

Brazil: the \$200 billion low carbon opportunity

Working with:



British Embassy Brasilia







The Carbon Trust wrote this report based on an impartial analysis of primary and secondary sources. The Carbon Trust's mission is to accelerate the move to a low carbon economy. It is a world leading expert on carbon reduction and clean technology. As a not-for-dividend group, it advises governments and leading companies around the world, reinvesting profits into its low carbon mission.

The British Embassy in Brasilia funded this report. The Embassy is the main British diplomatic mission in Brazil and is responsible for all aspects of the UK's bilateral relationship with Brazil. Under Ambassador Alan Charlton's leadership, the Embassy has a staff of more than 60 professionals who work in government-to-government relations; consular assistance; commercial relations and project development in association with Brazilian institutions.



UK Trade and Investment (UKTI) provided information for this report. UKTI is the government department that helps UK-based companies succeed in international markets and assists overseas companies to bring high quality investment to the UK's dynamic economy. It operates in 162 locations and 96 markets, with overseas staff based in British embassies and other diplomatic offices around the world.

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Foreword

In 2011, trade between Brazil and the UK grew to US\$8.57 billion, a 10% increase on 2010. At the same time, the UK has become the 4th largest investor in Brazil, with a total stock of US\$8.4 billion. With opportunities in oil and gas, pharmaceuticals, mining, retail and many others, prospects for even more trade and investment are extremely positive for 2012 and beyond. Alongside these extremely positive figures, the UK and Brazil are working together on a range of global challenges: the need to secure a sustained global economic recovery, while, by 2030, providing at least 50% more food, 45% more energy, and 30% more water without further damaging our environment and increasing greenhouse gas emissions.

Brazil and the UK have ambitious plans to shift their economies to a low carbon, high growth path. In addition to keeping aspirations high in international negotiations, both have developed climate legislation at national level, including ambitious emission reduction commitments enshrined in law. Our scientific communities are taking practical steps to strengthen the interface between policy and science. The 10,000 Brazilian students who will study in the UK over the next three years under the Science without Borders programme are an important part of this. An openness to the interchange of people, ideas, innovation, technology and capital is a key part of this and both sides need to remain committed to open economies as a way of achieving prosperity - it is clear that pioneers of the low carbon revolution stand a better chance to sustain economic growth and well-being in the 21st century.

The British Government has commissioned this report in order to provide a clear picture of areas where Brazil offers promising opportunities for UK low carbon businesses. The report aims to supply an overview of commercial opportunities in Brazil created by a transition to a low carbon economy, as well as detailed examples of six areas of strong UK competitive advantage.

In a globalised world, it is clear that we can only make the green economy gain its urgent traction by working together. The British Embassy and Consulates in Brazil is very much looking forward to helping you exploring the exciting opportunities described in this report.

Alan Charlton Her Majesty's Ambassador in Brazil



British Embassy Brasilia Executive summary

Executive Summary

Brazil's green growth agenda affords UK companies with significant commercial opportunities for their low carbon products and services. Through this report, we aim to describe which subsectors represent particular areas of opportunity for UK companies to participate in Brazil's low carbon development, and illustrate where along the value chain the biggest commercial opportunities lie.

Brazilian markets are of particular interest to UK businesses because they are both large and growing. Brazil surpassed the United Kingdom as the world's sixth largest economy in 2011, and has averaged 3.7% annual growth since 2000, compared to the UK's 1.7% average rate. Steady development and industrialisation are driving growth in all sectors, and have made Brazil an uncontested regional powerhouse and a major international player.

Its economic growth has been accompanied by rising greenhouse gas emissions. Indeed, when emissions from land use, land-use change and forestry are included, Brazil ranks as the world's fourth largest greenhouse gas emitter, with emissions of roughly 1,259MtCO₂e in 2008, and under a business as usual scenario, its emission are projected to climb by 35% to about 1,700MtCO₂e by 2030. But this path is at odds with Brazil's sustainable

development agenda. Instead, by applying targeted policy interventions and capitalising on cost-saving efficiency measures and practices, studies show that its emissions could fall by 35%, to about 810MtCO₂e by 2030.

Both policy and cost will chart the route along Brazil's sustainable development path. The low carbon policy landscape is already being steered by Brazil's 2008 National Plan on Climate Change, which includes a number of strategies to reduce emissions from all sectors in the economy. The cost profile of Brazil's carbon abatement opportunities has also been mapped on a marginal abatement cost curve, and illustrates which actions and technologies can generate both cost and carbon savings. The combination of these drivers builds a frame that delineates an opportunity space for commercial investment in Brazil's low carbon future.

By studying the Brazilian context and matching low carbon opportunities with areas of strong UK competitive advantage, we used a methodology to produce a list of six subsectors in which there is especially significant commercial opportunity for UK business. We then examined each subsector to determine which part of the value chain represents the area of greatest opportunity. The results of our analysis are shown in the table, below.

Subsector	R&D	Design & Planning	Manufacture & operate	Shipping & Iogistics	Finance	Proj	Projected investment (US\$)			
Solid waste						US\$10bn by 2020				
Water and wastewater						US\$13bn by 2014				
Airports and aerospace						US\$11bn	over 3 years			
Automotive						US\$50bn	by 2020			
Ethanol and biomass						US\$1.6bn	US\$1.6bn annually			
Buildings and sports infrastructure						+US\$42bn annually until 2014				
Size and qual	ity of the	identifie	d opport	tunity		Large	Moderate	Limited		

It is worth noting that all of these subsectors except for airports and aerospace also turn up on the cost-negative segment of Brazil's marginal abatement cost curve. Their close correlation helps to endorse the credibility and appropriateness of our final selection of subsectors: being cost-conscious, it makes sense that Brazilian policymakers would target low-cost solutions first. And it's logical that UK businesses have developed an expertise in similar carbon abatement solutions since they've operated in a policy and regulatory environment that has promoted low carbon development for over a decade. The overlap therefore represents an investable opportunity space in Brazil for the UK's low carbon commercial enterprises.

The opportunities for UK companies can be segmented according to their place on the value chain.

For research and development, there is opportunity in:

- certain waste treatment technologies, especially anaerobic digestion and pyrolysis
- automotive innovation, including engine improvements and components; transmissions and drive trains; and systems and components for both hybrid and full electric vehicles
- advanced biofuel production, like biobutanol development

For design and planning, there are opportunities in:

- waste reduction and non-generation through packaging design and lightweighting; design of municipal integrated waste and wastewater management strategies; and freshwater network delivery optimisation
- virtual testing of automotive and aerospace designs, lightweighting materials, and component design
- sustainability planning and design for buildings and airports, including architecture, engineering and design

In the **manufacturing and operation** of equipment, opportunities exist in:

- a variety of waste treatment and recycling equipment, including anaerobic digestions and incineration
- equipment for water quality monitoring and testing; leak detection; nitrate and pharmaceutical removal; anaerobic digester units; membrane bioreactors and integrated treatment facilities
- aerospace and automotive components; composites; ready-made structures; maintenance equipment; interiors and connectivity products
- buildings, sports infrastructure and airports for lowenergy lighting solutions; HVAC and refrigerant equipment; control technologies and temporary structures

For finance, there are opportunities in:

- financing the construction and refurbishment of water treatment and distribution facilities, and financing ethanol production plants and cogeneration equipment
- financing and providing insurance options for buildings, especially hotels and commercial buildings

There is also significant opportunity for UK companies to participate in the wind energy sector in many areas along the value chain.

Brazil has been designated as one of UKTI's High Growth Markets because of its broad and sophisticated industrial base and its vibrant economy that is opening up to trade and foreign investment. UK businesses command a worldleading position for low carbon technologies and services, and the two countries' strengthening trade relationship is set to enhance bilateral commerce in the emerging green marketplace. With a cadre of innovative companies eager to take advantage of the growing commercial relationship, the Brazilian frontier is ripe for commercial investment in the near term, and UK companies are well-placed to participate.

Part A Overview

- 1. Introduction
- 2. Commercial opportunities in Brazil created by a transition to a low carbon economy
- 3. Where the UK can provide the most value

1 Introduction

"Brazil was once described as a country of the future; clearly now it's the future that belongs to Brazil. And it's our shared future I want to talk about today. A new partnership between Brazil and the UK. A partnership for prosperity, where we work together to generate wealth and opportunity for our people...So how do we deepen our ties? The first part of the answer is trade. It brings people together, fostering new understandings. Not between governments, or diplomats, but people; businesses; their staff; and their communities too."

~ UK Deputy Prime Minister Nick Clegg¹

Brazil has grown into a major economic, political and cultural player on the world stage. The process of domestic industrialisation and development has helped tens of millions of Brazilians lift themselves up the economic ladder, and growth remains a government priority.

But Brazil's steady climb up the Human Development Index has been accompanied by rising greenhouse gas emissions and other environmental degradation, which is at odds with Brazil's sustainable development agenda. Reconciling the dual drivers of growth and sustainability means that investment must be carried out in ways that maximise resource efficiency and service provision while protecting and enhancing the natural environment.

To meet this challenge, Brazilian businesses and all levels of government have developed an appetite for green growth innovations, which are creating business opportunities for companies offering low carbon goods and services.

This report aims to highlight specific areas of opportunity where UK companies can participate in Brazil's growing economy in ways that facilitate low carbon development. First, we discuss the Brazilian frame, and then we analyse how UK capabilities fit within it.

To build the frame, we describe the composition of Brazil's economy, the related character of its emissions profile, and the policies and cost drivers that delineate its low carbon growth path. By joining these elements, we show where low carbon commercial opportunities are likely to be.

To align the Brazilian narrative with UK capability, we then apply a whittling methodology to shave away the opportunities that are less appropriate for UK businesses operating in the low carbon space. The methodology helps us determine which sectors can develop in a carbonconscious way, which sectors will attract significant Brazilian investment in the near term, and in which sectors UK organisations exhibit internationally outstanding competitive advantage.

The methodology narrows our analysis to six subsectors where low carbon business opportunities intersect with Brazilian demand and UK competitive advantage. They are:

- 1. Solid waste
- 2. Water and wastewater
- 3. Airports and aerospace
- 4. Automotive
- 5. Bioenergy (ethanol and biomass)
- 6. Buildings and sports infrastructure

We analyse each sector in turn, and describe the relevant context, the size of the investment opportunity, the emissions abatement potential, and where along the value chain the greatest potential investment opportunity lies.

Finally, we discuss what resources are available to help UK companies participate in these markets in Brazil.

2 Commercial opportunities in Brazil created by a transition to a low carbon economy

Brazil's economy is large, diverse, and growing

Brazil's economy has more than quadrupled in size since 1980 and is projected to maintain modest growth rates for the next several years, as shown below. It ranks just ahead of the United Kingdom as the world's sixth largest economy, and achieved an overall growth rate 7.5% in 2010. Growth slowed considerably in 2011 to about 3.0%, largely due to continued global economic uncertainty and downward pressure on exports stemming from a strong domestic currency.



Figure 1: Brazil's actual and projected GDP, 1980 - 2016

Source: International Monetary Fund. (September, 2011). World Economic Outlook database.²



Figure 2: Brazil's economy by subsector, 2011

Source: Instituto Brasileiro de Geografia e Estatistica. (2011). Contas Nacionais Trimestrais.³

In aggregate, the economy's structure resembles many other large, emerging economies, with agriculture constituting about 5.3% of GDP, industry representing about 25.1% and services making up the remaining 69.6%. Figure 2 disaggregates the economy into subsectors.

Coupling the absolute size of Brazil's economy with its forecast growth means that the country will not only continue to be a regional powerhouse, but will increasingly exert its influence on the world stage. This is especially true for agricultural commodities, where Brazil ranks amongst the largest global exporters of ethanol, sugar, coffee, beef, tobacco, broiler hens, orange juice, soybeans, corn and pork⁴.

Economic growth spans virtually all sectors and remains a government priority. Continued growth is seen as central to realising the country's development path, and will be aggressively pursued to raise living standards and enrich the people of Brazil.

Brazil's GHG emissions are large

The size of its economy, the nature of its land-use dynamics, and its geographic diversity make Brazil a material actor in global climate change mitigation efforts, as well in as in the protection and enhancement biodiversity. And while Brazil's economic performance has improved the socioeconomic situation of millions of people, growth has been accompanied by rising greenhouse gas emissions and environmental degradation.

Indeed, when emissions from land use, land use change and forestry (LULUCF) were last calculated in 2005, Brazil ranked as the world's fourth-largest greenhouse gas emitter. Figure 3 shows the sources of its 2008 emissions broken down by sector in the leftmost bar.



Figure 3: Brazil's GHG emissions by sector, 2008 and two scenarios in 2030

Source: World Bank. (2010). Brazil low-carbon case study.

Under a business as usual scenario, net emissions are projected to grow by about 35% between 2008 and 2030, from 1,259MtCO₂e to 1,697MtCO₂e annually, as shown in the middle bar. But through targeted policy intervention, Brazil's emissions could instead fall by about 35% between 2008 and 2030, from 1,259MtCO₂e to 810MtCO₂e, as is shown on the right.

Figure 4 illustrates in which segments of the economy carbon savings would be generated in 2030, by following the aggressive carbon abatement scenario rather than the business as usual scenario.

It is clear that the largest carbon saving opportunity lies in changing forestry practices, including sequestration which is largely achieved reforestation and reduced deforestation, and also in changing land-use dynamics.

In terms of forestry, Amazonian deforestation rates have fallen by more than two thirds, from over 19,000km² per year in 2005 to about 6,200km² in 2011⁵. The fall is due to factors including a stronger Brazilian currency which has softened international demand for the commodities that put pressure on forests, the global economic slowdown, more strictly enforced government policy, improved land tenure rights, expansion of protected areas and international financing through programmes^{6,7}.

While detailed information on LULUCF emissions has not been updated since 2005⁸, the World Bank estimates that deforestation comprised about 40% of gross national emissions in 2008 (when roughly 13,000km² of forest was lost) and anticipates that emissions from deforestation will stabilise at about 400-500 MtCO₂/year. The majority of forest loss is the result of pastureland expansion (65-70%), followed by small-scale agriculture (20-25%), large-scale agriculture (5-10%), and logging (2-3%).

In terms of land-use, agriculture produces roughly a quarter of national emissions. They mostly arise from fertiliser use, GHGs released from agricultural practices such as mineralisation of nitrogen in the soil, GHGs released from wetland rice cultivation, methane released from cattle digestion, and sugar cane burning, and also from fossil-fuel powered agricultural equipment⁹.

The next largest carbon saving opportunity is in the energy sector. Compared to the business as usual scenario, carbon savings stem mainly from improved energy efficiency, fuel switching in the industrial sector, expansion of biomass cogeneration, and exporting ethanol to international markets. Even under a low carbon scenario, 2030 emissions from the industrial sector are still projected to rise by about 28% compared to the 2008 reference case, though that is significantly less than the 97% rise that would otherwise occur under the business as usual scenario.



Figure 4: Carbon abatement potential by sector, 2030 (MtCO2e)

Source: World Bank. (2010). Brazil low-carbon case study.

Potential carbon savings in the waste sector could also be significant. By introducing methane capture and combustion at sanitary landfill sites and wastewater treatment facilities, emissions in the waste sector could fall by 80% in 2030 compared to the business as usual case.

For transport, emission reductions would come from increasing ethanol use, improving vehicle efficiency, and accelerating modal shifts. Compared to the business as usual scenario, increased ethanol use could reduce vehicle emissions by more than a third by 2030. For urban transport, moving away from private vehicles to urban rapid transport could reduce emissions by 51%. And for regional transport, shifting freight away from trucks to rail and marine, and moving from regional passenger flights to high-speed rail, could reduce emissions by another 9%. Transport emissions are still projected to rise by 17% by 2030, but that is significantly less than the 65% rise that would occur under the business as usual scenario.

Overall, significant carbon saving opportunities can be achieved across all the sectors.

Two things will drive emission reductions in Brazil: policy and cost

Achieving the emission reduction potentials outlined above demands that government policy drive technology deployment and innovation, and that it capitalise on the cost drivers that are already present in the marketplace. Some policy already exists that seeks to steer the economy's development along a lower carbon path, and analysis of costs signposts where cost-effective investments could be made that would achieve emission reductions in an economically responsible way.

Policy

To manage its emissions, the Brazilian government developed a National Plan to reduce emissions by between 36.1% and 38.9% from business as usual by 2020, and chose from a wide range of sector-based actions to meet its target¹⁰. The 2008 National Plan on Climate Change describes the country's two-pronged approach to climate change. It involves 1) reducing emissions from land use, and 2) continuously improving efficiency in the use of its resources, both in ways that protect and enhance the country's socioeconomic and environmental fabric¹¹. The land-use change targets include reducing deforestation by 80% compared to the 1996-2005 average by 2020, and pursuing significant reforestation¹². Subordinate policies to realise these goals include:

- Implementing the National Public Forests Register to help preserve, protect and manage forest land¹³
- Carrying out the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon Region, which involves partnerships between government and civil society¹⁴
- · Improving and expanding forest monitoring activities
- Unlocking funding to address deforestation through international partnerships and domestic funds

In terms of energy efficiency, the climate plan references a number of other strategies and policies to achieve its efficiency aspects. For example, Brazil's National Policy for Energy Efficiency aims to reduce energy consumption by 10% in 2030 by:

- Upgrading the stock of white goods, including replacing refrigerant gases
- Replacing coal with charcoal in steel plants
- Encouraging solar heating
- · Mechanising sugarcane agricultural practices
- Intensifying farming, updating agricultural methods and optimising farm inputs
- Increasing solid waste diversion by 20% by 2015

A series of other polices under the 2008 National Energy Plan describe how Brazil will marry its growing energy demands to its emission reductions goals¹⁵.

Other programmes and policies that relate to Brazil's carbon abatement pathway include Phase 2 of Brazil's National Growth Acceleration Programme, the National Policy on Solid Waste, the Building Energy Efficiency Programme *Procel Edifica*, and other commitments like Brazil's ambition to host an Olympic and Paralympic Games that is "at least as sustainable" as London's 2012 Olympic performance. These policies are outlined in more detail in the relevant sections below.



Figure 5: Brazil's Marginal Abatement Cost Curve

Source: McKinsey & Co. (2011) Global abatement cost curve v2.0. Pathways to a low-carbon economy for Brazil.

Cost (MACC)

Policy is an important driver of change that is being leveraged by the government to move Brazil along a low carbon development path. But policy can be applied intelligently to catalyse emissions abatement opportunities that also include a cost-savings element. By arranging a series of emissions abatement opportunities according to their cost, McKinsey has developed a marginal abatement cost curve (MACC), shown in Figure 5.

The emissions abatement opportunities that fall below the horizontal axis represent actions that save money and also reduce emissions, and those that fall above the axis represent opportunities that cost money and reduce emissions. The width of each bar represents the total size of the abatement opportunity in MtCO₂e/year.

Brazil's MACC shows that there are many opportunities that are cost-negative, especially in building energy efficiency, modified agricultural practices, industrial fuel switching, vehicle efficiency, liquid biofuel substitution, and waste cogeneration. The largest single abatement opportunity comes from reducing deforestation, which is reflected in Figure 5. More expensive abatement options include electric vehicle deployment, some agronomic practices, and the implementation of carbon capture and storage for industrial processes.

By integrating across the various policy and cost drivers, one can infer where investment is likely to be channelled as Brazil grows and develops. Competitive markets direct money towards cost-saving investments, and government policies help to overcome non-financial market barriers and also catalyse investment in areas with a strategic national objective.

Coupling the structure of Brazil's economy and emissions profile with these policy and cost indicators implies where commercial opportunities already exist or are likely to emerge in the near-term. The overview therefore provides initial guidance as to where Brazilian demand for low carbon products and services is likely to reside, and where UK companies might be able to benefit from emerging commercial opportunities.

3 Where the UK can provide the most value

Economic subsectors that are most accessible to UK companies

Reviewing Brazil's economic and emissions landscape, including its policy environment and cost drivers, we recognised that there is a wide near-term opportunity space for potential investment. To help determine which subsectors warranted further study, we ran each subsector through a methodological framework with three gates.

Given that the purpose of this study is to find low carbon business opportunities, the first gate sifted out opportunities that were not sufficiently low carbon. The second gate screened out subsectors where there was insufficient Brazilian demand. And the third gate screened out subsectors for which the UK does not have widely recognised global competitive advantage. Subsectors that passed through each gate were then profiled in greater depth. The output from the methodology is summarised in Table 1.

In the low carbon column, we only ruled out road infrastructure and rail infrastructure. According to our definition, low carbon opportunities represent any actions that reduce emissions compared to the business as usual case. Using this definition, subsectors that are popularly thought of as contra to low carbon development, like oil and gas, still manifest carbon saving opportunities through efficiency improvements or process optimisation, for example. For road infrastructure, however, few widely deployable carbon saving technologies or processes could be found in the literature. For rail infrastructure, there are sustainability solutions for rail stations and some potential for signalling and control systems, but there are few carbon saving options for the railroads themselves. The carbon savings from rail stem mostly from a modal shift away from road and air transport, which is too far removed from infrastructure construction to warrant inclusion in this study.

In the column that assesses Brazilian demand, we eliminated solar PV and solar thermal, as well as marine energy. Brazil's policy environment is not conducive to rapid deployment of solar PV technology because there is little market-enabling legislation to facilitate grid interconnection, and because solar PV is a relatively expensive technology compared to other renewable sources. While legislation is expected to come out in 2012 to encourage solar deployment, it has not yet been released and therefore cannot be evaluated. As for solar thermal, there is little appetite for the technology because the payback is less attractive compared to other investments, and there are no major policies or programmes to stimulate the market. For marine energy, Brazil has not mapped its potential marine resources, nor does it have legislation to facilitate deployment.

In the final column, we screened out areas in which the UK does not have high international competitive advantage. This gate is multifaceted and excludes subsectors where: Brazil's domestic capability significantly limited the degree to which UK companies could realistically access the market; foreign competitors were perceived to outperform UK companies; or, UK capabilities were few or nascent.

For all of the LULUCF subsectors, opportunities were either found to heavily favour local, domestic interventions by Brazilian outfits, or were areas in which there was little relevant commercial expertise in the UK that could be practicably exported to Brazil. Despite the enormous carbon abatement potential, these sectors were not deemed to be priority areas for UK business.

In the energy sector, Brazil has well-developed domestic expertise in hydropower, and foreign competitors from countries like the United States, Canada, China and Norway are better placed to access the market because of their significant construction and operational experience. For solar PV, the UK is not home to a major domestically-owned manufacturer, and faces stiff competition in the near term from China, as well as Germany, the United States, Japan, and South Korea. Solar thermal installations are low-tech, and are suitable for design and manufacture in Brazil if demand increases. For oil and gas and heavy industry, countries with a more robust domestically-owned heavy industrial manufacturing base are better placed to access commercial opportunities in Brazil. There are some niche opportunities for industrial energy efficiency, process optimisation through behaviour change, and some potential for industrial carbon capture and storage, but these opportunities were too disparate or future-oriented to be profiled in depth.

Sector	Subsector	Low carbon?	High Brazilian demand?	High UK competitive advantage?	Profiled subsector
	Agriculture	✓	1		
LULUCF	Forestry	✓	✓		
	Sequestration	✓	√		
	Hydro	4	1		
	Solar PV & thermal	✓			
	Bioenergy	✓	√	√	✓
F inanany	Wind	✓	1	1	*
Energy	Marine	✓		√	
	Oil and gas	1	1		
	Heavy industry	✓	1		
	Buildings	✓	1	1	√
	Road infrastructure		√		
	Automotive vehicles	✓	√	√	✓
	Rail infrastructure		1	1	
-	Engines & rolling stock	✓	√		
Transport	Ports	✓	√		
	Ships	✓	√		
	Airports	✓	✓	✓	✓
	Aerospace	✓	✓	✓	✓
N /2 = 1 =	Solid	✓	✓	✓	✓
Waste	Water & wastewater	✓	✓	√	✓

Table 1: Framework to select prioritised low carbon subsectors with an accessible UK commercial opportunity

* Note that wind energy satisfies all of the criteria, and according to the methodology deserves further study. The FCO has recognised the importance of this sector independently and is studying the commercial opportunities for UK companies to participate in this burgeoning Brazilian market. Since another report on this subsector is being developed in parallel to this one, we only discuss the opportunities cursorily, but recognise that it is among the priority investment areas for UK businesses.

In the transport sector, Brazil is fully capable of delivering its own road infrastructure, and while UK companies may be able to contribute expertise in motorway design and urban planning to streamline traffic flow and potentially reduce emissions, the opportunities were too specific to justify a full subsector analysis. The UK is home to only one manufacturer of rolling stock, but it is owned by a Canadian company, Bombardier, and foreign companies from Germany, the Netherlands, France and Spain already have an established Brazilian presence and a perceived competitive advantage for port construction and shipbuilding. After screening out the less relevant subsectors using the three-gate methodology, six subsectors remained: bioenergy, buildings, automotive vehicles, airports and aerospace (grouped), solid waste, and water and wastewater.

It is worth noting that all of these subsectors except for airports and aerospace also turn up on the cost-negative segment of Brazil's MACC. Their close correlation helps to endorse the credibility and appropriateness of our final selection of subsectors: being cost-conscious, it makes sense that Brazilian policymakers would target low-cost solutions first, which creates an opportunity space for investment in those areas. And it's logical that UK businesses have developed an expertise in similar carbon abatement solutions since they've operated in a policy and regulatory environment that has promoted low carbon development for over a decade. Factoring in contextual conditions, the overlap between Brazilian demand and UK capabilities therefore represents the commercial opportunity space that is accessible to UK companies, and signals where UK companies would be best placed to participate in Brazil's low carbon development.

Areas along the value chain that are particularly accessible and relevant to UK business

The six identified subsectors were studied in more detail to determine where the most relevant opportunities stood within the value chain. The value chain was divided into five segments, which are shown in Table 2, and the commercial opportunity was assessed based on its size and quality. The table's coloured boxes evaluate the opportunity as either large, moderate, or limited, and also show the level of investment that is projected to be spent in that subsector over a certain time period. To generate these results, we followed the evaluation methodology described in **Box 1**.

Subse	ctor	R&D	Design & Planning	Manufacture & operate	Shipping & logistics	Finance	Proj	Projected investment (US\$)		
Solid waste							US\$10bn by 2020			
Water and wastewate	er						US\$13bn by 2014			
Airports and aerospa	ace						US\$11bn d	over 3 years		
Automotive							US\$50bn ł	oy 2020		
Ethanol and biomass	5						US\$1.6bn	annually		
Buildings and sports						+US\$42bn annually until 2014				
Size and quality of the identified opportunity						Large	Moderate	Limited		

Table 2: Investment opportunities along the value chain

The value chain was created by structuring the typical development stages of a product or service. The stages include conception and prototyping in the R&D phase; design and planning of an object or system; the manufacture and operation of goods or implementation of a system; and in the case of equipment, transport and logistics to get it to the final site. Throughout the process, project financing and related services like insurance are also needed. Using this framework, we look through each column along the value chain to describe the nature of the opportunity.

For research and development, there is some opportunity for collaborative R&D to further refine anaerobic digestion facilities to suit Brazil's waste stream and create high-value fertiliser, and to calibrate other waste treatment options like pyrolysis to generate biochars that enhance specific deficiencies in agricultural soils. There is significant opportunity for R&D in the automotive sector as Brazilian firms aim to improve upon engines and engine components, transmissions and drive trains, and hybrid and full electric vehicle systems and components. For ethanol, Brazil is eager to reduce emissions from the airline industry by developing aviation biofuels from sugarcane, which opens up collaborative R&D opportunities with UK firms developing biobutanol, an energy-dense biofuel variant.

Exportable UK capabilities are significant in the design and planning segment of the value chain. UK companies can contribute to waste reduction and non-generation through lightweighting, sustainable packaging, product design and industrial process efficiency, as well as helping to design municipal integrated solid waste and wastewater management strategies. Designing and implementing leak detection and leak repair programmes are critical to improving the freshwater delivery network and reducing energy and emissions in the sector. For the automotive and aerospace sectors, potential crossover exists for lightweight materials and structures, aircraft interiors and connectivity, Computer Automated Design software, virtual testing of components and systems, and technical monitoring skills, as well as for automotive policy, consumer research, project management planning, and technical advice. For buildings, including airports and sports infrastructure, opportunity exists for planning, design, engineering, sustainability certification, project management, heating, ventilation and air conditioning (HVAC) & control systems, optimised materials, lighting design, and for airports specifically, air traffic control & runway optimisation.

The manufacture and operate column reflects commercialised technologies that are ready for deployment. For waste, needed technologies include recycling systems, anaerobic digester units, incineration and possibly gasification facilities. For water and wastewater, technologies include equipment for water quality monitoring

Box 1: Evaluation methodology

- 1 Reviewed major documents and country-specific analyses to identify specific areas of opportunity in each subsector in both Brazil and the UK
- 2 Carried out interviews with Brazilian and UK experts to determine the nature and accessibility of the opportunity
- 3 Gauged the market size and emissions abatement opportunity of appropriate subsectors through additional secondary research, including industry reports, government papers, and trade and investment information
- 4 Described the overlap, and substantiated it with examples of companies or organisations with capacity.
- 5 Looked holistically at the market size, the time horizon, the nature of the UK's international competitive advantage, the accessibility of the opportunity (trade barriers, etc) to judge where there were large opportunities, moderate opportunities, and limited opportunities
- 6 Recognised that this opportunity assessment was subjective and only reflects the degree and nature of the opportunity that we found; it does not presuppose that the search was exhaustive, only indicative, and areas identified as 'limited' may nevertheless be significant for companies with particular expertise in a niche in that segment of the value chain

and testing, leak detection, the removal of nitrates and pharmaceuticals, as well as anaerobic digester units, membrane bioreactors and treatment facilities. There are dozens of UK-based automotive Original Equipment Manufacturers (OEMs) with technologies and equipment that span the production process, and there are a number of British aerospace companies that manufacture lightweight components, composites, ready-made structures, maintenance equipment, and interiors and connectivity products. Some specialist airport equipment is also available for flight optimisation and runway debris detection. For buildings and sports infrastructure, there are hundreds of companies with low-energy lighting solutions, HVAC and refrigerant equipment, as well as companies specialising in temporary structures for sporting and auxiliary spaces. Particular opportunity did not surface in any of the subsectors in the shipping and logistics segment of the value chain. While the transport of large pieces of equipment would be necessary in some subsectors, it was difficult to determine the size or nature of the opportunity. As such, while the opportunity space has been classified as limited across the board, it does not preclude the possibility that opportunities might be open to actors specialising in this field.

Finally, financing was strong for water and wastewater, where new and refurbished distribution systems and treatment facilities would require significant investment in the near term. For ethanol, the magnitude of financing required by 2020, the increasingly consolidated market, and the relatively high proportion of foreign investment currently in the market makes this subsector attractive for UK financiers. In the buildings sector, financing options are particularly relevant for hotels, where many operators already have a strong international presence, and also for commercial buildings.

Taken together, the table helps to illustrate where the strongest opportunities lie along the value chain and within each of the identified subsectors, and prioritises the commercial opportunities in a way that can be notionally cross-compared. It's important to recall, however, that areas in which there is limited identified opportunity does not mean that no opportunity exists; rather, that in the course of our study, few opportunities were found for which accessible Brazilian demand overlapped with broadly recognised UK competitive advantage. To substantiate our selection and explicate the opportunity space that is accessible to UK companies, we've developed a series of subsector profiles that detail the overarching sector context, the market and emissions abatement potential, the specific opportunity space, and also where along the value chain UK companies would be best placed to access the market. We grouped the subsectors into:

- 1. Waste, water and wastewater
- 2. Transport, which includes airports, aerospace, and automotive
- Renewable energy, including ethanol and biomass, as well as some detail on wind energy
- 4. Buildings and sports infrastructure

Part B Sector analysis

1. Waste, water and wastewater

2. Transport

3. Renewable energy

4. Buildings and sports infrastructure

5. Available resources

1 Waste, water and wastewater

Context

Brazil's rapidly growing economy, increasing levels of affluence, and changing waste management practices have seen waste production increase apace with economic growth, or faster in some instances. To help manage this growing sector, the government has divided it into two segments: solid waste and liquid waste.

Solid waste is being addressed through the National Policy on Solid Waste, which was passed in 2010 after 20 years of fragmented state and municipal-level action. It set the rules to reduce waste generation and increase the collection and management of waste from all sources, and laid out guidelines and procedures to facilitate the new waste regime¹⁶. While the bill aims to reduce waste generation, more stringent management practices and the planned reduction of uncontrolled open dumps will likely result in an increase in the volume of waste that needs to be managed in a structured, sanitary way¹⁷. The policy's most urgent activities are to be implemented by municipal and state governments by 2014.

The Brazilian government is also investing in water, wastewater and sewage treatment facilities. New and upgraded infrastructure is being financed through Phase 2 of Brazil's National Growth Acceleration Programme (PAC2) and will see the deployment of water and wastewater solutions at an enormous speed and scale. UK companies can access routes to market in this sector through two major associations: ABCON¹⁸, the Brazilian Trade Association for Private Water Concessionaires, which promotes the participation of private companies in public water and sewage services; and AESBE¹⁹, the Brazilian Association of Basic State Sanitation Companies, which promotes the exchange of technologies and capacity, and represents companies servicing 76% of Brazil's urban population.

Together, the drive for integrated management solutions for both solid and liquid waste, along with the treatment and purification of drinking water and water effluent represent large opportunities for foreign expertise and investment.

The opportunities in solid waste and water & wastewater are assessed separately below.

Box 2: National policy on solid waste

Brazil's National Policy on Solid Waste (*Política Nacional de Resíduos Sólidos*, or PNRS) is a set of principles, objectives, instruments, guidelines, goals and actions to be implemented in partnership with states, municipalities and private sector actors to provide for integrated and environmentally sound management practices for solid waste. The policy formally recognises the role played by *catadores* as collectors of recyclable materials, but also aims to eliminate open dumps by 2014, from which *catadores* source most of their material. The logistical and social implications of the policy are expected to radically change the face of waste generation, collection, treatment and disposal in Brazil.

Solid waste

Key Findings

- US\$10 billion will be invested into new solid waste infrastructure, driven by increased tonnage of waste and Brazil's 2010 National Policy on Solid Waste
- Investment will be focused into recycling and treatment facilities
- Commercial opportunities are greatest for companies that provide equipment for treatment plants and recycling facilities, as well as for a range of design and planning companies across the waste hierarchy
- UK strengths that are relevant to the Brazilian market include industrial design for waste reduction and nongeneration, anaerobic digestion and plasma arc gasification technologies, mechanical sorting facilities for recyclables, and programme design for integrated municipal waste management strategies



Market and emissions abatement opportunity

Brazil produces roughly 40% less waste than the UK in total, but more than twice as much municipal solid waste (MSW). Between 2008 and 2009, municipal solid waste (MSW) grew by 7.7% to about 60 million tonnes, commercial and demolition waste grew by almost 14% to more than 30 million tonnes, and clinical waste by about 4%, but remained the smallest by far at less than half a million tonnes²⁰. For comparison, the UK produces about 23.5 million tonnes of MSW annually, 48 million tonnes of commercial and industrial waste, and about 87 million tonnes of construction and demolition waste.

Despite new legislation, waste production in Brazil is expected to continue to increase until beyond 2030²¹ and is currently increasing at about 7-10% per year²². This contrasts with the UK market, where primary waste production is falling by more than 2% per year, and an increasing proportion of waste is being diverted for recycling and compost²³.

Rapid growth in Brazil's economy coupled with new legislative requirements for sanitary waste management means that there is a significant investment opportunity in managing different segments of Brazil's waste stream. UKTI estimates that investment of more than US\$10 billion will be needed over the next decade to fulfil the demand for new waste infrastructure. The industry has turnover of roughly US\$5.4 billion annually, divided into the collection and disposal of MSW, valued at about US\$3.5 billion (R\$6.5 billion) in 2009, and that of commercial and industrial waste, valued at between US\$1.6-2.2 billion (R\$3-4 billion).

Waste management is important partly because of the sector's contribution to Brazil's GHG emissions profile. Waste (both solid and effluent) accounted for between 52-63 MtCO₂e in 2008, or between 4% and 5% of the country's total inventory^{24,25}. A World Bank study projected that emissions from the waste sector would grow to 99 MtCO2e by 2030, but that implementation of certain mitigation strategies could reduce future emissions to just 18 $MtCO_2e^{26}$. Another study by McKinsey & Company indicated that the largest GHG abatement opportunity lay in recycling new waste because of the knock-on upstream emission reductions realised by avoiding primary processing of inputs like wood for paper and bauxite for aluminium²⁷. While major GHG abatement opportunities may lie in landfill gas capture or recycling, there are investment opportunities throughout the solid waste management hierarchy. Each stage of the hierarchy is described below, and the areas of particular opportunity are outlined in the table.

Specific opportunities

The National Policy on Solid Waste divides the sector into a six-part hierarchy^{28,29}:

- Non-Generation, which refers to the avoidance of waste creation in the first place, either through superior design, improved manufacturing processes, changing consumption behaviours
- 2 Reduction, which includes process innovations, sustainable designs, and lightweight, low-material packaging
- 3 Reuse, which delays ultimate disposal of material and plays a part in avoiding waste generation
- 4 Recycling, which involves the collection, sorting, reprocessing and reintegration of materials
- 5 Treatment, which refers to any form of management after the removal of recyclables, including waste-toenergy
- 6 Final disposal, such as the final resting place of incinerator ash or unrecoverables

Additionally, designing a waste management programme and implementation strategy for municipalities and corporations is another opportunity that integrates all parts of the hierarchy. Investment will be focused into increased recycling and treatment infrastructure:

Recycling

Investment will be focused on logistics and infrastructure for separation and treatment of sensitive materials like batteries and tyres³⁰. There is an on-going debate in Brazil about whether municipalities should pursue pre-sorting (where individuals separate recyclables into different bins at the source) or invest in sorting facilities (where mixed waste is sorted mechanically and by workers). It is generally understood that sorting facilities result in higher recycling rates, but their cost coupled with the influence of *catadores*, (collectors of recyclable materials), who are recognised stakeholders in the recycling chain, may limit the degree to which sorting facilities are adopted in some circumstances. The degree to which sorting facilities are preferred will influence the size of the opportunity.

Treatment

Investment will also be focused into new treatment facility capacity and capabilities, including conversion of open dumps into sanitary landfills with gas capture and combustion and other increased waste to energy facilities.

Stage	Category	R&D	Design & Planning	Manufacture & operate	Shipping & Iogistics	Finance
Non-generation &	Design					
reduction	Industrial process					
Recycle	Collection					
	Sorting					
Reduce & reuse	Reduce & reuse material					
Treatment	Incineration					
	Anaerobic digestion					
	Gasification					
	Pyrolysis					
	Plasma arc gasification					
	Landfill gas					
Final disposal	Incinerator ash					
Management &	Municipal					
planning	Corporate					
Overall						

Table 3: Opportunities by solid waste stage and segment of the value chain

Opportunities across the value chain

Table 3 outlines the opportunities by each section of the solid waste value chain. The opportunity combines: the Brazilian demand for solutions at each level of the solid waste management hierarchy; and, the accessibility of the opportunity for UK firms.

The greatest opportunity is for companies that provide plant for or operate recycling and treatment facilities, as well as for a diverse range of design & planning companies across the waste hierarchy. The areas of identified opportunity highlighted in the table are described below:

R&D

Opportunities exist for collaborative research into technologies and techniques for both anaerobic digestion and pyrolysis. The UK has particular R&D capabilities in anaerobic digestion, and research is supported by the UK's Technology Strategy Board³¹ and through national

government priorities³². It is a flexible technology that is appropriate for organic municipal waste, sewage sludge, and farm wastes, and produces energy from methane as well as agricultural fertilisers. Pyrolysis can also enhance soils by producing biochars that enhance specific deficiencies in agricultural soils. Since these technologies interlock with agriculture, they represent a significant opportunity as Brazil aims to reclaim 40+ million hectares of degraded land, which is needed to reduce emissions from land use, land use change and forestry³³.

Design and planning

There are opportunities for UK companies to contribute to waste reduction and non-generation through lightweighting, sustainable packaging, product design and industrial process efficiency. UK firms are also experienced in developing municipal integrated solid waste management strategies, and the new National Policy on Waste Management requires that 5,500+ municipalities develop such plans by 2014.

Manufacture and operate

There is opportunity for companies that sell plant & equipment for waste recycling and treatment as well as for companies that operate these facilities. There are particular opportunities in all treatment technologies because municipalities are currently evaluating which treatment solutions are most appropriate for their specific context. Recycling incinerator ash to create a sustainable input material for the construction industry³⁴ complements Brazil's growing construction market and increasing demand for sustainable materials.

The UK has the potential to benefit from these opportunities, with strong capabilities in:

- Recycling particularly the mechanical sorting of both single stream and mixed recyclable materials³⁵
- Anaerobic digestion over 250 companies are members of the UK's Anaerobic Digestion and Biogas Association³⁶ and the government is focusing on accelerating technology deployment³⁷
- Plasma arc gasification the UK has leading technical capability in this area, and UK companies already have a presence in Brazil³⁸
- Incineration world leading manufacturer of incineration systems (and the largest provider in Europe) is based in Worcester, UK³⁹

Companies with technologies that are proven to be lowcarbon and energy efficient with superior odour control and innocuous visual aesthetic are more likely to overcome some vestigial cultural barriers to certain technologies like incineration.

Shipping and logistics

There are few opportunities for UK firms in this market segment. Whilst there will be significant investment in shipping and logistics infrastructure for recycling and treatment, the UK has few competitive advantages in this area.

Finance

The US\$10 billion investment opportunity in Brazil's waste management sector over the next decade is significant. However, there are limited opportunities for foreign direct financing in the solid waste sector due to the magnitude of funds dedicated to the sector through Brazil's investment plan, the PAC2 programme, the involvement of the Brazilian Development Bank (BNDES), and existing programme finance through multilateral organisations like the World Bank.

Water & wastewater

Key findings

- Roughly US\$13.4 billion (R\$25.2 billion) will be spent on sanitation between 2011 and 2014 as part of Phase 2 of Brazil's National Growth Acceleration Programme (PAC2)⁴⁰, which could include foreign financing.
- Priorities for Brazilian water and wastewater service suppliers include equipment for water quality monitoring; water distribution network instrumentation; energy-saving water and wastewater pumping and aeration technologies; membranes; and sludge treatment techniques.
- UK companies have equipment capabilities for water quality monitoring and testing; nitrate and pharmaceutical removal; instrumentation for leak detection; sludge treatment techniques; and turn-key solutions for water and wastewater treatment, including energy-saving processes and technologies.



Market and emissions abatement opportunity

Brazil produced about 14.3 billion cubic meters of piped water in 2008, with roughly half of it being delivered to people in the states of Sao Paulo, Rio de Janeiro and Minas Gerais⁴¹. Water provision and treatment is growing at about 15-20% per year as more people in rural areas get connected to piped service, and as the actions under the "Water and Light for All" segment of the second phase of Brazil's National Growth Acceleration Programme (PAC2) get implemented. It is estimated that about 40% of the water that is produced in Brazil is lost, mostly due to leakage, but also because of under-registered or non-existent water meters, unauthorised consumption, and metering and accounting errors. Waste (both solid and effluent) accounted for between 52-63 MtCO2e in 2008, or between 4% and 5% of the country's total emissions inventory^{42,43} though disaggregated emissions information about wastewater, preliminary water treatment and water supply is not available.

For comparison, the UK piped about 3.3 billion cubic meters of water in 2008, and the amount of water needed to be produced per capita is slowly falling as leaks are mended and consumption patterns change due to improved end-use efficiencies. Treating and supplying water, and dealing with wastewater and sewage led to the release of about 5 million tonnes of GHGs in 2006/07 in the UK⁴⁴.

Brazil's PAC2 programme will see significant government-led investment in the sector between 2011 and 2014. Of the US\$16.6 billion (R\$30.6 billion) of planned investment in the "Water and Light for All" segment of PAC2, US\$13.6 billion (R\$25.1 billion) will be put towards improving the water supply in urban areas, construction and expansion of pipelines and treatment plants and irrigation⁴⁵. While these levels of investment are steps in the right direction, various government and industry bodies put the cost of achieving universal access to water and sanitation at between US\$49-146 billion (R\$90-270 billion) by 2025. The majority of this investment would be in sewage infrastructure, collection, and treatment technologies, since about 53% of Brazil's population is without sewage treatment services.

Currently, the industry has an annual turnover of about US\$3.2 billion (R\$6billion), spread between about 100 organisations and mostly concentrated in Sao Paulo and Minas Gerais⁴⁶. That is less than a quarter of the UK's US\$13.9 billion (£9 billion) annual turnover in the water sector in 2008. Similiarly, annual capital expenditure under PAC2 amounts to about US\$3.4 billion, which is about half of the UK's US\$7.6 billion (£4.9 billion) capital expenditure on water in 2008⁴⁷, but the PAC2 figures only reflect public spending and do not include private investment, which is more common in more populated and wealthier regions like the state of Sao Paulo.

There are several emissions abatement opportunities for the water and wastewater sector. Emissions from the primary production of clean water can be reduced by installing flow and pressure monitoring and optimisation technologies to detect leaks, repairing and better maintaining the water system to reduce leakage, and installing metering equipment to help manage demand. Emissions from wastewater can be minimised by improving effluent collection, treating it anaerobically, and fully capturing the resultant methane for use in energy production⁴⁸.

Specific Opportunities

The water and wastewater sector can be divided into four stages: water treatment, distribution, wastewater treatment, and systems management and planning. There are a number of different areas in which UK experience and technology would be welcomed:

In water treatment:

- Water quality monitoring and testing
- Removal of endocrinal disrupters and pharmaceutical contamination

In distribution:

- · Flow and pressure monitoring and optimisation
- Leak detection and repair
- New and refurbished pump stations
- Pipes and mains infrastructure

In wastewater:

- Municipal and industrial sludge treatment through anaerobic digestion (with energy generation)
- Municipal wastewater treatment facilities, including sludge treatment techniques
- Removal of contaminants (especially nitrates)

In systems management:

- System design and planning
- Professional services

Opportunities will be likely be most prevalent in equipment provision and operation, design and planning, and financing.

Opportunities across the value chain

Table 4 outlines where along the value chain the specific opportunities in the water and wastewater sector lie.

Stage	Category	R&D	Design & Planning	Manufacture & operate	Shipping & logistics	Finance
Water treatment	Water quality monitoring					
	Water quality testing					
	Pharmaceutical removal					
Distribution	Leak detection					
	Leak repair					
	Pump stations					
	Pipe/mains infrastructure					
Wastewater	Anaerobic digestion					
	Treatment facilities					
	Nitrate removal					
Systems	System design & planning					
	Professional services					
Overall						

Table 4: Opportunities within the water and wastewater value chain

R&D

Brazil has set a goal to come up with a low-cost, high-volume approach to remove nitrates from the potable water supply by 2012. UK companies have some globally deployed technical capacity for nitrate removal from municipal, industrial and agricultural wastewater, and continues to innovate through research and development^{49,50}. The UK also hosts a research sharing and coordination platform called the Environmental Sustainability Knowledge Transfer Network (ESKTN), which has made sustainable water management and resource efficiency one of its four research priorities. The ESKTN works to connect UK labs and institutions with public and commercial research and technology development capacity, funding opportunities and commercialisation support, both domestically and internationally⁵¹. Separately, UK research institutions like Cranfield University have postgraduate specialty science and technology development programmes for selective water filtration membranes to remove various contaminants from drinking water, such as arsenic⁵².

Design and planning

At the municipal level, designing and planning an integrated water supply and wastewater collection and treatment strategy requires specialist skills and experience that British firms could provide. Companies like MWH Farrer Consulting offer design and professional services associated with water, wastewater, and industrial treatment plants and networks. This company undertakes studies to assess investment needs, feasibility, design, commissioning and operation at business strategic, programme and project levels. It also helps manage assets through clean and wastewater hydraulic modelling, flow and pressure testing, condition assessments, demand analysis (including commercial and domestic usage, non-revenue water and rainfall), pump testing, water auditing, network management, pressure management, leakage management and detection, and water efficiencies⁵³. Since leakage is by far the largest source of water loss in Brazil, designing and planning an approach to leak detection and repair could significantly reduce demand for water production which would save energy and reduce emissions.

Manufacture and operate

The UK's capabilities in the manufacture and operation of equipment across water treatment, distribution, and wastewater management match with Brazilian opportunities.

- Water treatment UK-based technology firms like Salamander have developed advanced monitoring and remote sensing equipment and software to continuously test water quality with low cost, low power sensors and wireless networking⁵⁴. Companies like Biwater design and supply high quality, cost effective and reliable treatment solutions for all stages of the water production process that range from proven conventional treatment systems to high technology innovative processes which have been extensively researched, developed and tested. The company is currently working in over 30 countries, offers integrated expertise including wastewater treatment and professional services, and is committed to providing sustainable water solutions, conserving energy, and recycling⁵⁵.
- Distribution Companies like Halma Water Management • deliver products and services that monitor water flow and level, detect leaks, control pressure and collect data throughout the network. They produce some of the world's most advanced, accurate and easy to use monitoring and measuring equipment and are dedicated to providing innovative and cost effective solutions to help their customers manage their resources more effectively, thus providing energy savings and reducing the carbon footprint of any operation⁵⁶. Palmer Environmental, a subsidiary of Halma, sells Palmer Pressure Controllers that are designed to maintain optimum performance and longevity of the water network by controlling pressure in response to the changing demand for water throughout the day, contributing to lower carbon operations. Firms such as Fusion Provida have an international presence in the water market because of their global leadership in polyethylene pipe jointing expertise through butt fusion and electrofusion equipment that reduces the carbon footprint of plant operations⁵⁷.
- Wastewater UK-based Bluewater Bio International is a global specialist in delivering end-to-end wastewater treatment solutions for municipal, industrial and agricultural applications, including on-going operations and maintenance options. Their technology produces a very high quality, odourless and re-usable water resource by removing harmful nitrates, phosphates and other pollutants, which is a priority for the Brazilian government to reduce eutrophication of water bodies. Bluewater Bio's technology has a unique aeration mechanism that achieves improved performance with reduced power consumption, and the company can provide flexible

annuity purchase agreements that allow clients to treat wastewater without major expenditure by spreading the capital cost over several years⁵⁸. Process Instruments also supplies a variety of water and wastewater technologies, and has capability in automatic polymer control on centrifuge dewatering for sludge, centrifuges and filters⁵⁹. Such products are in demand from Brazilian service providers like SABESP, Sao Paulo's state water company⁶⁰. Sembcorp is another integrated water and wastewater treatment equipment and service provider with extensive international operations and capacity, with a strong presence in the UK⁶¹. There is also capability in metals recovery from wastewater (relevant to Brazil's mining sector)⁶².

Finance

Achieving universal access to clean piped water and sanitation services requires investments estimated at between US\$49-146 billion by 2025, and US\$13.6 billion has already been committed by 2014 under PAC2. PAC2 mixes federal government funding with investments from municipalities and privately owned companies, and the difference between PAC2's allocation and the total demand is significant. The gap represents an opportunity for foreign investors as municipalities and private companies will likely look to borrow private capital from international markets.

2 Transport

Context

A robust transport network is vital to facilitating trade and mobility. The quality of transport infrastructure coupled with the sort and suitability of the vehicle fleet determines a transport system's coverage, efficiency, and environmental impact.

The Brazilian government has supported a decade of healthy economic growth with heavy investment in roads and motorways to open up Brazil's interior to trade and to mobilise urban spaces. But its focus on the road network has led to underinvestment in other modal systems like rail and waterways⁶³. Recognising the growing pressure on inadequate and deteriorating airports, railways and ports, the government has committed to building and refurbishing these arteries, as well as investing in urban mobility through rapid transport in Phase 2 of Brazil's National Growth Acceleration Programme (PAC2). To ease the pressure on the public purse and accelerate upgrades, the government is experimenting with privatisation, and has already privatised the operation of Sao Paulo's, Brasilia's and Campinas' airports⁶⁴, with Rio de Janeiro's and Belo Horizonte's airports expected to feature in a forthcoming round of privatisation.

The 12 host cities of the 2014 FIFA World Cup, as well as the location of the 2016 Olympic Games in Rio, signpost where a lot of the significant infrastructural investment will be funnelled. While investment will be directed at all types of transport, the focus of this section will be on the aerospace and automotive sectors (spanning infrastructure and vehicles) because they represent especially large, near-term investment opportunities in Brazil, and because UK expertise dovetails with the demand.

Transport opportunities in rail and waterways will not be profiled in this section. Although rail transport represents a significant investment opportunity in Brazil, with £30 billion budgeted to be spent over the next five years⁶⁵, its overlap with UK capabilities is patchy. Roughly half of the total investment is earmarked for high-speed rail development, but the companies with global leadership in this specialty field mainly hail from China, Japan, Spain, Germany and South Korea. The UK is home to only one traditional passenger rolling stock manufacturer in Derby, but it is a subsidiary of Bombardier Inc., a Canadian company, and mainly supplies the UK's domestic market. Potential overlap does exist in developing the rail network, however, which is planned to grow from 29,000 km to 40,000 km by 2020. Since UK companies were instrumental in designing and building Brazil's first railroads, they could leverage the

historical link and their well-developed global connections to form international consortia to bid on future design and construction tenders⁶⁶.

The story is similar for shipping via waterways. While port construction and dredging of inland watercourses is needed to promote accessibility for deep-water craft and to open up Brazil's interior, companies in Germany, the Netherlands, France and Spain already have an established presence in Brazil and are perceived to be particularly suited to this market⁶⁷. There are opportunities for UK companies, however, in planning, project management, financing, insurance, and workforce training and capacity building, though competition from established firms will likely be high⁶⁸.

The remainder of the transport section looks at the aerospace and automotive sectors separately. Within the aerospace sector, the analysis is segmented into two pieces: infrastructure and vehicles.

Airports and aerospace

Key Findings

- More than US\$4 billion is earmarked for investment in airport infrastructure by 2014
- UK firms can tender their services to enhance muchneeded longer-term capacity, and to contribute to nearterm demands as projects are rushed to be completed before the 2014 FIFA World Cup and the 2016 Olympic Games
- UK opportunities for airport infrastructure stem mainly from design and planning, where a number of UK firms have world-renowned experience in sustainable airport design
- Brazilian company Embraer is the world's third-largest aircraft manufacturer, has a firm order book of more than US\$15 billion, and mostly supplies European, North American and South Asian carriers. They are keen to buy ready-made parts and outsource manufacturing
- UK capabilities overlap with Embraer's requirements for aircraft interiors, lightweight composites and components, maintenance products and services, and connectivity equipment
- Emissions from air travel are set to triple by 2030 in Brazil, but the durability of both aircraft and airport infrastructure means that early integration of sustainable design and production will have a lasting effect on the sector's overall emissions, within Brazil and internationally

Box 3: Low carbon aviation

The aerospace industry is not traditionally pegged as an obvious low-carbon opportunity. The sector represents roughly 3% of global GHG emissions, and its climate change impact is unusual because emissions are mostly discharged in the troposphere and stratosphere rather than on the ground.

The intensity of aircraft emissions can be mitigated, however, through technical efficiency gains and optimised capacity utilisation, and potentially through fuel switching.

In terms of efficiency, companies that contribute to accelerating the implementation of components and systems that improve aircraft efficiency are participating in reducing emissions from air travel, and are therefore considered to contribute to lower-carbon aviation.

In terms of fuel switching, producing bio jet fuel, or developing jet engines capable of burning low carbon alternative fuels, would also contribute to lowering emissions from aviation.

Airport infrastructure can be made lower carbon through better design and more efficient building systems, though carbon savings from airports will be marginal relative to overall emissions from aviation.

Market and emissions abatement opportunity

Airports

Construction and expansion of Brazil's airport network is an identified necessity. A lot of investment money has been committed to be spent in the near-term, and targeted investments in this area could generate some carbon savings in the sector compared to business-as-usual development.

In terms of need, a study by Brazil's Institute for Applied Economic Research suggests that 17 of Brazil's 20 largest airports are currently running over capacity⁶⁹. Using different assessment methodology, the government-owned company *Infraero*, which is responsible for operating Brazil's main commercial airports, believes that only three airports are critically saturated, with another four requiring attention⁷⁰. Either way, it is widely agreed that immediate investment in airport infrastructure is badly needed⁷¹.

The government has responded to this need by budgeting R\$104.5 billion (US\$59 billion) to improving transport infrastructure, including modernising airports, ports, railways and motorways through PAC2 between 2011 and 2014⁷². Airport spending estimates vary: Brazil's 2011 federal budget earmarked R\$2.7 billion (US\$1.6 billion) for airport spending, with roughly 80% of it going to Infraero, Brazil's nationalised airport authority, and the remainder going directly to infrastructure spending. Infrearo has budgeted R\$5.15 billion (about US\$3 billion) to be invested in airport terminals in the cities hosting the 2014 FIFA World Cup, and airports outside of these cities will be upgraded as well to accommodate the sustained increase in passenger numbers. Hundreds of millions more investment is expected to come from the private sector in airports in the states of Rio Grande do Norte, Rio de Janeiro and Sao Paulo⁷³. Historically, though, only about 44% of government funds budgeted for airport improvements have actually been spent, so some doubt whether this large-scale investment commitment will have the impact it ought to⁷⁴. One difference between budgets since 2002 and current and future spending plans, however, is the recognition of steadily growing passenger and freight demand due to competitive pricing and growing wealth, and pressure stemming from the two major forthcoming sporting events.

The 2014 FIFA World Cup sets a non-negotiable deadline for many airport improvements, and the Olympic Games in 2016 represent another investment fencepost. While it may be challenging to complete all permanent airport structures by 2014, planning authorities and analysts are confident that investments in runways, tarmac areas and temporary terminals will be completed on schedule, and opportunities still remain for new entrants to participate in the market⁷⁵. Overall, infrastructure investment is significant, there are many different airports with need, and the timeframes for activity are very near-term.

In terms of the emissions abatement opportunity for airport infrastructure, the emissions reductions are likely to come from low-carbon design and construction, and from the optimisation of landing, turnaround, taxiing and take-off procedures to minimise tarmac idling^{76,†}. While new terminal buildings built with a sustainability focus have achieved emission reductions of up to 32%⁷⁷, few figures are available to quantify possible emission reductions from Brazil's new and refurbished airport infrastructure.

Aerospace

The market for airplanes is growing rapidly in Brazil as its major airlines keep pace with accelerating demand. Passenger travel more than doubled between 2003 and 2010, and the number of flights has gone up by 50%⁷⁸. While many of the planes operated by Brazil's largest carriers are Airbus and Boeing, Brazilian aerospace manufacturer Embraer is also powering growth in air travel throughout South America. Embraer is the world's third largest commercial airplane manufacturer, has 45% of the regional market of 30-60 seat planes, and is a leader in commercial aircraft up to 122 seats. Europe is its most important regional commercial aviation segment with 32% of sales, followed by North America (23%) and Asia Pacific (21%). It had turnover of US\$5.25 billion in 2010 and a firm order book of 250 aircraft worth US\$15.6 billion at the beginning of 2010⁷⁹.

The majority of Embraer's supply chain is located outside of Brazil, with US companies dominating the supply chain. UK firms account for less than 2% of the content of Embraer aircraft. The Brazilian government, which holds only 0.3% of the company's shares but retains veto power through the possession of "golden shares," is eager to increase the domestic content of Embraer's future aircraft, which could create opportunities for UK firms looking to establish partnerships with local companies and develop a domestic manufacturing base for aircraft components⁸⁰. The emissions scenario from the sector has been estimated in a World Bank study, and indicates that emissions from air transport will nearly triple between 2007 and 2030, from 8.4 to 23.7 MtCO₂. In its analysis of future carbon savings, the study bundled together all modes of transport, and identified the biggest abatement opportunity coming from a modal shift away from air travel towards intercity rail. Even under the scenario where a modal shift towards rail occurs, emission reductions were only projected to be 1.3% by 2030⁸¹. Moreover, while treating transport modes as fungible was appropriate in the World Bank study, such bundling may forego some analysis about potential carbon saving opportunities within aerospace sector itself.

Staying within the envelope of air travel, emission reductions will likely come from lightweighting through advanced materials, innovative aircraft design, efficiency in jet engines and on-board systems, and potentially from advances in bio-jet fuels^{82,83}. Improving the efficiency of Embraer's fleet will not only impact upon Brazil's emissions trajectory, but will also radiate out to global air carriers because of the international make-up of Embraer's export market. Efficiency improvements in Embraer's aircraft will therefore have an impact beyond Brazil's borders, though the projected magnitude of emission reductions from these measures has not been measured.

Specific opportunities

Opportunities in the aerospace sector can be divided into infrastructure and aircraft.

For airports, the low-carbon opportunity focuses mostly on sustainable design, including:

- Building HVAC and integrated control systems
- Optimised construction materials
- Lighting design to reduce thermal gain
- Water management
- · Air traffic control and runway optimisation

For the aircraft themselves, the lower-carbon opportunities include:

- Lightweight components and composites, and readymade structures
- Maintenance
- Interiors and connectivity



Subsector	Category	R&D	Design & Planning	Manufacture & operate	Shipping & Iogistics	Finance
Airports	HVAC & control systems					
	Optimised materials					
	Lighting design					
	Water management					
	Air traffic control & runway					
Aerospace	Materials & structures					
	Maintenance					
	Interiors and connectivity					
Overall						

Table 5: Opportunities within the airports and aerospace the value chain

Opportunities across the value chain

The highlighted areas of identified opportunity are described below.

Under airport infrastructure:

The biggest opportunity in airport infrastructure given the UK's capabilities is in the design and planning of airports. UK firms offer integrated design expertise that spans most or all categories. UKTI has compiled a report that details the UK's impressive track record delivering world-leading sustainable airport solutions that include emission reductions, noise management, air quality, biodiversity, surface and ground water pollution and the efficient management of resources such as energy, waste and water⁸⁴. Some firms they highlight are described below:

- Arup has coordinated and designed over a dozen airports and related infrastructure. Its extensive experience and integrated service offerings incorporate sustainability designs including natural light optimisation, passive systems, water and heat capture and recycling, intelligent building envelopes, automatic environmental control systems, and optimised construction materials⁸⁵.
- Foster & Partners has helped design airports in Beijing, Hong Kong, Jordan and London, and designed the world's first Spaceport, which is under construction in the US. Sustainability elements they design into their projects include integrated environmental control systems, natural lighting to minimise thermal gain, sustainable selection of

construction materials with minimal embodied carbon, and integrated transportation links⁸⁶.

- Pascall & Watson has contributed to the design of over a dozen airport structures, and develops projects according to its Green Design Guide, which has helped it achieve ISO 14001 accreditation for Environmental Management Systems. Their designers optimise energy efficiency, sustainable design, low running costs and waste reduction throughout all work stages of a project, and across the economic, environmental and social pillars of triple-bottom-line sustainable practice⁸⁷.
- TPS has designed and advised on elements for airports in London, Madrid, and Dublin. TPS uses the Carillion model for sustainability, which integrates community, social and environmental factors into each design and development decision, from first concept to procurement and delivery⁸⁸.
- NATS⁸⁹ is one of the world's first air traffic control organisations to set firm targets for reducing emissions in its air traffic management system. Their system applies analytical tools that provide airport CO₂ assessments, which can be used to develop airport and airspace efficiencies and CO₂ reduction strategies.

 QinetiQ⁹⁰ designs and produces the QinetiQ Tarsier system, which automatically detects foreign object debris on airport runways. It increases safety whilst minimising the cost of runway closures and aircraft damage. The environmental benefit of the system stems from emission reductions achieved by reducing the need for aircraft to stack.

Other UK firms highlighted for their airport design and planning experience include: Atkins⁹¹, BAA⁹², Buro Happold⁹³, Davis Langdon⁹⁴, DSSR⁹⁵, Grimshaw⁹⁶, Halcrow⁹⁷, Mace⁹⁸, Mott MacDonald⁹⁹, Rogers Stirk Harbour & Partners¹⁰⁰, Sandy Brown Associates¹⁰¹, Vector Management¹⁰², and WSP Group¹⁰³.

Under aerospace:

There are a number of aerospace equipment manufacturers in the UK. A low-carbon and sustainability element tends to be intrinsic in the manufacture and operation of top-of-theline equipment since efficiency gains are highly prioritised in the aircraft sector. For example, market-leading composites are those that combine strength, durability, and lightweighting, and since those characteristics reduce inflight weight and also minimise maintenance and replacement, they also reduce carbon.

UKTI listed a set of aerospace companies that have experience in the design, manufacture and/or export of products and services. Companies that design and manufacture lightweight components, composites, and ready-made structures include:

- GKN Aerospace¹⁰⁴, a Tier 1 supplier to Airbus and Boeing who manufacturer highly complex aerostructure products that include wing trailing edge structures.
- SpiritAerosytems¹⁰⁵, a Tier 1 supplier to Airbus and Boeing that supply, assemble and manufacture composite wing components.
- Hampson Aerospace¹⁰⁶, an aerostructure composite manufacturer and the largest independent aerospace tooling solutions business in the world, combining three best-in-class tooling suppliers.
- Atlas Composites¹⁰⁷, a manufacturer of carbon fibre components into the aerospace engineering industry. Services include CAD Models, master patterns, and mould tooling through to component manufacture.
- Brookhouse¹⁰⁸ is part of Kaman UK, and provides expertise in the design and manufacture of composites aerostructures, composite tooling, repair and overhaul.

Companies involved in maintenance include:

• AmSafe¹⁰⁹, which offers maintenance, repair and overhaul products and services, and safety and securement equipment including seatbelts, restraints, airbags, and cargo and airframe products.

Companies that design and manufacture interiors and connectivity products include:

- B/E Aerospace¹¹⁰, supplier of aircraft interior products, fasteners and consumables.
- Aeropair¹¹¹, design, manufacturer and repair of aircraft interiors, including composites, sidewalls flooring and structures.
- Thompson Aero Seats¹¹², supplier of aircraft seating and business-class flat beds.
- Page Aerospace¹¹³, manufacturers electronic cabin power and lighting products.

Automotive

Key Findings

- Brazil is the world's sixth largest automotive maker and fourth largest automotive market
- The automotive manufacturing industry generated revenue of about US\$71.1 billion in 2010, and will invest roughly US\$11.2 billion between 2010 and 2012
- The autoparts industry had turnover of US\$49 billion and invested US\$1.5 billion in 2010
- Low carbon opportunities stem from improving manufacturing productivity, which lags internationally, by integrating technologies, process optimisations and designs to reduce emissions, waste, energy and water use
- Significant opportunity also exists for R&D collaboration for low-carbon vehicles, OEMs to export low carbon vehicle components, and consultation on design, monitoring and evaluation, and process optimisation

Market and emissions abatement opportunity

There is a large and growing automotive market in Brazil, with major manufacturing, assembly and OEM capacity across all vehicle types. Significant investment is planned in the near-term to improve the productivity of the industry, and there are opportunities for collaborative technology development and trade in components. Brazil's auto industry also has a unique low-carbon element related to the high penetration of flex-fuel vehicles, and is eager to further reduce emissions across its fleet. The sector will be analysed in terms of domestic production and domestic consumption. Following that, the emissions abatement opportunity will be explored.

The automotive industry is enormously important to Brazil, with the manufacture of vehicles and auto parts representing roughly 23% of its total industrial production and employing over 136,000 people¹¹⁴. Brazil is the world's sixth-largest vehicle manufacturer, generating total revenue of US\$71.1 billion in 2010, and has an 80% market share in South America¹¹⁵. Most major international players have plants in Brazil: the country has 21 plants making automobiles and light commercial vehicles, 8 plants making heavy trucks and buses, 12 agricultural machinery plants, 12 engine and component plants, 500 autopart manufacturers with 650 plants, and over 4,000 dealerships. In 2011 it was announced that two new vehicle plants would be built by Toyota and Fiat, as well as one new engine plant by General Motors^{116,117,118}.

Investment by the automobile industry will total US\$11.2 billion between 2010 and 2012, and is being directed at new plants, technology and product development, and improving processes to increase throughput capacity. Turnover in the autoparts sector was US\$49 billion (R\$79.7 billion) in 2010, and is expected to grow by about 8% in 2011, while investment in the subsector was US\$ 1.5 billion in 2010, representing a 137.7% increase over 2009. The trade deficit of the autoparts sector grew, however, to US\$4.5 billion (US\$8.7 billion on exports vs. US\$13.2 billion on imports)¹¹⁹. The Brazilian automotive sector still lags behind international competitors in terms of productivity, and there is lots of room for domestic manufacturers to invest in automation and improved production methods to close the productivity gap.

In terms of the domestic consumption market for automobiles, Brazil overtook Germany as the world's fourthlargest car market in 2011¹²⁰. Brazil's National Association of Motor Vehicle Manufacturers, Anfavea, pegged new vehicle sales at a record 3.69 million in 2011, up 5% from 2010, and 14.3% from 2009¹²¹. Vehicle sales are expected to double by 2020¹²². Trends within the overall figures show that imported vehicles sold much faster than domestically-produced ones, despite a whole-vehicle import duty of 35%: between 2009 and 2010, imported vehicle sales jumped 35% whilst sales of domestically produced ones grew at 7.6%. Such strong growth in imports reflects the strengthening Brazilian currency, increasing wealth and shifting preferences, and overall sales growth is attributed to the volume of credit extended to consumers in 2010 (roughly 18% more than in 2009) and rising consumer confidence.

Comparing the dynamics of domestic production and consumption shows that in 2010, Brazil had a trade deficit of US\$5.7 billion in the automotive sector (US\$18.1 billion on exports vs. US\$23.8 billion on imports). While exports grew in 2010, the figures reflect a rebound from a serious decline in 2008, when the number of exported vehicles nearly halved due to the global economic recession¹²³.

There is a distinct low-carbon opportunity in the Brazilian automotive sector because of the prevalence of ethanol in Brazil's fuel supply. Flex-fuel engines are able to run on a mixture of bio-ethanol and gasoline, and the share of new vehicles sold in Brazil with flex-fuel technology has risen from 7% in 2003 to 86.4% in 2010¹²⁴.

Further emission reductions in the transport sector are wanted, and can be achieved through emissions controls, the use of lightweight components and advanced materials, like substituting steel with aluminium or composites in a costcompetitive way. Local Brazilian research institutions and OEMs are also eager to see large multinationals base aspects of their low-carbon R&D programmes in Brazil, especially with regards to the development of electric motors and electric vehicles.

Generating emission reductions in the automotive sector is also supported by government policy. It offers some relief on import duty for vehicle components that generate carbon savings (import duty for vehicle components varies widely depending on the part, but currently sits at 14% on average).

Specific opportunities

There is very extensive automotive capability in the UK that spans many low-carbon opportunities and work areas. Organisations in the UK have focused on improving the sustainability of their manufacturing operations, and the effort has returned impressive results. Between 2009 and 2010, almost all environmental indicators of vehicle production improved:

- both energy and water used per vehicle built fell by 8%;
- CO₂e released per vehicle built fell by 10.5%;
- Volatile Organic Compound emissions per car fell by 5.6%; and,
- waste to landfill per vehicle built fell by 18.5%.

Outside of the factory, the environmental performance of new vehicles also improved, with new car CO_2 emissions falling by 3.5% on average, to $144.2gCO_2/km^{125}$. Brazilian manufacturers are eager to implement process efficiencies in their plants, and the aptitude shown by UK companies in improving their sustainability performance could be shared internationally.

In terms of the operating performance of the vehicles, it is appropriate to list the UK's full suite of capabilities since Brazil operates in a diverse automotive market with hundreds of OEMs, has a strong presence from most major multinationals automakers, and works in operational areas in every automotive segment.

UKTI's Low Carbon Automotive Directory¹²⁶ lays out in detail the capabilities of the UK's automotive market, including the strengths of government, NGOs, trade bodies, academic institutions, manufacturers, developers, consultants, educators, and aftermarket specialists.

Table 6 below shows the number of organisations described in the directory that are involved in each of 14 categories across seven operational areas.

Box 4: Promoting low carbon vehicles

Various organisations are working to advance the interests of UK companies working on low carbon vehicles, and are helping actors access international markets. The Low Carbon Vehicle Partnership[†] operates five targeted working groups that help to ensure that UK companies working on passenger cars, buses, commercial vehicles, alternative fuels and technology innovation are best placed to capitalise on low carbon markets in the UK and abroad.

Cenex^{*f*}, the UK's centre of excellence for low carbon technologies, has programmes dedicated to assisting with RD&D for low-carbon vehicles and alternative fuels infrastructure deployment. Cenex also supports the Transport Knowledge Transfer Network[±], which coordinates a national network of stakeholders to promote innovation, knowledge sharing, and collaboration.

[†] www.lowcvp.org.uk/

f www.cenex.co.uk/

[±]connect.innovateuk.org/web/transportktn

Category	Gov't / NGOs / Trade bodies	Academic research	Development	Production / Manufacture	Consulting	Training and qualifications	Aftermarket
Advanced materials and fluids	1	3	3	12	3	-	-
Specialist manufacturing	5	1	7	20	4	-	-
Engines and engine components	-	4	15	12	8	2	2
Transmissions and drive trains	-	2	10	9	2	1	-
Energy recovery and storage	1	5	12	12	4	1	-
Electrical recharging infrastructure	3	4	-	4	4	-	-
Alternative / low carbon fuels supply	4	4	5	13	13	3	2
Emissions control	1	2	6	7	3	4	4
Systems integration & power management	-	-	-	-	-	-	-
Design and simulation	-	5	21	7	10	-	-
Monitoring and evaluation	5	5	3	4	13	3	1
End of life vehicle recycling	1	1	-	1	1	-	-
Fuel cells	-	2	3	4	1	-	-
Entire vehicles	11	2	16	25	15	1	-

Table 6: Number of UK organisations involved in each work stream

Segment	Category	R&D	Design & Planning	Manufacture & operate	Shipping & Iogistics	Finance
Automotive	Advanced materials and fluids					
	Specialist manufacturing					
	Engines, transmissions & drives					
	Energy recovery & storage					
	Alternative fuels supply					
	Design and simulation					
	Monitoring and evaluation					
	Process optimisation in plants					
Overall						

Table 7: Opportunities within the aerospace the value chain

Opportunities across the value chain

Table 7 consolidates Table 6 to draw focus to highlight opportunities where UK capabilities significantly overlap with Brazilian demand. Some categories have been combined and others have been eliminated to make the chart more manageable, and a category for process optimisation in plants has been added since it was not the focus of UKTI's Low Carbon Automotive Directory.

Unlike in other sections, company-specific examples of UK capabilities are not presented for low carbon automobiles because the 2011 Low Carbon Automotive Directory presents a more holistic and descriptive list than space permits in this report. High-level descriptions of UK capabilities are presented below, however, as are some company examples for low carbon capabilities related to process optimisation since that falls outside of the scope of the Directory.

R&D

The UK's research capabilities lie in both the public and private sector. Specialty exists in academia, within various government agencies, in private enterprise, and throughout a variety of consortia that link business with other research sectors. Expertise lies especially in engines and engine components, transmissions and drive trains, and hybrid and full electric vehicle systems and components, though there are strong players in other categories as well. The R&D column in Table 7 reflects an agglomeration of the first three operational areas in Table 6: Government / NGOs / Trade Bodies; Academic Research; and elements of Development. Many organisations with R&D capabilities also design and produce components.

Design and Planning

Companies with design and planning capabilities span most automotive categories. Companies with these specialties often have the capacity to produce their own components and systems, or have relationships with domestic and foreign manufacturers to bring their designs to market. Organisations working in this segment of the value chain may also have expertise with Computer Automated Design software, virtual testing of components and systems, and technical monitoring skills. Highlighted segments in the design and planning column of Table 7 reflects capabilities across both the development and consulting operational areas in Table 6, and therefore include elements that span policy, consumer research, project management planning, and technical advice.

Manufacture and operate

There are dozens of UK-based companies with manufacturing capabilities across almost every category described in the 2011 Low Carbon Automotive Directory that are eager to export their products. There is a particular export opportunity for makers of carbon-reducing automotive parts since they can qualify for some breaks on Brazil's relatively high import duty. Brazil is already a net importer of components, but Brazilian automotive manufacturers are still searching for additional suppliers for a variety of components. There are also opportunities for firms specialising in technologies and process optimisations that cut energy, water, CO₂ emission, and VOCs, and result in less material waste. For example, painting is a highly energy intensive step of the vehicle manufacturing process, and an innovative painting method being developed by the Warwick Manufacturing Group dramatically cuts energy use and is in the commercialisation stage¹²⁷.



3 Renewable energy

Context

Brazil has the cleanest energy supply in the world, with 44.8% of its total energy supply coming from renewable sources in 2010. That is expected to grow to 46.3% by 2020, even though total energy demand will also grow by 60% in the decade up to 2020¹²⁸. Maintaining such a high proportion of renewables while adding tens of thousands of additional megawatts of installed electric capacity, expanding industrial output and doubling vehicle sales will require enormous investments in the near term.

Brazil invested roughly US\$7 billion in new renewable capacity 2010, making it the world's fifth-largest investor in renewables (excluding large hydro)¹²⁹. This figure is down from an investment high of US\$10.8 billion in 2008, and reflects large spending on consolidating a highly fragmented ethanol market through mergers and acquisitions, which doesn't count as new investment^{130,131}. Even with two years of scaled back investment in new capacity, Brazil still rounds out the top five global investment destinations for renewables. Projections indicate that Brazil will continue to be a dominant world player for the rest of the decade due to its plans to expand capacity whilst maintaining global leadership in clean energy production.

Specifically, Brazil's national Energy Research Company (EPE) projects that installed electric generating capacity will grow from 110,000 MW in December 2011 to 171,000 MW by the end of 2020. Brazil currently boasts one of the cleanest electricity supplies in the world, with 83% of supply sourced from renewables, including large hydro. To maintain what is increasingly being viewed as a global competitive advantage, investment priority will be given to renewable sources, especially hydro, wind and biomass. The total share of wind power is projected to grow significantly, from 1% to 7%, and small hydro and thermal biomass together are anticipated to grow from 7% to 9%. The proportion of large hydro in Brazil's electricity mix will likely fall from 76% to 67%, despite the installed capacity of large hydro growing by more than 30,000 MW in absolute terms. It is also a national priority to produce non-electric energy from renewable sources. Transport as a sector consumes the second-most energy in Brazil after industry, and while the efficiency of vehicles is steadily improving, vehicle sales are expected to double by 2020¹³². To manage this growth whilst maintaining its low carbon energy mix, Brazil intends to help meet demand by tripling ethanol production from a baseline that is already the second-largest in the world¹³³.

This section will therefore focus on the biofuels market because it is a major investment area in Brazil, and because the low carbon credentials of Brazilian ethanol are clear and robust. In particular, ethanol production is poised to grow enormously over the next ten years, and the opportunity for finance and technology sharing is large. Heat and electricity from biomass, especially from sugarcane bagasse, is another growth area in which the UK can participate through financial services. These two sectors will be described in more detail below.

Despite the large and growing market for other types of renewable electricity in Brazil, this section will not focus on large hydro, wind power, solar PV, or other alternative fuels like tidal or wave power.

As the world's second-largest hydroelectricity producer, Brazil already has well-developed competencies in dam construction, the manufacture of generating equipment, site planning, and related activities. Other countries like the United States, Canada, China and Germany are better placed to access any unmet demand in Brazil because of their significant experience with large hydro construction and equipment. Large hydro projects are also publically financed, which limits financial services opportunities. So while there will be significant investment in this sector in the near and medium term, Brazil's domestic market is minimally accessible for UK companies. Therefore, this market segment will not be described in detail in the section. Although wind power represents a significant commercial opportunity, it has been excluded from this report. It is worth noting, however, that wind energy is slated to grow very quickly over the next decade in Brazil. More than 1 GW of new generating capacity was awarded to wind developers in the Brazilian government's latest round of power auctions, and several additional gigawatts have already been contracted and have yet to be installed. The investment needs are very large - up to US\$15 billion by 2014 - and an average additional installation of 2.5 GW per year until 2020 will see roughly US\$50 billion spent on new capacity over that time period^{134,135}. The existence of significant UK-based expertise in various stages of wind power development, including site planning, impact assessments, visualisation, logistics, components manufacturing, installation, operation, and maintenance suggests that there are significant opportunities for UK businesses to participate in Brazil's rapidly expanding wind energy market. Wind energy is a major opportunity for UK businesses operating across all segments of the value chain, and interested companies should contact the FCO and UKTI for further guidance as to how to best access this market.

Regarding solar, there are currently very few solar installations in Brazil. Little solar PV capacity has been deployed largely because there has been a lack of marketenabling legislation to permit grid interconnection and because it is a relatively expensive technology compared to other types of renewables. Much of Brazil's existing solar PV installations service off-grid applications, like radio repeater stations or small, isolated communities, but legislative advances that facilitate grid interconnection and a renewed government focus on solar PV may see the market landscape change within the next year¹³⁶. The government is set to release a solar PV strategy later this year and is also preparing to hold a solar PV auction in 2012, but at present there is little market information available. As for solar thermal, while the technology is cost-competitive, many companies are not investing in it because the payback is less attractive compared to other investments¹³⁷.

From the UK business perspective, there is limited capability for domestically-produced first-generation solar PV, with the vast majority of solar producers based in China, as well as Germany, the United States, Japan, and South Korea. There are promising UK capabilities in research, development, and pre-commercialisation of second and third generation solar PV, but these may to be too future-oriented to offer much near-term export potential to countries with a nascent solar market like Brazil. Solar thermal deployment is scarce in the UK, and the relative simplicity of this technology likely means that any accelerated demand in Brazil will either be serviced by local outfits or by countries like China, where deployment is widespread and manufacturing is relatively inexpensive. For all of these reasons, the solar market has been excluded from this section.

As for ocean energy technologies like tidal and wave power, their relative immaturity compared to other forms of renewables coupled with underdeveloped mapping and regulation in Brazil limits their near-term commercial potential. There is no official map of ocean power potential and no government guidelines for deployment¹³⁸, so while Brazil's long coastline may offer abundant opportunities in the future, the marine energy sector has been excluded from this section for now.

The remainder of this section will therefore focus on ethanol and energy from biomass.

Ethanol and biomass

Key Findings

- Investments in new and refurbished ethanol mills and cogeneration equipment will top US\$50 billion by 2020, making finance a key opportunity for UK financial institutions and investment funds
- Brazil is the second-largest ethanol producer in the world; by 2020, it is planning to triple ethanol production and potentially triple cogenerating capacity from bagasse combustion
- Expanding ethanol production and bagasse electricity generation could save over 28 MtCO₂ annually by 2030, and enable Brazil to develop whilst maintaining its lowcarbon energy matrix
- Some opportunity exists for collaborative R&D in niche areas like biobutanol, aviation biofuels, and advanced biofuel production methods and processes



Market and emissions abatement opportunity

Brazil is the world's second-largest ethanol producer after the United States, and the industry has grown continuously since 2000, reaching production of more than 27 billion litres in 2010^{139,140}. Virtually all ethanol produced in Brazil is derived from sugarcane, which differs from the feedstocks of other countries, notably the United States, where corn is the main feedstock.

Brazil's ethanol production is expected to triple in this decade, from 27 billion litres in 2010 to 73 billion litres in 2020, including 6.8 billion litres for export. Total investment planned for biofuels is estimated to be about R\$97 billion (US\$55 billion) by the end of the decade, almost entirely concentrated on ethanol production, with R\$90 billion (US\$51 billion) going to production plants, and R\$7 billion (US\$4 billion) going to pipelines and ports. Biodiesel is expected to receive only R\$200 million (US\$114 million) in new investment over the decade.

Ethanol production in Brazil comes with an additional lowcarbon opportunity. Bagasse, the fibrous material that remains after crushing sugarcane to extract the juice, is burned at the mill to produce heat and electricity. Bagasse stands out among the various potential biomass feedstocks because of its dominant market share, so when discussing biomass opportunities in this report, bagasse remains the focus¹⁴¹.

All new mills are equipped with cogeneration equipment that produces heat and electricity. Rising electricity prices coupled with increasingly efficient cogeneration equipment means that electricity sold to the grid can comprise up to 30% of a new mill's revenue and also potentially qualify for carbon credits. The current national electric generating capacity from bagasse combustion is about 4.5GW, with much of it being consumed by the mills themselves. But with the expanding electricity grid reducing interconnection costs and improving equipment efficiency, forecasts estimate that newly built mills and refurbished older ones will see power production increase to between 9 and 13 GW by 2020¹⁴².

Financing the construction of new sugar and ethanol mills and refurbishing older ones is a major opportunity for UK banks and investment funds. Up to 2008, foreign investment made up about 25% of total investment in the sector, with major multinationals like Shell, BP, Abengoa, and others taking significant stakes in the market. Since then, the market has been in a state of flux as it continues to be consolidated. Small producers are being absorbed by larger players, and foreign involvement in the market is still strong. Factors driving the market for ethanol include the complexion of the domestic vehicle fleet and Brazil's regulatory environment. Demand for ethanol is increasing in large part because of the prevalence of flex-fuel engines in its vehicle fleet. Fully 86.4% of new vehicles sold in 2010 were equipped with flex-fuel technology, up from 7% in 2003¹⁴³. Currently, about 50% of the country's vehicle fleet is equipped with flex fuel technology, and that is projected to reach 86% by 2020. The changing face of the automotive industry is being supported by lower taxation on flex fuel vehicles and by shifting consumer preferences¹⁴⁴.

There is also an emerging demand for additional types of biofuels from sugarcane, such as biobutanol and aviation biofuels, which have a higher energy content and are less corrosive than ethanol, enabling them be shipped more easily via pipelines. There are technology development and manufacturing opportunities for UK companies in this emerging field as well.

The emissions story is positive for ethanol, too. Sugarcane grown to produce ethanol in Brazil boasts the world's best energy balance for large-scale commercial biofuel production, generating roughly eight times more energy than it uses to grow, collect and process the feedstock into fuel¹⁴⁵. Brazil also undertook a major agro-ecological zoning initiative in 2009 that mapped Brazil's geographical regions for the purpose of promoting sustainable sugarcane growth and development, accommodating for social, environmental and economic factors¹⁴⁶. The project, dubbed ZAE Cana, helps to ensure that sugarcane plantations do not result in land-use changes that have negative consequences for their lifecycle emissions and for the broader environment¹⁴⁷. To quantify these emission reductions, a World Bank study estimated that, under a reference scenario, the rate of substitution of ethanol for gasoline could increase from about 40% in 2010 to about 60% in 2030. But with sustained policy intervention, like the differential tax treatment described above, the rate of substitution could climb to 79% by 2030. In that case, transport emissions would be 12% lower than the Bank's reference scenario, saving an additional 28 MtCO2e annually by 2030¹⁴⁸. Coupling that emissions advantage with increased electricity generation from bagasse, which is virtually carbon neutral, demonstrates the low-carbon nature of this dual industry.

Specific opportunities

Financing is the largest identified opportunity for UK involvement in Brazil's ethanol industry. Financing ethanol production plants, including the refurbishment of older cogeneration equipment, will be needed as Brazil significantly increases production capacity between now and 2020. Other more limited opportunities include:

- Technology R&D and deployment for biobutanol and biofuels for aviation, and advanced biofuel production and process
- Shipping and logistics to transport ethanol from production areas to population centres

Opportunities across the value chain

Table 8 highlights opportunities where UK capabilities significantly overlap with Brazilian demand.

Segment	Category	R&D	Design & Planning	Manufacture & operate	Shipping & Iogistics	Finance
Ethanol	Standard new production plants					
	Refurbished cogeneration equipment					
	Ethanol pipeline infrastructure					
	Transporting product to market					
	Biobutanol and aviation biofuels					
	Advanced biofuels & processes					
Overall						

Table 8: Opportunities within the ethanol and biomass value chain

R&D

The UK has R&D capability in niche and emerging areas, especially in lignocellulosic conversion to bioethanol, second generation sustainable bacterial biofuels, and biobutanol development with limited research into aviation biofuels. The UK's Biotechnology and Biological Sciences Research Council (BBSRC)¹⁴⁹ represents a £24 million investment that spans the biofuel production spectrum, from growing biomass to fermentation. It also brings together the knowledge and expertise of over a dozen leading industrial associates and academic institutions. UK-based companies such as Green Biologics¹⁵⁰ and Butamax Advance Biofuels¹⁵¹ (a joint venture between BP and DuPont) specialise in technology development including research and production of biobutanol, and aviation biofuels from feedstocks including sugarcane. Other companies like TMO Renewables¹⁵² are focussing on developing commercially viable production of ethanol using bacteria to transform agricultural residues and municipal solid waste. These niche segments, especially aviation biofuels, are potential growth areas in Brazil's market, but their limited near-term commercial potential only warrants the R&D segment of the value chain a 'moderate' ranking in the overall opportunity.

Design and Planning

Petrobras has already begun construction of an ethanol pipeline. It will eventually stretch 850 km and carry up to 21 MMcm/a of ethanol from a handful of collection centres in Brazil's mid-west to population centres in Sao Paulo and Rio de Janeiro. Some UK engineering experience may be relevant to future pipeline extensions, but this is not considered to be a strong opportunity for UK businesses.

Manufacture and operate

There are already some UK technology companies with equipment-building capabilities and satellite bases in Brazil, like Green Biologics¹⁵³. They are interested in developing project opportunities for retrofitting ethanol plans and building new biobutanol facilities. There is already significant domestic capacity in Brazil for designing and building new traditional ethanol infrastructure, however, so new equipment is not considered a highlight opportunity.

Transporting product to market

An identified bottleneck for Brazilian ethanol is the route to market. While the new pipeline infrastructure is designed to help alleviate this challenge, transport logistics are a potential opportunity for UK-based firms such as Arup¹⁵⁴. Routes to market, however, are fairly limited, so this is not considered a major opportunity.

Finance

The biggest opportunity for UK business to participate in Brazil's burgeoning ethanol market is through finance. This includes finance for new and refurbished cogeneration equipment to produce electricity and heat from bagasse. The magnitude of investment is roughly US\$50 billion by 2020, and foreign investment has historically comprised about a quarter of Brazil's investment in this sector. With market consolidation through mergers and acquisitions, and the involvement of major multinationals in rationalising the market, there is a significant opportunity for financial institutions and investment funds to lend, which warrants it a 'large' overall ranking.

4 Buildings and sports infrastructure

Context

Brazil's construction industry boomed in 2010 and continued to grow rapidly throughout 2011. It is expected that near-term investment delivered through the second Growth Acceleration Programme (PAC2) will keep growth rates high until 2014 and beyond. The FIFA World Cup in 2014 and the Olympic and Paralympic Games in 2016 are putting high pressure on the construction sector. The sector's fundamentals are strong as the country's population urbanises, living standards improve, and the lending market remains solid.

Sustainable building designs, building materials and construction methods are gaining traction in Brazil. The national electric utility Eletrobras launched a labelling initiative to measure the performance of new and existing buildings under its energy efficiency of buildings programme, Procel Edifica, and has several complementary initiatives to boost efficiency in the built environment¹⁵⁵. Other standards gaining popularity include LEED building certification, administered through the Brazilian branch of the Green Building Council¹⁵⁶, and Processo AQUA, a technical reference guide adapted from France's HQE programme by the Fundação Vanzolini, a not-for-profit certification outfit managed by the University of Sao Paulo¹⁵⁷. Another programme related to sustainability in the construction sector is the PBQP-H, a Portuguese acronym for Brazilian Programme for Quality and Productivity in the Construction Sector. It is aimed at improving the business practices and sustainability of companies along the construction supply chain. Participating companies that achieve certain performance milestones gain preferential access to social housing tenders, which helps streamline social housing delivery by improving quality and reducing costs¹⁵⁸. Overall, it is clear that the drive to deliver sustainable buildings is growing.

Interest in sustainable buildings is particularly strong for the major sports infrastructure being built in preparation for the 2014 FIFA World Cup and the 2016 Olympic and Paralympic Games. Both events are catalysing large investments in the host cities, and the opportunity to showcase global leadership in environmental design along with the practical dimension of building durable legacy infrastructure with lower operating costs has encouraged event organisers to promote sustainability. A strong UK-Brazil connection is being actively cultivated at different levels of government since London is hosting the Olympic Games in 2012, and commercial and technical sharing is being pursued to enhance sustainability. Authorities from London and Rio signed a 'Host 2 Host agreement' in 2010 to encourage cooperation for logistics and commercial enterprise related to the Games. The UK is eager to help Rio fulfil its ambition to deliver an experience 'at least as sustainable' as London's performance in 2012¹⁵⁹.

In addition to these highlight sporting events, domestic preferences for sustainable buildings and a growing acknowledgement of their practicality is piquing the interest of residential and commercial property developers. The booming construction sector and shifting consumer preferences combine to create significant opportunities for UK companies. This partly stems from a looming shortage of Brazilian engineers and architects who are schooled in sustainable construction, and is complemented by the strong capabilities and experience of UK firms with green construction and design credentials. UK-based companies would be best positioned to take advantage of this market either through sub-contracting under local Brazilian firms or by selling equipment and controls to improve building efficiency.

* Note: LEED stands for Leadership in Energy and Environmental Design, Processo AQUA stands for *Alta Qualidade Ambiental* or High Environmental Quality, and HQE stands for *Haute Qualité Environnementale*, also High Environmental Quality

Buildings and sports infrastructure

Key findings

- The buildings sector is growing quickly, and sustainable design and construction is in demand, especially for residential and commercial complexes, hotels, and sports buildings
- Opportunities for UK companies include sustainable planning, design and engineering; provision of specialist equipment and materials; control systems; and temporary structures
- Partnering with local firms is often required to operate in Brazil, and is otherwise almost essential for foreign firms to navigate Brazil's legal and regulatory system, and its contextual nuance
- There are many opportunities outside of Brazil's largest centres that are often overlooked by foreign firms; these could be targeted with the help of appropriate local partners

Market and emissions abatement opportunity

As Brazil's economy grows and its socioeconomic demographics shift, demand for all categories of buildings is growing^{160,161}:

- 24 million new residential units will be built by 2022, both in the private sector and also publically through the social housing programme of PAC2
- 24 new shopping malls were added to the country's stock of 408 in 2011
- Sao Paulo ranked 5th in the world for new floor area under construction for corporate buildings
- Hotel construction, for which 50% of investment activity comes from abroad, continues to boom as the tourism industry grows at 10% annually
- Industrial buildings are being built, renovated and expanded to accommodate surging industrial output
- Sports infrastructure, including 12 stadia for the World Cup and a suite of sports facilities for the Olympics and Paralympics, will be built for their 2014 and 2016 start dates

Under the PAC2 programme Minha Casa, Minha Vida (My House, My Life), the government plans to spend about US\$42 billion per year until 2014 to support the construction of millions of residential units for low-income households. Model homes like Casa Aqua are 40m² (430 ft²) and have been designed to be built for less than US\$30,000 (R\$40,000) in ways that reduce resource use and waste during construction, minimise energy and water use during their lifetimes, and improve indoor air quality and comfort¹⁶². Applying these innovations to individual units or large residential complexes could attract attention from bulk contractors looking for easy-to-build, inexpensive and sustainable housing solutions to meet public housing demand. Lower operating costs derived from higher efficiency also mesh with the financial realities faced by many of the low-income families that are expected to live in these homes.

The story is similar for hotel operators, who are keen to reduce overheads in the face of high operating costs. Hotels in Rio de Janeiro spend up to 14% of their total expenditure on energy – much higher than the usual 6-8% – and also spend a comparatively high amount on water because of progressive charging. Not only is there is a significant costsaving incentive to improve resource efficiency in hotels, but Brazil's National Development Bank (BNDES) also offers favourable credit conditions and financing arrangements (like extended payback periods of up to 18 years) for hotels that are designed in an efficient way and meet certain BNDES sustainability criteria. Near-term investment in this sector is also significant: across 21 identified hotel groups, investment of over US\$3.7 billion is planned within the next five years¹⁶³. With the right domestic partner, UK equipment companies could participate in this market, and the scale and global nature of the sector also creates opportunities for international financing and insurance.

In terms of sports infrastructure, the scope of discussion could be broad. The World Cup and Olympics are not only creating demand for sports buildings, but are also stimulating enormous investment in auxiliary infrastructure to support both events. Major investments are being made in Bus Rapid Transit and traffic optimisation, upgrades to rail lines, roads, airports and ports, civil infrastructure like sewers, facilities for waste and wastewater treatment, and urban development. Since several of these investment areas are detailed in other sections of the report, and to keep this section focused, only the sporting opportunities related to buildings will be discussed.

Despite the near-term nature of World Cup's delivery deadlines, there is still opportunity for UK companies to get involved, in part because some of the construction is running behind schedule and last-minute contracts are still up for offer. The two years separating the Olympics from the World Cup, however, and the Games' concentration in Rio de Janeiro might mean that it is more realistic for businesses to target opportunities related to that event.

It is worth noting that while sustainability is a sought-after ambition for Rio's Olympics, there are few published guidelines or prescriptive metrics against which project proposals are being judged. This definitional flexibility could be viewed as an opportunity for some UK firms. Companies may be able to offer added value in partnership with local Brazilian firms if they either participated in London's 2012 Games, which had exacting sustainability requirements, or if they can substantiate their green credentials based on other projects. For example, the master planning contract for Rio's Olympic Park was won by the UK firm AECOM largely because of their sustainability experience in London's 2012 Games and other major projects¹⁶⁴.

With the multiplicity of building projects planned and in progress, and other non-building infrastructure developments tightening competition for labourers, engineers, architects, designers, and equipment, there is an emerging need for additional capacity that UK firms could capitalise on. This is especially the case for projects looking to be built more sustainability, from conception through to construction and use. Brazil does have significant domestic capability, however, including a number of well-established engineering firms with service offerings across many infrastructural areas, including buildings. But while hard, traditional engineering services are available in Brazil, 'green' certification and sustainability consultation work is often contracted out because many firms, even large ones, lack in-house expertise and experience. Many Brazilian firms see international partnerships as an opportunity to enhance their own capabilities, especially in relation to the World Cup and Olympics where the focus on sustainability is drawing expertise into the country.

In terms of architecture, Brazil also has a strong heritage of modernist buildings with high-quality, creative design. But architecture is the most underdeveloped segment in the construction industry's chain¹⁶⁵. Operating in informal corporate structures with few fully integrated service providers, a lot of work is won by experienced domestic firms and then subcontracted to specialist service providers. Day rates charged by Brazilian architects are typically about half that charged by similar professionals in the UK, so foreign firms need to remain flexible in their work arrangements. UK firms can leverage the added value of their integrated, one-stop packaged offerings, which can reduce the burden of project management costs faced by the Brazilian partner.

The low-carbon element of the sector is likely to be modest compared to the national emissions profile, but is still important. Buildings comprise only about 1% of Brazil's total emissions, if deforestation and agriculture are included. Excluding those sectors, buildings make up about 6% of national emissions, which is closer to the global average of 7%, though still below average because of Brazil's amenable climate and low-carbon electricity supply. A McKinsey study pegs about 65% of building emissions on the residential sector, with the remainder coming from commercial and public buildings. The study estimates that under a base case scenario, emissions would climb by 43% by 2030, but through the implementation of efficiency measures, emissions could fall by 24% instead, saving 8.5MtCO₂e annually by 2030¹⁶⁶. The measures include:

- improving building design, including the more efficient use of building materials (20% abatement potential)
- optimising lighting and hot water systems (each with a 25% abatement potential)
- replacing white goods and consumer electronics with more energy efficient models (35% abatement potential)

All of these measures are cost-effective, too, averaging a cost *savings* of more than US\$130/tCO₂e.

Specific opportunities

Firms are best-placed to win work if they can partner with a well-connected local firm, offer integrated turnkey sustainability solutions, and put together a consortium of designers, planners, financiers, and insurers. The opportunity space for UK companies to participate commercially in the World Cup and Olympics is detailed in a pair of reports from UKTI called "Brazil's moment to shine: Opportunities for UK business in the Rio 2016 Olympic and Paralympic Games"¹⁶⁷ and "Game on: Progress in Brazil's preparations for the 2014 FIFA World Cup"¹⁶⁸. These reports lay out a series of commercial opportunities for companies related to the two events[†]. Combining those reports with a series of interviews that were conducted with in-country experts, and overlaying that information with market segments related to buildings that have a sustainability element, the specific opportunity space for UK commercial involvement includes:

- provision of high-end planning, design and engineering services
- supply of specialist construction materials, equipment and technology
- project management for sustainability, including certification
- environmental control systems
- temporary structures



[†] Note that the full version of either report can be requested from Andrew Whitnell of UKTI Global Sports Projects Team, at andrew.whitnell@ukti.gsi.gov.uk

Segment	Category	R&D	Design & Planning	Manufacture & operate	Shipping & Iogistics	Finance
Buildings	Planning, design and engineering					
	Certification					
	Sustainability project management					
	Lighting equipment					
	Control technologies					
	Temporary structures					
	Finance and insurance					
Overall						

Table 9: Opportunities within the buildings and sports infrastructure value chain

Opportunities across the value chain

R&D

There are few opportunities for R&D in Brazil's buildings sector that overlap with UK capabilities.

Design and Planning

Architects and designers with capabilities in sustainable design, water management, and passive systems would be well-placed to partner with local Brazilian firms. Organisations like the Chartered Institution of Building Services Engineers amalgamate UK experience for companies operating in sustainable engineering and design for the built environment¹⁶⁹. There is particular opportunity in master planning for larger projects, as evidenced by AECOM's successful bid for the master planning project of the Olympic Park in Rio, based largely on their track record and sustainability experience¹⁷⁰. Some niche markets include design for the integration of passive cooling systems, which could be applied for low-technology favela development, and integrating automatic control systems, especially in commercial and public buildings.

The diversity of building certification standards in Brazil means that flexible UK companies working with multiple standards such as BREEAM, LEED, and HQE can adapt their skills to the Brazilian market. UK-based organisations like BRE (Building Research Establishment), which pioneered certification in the UK, offer sustainability certification and consultancy, and are working to harmonise standards internationally¹⁷¹.

Manufacture and operate

There are hundreds of companies in the UK providing lowenergy lighting solutions for all types of buildings. The Lighting Association in the UK is a repository for information about UK companies and their specialisation¹⁷². Similarly, the Heating and Ventilation Contractors' Association is the professional body representing UK businesses working in HVAC and refrigeration systems, many of whom operate internationally and focus on sustainable product and service offerings¹⁷³.

Other specialist, lower-carbon construction materials, equipment and technology that are in demand in Brazil include paints and coverings, especially coatings with titanium dioxides that absorb dioxins, non-PVC materials, and sustainably sourced wood.

Temporary structures are another near-term equipment opportunity, especially related to sports and airport venues. For the FIFA World Cup and Olympics, these include display tents, kiosks and temporary seating to expand stadium capacity in the short term. For airports, they include structures like temporary passenger terminals and modular operational areas. In almost all cases, accessibility for disabled people is required, and facilities that exhibit lowcarbon or sustainable construction and operation would have an advantage.

Shipping and logistics

Low-carbon opportunities have not been identified for this segment in buildings and sports infrastructure.

Finance

UK-based financial service providers and insurance agents that operate internationally will find opportunity in Brazil's expanding property market. The opportunity may be more easily accessed in hotels and some industrial facilities, where firms have a strong international presence, but could also go to support the very large near-term investments in the residential sector.



5 Resources available to UK businesses

Aligning Brazil's growth trajectory with its sustainable development agenda creates significant opportunities for UK companies to participate in Brazil's low carbon development. Billions of dollars need to be invested in Brazil's economy to realise its green development goals, and UK companies are well-placed to take part. The subsectors highlighted in this report describe the size and quality of the commercial opportunities, and we've helped to prioritise them by segmenting them into stages along the value chain.

There are high-quality resources available to help match Brazilian needs with UK capabilities. Companies that are interested in learning more about the specific nature of these and other opportunities can contact UK Trade and Investment (UKTI), the Foreign and Commonwealth Office (FCO) and the Carbon Trust for more information.

UK Trade & Investment (UKTI)¹⁷⁴ staff are experts at helping businesses grow internationally. They provide expert trade advice and practical support to UK-based companies wishing to grow their business overseas. With 2,400 staff and a presence in 96 countries, including offices in Rio de Janeiro, Sao Paulo, Brasilia, Porto Alegre, and Recife, UKTI can assist businesses on every step of the exporting journey. Whatever stage of development the business is at, they offer support to help businesses expand and prosper.

Through a range of unique services, including participation at selected trade fairs, outward missions and providing bespoke market intelligence, UKTI helps businesses crack foreign markets and get to grips quickly with overseas regulations and business practice.

The Foreign and Commonwealth Office (FCO)¹⁷⁵ works to build Britain's prosperity by increasing exports and investment, opening markets, ensuring access to resources, and promoting sustainable global growth. It works across government with domestic departments to promote the British economy and to lobby for British business overseas, as well as inward investment into the UK. The FCO advances UK interests through trade agreements, improved market access, sound intellectual property regimes, and through effective bilateral and multilateral agreements. The FCO's main branch in Brazil is in Brasilia.

The Carbon Trust¹⁷⁶ is a not-for-dividend company providing specialist support to help business and the public sector boost business returns by cutting carbon emissions, saving energy and commercialising low carbon technologies. The Carbon Trust:

- runs advisory services to help large companies cut carbon and costs;
- supports businesses select and implement the best energy efficient equipment solutions for their area of work;
- helps companies measure, manage and reduce their carbon footprint and realise the business benefits; and,
- accelerates the commercialisation of low carbon technologies by supporting low carbon entrepreneurs and leading collaborative projects to deliver commercial breakthroughs.

Companies that are eager to maximise their low carbon service offering and enhance their competitive position when approaching Brazilian firms with a green agenda can get in touch with the Carbon Trust.

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