce Industry: [36% London total] (2006) Transport [36% energy consumption London total] (2006) (2)
CO2 emissions		-		-
Overall CO2 emissions	330.497 mt CO2 (2004) 1.2% world emission. rank17 442,321.56 ktCO2eq (2007) (1)	587.261mt CO2 (2004) 2% world emission rank 8 (3)	9,862 ktCO2-eq (2005) (3)	44.3 mt CO2 (2006). 8% UK total 76 mt CO2 incl aviation (4)
Housing (*)		42 mt carbon equivalent (2001) (5)	(*) includes commercial and institutional: 29% (2004)	16.7mt CO2 2.26 CO2 t/capita (2006) 38% total London CO2 emissions
Road transport		58 mt carbon equivalent (2001) (5)	53% (2004) (4)	9.6 mt CO2 (2006) (6) 1.38 CO2 t/capita (2006) 22% total London CO2 emissions
Commerce Industry Public sector (*)	Industry 7.38%	42 mt carbon equivalent (2001 industry) (5)	(*) for commerce and public sector see housing Industry and waste: 4.5% (2004)	17.9 mt CO2 2.87 CO2 t/capita (2006) (33+7% total London CO2 emissions
Other CO2 emissions	Energy sector 78.09% Agriculture 10.5% (1)	-		London Aviation 20 mt (2006) = Total London CO2 emissions 67 mt = 11 of total UK emissions
Waste	Waste 3.5% (4)	-	(*) see industry	25% (2007/08)

Sources: Madrid: (1) Observatory of the Sustainability in Spain, 2009 Report. (2) Energetic balance of the municipality of Madrid 2008. (3) GHG direct and indirect inventory. Madrid City Council, 2005. (4) Plan for the Sustainable Use of Energy and Climate Change Prevention 2008-2012. Madrid City Council. London: (1) LECl data 2003. Defra Inventory. (2) London Energy and CO2 Emission. (3) CityLimits. Wikipedia ranking. (4) The Mayor of London. Climate Change Action Plan 2006. (5) National Environment Technology Centre. (6) Department of Transport.

In Madrid, the Government Department of the Environment (GDE) has the responsibility for the implementation of the Plan for the Sustainable Use of Energy and Climate Change Prevention 2008-2010. As a strategic planning and coordination instrument, the plan's targets and design actions integrate the contributions of different municipal services, the GDE being the main driver. Depending on the type of measure, action is taken by different

Departments, mainly Urban Planning and Housing, Safety and Mobility, Municipal Housing and Land Company (EMSV), Public Works and Treasure and Public Administration. In terms of public transportation, the municipal companies of buses (EMT) and underground (Metro) also play an important role by incorporating less pollutant vehicles and extending the metro lines.

The Mayor of London and the Greater London Assembly, his scrutinising body, are responsible for devising CO2 reduction targets and implementation procedures London-wide. The Mayor has jurisdiction over the London Development Agency, Transport for London, the Metropolitan Police Authority and the London Fire and Emergency Planning Authority which can play a significant role in implementing CO2 emission reductions. They have mobilised knowledge on climate change, remedial actions and management advice for their implementation.^{xxix} The London Plan provides the framework for London's long term development. Measures to reduce CO2 emissions form part of the Plan, although they depend on many other players. The mayoral group is leading with actions in its jurisdiction, expecting London Boroughs and the private sector to assist in gradually transforming London into an eco-city. Implementation finance is being sought from the EU, the national government, local public sources and the private sector.

3. The Climate Change Targets for Madrid and London

National targets are of great importance for Madrid and London. Together with guidelines and incentives they are setting the framework for targets and implementation at city level.

Comparative Table: CO2 emission reduction targets Spain – UK

CO2 emission reduction targets	Overall	Housing	Transport	Industry/ commerce	Government own estate
Spain	14% by 2012 (2004 base)	13,1% building 11,7% domestic equipment	17,2%	8,9% industry others: 7,7% agriculture, 5,3% energy	22%
UK	-20% by 2010 -26% by 2020 -60% by 2025 -80% by 2050 annual targets foreseen (1)	15% improved energy efficiency by 2020 (2)	-34% by 2020 10% transport energy from renewable sources by 2020 (3)	40% electricity from low carbon sources by 2020 (4)	(base 1999/2000) offices: -12.5% (2010) vehicles: -30% (2020) -15% (2010) (4)

Sources: Spain: Action Plan 2008-2012. Ministry of Industry, Tourist and Commerce, IDAE, 2007. UK: (1) Department for Environment, Food, Rural Affairs. (2) Department for Communities and Local Government. (3) Department for Department for Transport. (4) Department for Business, Innovation and Skill.

3.1 National Targets: Spain

The challenge of climate change for Spain is particularly defiant, due to of its geographical position and socioeconomic conditions. As a result of the Kyoto Protocol Agreement^{xxx} Spain committed itself to limit the increase of its emissions to 15%. The National Climate Council, set up in 2001 under the Ministry of the Environment, drew up the "Spanish Climate Change and Clean Energy Strategy, Horizon 2007-2012-2020" as part of the Spanish Strategy for Sustainable Development. However, due to population growth and rapid economic development over recent years in 2005 the total green house gas emissions still represented 52.2% compared to 1990 levels. In response the Government limited the total increase to 37% for 2008-2012.^{xxxi}

The urgency to reduce green house gas emissions gave rise to the Plan of Urgent Measures, the 2008-2012 E4 Action Plan and the 2008-2012 National Plan of Emission Allowances. Other measures are the Spanish Air Quality Strategy 2007, the Technical

Building Code 2006, the National Climate Change Adaptation Plan 2006, and the Renewable Energy Plan 2005-2010. The Institute for Diversification and Saving of Energy (IDAE) is in charge of achieving the targets set by the 2007-2012 Action Plan. The Spanish green house gas emissions reduced slightly to 51,6% in 2007, putting Spain in the 5th place in the EU-27 region, behind Germany, UK, Italy and France.^{xxxii}

The Government is using two mechanisms of emission trading to reach the target of 37% increase: buying CO2 emission rights, mainly from Western European countries- Poland, Ukraine, Czech Republic, Latvia, Estonia and Lithuania - and promoting clean energy projects, mainly in Latin American countries. Spain has spent 479.8 million euros in CO2 to international institutions to compensate its excess.^{xxxiii}

3.2 National Targets: The United Kingdom

Climate change trends present serious challenges to the UK which is prone to more extreme weather, flooding, raising sea levels and land erosions, notwithstanding demographic pressures extending urban sprawl into flood planes. The government considers the transition to a low carbon Britain^{xxxiv} as an inevitable environmental and economic imperative.

Despite the recession the UK maintains its stringent climate change mitigation and adaptation targets in three key areas after public consultation and on the basis of a number of scientific^{xxxv} and economic studies.^{xxxvi} Under the Kyoto Protocol, the UK has subscribed to 60% cut by 2050 compared with 1990 levels, and intermediate targets between 26% and 32% by 2020. The considerably more ambitious 2008 Climate Act sets a target of 80% CO2 reduction over 1990 by 2050, with 20% intermediary reductions by 2010, in order to stabilise CO2 concentrations at 550 ppmv (parts per million by volume) and to limit global temperature rise to no more than 2°C, i.e. 65 MtC (million tons of carbon) reduction by 2050.

Renewable energy generation mainly from wind is targeted at 15% by 2020 from the base line 2008 when it was 1.8%. The UK target (below the EU target of 20%) is unlikely to be met and presently 10% are expected due to costs. Substituting with nuclear power is controversial, despite Lovelock's theories.^{xxxvii} UK greenhouse gas emissions (six including CO2) from transport were 40.3% of total UK emissions in 1990 (base line) and 43% in 2000. They are estimated at 45% in 2010 and 47.8% in 2020.^{xxxviii} The UK is not singling out a specific target for road transport CO2 emission reductions. However heavy investment in transport technology and behavioural change^{xxxix} is needed to achieve the UK overall goal of 62.2 MtC (550 ppm) with transport increasing to 41%; or more ambitiously of 31.1 MtC (450 ppm), with transport stabilising at 26%. By 2012 10% of new cars sold should have CO2 emissions of 100g/km or below; 600 or more buses coming into operation should produce 30% below average carbon emissions; and 25% CO2 reductions are planned for stop-start urban delivery by hybrid light vehicles. Reduction of 10% CO2 emissions from government vehicles have been achieved in 2006 (base = 2002/03).

3.3 City Targets: Madrid

Madrid is aware that climate change prevention is one of its main challenges, since its geographic location conditions exacerbate the effects of the emissions produced by urban activities and gives rise to periods of dangerous levels of pollutants. The first Ordinance to control the air contamination was adopted in 1968, followed by numerous measures. Following the dynamic existing measures at international and national levels, the first action towards the green house gas limitation was the General Ordinance for Urban Environment Protection 2002, followed by the Local Air Quality Strategy 2006-2010 in the preparation of the current Plan for the Sustainable Use of Energy and Climate Change Prevention 2008-2010 was proposed.

Comparative Table: CO2 emission reduction targets per key sector Madrid - London

CO2 emission reduction	Overall	Housing*	Transport	Commerce / public sector*	Other
Madrid CO2 t/year (Municipal Plan) (Other initiatives)	-728,419	*housing, commerce, institutional: -130,505	-111,631	* industry: -40,283	waste: -437,000 sink -9,000
Total	-2,604.08	-104.7	- 2,500		
	-731,023.08	-130,541.12	-114,131.1	-40,283	-446,000
London	-60% by 2025 -33 m t CO2 pa = -600mt (2007-2025) (UK -60% by 2050).	(1990 base) = -12.2 mt CO2 (-7.7 mt CO2 = realistic) -39% savings for London total by 2025 2004: meeting level 3 by 2010, level 6 by 2016. Code for Sustainable Homes	-7.1 mt CO2 by 2025 (-4.3 = realistic) -22% saving re London total by 2025	-13.7 mt CO2 by 2025 (-7.6 mt CO2 = realistic) -39% saving re London total by 2025	More than a third has to be contributed by government action to reach the -60% target by 2025. Energy supply 13.8 mt by 2025.
Potential savings of Mayoral Group: 133,400 t CO2 (GLA own)	2004: 15%by2010, 20%by2015, 25%by 2020, 30% by 2025. GLA demands targets for 2012, 2016 and 2020.				

Sources: Madrid: Plan for the Sustainable Use of Energy and Climate Change Prevention 2008-2012. London: The Mayor of London. Climate Change Action Plan 2007. Greater London Assembly Environment Committee. Energy Action Group. London Sustainable Development Commission. 1st (and last) report 2003. Energy sub-group. London Leaders 2008, 2009. The London Plan and its Alterations. The Mayoral Group: CO2 emission reduction targets for own emissions.

In contribution to the national Kyoto target, the goal of this Plan proposes 14% emission abatement by the year 2012 with respect to emissions in 2004. The Plan, with a budget of 101,229,000 euros, consists of 55 measures in five sectors of activities (residential, commercial and institutional, transport, waste management, and industry), together with transversal and adaptation measures and measures previously implemented.

Madrid took its own CO2 emission reduction measures. They include the creation of a Local Energy Agency, an Ordinance on sustainable energy use, quantifying emissions in municipal plans, legislation and technical regulatory framework, tax-related incentives, public assistance for promoting and co-financing specific projects, promotion of new market areas, products and technologies, voluntary agreements with different agents, information and communications.

Other municipal measures focus on housing, commerce, industry, institutions, waste, sink capacity and health. In the housing and commercial sectors, subsidies were put into place to replace diesel boilers, for the efficient use of domestic appliances, the installation of domestic infrastructure, and to foster energy certifications for buildings. For all types of buildings collective heating and air conditioning systems are supported, together with efficient lighting in buildings and streets, including traffic lights. More generally, the development of bioclimatic architecture in new and existing buildings is encouraged, as well as the setting up of eco-neighbourhoods.

Regarding transport, Madrid has instated a Cyclist Mobility Plan, drafted an Urban Mobility Plan, promoted alternative fuel supply, negotiated voluntary agreements with vehicle hire companies, set up a car sharing system, and limited the number of parking spaces in commercial buildings. It has also put into place European CUTE and BEST projects - buses powered by clean fuels - and Bioethanol in urban transport, designated Low Emission

Zones, and initiated the Madrid Walking Programme to recover urban areas for pedestrians. In the industrial sector energy efficiency auditing has been introduced, as well as certification and information, especially for SMEs. Efforts to improve sink capacity focuses on green roofs and the increase of forest mass. The future Local Urban Waste Strategy includes biogas production, besides the improvement of waste collection, infrastructure, disposal and management.

On a broader basis Madrid encompasses health issues. It assesses the risks of natural phenomena, monitors atmospheric pollutants, sets targets and instates containment measures. It has initiated a conservation and protection programme for areas of biological diversity. Foro Pro Clima Madrid and Fundacion Movilidad are two initiatives promoted by the City Council to gather private and public efforts for the climate change issue. Finally, 15 large enterprises have founded the CO₂ Action Programme in 2008. This is the first voluntary and multi-sectoral initiative in Madrid to reduce CO₂ emissions by 8,300 tons.

Madrid has also undertaken awareness raising campaigns aimed at the general public, the construction and industrial sector and municipal authorities regarding energy consumption. It also aims to curb green house gas emissions of the vehicles fleet by influencing drivers in the purchase of their new vehicles. They encourage collaboration with public and private agents and promote carbon neutral City Council events. Madrid is a member of the Large Cities Climate Leadership Group initiated by London. It subscribes to the Covenant of Mayors to meet the climate change targets. It actively participates in the C40 cities network and in Eurocities.

3.4 City Targets: London

London has a long track record of caring for the environment reflected in the Greater London Development Plan of the Greater London Council (GLC). During the seventies energy shock, it adopted Environmental Impact Assessment and an energy efficiency strategy, applied ecological design to its own buildings, and instigated sustainable waste disposal technologies with the private sector on long term contracts. After its abolition the London Planning Advisory Committee (LPAC) pursued these issues which were taken up by the Greater London Authority (GLA) founded in 2000. They are dealt with in the Mayor's London Plan and the accompanying energy, waste and flood defence strategies.

In response to the Kyoto objectives, the current Mayor of London incorporated even more stringent CO₂ emission reduction targets in his Plan (-60% by 2025) and for the bodies he controls, (the London Development Agency (LDA), Transport for London, the London Fire and Emergency Planning Authority). Specially created agencies undertook surveys to prepare sectoral targets. The Climate Change Action Plan 2007^{x1} is the most comprehensive compendium of targets and proposed sectoral measures, including for GLA's own stock and movements pledged by the Mayoral Group. Insulation targets and eco-design features are built into the Green Homes Programme and recommendations for the existing stock in Lagging Behind (2008). Energy efficiency subsidies are expected from the utilities but need encouragement by GLA which has set up programmes like green concierge, green landlord initiative, a fuel programme for social housing, Better Building Partnerships and London Energy Partnerships for a low carbon future. Some of these initiatives are shared with London Boroughs. Targets and measures for commercial buildings are laid down in the Green Organisations Programme, guidelines and the London Business Link.

Spatially, London was designated as a Low Carbon Zone where Energy Action Areas and Energy Efficiency Community Projects with the London Boroughs obtain specific treatment. The introduction of congestion charging was the most visible intervention to curb transport CO₂ emissions. Many efforts are undertaken to improve conditions for cycling, such as a cycle lane network and public hire bikes, walking and public transport. Major regeneration schemes, such as for the Olympic Games of 2012 follow ecological principles and prepare for a sustainable legacy.

Economically, the financial and business service sectors of the City of London are also involved in climate change. The ambition of the London City Corporation is to make London the World Centre for Carbon Finance (carbon trading) as it was instrumental in founding the Carbon Market, while carbon offsetting remains voluntary. The insurance industry is also concerned with increasing risks of flooding, hurricanes, heat waves, etc and has engaged in 'climate proofing'. The City of London's climate adaptation strategy^{xii} consists of management measures regarding floods, water resources, heat, air pollution and ground conditions, classified according to no regrets, low regrets win-win measures and flexible approaches to dealing with uncertainties.

4. Concrete Strategic and Local Examples in Madrid and London

Both Madrid and London have responded to the Kyoto Agreement and its adoption by their respective governments. They elaborated their own low carbon strategies, set up new agencies, mobilised funds, sought cooperation through partnership and devised projects. Few practical projects have been realised so far though. Some are briefly described below.

Examples of interventions at all levels: Madrid and London

	Madrid	London
City region level	Valdemingomez Technology Park	Blue-green development strategy for the Thames Gateway by Terry Farrell Ecotowns in the South East
City wide	Cycle Mobility Plan (2008) Clean fuels programme.	Updated London Plan 2009 Planting 15,000 trees. Low carbon zone.
City areas	Madrid Walks Plan. Restriction of zones to vehicular traffic. Pedestrianisation.	Outer London Commission CO2 recommendations. Greenwich Peninsula microclimate design; eco layouts Plantation House. 6000 communal bikes in Inner London.
Regeneration projects	Madrid Rio: environmental, sports and cultural axis on former M30 motorway. Greening the city, planting of 1.5 million trees by 2011.	Stratford City, Olympic Games 2012 sustainable legacy objectives. Tree planting in the public realm and creating green ribbons.
Neighbourhoods	Echo Valley Strategy, Eco-barrios	BedZED, Bromley by Bow Centre
Buildings (models, prototypes)	Regent Link, Sunrise The House of Bamboo	'green' tower project (Llewellyn Davies Younge. Zero carbon houses. CO2 reduction retrofitting project. Green roofs Canary Wharf. CO2 reduction retrofitting projects.

Sources: Madrid: City of Madrid administration. London: Greater London Authority and the Mayor's Office.

4.1 City-Wide Measures

Both Madrid and London have initiated a large amount of programmes and projects, incentives, awareness campaigns, and dissemination of technical information. They are lobbying their central governments for more resources and powers, and negotiate with the Madrid Districts and the London Boroughs, developers, housing associations, land owners, utilities, the private sector and NOGs. The table is compiling key undertakings and agencies created specifically to implement CO2 emission reduction as well as energy efficiency.

Although climate change has become a broad political concern, party politics influence the preferences and measures selected to deal with it. With unchanged politics, Madrid showed more consistency than London and is able to implement longer term strategies.

Comparative Table. Selected CO2 emission reduction policies and measures: Madrid – London

CO2 reduction policies / measures	CO2 reduction funds / gains	City's own CO2 reduction measures (examples)	Awareness raising campaigns, lobbying, agency building	Initiatives per sector
Madrid [See text para 3.3]	(2008-2012) 101,229,000€	-Local Energy Agency -Ordinances, quantifying emissions in plans -Tax related incentives -Promoting markets, products, technologies -Voluntary agreements -Information and communication	-Aimed at general public, construction sector, industry and local authorities -Energy consumption and green house gas emissions from vehicles -Promoting carbon neutral City Council events -Covenant of Mayors re climate change targets.	<i>Housing:</i> -Subsidies for energy efficient equipment <i>Transport:</i> -Cycling mobility plan -Urban Mobility Plan <i>Commerce:</i> -Energy efficiency auditing <i>Waste:</i> -Local Urban Waste Strategy -Biogas production
London	(2009) £600m pa GVA from CO2 mitigation Mayor's 100m£ green fund (2009-12) Internal revolving fund Public/Private London Green Fund managed by LDA	-Emissions from existing homes (1) -Low Carbon Zones (2) -Zero and Low Carbon Developments with private sector -Decentralised energy (3) CHP, district heating -Renewable electricity for Underground -Green Grid and Urban Greening Programme (2008) -Green Enterprise District in Thames Gateway to implement Olympic Green Legacy Plan.	-Green Homes Programme -Government lobbying re deregulation -London Climate Change Agency -London Energy Partnership Congestion charging (4) -Changing travel behaviour -Low Carbon Zones -Carbon trading. Carbon offsetting, taxation -Fostering an innovative CO2 emission reduction industry. -Outer London Commission	<i>Housing:</i> -Building Energy Efficiency Programme and subsidies -Retrofit Academy <i>Transport:</i> -Hybrid bus fleet -Bike hire scheme -LED traffic lights -Electric vehicle Delivery Plan -Green taxis <i>Offices: (5)</i> -GLA building energy efficiency programme -ESCO performance contracting tenders <i>Public Realm:</i> 15000 new trees

Sources: Madrid: Plan for the Sustainable Use of Energy and Climate Change Prevention 2008-2012. Government Department of Environment, Madrid City Council. London: (1) Lagging Behind, insulating homes in London (2008). Low Carbon London (2009). (2) London Climate Change Partnership. (1) London Plan and Alterations. State of London 2009. (3) Mayor of London. Climate Change Action Plan 2007. (4) Transport for London. (5) London Development Agency. Ernst &Young (2009). Prospectus for London, the Low Carbon Capital (2009).

4.2 Madrid: City Wide Strategies and Experimental Pilot Projects

In the field of transport Madrid has devised a Cycle Mobility Plan (2008). The bicycle represents 0.14 % of total mobility at present and warrants the promotion of the use of the bicycle. 575 Km of line bicycle are planned to be implemented by 2016. It has promoted a Clean Fuels Programme for the fleet of the Madrid Municipality, whereby more than 1,800 municipal vehicles are to use less pollutant alternative fuels: electricity, natural compressed gas and bio-combustibles (bio-diesel and bio-ethanol). The Madrid Walks Plan imposes traffic restrictions in certain zones of the city. They consist of designated residential priority areas and pedestrian urban spaces.

In terms of energy, innovative solutions are generated in the Valdemingómez Technology Park. In the park itself, innovative waste management measures have been adopted. They have managed to reduce the green house gases produced by waste treatment by 50 % (300.000 ton CO₂). This measure will produce biogas to be distributed across the general network throughout Madrid. There is also a programme for geothermal air conditioning. An experimental project is under way in a transport underground station and will be adopted more widely once put to the test.

4.3 London's Latest Approach to CO₂ Reduction Strategies

In London the current mayor has changed the emphasis to market mechanisms and deregulation. He sharpened the CO₂ reduction targets and devised a multi-layer, London-wide strategy (by means of influencing, a planning framework, broader programmes, own procurement) to achieve a low-carbon economy for London. He set up an internal revolving fund (100m£ for 3 years) to kick start pilot projects, with the expectation that the market would take over as pilots would prove profitable economically.

The first step are CO₂ emission reductions at scale in buildings, initially in GLA's own offices by Performance Contracting and 'de-risking'^{xlii} with ESCOs,^{xliii} a widespread practice in the USA. It is expected to serve as an exemplar for all public buildings in London. Pay-back from energy efficiency is ploughed back into the up-front capital funds and redeployed as a medium term solution, until the market and off-balance sheet financing takes over. Potential conflicts with incumbent energy utilities could be solved by changing regulations. Large scale private and public home retrofitting will take place with existing housing funds and GLA capital in cooperation with London Boroughs. 1£b can treat 2m homes and deliver 3mt CO₂ reduction. These measures would also create 2000-6000 jobs after training. Concerning transport, GLA's own fleet would be changed to 1000 ultra low carbon vehicles, the 8000 vehicle bus fleet would be converted to full hybrid, traffic lights to LED, and the London underground would be run with renewable energy electricity.

The newly created Decentralisation Energy Delivery Team of LDA will compile a London-wide plan showing opportunities for decentralised energy provision. The Low Carbon Zones status for which London Boroughs can compete will establish synergy between existing funding streams and GLA subsidies to reduce CO₂ emissions by 20% by 2012.

2billion of 12billion£ of London's energy consumption would be sourced by waste. The voluntary London Waste and Recycling Board has 84m£ to fund 142 successful bids while paying recycling banks would be installed. In the revised London Plan, more small local parks, trees green walls and green roofs aim to combat heat islands.

4.4 Madrid: Local Schemes

Arguably the most important special urban project to increase Madrid' sustainability is 'Madrid Rio'. It constitutes a great environmental, sports and cultural area on the former land of the M-30 ring road which has been displaced under ground into tunnels. This new development provides the opportunity to reunited Madrid's inner city with its surroundings and supply the overall urban fabric with more green space and space for innovative activities. It also reinstates Madrid's main Manzanares river by turning it into a key urban feature and a recreational area. Madrid has extended its green legacy substantially throughout the city. It is planning new parks and planting one million and a half trees by 2011.

The Municipal Housing and Land Company (EMSV) has initiated a number of projects to produce innovative residential areas and premises. Among them there are the Regent Link, the strategy for the Echo Valley, the Sunrise estate and several experimental buildings such as the House of Bamboo. Various eco-quarters are also being designed, such as the San Francisco Javier and Our Lady of the Angels estates.

4.5 London: Local Schemes

Test-bed projects include fitting smart meters, a small smart grid to the Olympic Village (£5m); building ten 'green' hospital/universities (£40m); refurbishing 200 deprived schools with low energy lighting, security, cctv and building management systems (£150m); retrofitting LED traffic signals across London (£20m); and a wind farm in the Thames Estuary (£1.4b). The mayor's own projects include 50'000 new affordable low carbon homes in cooperation with the London Boroughs, the central London hire cycle scheme, 15,000 new trees to absorb CO₂, a green fund to assist SEMs in low carbon initiatives and households to lag their dwellings, and 10,000 vehicle charging points for electric vehicles. The London City Corporation aims to become the world centre of carbon trading.

The most quoted low carbon example in London is 'BedZED', an independent eco-development which has adopted a host of ecological measures, mixed use, car sharing, local supplies, renewable energy technologies, sustainable building design, and collective heating with renewable resources. Monitored from the outset it is being adjusted accordingly.

5. Conclusion

5.1 Turning Madrid and London into eco-cities?

Eco-cities are not just about CO₂ emission reductions and techno-fixes in the race against time. They follow the sustainability principles of economic, social and environmental balance and both Madrid and London claim to adopt these principles.

Climate change, although potentially far more devastating than the current economic recession, does not fetch people's imagination. What many perceive as a far-fetched unproven goal fails to curb their individual actions, especially those impeding on their quality of life. Confronted by so many unknowns, decision makers have a hard task to steer between coercion and voluntary cooperation.

Spain and the UK have pledged a plethora of ad hoc targets, introduced new legislation and made financial means available to curb CO₂ emissions, despite the steep economic downturn which may be a unique opportunity to prepare for a more sustainable future. Madrid and London have followed suit and adapted measures to their local circumstances. Madrid has political interests to maintain its CO₂ emissions within the limits adopted by such measures. However, alternative perceptions are held by the political opposition and other social groups which have managed, for example, to shift the Pollutants Control Network in Madrid from congested areas to peripheral ones. London has devised policies, set up agencies, freed budget streams, provided incentives and stimulated public awareness.

Funds in both cities seem to have been spent mainly on preparatory activities, such as institution building, surveys and R&D into mitigation and adaptation measures, rather than on subsidies for concrete action. Until now few new technologies and design principles have been transformed into concrete schemes with real CO₂ emission reductions. This leaves few opportunities for monitoring and adjustment, notwithstanding the notorious difficulty of measuring the effects of campaigns designed to mobilise behavioural change. These circumstances may explain the slow progress of reducing CO₂ emissions in Madrid and London, notwithstanding the genuine obstacles to overcome.

5.2 Weighing up Deficiencies and Successes

Madrid is the most contaminated Spanish city which has most cars per inhabitant. Together with Barcelona it is the most unsustainable city of the country. In spite of all the measures adopted, the transport sector has generated 52.7% of the CO₂ emission in 2008.^{xiv} The City Council is criticised for its slowness in developing measures to improve air quality. For example, the decision to designate Low Energy Zones, one of most ambitious measures, should have started in 2008 but was postponed to 2010. Similarly, the development of the Local Agenda 21 has deficiencies in its implementation which progresses at a slow pace.

The initial declaration was adopted in 2001 but so far the plans of action have not been approved. Conversely, there are positive results. In the central area where 78% of the motorised displacements are made by public transport. However, 77 % of private vehicles circulate only with the driver^{xiv} and there is a great need to increase the use of public transport in peripheral areas, Madrid actively combats its severe heat island effect by participating in the international scientific DESIREX-2008 project.

Through its sheer size, London is the UK's most polluting city. Efforts such as congestion charging in central London had short lived environmental effects as traffic has reverted to previous levels, albeit by users who can afford the charges. Scarcity of parking spaces on London housing estates has driven some further out, including onto new developments on flood plains. The proposal to make low carbon projects benefit from a favourable tax regime and accelerated planning consent may backfire, judging from the stiff resistance encountered by the eco-town initiative. Most controversially, a third runway proposed at Heathrow airport within London's urban fabric contradicts all CO2 emission reduction targets.

Positive initiatives are the ring fenced mayoral revolving Green Fund to kick start sustainable experiments and the Low Carbon Task Force to broker relationships across the stakeholder spectrum and establish synergy between the plethora of proposed low carbon projects. Better cooperation with existing interested parties such as London Boroughs or Housing Associations and the pursuit of private capital for up-front funding of innovative solutions should provide better results, but behavioural changes remain crucial to reach the ambitious targets.

Both cities are intensifying their regional motorway network to accommodate road user pressures, and have made little inroads into renewable energy use in transport and in buildings. Privatisation of utilities has made interventions at city level difficult, and the cities do not seem to lobby for more say in energy and water management within their constituency. Waste also requires cross boundary cooperation and little attention is attributed to the public interest as regards private sector involvement.

Fiscal and financial measures encounter criticism in Madrid and London, akin to the criticisms of international measures and their unequal repercussions between countries which produce green house gases and can sell their CO2 emissions or compensatory projects elsewhere and those which cannot externalise their pollution, notwithstanding that such transfers are unlikely to curb overall CO2 emissions.

Considering the dynamic momentum and political will in Madrid and London there is hope that they may evolve toward sustainable cities, albeit slowly and by mobilising many more stakeholders and resources. The greatest challenge remains to win over their citizens to subscribe to a more sustainable lifestyle.

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ⁱⁱⁱ London: e.g. A Framework for Pro-Environmental Behaviours. 2008. Defra. Urgent Measures of the Spanish Strategy of Climatic Change and Cleans Energy. Spanish Government. 2007

^{iv} London: Department for Business Innovation and Skills. 2009. The UK Low Carbon Industrial Strategy. BIS. Actions

- ^v See reflections of Judith Ryser on eco-cities in: 'Sarriguren Ecociudad Ecocity'. 2009. Gobierno de Navarra
- ^{vi} Leonardo Benevolo. 1980. *The History of the City*. Scolar
- ^{vii} Amos Rappoport. 1969. *House Form and Culture*. Prentice Hall. Also Bernard Rudofsky. 1964. *Architecture without Architects*. Moma
- ^{viii} Amos Rappoport. 1981. Some Thoughts on Units of Settlement. *Ekistics* 48. 291: 447-453.
- ^{ix} Jane Jacobs. 1985. *Cities and the Wealth of Nations*. Vintage Books.
- ^x E.g. the urban village of 'Oil Free Oakland by 2020', California; the GreenCityBlueLake ecocity in Cleveland Ohio.
- ^{xi} Richard Register. 1987. *Ecocity Berkeley. Building cities for a healthy future*. North Atlantic Books.
- ^{xii} See *Ecocities Emerging: ecocities support humanity's transition into the Ecozoic Era*.
- ^{xiii} Inter alia: the Aalborg Charter on European Sustainable Cities; the Ahwahnee Principles; the Charter of New Urbanism; the Shenzhen Declaration on Ecocity Development; as well as various EU guidelines: ESDP, New Athens Charter, Green Paper on the Urban Environment 1990; Local Agenda 21 (1992); European Sustainable Cities Project (1993), Sustainable Urban Development in the European Union, a Framework for Action (1998); Towards a Local sustainability Profile" European Common Indicators (2000).
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- ^{xxii} Definitions from 'Think_Again, Milton Keynes.
- ^{xxiii} See policies proposed by the London City Corporation.
- ^{xxiv} Nicholas Stern. 2006. *The Economics of Climate Change*. HMT
- ^{xxv} The UK emits 544mt CO2 (2007) [Defra], London 44. mt CO2 (2006) 76 mt CO2 inclusive aviation [London Climate Change Action Plan]. Spain emits 442.321556mtCO2eq (2007) and Madrid 9.862mtCO2eq (2005).
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- ^{xxviii} e.g. in Madrid Ciudad Global Foundation, Energy Diversification and Saving Institute (IDEA), Centre of Energetic, Environmental and Technological Research (CIEMAT), Fundacion Entorno; in London the London Development Agency, London for Transport, London Assembly Environment Committee, London Energy Partnership, London Energy Forum, London Climate Change Agency Limited, London Climate Partnership, South East Climate Change Partnership).
- ^{xxix} e.g. London Sustainable Development Commission. 1st (and last) report 2003. Energy sub-group. London Leaders 2008, 2009.
- ^{xxx} Adopting measures to reduce Green House Gases with respect to those in the year 1990 during the 2008 -2012 period.
- ^{xxxi} Spanish Climate Change and Clean Energy Strategy 2008-2011, Ministry of Environment, Rural and Maritime Areas
- ^{xxxii} Observatory of the Sustainability in Spain, 2009 Report
- ^{xxxiii} Observatory of the Sustainability in Spain, 2009 Report
- ^{xxxiv} Details are given in the UK contribution by Judith Ryser to the Isocarp Low Carbon Cities Project, comparative study of national responses to the challenge posed by climate change and energy

resource constraints. See also Judith Ryser. 2009. Low Carbon Cities: The Case of the United Kingdom. In: Isocarp Review no 5.

^{xxxv} Royal Commission on Environmental Pollution reports 22, 23 and 26.

^{xxxvi} For example the Kate Barker report and the Nicolas Stern report.

^{xxxvii} James Lovelock. 2006. The Revenge of Gaia: why the earth is fighting back and how we can still save humanity. Allen Lane.

^{xxxviii} MR Tigh, AL Bristow, AM Pridmore, AD May. 2005. What is a sustainable level of CO2 emissions from transport activity in the UK by 2050? Institute of Transport studies, White Rose, universities of Leeds, Sheffield and York.

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^{xl} GLA. 2007. Action Today to Protect Tomorrow, the Mayor's Climate Change Action Plan.

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^{xliii} http://en.wikipedia.org/wiki/Energy_service_company

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