FOREWORD

Climate change is the biggest threat we face globally. But all too often it is discussed in the abstract, and can appear disconnected from our daily lives; and yet there are very real and immediate links.

Across the globe, as in the UK, our homes account for between 20% and 25% of all man-made CO₂ emissions. As we strive towards smarter design and construction of low energy homes, they need to be placed within the wider context of low energy, low carbon cities, with solutions relating to infrastructure and human behaviour working in harmony.

A holistic and strategic approach to low energy, low carbon cities can make an enormous difference. For many governments, cutting greenhouse gas emissions is regarded as central to their ability to meet national and international emissions reduction targets. As a result, a wide range of approaches and policies have developed or are emerging in different countries with the common aim of facilitating low carbon living. Some of these are already providing powerful examples which are informing international thinking. Originally published in 2009, this updated Compendium provides a broad synthesis of international activity in this field. It gives a unique snapshot of how 15 different countries and their cities are demonstrating leadership in low carbon technology, energy supply and demand, cultural change, policy development and change management. For each country, headline energy consumption and climatic data have been assembled to provide context. This is accompanied by an analysis of progress against national aspirations and policy targets for emissions reductions. As in the 2009 and 2011 editions, the information has been organised to facilitate easy comparisons between countries, providing clarity for those wishing to learn from international experience and those seeking to build international links and collaboration.

For the UK, where meeting the 2016 zero carbon target requires challenging performance improvements, there is an obvious need to learn key lessons from other countries. While every city and country has unique domestic circumstances, the 2015 Compendium, with its expanded scope and additional insight gained over time, helps us all to greatly benefit by learning from others, whether on policy, planning, process, technology or construction design and practice.

While the global market can bring powerful international perspectives to our decision making, we rarely have the time to step back and take in the significant progress that is being made across the world. We hope that the 2015 Compendium, like its predecessors, will make a valuable contribution by raising international awareness of the global importance of creating low energy, low carbon cities and places that will begin to tackle climate change across the world.

Paul King
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Neil Jefferson
Director, NHBC Foundation and Chief Executive, Zero Carbon Hub
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INTRODUCTION

The 1997 Kyoto Protocol (born out of the World Summit in Rio de Janeiro 1992) was the world’s first collaborative initiative to reduce carbon emissions on a global scale. Buildings, and housing in particular, play a major part in the emissions of the world’s developed and rapidly-developing nations and as such, have been the subject of increased regulation and emission controls since the early 1990s. The challenge of improving coordination between the Kyoto signatories and meeting the tougher targets set at Copenhagen and Cancun, as well as the Doha 2012 extension of the Protocol to 2020 and beyond, mean that these issues remain at the forefront of global concern.

In 2009, the Zero Carbon Hub’s first compendium edition provided a snapshot view of the positions countries around the world have taken in addressing the carbon emissions in their respective residential sectors. That study proved a valuable international reference, which attracted the attention of several new countries. This formed the basis for a second edition released in 2011 which included further information on exemplar projects; updates of national targets; a standard format for comparison of geographic, climatic, and statistical indicators; and further assessment of programmes, government policy and incentives.

This third edition compendium continues the work established with representation from fifteen international countries. However, this edition also seeks to understand the various approaches made nationally and locally to achieve low energy and sustainable targets. It aims to highlight the collaborative methodologies necessary for the built environment, energy and transport infrastructure to work in harmony to create the cities of the future.

This 2015 Compendium aims to create a better understanding of the issues surrounding the achievement and delivery of low energy homes, in partnership with energy generation and storage, transport, innovation, space organisation and comfort. All of this combined ensures that cities, collectively, lower emissions and ensure sustainable communities.

Furthermore, this publication wishes to improve the quality of the debate, and set out a basis for better international comparisons and information sharing. While the data from the country case studies do identify a lack of harmony of approach to assessing building performance, they also provide a basis for more detailed evaluation of specific energy and carbon emissions criteria on an international level, as well as factoring in holistic city-wide approaches to achieving low and zero carbon targets.
CITIES AND COMMUNITIES EVOLVED OVER TIME?
WHAT'S IN A NAME? HOW HAS THE CONCEPT OF SUSTAINABLE HOMES, THE LOW-ENERGY CITY IN MODERN HISTORY

LOW ENERGY & ZERO CARBON CITIES: A TANGIBLE FUTURE

ECOTOWNS, SOLARITIES, SUSTAINABLE CITIES, ZERO CARBON, AND NOW 'SMART' CITIES - SOCIETY’S VISION FOR THE CITY OF THE FUTURE HAS TAKEN ON MANY NAMES THAT EMBODY OUR ASPIRATIONS FOR SUCCESSFUL, VIVID AND PROGRESSIVE FUTURISTIC CITIES. ALTHOUGH THE ROOT BUZZWORD HAS CHANGED OVER THE PAST TWO DECADES, THE DEFINITION REMAINS THE SAME - FOR CITIES TO BE HEALTHIER, SAFER, BETTER INTEGRATED AND MORE SUSTAINABLE.

THE TERM 'FUTURISTIC' MAY CONJURE UP IMAGES OF FLYING CARS, STREETS IN THE SKY AND AMAZING SCYCLERS THAT SEEM TO STRETCH INTO INFINITY - A FUTURE WHERE EVERYTHING IS CLEAN AND SHINY, PEOPLE ARE HAPPY AND HEALTY AND WHERE TECHNOLOGY HAS FREED US FROM ANY INCONVENIENCE AND DISCOMFORT. WHERE ENERGY IS 100% CLEAN, OUR HOMES ARE ZERO CARBON AND WHERE MEETING OUR Needs AS A CIVILISATION DOES NOT MEAN WE HAVE TO DESTROY OUR NATURAL ENVIRONMENT TO DO IT. AND IT SEEMS LIKE THE WHOLE WORLD IMAGINES 2050 TO BE THE PEAK YEAR WHEN THIS WILL BECOME A REALITY.

But there is no need to wait - the future city is here. Maybe not the flying cars or the infinite skyscrapers, but smart technologies and advancements in zero carbon buildings mean that most of the important features which will help both developed and emerging cities reach zero carbon are already available. This third edition of the Zero Carbon Compendium illustrates this fact, with numerous cities spread across multiple countries and continents making remarkable progress in securing a low carbon future. Indeed, much of what will influence the future of cities is occurring now, setting the stage for the next century, a period which is frequently stated to be one which will test our urban centres in ways we have never experienced.

THE SHIFT TOWARDS ZERO CARBON HAS EXISTED SINCE THE BEGINNING OF THE TWENTIETH CENTURY IN VARIOUS GAVES, AND THE DRIVE TO REDUCE ENERGY CONSUMPTION IS CERTAINLY NOT NEW. BUT PROGRESS, CERTAINLY IN THE DEVELOPED WORLD, HAS RAPIDLY GAINED PACE IN THE PAST TWO DECADES, THANKS TO THE CATALYST PROVIDED BY THE KYOTO PROTOCOL IN 1997. HOWEVER, DESPITE THE SOMETHING INDEED, POSSIBILITIES AND OPPORTUNITIES, ZERO CARBON CITIES ARE STILL NOT A REALITY, DUE TO A NUMBER OF BARRIERS, MOST OFTEN RELATED TO A LACK OF GOVERNMENT FRAMEWORKS, CITIZEN ENGAGEMENT AND SUPPORT, OR SECURE LONG-TERM FINANCE. BARRIERS EXISTS FOR ALL CITIES, REGARDLESS OF LOCATION OR LEVEL OF ECONOMIC DEVELOPMENT. OTHER BARRIERS INCLUDE THE LACK OF INTEGRATION BETWEEN NEW LOW CARBON DEVELOPMENTS AND EXISTING COMMUNITIES WITHIN A CITY, WHICH PREVENTS THE ACHIEVEMENT OF ECONOMIES OF SCALE IN TERMS OF ENERGY, WATER AND WASTE MANAGEMENT, AND THE CHALLENGING ISSUE OF GOVERNING AND USING DATA IN WAYS THAT FACILITATE CHANGE. THIS IS WHERE NEXT-GENERATION 'SMART' CITIES CAN BRING SOMETHING TO THE ENVIRONMENTAL DEBATE, BY CREATING A POWERFUL DATA INFRASTRUCTURE TO SUPPORT AND BRING TOGETHER THE DIFFERENT COMPONENTS OF OUR IDEAL ZERO CARBON CITY.

Based on research related to global best practices in low and zero carbon city initiatives, it is clear that the most successful cities are those which have a holistic approach to sustainability. These cities seek to reduce emissions and improve efficiency in a broad range of areas, including not only energy but also water, waste supply, lighting, heating, cooling and urban transport, combined with government support and consumer engagement initiatives. These successes show that cities, both established and emerging, should always consider a wider strategy to improve not only energy supply or transport but also the wider livability and sustainability of a city.

AN EMERGING BLUEPRINT FOR ZERO CARBON CITIES

The emerging blueprint for zero carbon cities is not one which features space-age experimental technology and flashy high-tech buildings, but a more discreet yet powerful toolset which is being implemented now in a small selection of locations around the world. While the strategy for the next 20 years will require more integration at a larger scale than what has been achieved to date, the blueprint for our future zero carbon cities is one which maximises the best solutions that already exist while remaining flexible and adaptable to future improvements.

The key elements for a zero carbon city would include efficient and reliable low energy zero carbon technologies and intelligent infrastructure systems, supported by visionary and robust governance and policy and engaged and empowered communities, and by environmentally and socially responsive architectural and urban design and sustainable financial frameworks.

There is no need to wait - the future city is here.
Goverance and Policy
Zero carbon cities should have a clear vision of what their strengths and weaknesses are, and where they aim to be by 2050. As cities increasingly compete to attract progressively mobile and highly talented populations, it is essential that cities create the right business environment for low carbon enterprises to flourish, an important consideration as outlined in the section below. As a result, a clear vision is one with absolute carbon and other environmental targets (such as Copenhagen’s) goal to be completely carbon neutral by 2025, and not just vague overarching aims that are visionary yet impossible to quantify and measure.
Successful zero carbon cities will be able to look beyond the short term, which often characterises many local governments, while combining this with strong leadership and consistent implementation.

A clear vision is essential to ensure the security and resilience of low carbon cities in the future

A strong vision therefore is more of a thorough implementation framework which helps to identify solutions in the face of immense complexity. Not only will the city itself benefit, but a strong scalable model issomething that is a marketable tool for intercity collaboration. Whether it is a brand new city, like Tianjin eco-city, or an existing historic city like Vienna, a clear plan is essential to ensure the security and resilience of low carbon cities in the future. Without it, it is all too easy to defer action to a later date in the seemingly distant future.

Community Engagement
A focus on technology often leads people to forget that cities are not simple machines but are rather in a state of flux, an organic entity which is constantly shaped by its inhabitants. Most successful cities to date have realised this issue, and have worked to engage citizens to varying degrees. Successful examples include cities in Scandinavia which already have an established culture of sustainability and low carbon living to which residents subscribe. What did they do? Citizens of every city will need to be made to feel like they are part of the solution in reducing carbon emissions in their communities. While improved digital technology and data collection will be central in shaping the future cities, the development of smart technology should not automatically gain priority over the importance of smart citizens.

Financial Support
The majority of the case studies featured in this document have been successful as a result of the implementation of strong private-public partnerships (PPP), helping cities move beyond the initial funding sources that are commonly established by local and national governments but which most often have end dates when funding runs out and a project concludes. There are numerous benefits to having such partnerships lead low carbon initiatives, including the even distribution of risk, access to increased finance for public bodies and the improved delivery of enhanced public services. Private partners benefit equally, with opportunities for secure, long-term investment opportunities with reduced risk. By helping support the local economy, as well as creating employment, cities will be able to deliver on the benefits so often promised by an emerging ‘green economy’.

Given the scale of the challenge in transitioning to low carbon, partnerships between private, public and third sector bodies will help to remove some of the barriers to green investment. However, not all jurisdictions have the capacity to administer these types of arrangements, illustrating the fact that it is not necessarily technology which is keeping cities from becoming low carbon but rather a lack of sufficient policy frameworks for new ways of working.

The toolbox is ready - cities around the world have been mobilising to reduce carbon emissions, and a wide range of resources, technologies, pilot projects and case studies are available. The next key step is integration of the above elements - in order to achieve zero carbon, cities and communities will need to combine a range of improvements, technologies, policies and programmes to reach their targets. There is no one-size-fits-all solution. There are a variety of possible approaches and routes which cities can take in securing a low carbon future, and the challenge is to use the right combination of techniques that are appropriate for each location, optimising the unique resources and features of the local area and responding to the current and future needs of the local population.
GUIDE TO THE CASE STUDIES

The 2015 Compendium continues the work established by the first and second editions but aims to analyse zero carbon from a larger and broader scale by moving beyond buildings to cities and communities from across the world which utilise community and district-wide energy solutions.

The document is divided by global region, in which the country profiles are set, and focuses on exemplar case studies of low and zero carbon initiatives in cities and towns within each country. A case study approach was used to select the exemplar countries in which a number of best practice approaches to low and zero city and community implementation are being applied.

In order to be selected, case studies had to be illustrative of leadership and innovation in the implementation of low and zero carbon initiatives, in one or more of the following areas:

- Energy Generation
- Passive Solar Energy Design
- Energy Storage
- Smart Energy Systems

This Compendium aims to create a better understanding of the issues surrounding the achievement and delivery of zero carbon communities and cities, improve the quality of the debate, and set out a basis for better international comparisons and collaboration. While the data from the country case studies do suggest a lack of harmony of approach to assessing zero carbon performance, they do provide a basis for more detailed evaluation of specific energy and carbon emissions criteria on an international level.

Country Overview and Key Facts

Each country profile begins with a country overview and key facts section. This section is intended to provide a brief summary of the key energy and climate concerns of a given country (with a particular focus on improving the performance of the nation’s buildings and homes), and how they are working to address these issues. Each overview typically includes the status of the country’s shift to renewable energy sources, any emission or energy use reduction targets and policies or initiatives that support improving its energy efficiency.

Key facts include demographic data on population area, density and level of urbanisation, as well as other features such as average climate, renewable energy generation, and the number of houses, among others.

Energy and Climate Graphs

Each country profile includes energy and climate graphs to provide an overview of the specific climate conditions and current energy performance under which the case studies operate.

The energy statistics relate to energy use in housing, including the percentage of residential energy use in relation to the country’s total energy consumption, the residential end-uses, and the mix of sources for residential energy consumption.

Climate graphs (an example of which is included below) includes data from the city featured in the main case study, illustrating the monthly variations in temperature and humidity, rainfall and wind speed, daylight hours and solar radiation. Three temperature lines are shown corresponding to maximum, average and minimum monthly values.

Key Features

The six key feature icons to the right represent what we believe to be important areas of consideration for a zero or low carbon community, town or city.

These icons appear with the central case study for each country and highlight the project’s achievements, innovations and targets, and have been quantified where possible.

Though some key features may be applicable to some case studies and not to others, the icons help to facilitate a comparison of initiatives between case studies in order to understand the commonalities and differences between them in achieving zero carbon futures.
THE AMERICAS

CANADA
EXEMPLARY CASE STUDY
1. Vancouver Neighbourhood Energy Strategy
CASE STUDIES
2. Deep Lake Water Cooling, Toronto

CHILE
EXEMPLARY CASE STUDY
3. Smart City Santiago

UNITED STATES
EXEMPLARY CASE STUDY
4. Seattle 2030 District
CASE STUDIES
5. Pecan Street, Austin
As a result of its varying climates and geography, not to mention its sheer size, Canada is one of the highest carbon per capita emitters in the OECD countries despite having one of the lowest emitting generation portfolios. Though 62% of Canada’s electricity is generated from renewables (with the majority at 58.9% generated by hydroelectric power), a reliance on private vehicles to navigate long distances and growing oil and gas production means national greenhouse gas emissions continue to increase despite Canada being a signatory to the 2009 Copenhagen Accord. With massive fossil fuel reserves (23.6 billion tonnes of oil) and increased development of the tar sands in the western provinces, Canada remains one of the largest energy exporters in the world. Notwithstanding the country’s high energy security, the federal, provincial and territorial governments are working together to further diversify electricity and to sustainably develop Canada’s abundant natural resources. In fact, the federal government has committed to having 90% of electricity produced from non-emitting sources by 2020.¹

The federal government has also put a focus on reducing emissions, concentrating on two areas for improvement: carbon capture and storage (CCS) and energy efficiency in the built environment. With regard to the latter, provinces and territories have agreed to increase energy efficiency by 20% by 2020, with a focus on improving building codes, green building policies for new government buildings and providing retrofit assistance. With a focus on progressing toward net-zero energy buildings, increasingly stringent energy codes will play an important role, with the next iteration of the National Energy Code expected in 2015.²

Key Facts:

- **Population**: 34.8 million
- **Area**: 9.98 million km²
- **Density**: 4 people/km²
- **% of population in cities**: 80.7%
- **Electricity generated from renewables**: 60.7%
- **Number of housing units**: 13.3 million
- **Population in megacities**: 45%
- **CO₂ emissions per capita**: 14.7 tCO₂/yr
- **Electric power consumption per capita**: 16,473 kWh/yr
- **Motor vehicles per 1000 people**: 608
- **Energy security**: 83% of total energy used by residential sector
- **Electricity generated from renewables**: 45% of total energy used by residential sector
- **Temperature range**: -63°C to 45°C

Canada has a target to reduce emissions by 17% by 2020 from their levels in 2005 as part of the Copenhagen Accord. The federal government has also put a focus on reducing emissions, concentrating on two areas for improvement: carbon capture and storage (CCS) and energy efficiency in the built environment. With regard to the latter, provinces and territories have agreed to increase energy efficiency by 20% by 2020, with a focus on improving building codes, green building policies for new government buildings and providing retrofit assistance. With a focus on progressing toward net-zero energy buildings, increasingly stringent energy codes will play an important role, with the next iteration of the National Energy Code expected in 2015. Therefore, it is crucial for Canada to continue to diversify its energy mix and improve energy efficiency to meet its emission reduction targets.
The first renewable energy system in Canada to use lake water for air conditioning was installed in Toronto in 2002, delivering district cooling to 63 buildings (both commercial and residential) in Toronto’s dense downtown core, covering a total of 29 million square feet. The system uses the natural low temperature of deep water in Lake Ontario, which does not rise about 4°C even in summer. With additional funding provided by the Canadian Department of Natural Resources and the Federation of Canadian Municipalities, the privately owned Enwave Energy Corporation installed three large intake pipes 5.1m into the lake, at 83 metres below the surface. The cold water is received at one of the city’s central pumping stations, where heat exchangers make use of the coldness of the lake water, and not the water itself, which then enters the city’s potable water supply. This means in-building electricity driven chillers are removed, helping to decommissions older systems that contain harmful refrigerants.

The system saves 85 MWh annually in electricity, helping to reduce electricity usage by 50%. The equates to the removal of 70,000 tonnes of CO₂ annually, and the freeing of 61MW for the Toronto and Ontario electrical grids. The response has been considerable, with the system sold-out within three years of becoming operational in 2004, and with Enwave likely to further invest to increase capacity by 25%. The system can help buildings achieve up to 10 LEED points in a number of categories.

Exemplar Case Study

VANCOUVER GREENEST CITY ACTION PLAN 2020

Start 2011 Completion 2020

As part of Vancouver’s Greenest City 2020 Action Plan, the city is working to tackle emissions by improving both energy supply and the built environment. A major aspect of the plan is the Neighbourhood Energy Strategy, which is expected to contribute an 11% reduction of the city’s greenhouse gas emissions, a significant portion of the city’s larger target of reducing city-wide emissions by 33% (or 1.2 million tonnes of carbon dioxide) by 2020. The aim of the strategy is to deploy neighbourhood energy centres for both new and existing gas-heated buildings in mixed-use, high density neighbourhoods, providing low emission and cost effective heat and hot water.

The first project deployed as part of the strategy, and the city’s first renewable district heat system, was the False Creek Neighbourhood Energy Utility (NEU) in 2010, a 32 hectare site in Southeast False Creek, which also includes the Olympic Village. Supplying 70% of the utility’s energy production (with the remaining 30% supplied by high-efficiency natural gas boilers), the plant is integrated within the area’s sewage system and uses a heat exchanger to use waste thermal energy from the untreated waste water. This is the first utility in North America to utilise waste heat recovery from untreated waste water. Additional energy is provided by the solar panels installed on three neighbourhood buildings.

The system’s economies of scale and flexible infrastructure means the system can use a wide number of renewable energy. Its inherent adaptability means it helps to stabilise costs for customers, protecting them from the volatility of energy generated from fossil fuels. The system itself is ultimately self-funding, providing a return on investment to City taxpayers, while at the same time, providing cost-competitive rates to customers. Vancouver is also improving its built environment through the Energy Retrofit Strategy for Existing Buildings, which will be implemented by 2016. The strategy includes voluntary emissions reductions across the existing building stock in a range of sectors. In homes, the city will pilot the effectiveness of neighbourhood scale thermal imaging and promote energy retrofit opportunities. It also includes the provision for important amendments to the Vancouver Building Bylaw, with the 2014 amendment now requiring energy upgrades to existing buildings.

11% reduction in the city’s greenhouse gas emissions by 2030 from Neighbourhood Energy Strategy (120,000 tonnes CO₂ per year).

Flexible energy infrastructure allows use of different sources of renewable waste energy.

References
2.  Ibid.
3.  Ibid.
6.  Ibid.
8.  Ibid.

Deep lake water cooling.

Start 2002 Completion 2009

Canada’s Energy Profile

Homes are responsible for 15% of total energy consumption

Energy consumption by sector

Homes

Others

Coal

Natural Gas

Oil

Biomass and Waste

Renewables

What renewable energy sources are available?

Deep Lake Water Cooling

Since 1990, when the country’s first democratically elected President was inaugurated, Chile has gained an increasingly important leadership role as the fastest growing economy in Latin America.

To match this growth, the need to diversify energy sources in the country in order to improve long term energy security has continued to intensify over the past decade. Although the privatisation and liberalisation of the electricity sector in the 1980s helped to lift a significant number of people out of poverty, long term energy security in Chile remains limited as a result of importing two-thirds of the country’s energy requirements, 80% of which is from fossil fuel sources.

Additional pressure has been placed on the current energy system because of the anticipated decrease in annual precipitation as a result of climate change, which will have far-reaching consequences in a country which relies heavily (over 37%) on hydroelectric power for its electricity supply. However, Chile’s unique geography, ranging from the world’s driest desert in the north of the country, to a Mediterranean climate centrally and Alpine tundra in the south, means there is significant opportunity for the utilisation of a wide range of renewable energy including underdeveloped sources such as solar and ocean and wave power. Chile has also proved itself as a leader in sustainable buildings, ranking within the top 10 countries outside of the United States with the most LEED-certified and registered buildings in 2013. Chile was also the first country in Latin America to build a LEED Certified Residential Building in 2013 and the UK’s British Research Establishment (BRE) recently helped establish the country’s first Sustainable Construction Code with the help of the Chilean Ministry of Housing.

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<th>KEY FACTS</th>
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<tr>
<td>Country Population</td>
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<tr>
<td>Area</td>
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<td>Density</td>
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<td>CO₂ emissions per capita</td>
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<tr>
<td>of total energy used by residential sector</td>
</tr>
<tr>
<td>Electricity generated from renewables</td>
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CHILE
CAPITAL SANTIAGO
4,300 KM LONG
BUT ONLY 175 KM WIDE
HOME OF THE ATACAMA DESERT, THE DRIEST IN THE WORLD
40% OF CHILE’S POPULATION LIVES IN THE SANTIAGO METROPOLITAN REGION
THE EARTHQUAKE IN 1960 MEASURED 9.5 MAGNITUDE
THE WORLD’S STRONGEST RECORDED EARTHQUAKE
80% TOTAL ENERGY SUPPLY IS FOSSIL FUELS
IN 2013, CHILE IMPORTED 300K BARRELS OF OIL PER DAY
CHILE HAS A TARGET OF RENEWABLE ENERGY SOURCES OF 20% BY 2020

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THE AMERICAS
In northern Santiago, in the large business community centred around Cuidad Empresarial, the city is being transformed into a living laboratory where the latest generation technologies are being tested in the first smart city roll-out in Chile. Adapted to suit unique local requirements, the innovative prototype seeks to address the major issues currently facing Santiago, a city which is already home to 40% of Chile’s population and is expected to experience significant population growth over the next decade, growing at more than 5% a year. The biggest concerns for the city include controlling urban sprawl and traffic congestion, both of which Smart City Santiago will seek to address, along with other issues.

Another reason for such a project is the growing level of prosperity and the associated increased demand for new and better housing. The US million USD investment will involve the installation and trialling of numerous technologies, including smart meters with two-way communication, home automation, PV solar generation, smart grids, free Wi-Fi and LED lighting, as well as electric buses and taxi – in addition, the project will include the installation of advanced metering, with the aim of creating the ‘Santiago of Tomorrow’, with environmentally friendly homes. All the initiatives seek to improve energy efficiency, reduce carbon emissions, improve the operation of the grid and provide better demand management. This is particularly important in Chile, where it is hoped that improved management of distributed generation and automation will help to quickly address blackouts, a regular occurrence in the country. Monitored by the Interactive Technology Centre, the project allows those who live and work in Cuidad Empresarial to actively participate in energy management and includes an interactive showroom which will monitor the initiative. One of the central aims of the project is to raise awareness of smart technologies among the local population, so the interactive learning centre will be vital in achieving this goal.

Intended to be replicated at a much larger scale in both Chile and wider Latin America, the results of the project will be analysed from technical, social and economic perspectives. Led by the same company which is rolling out smart city initiatives in Italy, Spain and Brazil, Smart City Santiago is part of this growing smart city network which is sharing lessons learned to create shared knowledge for each city to use as they continue to grow and develop. It is hoped that similar projects will be rolled out in order to meet the national target to reduce energy consumption in Chile by 20% by 2025.

The Interactive Technology Centre will help educate the local community of the smart technologies being deployed. It is expected that as people begin to experience and understand the benefits of the new technologies, the benefits of such a project will be shared with others, allowing the technology to be shared more widely.
As the world’s largest energy consumer, as well as the largest economy, it is not surprising that the United States is the second highest emitter of greenhouse gases globally. In order to tackle these issues while continuing to maintain a strong economy, the US has put a focus on tackling emissions through technological advancements, specifically related to becoming leaders in second-generation biofuels and carbon capture and storage.

In November 2014 the national government made a historic pledge to reduce net greenhouse gas emissions 26-28% below 2005 levels by 2025. In addition, the 2013 Climate Action Plan seeks to reduce national carbon emissions and prepare the US for the effects of climate change, while also positioning the country to lead international initiatives related to climate adaptation. The plan includes a number of targets and proposed initiatives, including plans to cut CO₂ emissions from both new and existing power plants by 30% from 2005 levels by 2030 and a 20% improvement in the energy efficiency of commercial, industrial and multi-family buildings, as part of the government’s Better Building Challenge.

Although the country did not ratified the Kyoto Protocol, a number of American mayors have joined together to advance the goals within the agreement by signing the US Conference of Mayors Climate Protection Agreement, which has over 1,000 signatories to date. Recent extreme weather has also prompted 182 mayors and other local elected officials to team up as part of the Resilient Communities for America campaign, to deliver recommendations for federal policy that will help cities tackle issues related to climate change and energy security.

KEY FACTS

<table>
<thead>
<tr>
<th>Country Population</th>
<th>316 million</th>
</tr>
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<tr>
<td>Area</td>
<td>9.82 million km²</td>
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<tr>
<td>Density</td>
<td>34 people/km²</td>
</tr>
<tr>
<td>% of population in cities</td>
<td>82.4%</td>
</tr>
</tbody>
</table>

116 million
Number of housing units

48%
Population in megacities (over 1 million residents)

786
Motor vehicles per 1000 people

13,246 kWh/yr
Electric power consumption per capita

17.6 t CO₂/yr
CO₂ emissions per capita

18%
of total energy used by residential sector

13%
Electricity generated from renewables

-62°C to 57°C
Temperature range
Seattle is one of the fastest growing cities in the United States, and is also one of five national cities taking part in the 2030 Challenge. The scheme aims to create robust business models for urban sustainability, tackling the areas of water, transportation and energy through design strategies, on-site technologies and off-site renewable energy. The interdisciplinary public-private collaboration involves the City of Seattle, along with local property owners and managers, utility providers, engineers and other community stakeholders.

Focusing on improving the performance of new and existing commercial and residential buildings to create a high performance building district in downtown Seattle, the project uses cloud service analytics to understand energy use in buildings, for the data which is generated from building management systems, sensors and meters that control building systems. Using real-time tracking of energy efficiency, building owners and managers are able to identify inefficient performance or sources of waste and assess the health of installed equipment, and make necessary adjustments related to lighting, temperature and passive design elements such as window shading.

Currently being piloted on a handful of buildings of varying uses, including multi-residential homes, the intention is to scale up to 500 buildings (over 70% of the existing downtown buildings). The aim is to save up to 10-25% of the current costs associated with energy use and maintenance with the use of data analytics (contributing significantly to the project’s overall goal to reduce energy use by 50% across downtown by 2030). The project also involves the pilot of Energy Efficiency Contracting Packages with approved Energy Service Contracting companies (ESCs) for both commercial and residential rental buildings.

The approach highlights the role IT can play in helping the city significantly reduce carbon emissions (the overarching goal of Challenge 2030, where all new buildings and major renovations will be required to be carbon neutral by 2018). In doing so, the city is able to make improvements without the need for retrofit or disrupting current tenants. It is the city’s intention that their involvement in the 2030 Challenge will help to establish Seattle as a global leader in clean technology innovation with expertise that can be exported to other cities both nationally and internationally.

Energy analytics will help to reduce maintenance and energy costs by 10-25% in the buildings involved.

Funding provided by the national i6 Challenge. The scheme aims to create robust business models for urban sustainability, tackling the areas of water, transportation and energy through design strategies, on-site technologies and off-site renewable energy. The interdisciplinary public-private collaboration involves the City of Seattle, along with local property owners and managers, utility providers, engineers and other community stakeholders. In Seattle, the project uses cloud service analytics to understand energy use in buildings, for the data which is generated from building management systems, sensors and meters that control building systems. Using real-time tracking of energy efficiency, building owners and managers are able to identify inefficient performance or sources of waste and assess the health of installed equipment, and make necessary adjustments related to lighting, temperature and passive design elements such as window shading. Currently being piloted on a handful of buildings of varying uses, including multi-residential homes, the intention is to scale up to 500 buildings (over 70% of the existing downtown buildings). The aim is to save up to 10-25% of the current costs associated with energy use and maintenance with the use of data analytics (contributing significantly to the project’s overall goal to reduce energy use by 50% across downtown by 2030). The project also involves the pilot of Energy Efficiency Contracting Packages with approved Energy Service Contracting companies (ESCs) for both commercial and residential rental buildings.

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Energy analytics will help to reduce maintenance and energy costs by 10-25% in the buildings involved.
EUROPE

AUSTRIA
EXAMPLE CASE STUDY
1. Smart City Wien, Vienna
CASE STUDIES
2. SolarCity, Linz

DENMARK
EXAMPLE CASE STUDY
1. The North Harbour, Copenhagen
CASE STUDIES
2. ZEROfamily, Sonderborg

GERMANY
EXAMPLE CASE STUDY
1. Berlin Energy Saving Partnership
CASE STUDIES
2. Smart Power Hamburg
3. Bahnstadt, Heidelberg

RUSSIA
EXAMPLE CASE STUDY
1. Akademia City, Ekaterinburg

SPAIN
EXAMPLE CASE STUDY
1. Barcelona Solar Hot Water Ordinance
CASE STUDIES
2. Almacena Project, Carmona

UNITED KINGDOM
EXAMPLE CASE STUDY
1. North West Bicester
CASE STUDIES
2. Low Carbon London
3. Bristol Green Doors
Sustainability and low carbon initiatives feature prominently in Austrian politics, culture and tourism. The landlocked country in central Europe, which is situated on a large portion of the Alps, has been a pioneer since the 1980s in investing in a low carbon future. Climate adaptation has been identified as an important element of the country’s political agenda, in part due to its large and active scientific community and the influence of European Union initiatives. In fact, the protection of the environment has been maintained as an important objective of the national government and has been given constitutional status.

Austria produces a significant amount of renewable energy, predominantly hydroelectric and biomass, the influence of which has been a strengthening of the local economy, improved energy security and a decrease in the use of fossil fuels. Since 2007, the environmental goods and services sector of the national economy continues to grow, in part due to the use of renewable energy, with Austria becoming recognised as an international expert in the field.

Though the population is expected to remain stable over the coming decades, the increased standard of living and growing trend of urban sprawl has led to increased pressure on the country’s environment. Austria has the capacity to tackle this issue as a result of its ambitious policy to improve efficiency, particularly with regard to buildings. It is little wonder, considering the most Passivhaus structures are built in either Austria or Germany. Homes built to Passivhaus standards amount to 20% of all new homes built in Austria annually.

KEY FACTS

Country Population
8.2 million

Area
83,871 km²

Density
102 people/km²

% of population in cities
67.7%

3 million
Number of housing units

21%
Population in megacities
(over 1 million residents)

585
Motor vehicles
per 1000 people

8,374 kWh/yr
Electric power consumption per capita

8 tCO₂/yr
CO₂ emissions per capita

24%
of total energy used
by residential sector

74.6%
Electricity generated
from renewables

-53°C to 40°C
Temperature Range
Case Study
SOLARCITY LINZ
Start 1995  Complete 2005

Spurred on by the growing demand for housing in the city, particularly for low and middle income earners, and a growing awareness of the negative impacts of continued high-use of fossil fuels, the City of Linz led the development of solarCity, widely considered to be an exemplary urban development internationally. The 32 acre development involved the construction of 1294 homes, all of which have been designed and built to a high environmental and architectural quality. The term ‘solar energy’ has been considered broadly to incorporate both passive design principles throughout the scheme, as well as active solar energy.

Four Citizens’ Solar Power Plants save approximately 800 tonnes of CO2 per year.

100% of Aspern’s Vienna’s Urban Lakeside heating demands will be met by geothermal systems.

All new buildings in the scheme were built according to the best practice principles of solar architecture, including appropriate height and orientation which allow for sunlight penetration into the home even in winter, and low-energy building construction that maximised optimal thermal insulation and compact design. Solar panels were installed on the roofs of each new building (the construction of which were subsidised by the city) and solar water heating systems in each home. A new biomass cogenerating district heating system was also installed which supplies 17% of the area’s total district energy. As a result of these initiatives, the average energy demand in the district is only 36 kWh/m²/annum.

Vienna’s Climate

Austria’s Energy Profile

Energy consumption by sector
- Residential
- Other sectors

Where does this energy come from?
- Coal and Coke
- Oil and Gas
- Renewables
- Waste
- Hydro
- Geothermal
- Solar Thermal

What renewable energy sources are available?
- Biomass
- Biogas
- Sun

Case Study
SMART CITY WIEN
Start 2012  Finish 2015

Smart City Wien is just one programme in Vienna’s long history of low carbon initiatives. Considered to be Europe’s third most innovative city according to the Innovation Cities Global Index 2014,12 Smart City Wien aims to give citizens the knowledge to make informed decisions regarding the responsible use of resources. In a city where 39% of all journeys are made via public transport (the highest in Europe) and 14% of energy is already generated from renewable energy, local government and business initiatives need to go above and beyond to achieve even greater carbon savings.

In addition the city is part of projects such as Climate Neutral Urban Districts in Europe (which seeks to develop guidelines which will aid the implementation of climate neutral and energy efficient urban district(s), and Vienna’s Citizens’ Solar Power Plants. The first scheme of its kind to be realised in an urban area, the latter initiative is run by Wien, the city-owned energy provider, and shares can be bought by any individual living in Austria. Already, over 20,000 panels have been sold and even without feed-in-tariffs, the project has proved to be highly economical. With four sites now operational, the scheme is saving approximately 800 tonnes of CO2, each year.

The project also includes one of Europe’s largest developments called Aspern Vienna’s Urban Lakeside. Over the next 20 years, Aspern will become home to 20,000 people. The first residents have already moved in, and the site’s first non-residential building, the technology centre Aspern IQ, is a fully sustainable energy-plus building, completed in 2012. Centred around a lake, half of the total area has been reserved for public spaces. Heat is provided by a district system, while the overall development will be built in preparation for the integration of a smart grid. All building stock will be assessed and certified by the Austrian Sustainable Building Council. The site is expected to act as a living laboratory, where research and development can occur in real infrastructure, including the testing of intelligent building control systems, solar collectors, heat pumps and thermal and electrical storage systems. It is anticipated that the site’s energy will be provided by local generation (100% of Aspern’s heating demands will be met by geothermal systems) and storage, as well as a low-voltage grid, all of which is coordinated by building control systems.

Aspern Vienna Urban Lakeside will be part of ‘Aspen Smart City Research’ testing new smart technologies in residential, education and student housing settings.

References
2. City of Maui. 2015. Energy svgs with the highest percentage of their countries’ residents.
4. Wiener WirtschaftsWoche. 2015. Austria and Germany – a hot U and Internal Low澹cuance
10. Centre for Climate Adaptation. Austria.

Austria’s Energy Profile

HOMES ARE RESPONSIBLE FOR 24% OF GLOBAL ENERGY CONSUMPTION

33% OF AUSTRIANS’ ENERGY IS GENERATED USING BIODEFUS & WASTE

62% OF AUSTRIAS’S RENEWABLE ENERGY IS FROM BIOMASS

Vienna’s Climate

Exampliar Case Study
SMART CITY WIEN
Start 2012  Finish 2015

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Denmark, Denmark

Consistently recognised as a global leader in climate change with a broad range of initiatives and ambitious energy targets, Denmark has successfully combined a high standard of living with reducing national carbon emissions. In fact, between 1990 and 2007, economic activity in the country increased by 40% despite a reduction of 14% of CO₂ emissions during that same time.

Denmark’s leadership in clean energy began over 40 years ago with the 1973 and 1979 oil crises, which motivated the country to invest in research and development related to renewable energy sources. Since then, Denmark has become the international leader in wind energy, in part due to its extensive coastline, and the ever increasing development of innovative technology.

Currently, 28% of electricity in Denmark is generated by wind, with the aim of reaching 50% by 2020. Internationally, 90% of offshore turbines have been installed by Danish companies. The Danish government has long focused on the importance of sustainability in the built environment, having implemented some of the strictest green building legislation in the world. As energy prices rose in 2010, politicians worked to implement energy saving requirements in both homes and other buildings. In fact, the majority of Denmark’s existing homes have been energy-renovated, including both rental properties and owner-occupied. It is not surprising that international mayors regularly visit Danish cities, which have become models for how sustainable cities can benefit both the environment and its residents.

**KEY FACTS**
- **Country Population**: 5.6 million
- **Area**: 43,094 km²
- **Density**: 132 people/km²
- **% of population in cities**: 73.9%
- **Population in megacities (over 1 million residents)**: 22%
- **Electric power consumption per capita**: 6,122 kWh/yr
- **Motor vehicles per 1000 people**: 481
- **Electricity generated from renewables of total energy used by residential sector**: 32%
- **CO₂ emissions per capita**: 6.2 tCO₂/yr
- **Temperature Range**: -31°C to 36°C

**DENMARK**

**CAPITAL**: Copenhagen

OF THE 406 ISLANDS, ONLY 78 ARE INHABITED

COPENHAGEN HAS NEARLY 400KM OF CYCLE PATHS

THERE HAS BEEN A BAN ON THE BUILDING OF NUCLEAR PLANTS SINCE 1985

€600 MILLION
12% OF ALL PRIVATE RESEARCH IS INVESTED IN ENERGY RESEARCH EACH YEAR

GREEN PRODUCTS AND SERVICES ACCOUNT FOR 10.4% OF TOTAL DANISH EXPORTS

DENMARK AIMS TO BE COMPLETELY FOSSIL FUEL FREE

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Copenhagen’s North Harbour, currently one of Europe’s largest urban developments, is set to become a leading example of a sustainable urban area. While numerous sustainability measures are currently being implemented across the city (helping the city to win the European Green Capital award for 2014), the North Harbour’s combination of sustainable energy, well-planned transport routes and social sustainability, with goals for both the short and long term, sets it apart from other eco-districts.

The new development is approximately 200 hectares, which is expected to be home to 40,000 people and contribute significantly to the Danish economy. The project is one of the first urban masterplans to be certified by the German Sustainable Building Council (DGNB), obtaining a gold certificate, the highest possible ranking. All new buildings on site will need to obtain a DGNB bronze certification as a minimum, which is higher than what is required by the current building code.

The aim for the development is to create a highly liveable and socially sustainable area in Copenhagen, which is also highly liveable and socially sustainable. The city has identified the importance of allowing a greater number of residents the opportunity to live by the water, regardless of income. The district is also divided by canals into 11 different islands, meaning that despite the phasing of the development, residents will never feel as if they are living within a construction site.

The savings from these initiatives will help the North Harbour to reach the goal of being a carbon negative district, and ultimately to export excess energy generated to the rest of the city, helping other districts to reduce their carbon emissions.

A mix of renewable energy sources will mean the North Harbour is carbon negative, exporting excess energy to the rest of Copenhagen.

Neighbourhood will serve as ‘green laboratory’, testing eco-technologies and other urban solutions in real life.

An express bike lane and elevated metro loop will reduce car journeys to just 25% in the area.

In the town of Sonderborg, Southern Denmark, a focus on sustainable growth and new green jobs, combined with citizen participation, is illustrative of the capacity for smaller cities and municipalities to move toward reduced energy consumption. The city has set the goal of becoming a zero carbon community by 2029 which it is on target to achieve, with an expected reduction in carbon emissions by 25% in just three years by 2015. Although the wider ProjectZero scheme includes initiatives to help businesses reduce their emissions while also promoting growth and expanding the area’s existing district heat system, a major focus has been placed on turning Sonderborg’s residents into ambassadors for the city’s zero carbon future.

One such programme was ZEROfamily, which offered workshops to local families to help identify ways to reduce their carbon emissions while also saving money. One hundred families took part, all of whom were also challenged to check their energy meters monthly and log the results with ProjectZero. In just one year, the families were able to reduce their electricity use by 31% and their water consumption by 50%.

References
5. IEA. 2013. Denmark 2013 Review.
Germany has long maintained its global position as one of the most ambitious countries in shifting toward a low carbon economy. With the desire to be prosperous and maintain affordable energy for Germans while also becoming the world’s more energy efficiency country, Germany’s national emission targets go above and beyond those set by the European Union, seeking to reduce the nation’s greenhouse gases by 40% by 2020 and 80% by 2050 while increasing renewable energy generation to 60% by 2050.

Germany’s success to date can be attributed in part to the strength of sustained political consensus regarding the importance of creating an environment-friendly economy and the long tradition of the development and manufacturing of innovative technology. Other contributory factors include its position as the biggest energy user in the European Union, significant energy price increases in recent years and concerns over energy security as a result of limited internal energy supplies. Consistently ranked as a leader in terms of low and zero carbon, and even energy positive, buildings and communities (with globally recognised developments such as the pioneering sustainable community of Vauban in Freiburg), Germany aims to have a climate neutral building stock by 2050. This is an achievable target, considering the widespread support from both the government and citizens to promote construction to Passivhaus standard, which is based on a fabric first approach to low energy buildings that dramatically reduces space heating and cooling requirements.

As a result, 1 billion EUR of public money is invested annually in a comprehensive low energy and PassivHaus Standard building refurbishment.

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**Case Studies**

**SMART POWER HAMBURG**

*Start 2011 Finish 2016*

Innovative approaches to energy distribution are being developed in Hamburg, Europe's 10th largest city. Considered to be at the centre of Germany's energy industry, Hamburg was also voted as the European Green Capital in 2011. Smart Power Hamburg is a project which aims to develop new methods of electricity and heating generation and supply in the city, with a target to reduce carbon emissions by 40% by 2020 compared to 1990 levels. Funded by Hamburg ENERGIE (the city's energy provider) and the German Federal Ministry of Economics and Technology, the project's focus is on improving the integration of renewable power into Hamburg's energy grid. An interesting element of the project is the work to develop a Virtual Power Plant (VPP) which is run by an advanced energy management system to combine multiple distributed generation systems. The project remains in the simulation mode, modelling and evaluating different system components with the aim of creating a grid which is able to combine decentralised, often volatile renewable power generation plants with improved connections between producers, consumers, and storage units, making green electricity more reliable and attractive. The project is also testing other technologies, including thermal storage and the integration of OaP, as well as demand-side management within buildings.

**BAHNSTADT**

*Start 2009 Finish 2021*

More than €2 billion will be invested in the new district of Bahnstadt, in central Heidelberg, to create a large-scale zero carbon city development. The 116 hectare site which was once a former freight yard will be transformed into what is hoped to be the largest Passivhaus housing community in the world. With homes for up to 5,000 people and commercial buildings for 3,500 jobs, the entire mixed-use site will be built according to Passivhaus standards. An in-depth energy plan was developed prior to the start of construction on-site: all heating will be supplied by a district system, all of which will be sourced from renewable energy sources with a particular focus on deep geothermal and biomass thermal power plants. Other features include a strong public transportation infrastructure, new electricity saving concepts and rainwater management systems. Buildings will feature smart controls of power consumption and be structurally optimised with a focus on preventing summer overheating. As of December 2011, 1,200 people now live in Bahnstadt, with that number expected to grow as the second phase of construction continues.

**Germany’s Energy profile**

- **45% of Germany’s energy is from renewable natural gas.**
- **70% of Germany’s renewable energy is from biomass.**

**Energy consumption by sector (residential)**

- **62%**
- **26%**
- **12%**

**What renewable energy sources are available?**

- **Biomass**
- **Solar**
- **Hydro**
- **Wind**
- **Geothermal**

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Russia's role in the global energy market has continued to rise, becoming the dominant energy supplier to the booming markets in Asia, particularly China. In turn, this has helped support Russia's own economy to grow over the last decade. However, despite being a major producer and exporter of natural gas and oil, in addition to its existing hydropower capacity and growing nuclear generation (with 10 new reactors currently under development), significant reforms will need to be undertaken to improve the country's rapidly aging energy infrastructure to ensure the country's long term competitiveness globally.

The need to modernise offers ample opportunity for Russia to improve its energy efficiency, with an economy that is one of the most energy and carbon intensive in the world, a trend which has continued to increase in recent years. The government has responded with the development of policies that will help to advance Russia’s large energy efficiency potential across the economy, with particular opportunities in the industrial, residential and transport sectors. Efficiency in the built environment has continued to gain traction; although largely introduced by foreign companies seeking to improve the sustainability credentials of their Moscow offices, Russian companies have also taken green building techniques on board. As of October 2013, 26 projects in Russia had been certified or were undergoing certification under global schemes such as LEED and BREEAM.

The last 100 years the average temperature has increased by

1.29°C
0.74°C

Compared globally

The last 100 years, the average temperature has increased by 1.29°C compared to the global average of 0.74°C.

One of the top producers and consumers of electric power in the world

The government envisions the nuclear power share to be 45%-50% by 2050.
A new residential district is emerging in the southwest area of Ekaterinburg, one of the largest cities in Russia located on the European and Asian border. Combining residential, commercial, retail and office buildings, Akademia City is intended to be home to 325,000 people by 2030. Intended to be a pilot region for energy efficient urban development, the scale and ambitions of the city remain unique in Russia.

Surrounded by forest, the masterplan for the 1,300 hectare site is focused on the importance of green areas as a structural element of the fabric, and will be built around the local river and feature a 65 hectare park. The city will include trolley buses and bus lines, as well as a high speed train which connects the city to the centre of Ekaterinburg in 18 minutes. The main innovations however are related to the buildings and energy infrastructure, which are significantly different to those which define the status quo of urban development in Russia. A new gas-powered trigeneration power plant has been developed for Akademia City which is able to produce up to 250MW of electricity and 2000MW of heat power.

A district’s new infrastructure system is intended to help residents save 32% on electricity and potable water bills compared to the average energy use in Ekaterinburg.11

Trigeneration is a sensible solution for much of Russia, providing heat in the winter and cooling in the summer. In a country where an aging infrastructure impedes the development of a more modern energy system, the project has helped prompt the reconstruction of 3 kilometres of gas mains. The power system will help to reduce the risk of energy shortages in the Sverdlovsk region and help to meet peak load needs of the city. Importantly, the system will replace the common communal services found throughout Russia. With heat-exchangers located directly in the homes, this system will encourage more efficient behaviour as households will only pay for the electricity and heat that they use.

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Ekaterinburg’s Climate

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As the third highest country in the world in terms of wind power generating capacity (19% of the country’s electricity is supplied by wind), Spain’s electricity system is already made of a high proportion of renewables. Despite taking major steps to improve national environmental policy and associated institutional frameworks, the increase in Spain’s carbon emissions between 1990 and 2009 was among the highest in the OECD.

The main drivers for increased emissions during this time have been significant population growth, as well as substantial economic and social development, with transport being a major contributor, accounting for 40% of national energy consumption. Low prices and high fossil fuel subsidies also contributed to the partial distortion of Spain’s energy market. Over time, Spain has successfully reduced the use of coal, oil and nuclear, with renewable energy output doubling between 2006 and 2012.

With the construction industry heavily affected by the European economic crisis, less housing is being built than before. However, what is being built is being led by large foreign investors who are advancing sustainable construction and quality in Spain, helping to create new construction trends in the country. Overall, low carbon construction in Spain is largely still in its infancy, prompted in part by the introduction of the European Energy Performance Certificate regulation (part of the EU Energy Performance of Buildings Directive).
Exemplar Case Study
BARCELONA SOLAR HOT WATER ORDINANCE
Start 2000 Finish Ongoing
The first city in the European Union to introduce a Solar Thermal Ordinance, Barcelona first introduced the requirement for all new or renovated buildings, or buildings undergoing a change of use, to meet 60% of their hot water needs through solar energy. Managed by the Barcelona Energy Agency (BEA), the regulation seeks to take advantage of the 28,000 hours of sunshine the city has each year. Between 2000 and 2006, 31,050 solar hot water panels were installed in the city on 597 building projects.

The ordinance was further strengthened in 2006, eliminating the threshold that only buildings which use 0.8MW or more of hot water each day and that only buildings which use 1,000 smart meters, as well as more in-depth energy efficient solutions, in 50 homes (which includes consumption monitoring as well as control and demand response management, providing consumers with more advanced information about the electricity demand in their homes). The overarching aim of the project is to offer improved energy services to customers and improve consumer awareness, enabling consumers to review and understand their consumption and environmental impact, all of which is available online. It is hoped that the project will not only lead to energy and carbon savings, but help to create more informed customers, retailers and distributors.

The Porta Porta (door-to-door) education campaign means residents and building owners understand how to use and maintain the panel.

Barcelona’s Climate
Between 2002 and 2010, solar thermal energy has produced up to 70,121 MWh per year.

Spain’s Energy Profile
HOMES ARE RESPONSIBLE FOR 15% OF SPAIN’S ENERGY CONSUMPTION
Where does this energy come from?

Where do the buildings in Spain run the risk of being exempt?

35% OF SPAIN’S ENERGY IS GENERATED USING NATURAL GAS

55% OF SPAIN’S RENEWABLE ENERGY IS FROM BIOMASS

References
1. Banco de España.
2. Ibid.
5. Burgos, have been inspired by Barcelona’s policy, including Pamplona, Seville, Madrid and
6. The Porta Porta (door-to-door) communication campaign means residents and building owners understand how to use and maintain the panels.
10. Center for Clean Air Policy. The solar thermal ordinance for efficient water heating in Barcelona.
As the world’s first industrialised nation, fossil fuels have played a key part in the United Kingdom’s rapid growth since the 19th century. However, recent years have seen strong political support for the decarbonisation of the UK’s energy system, placing it ahead of most countries in the recognition of the importance of this shift. Climate change mitigation and adaptation have been made a priority domestically, while the UK is a global leader in promoting energy efficiency worldwide. Another focus area has been the decarbonisation of the national electricity grid. The government has identified nuclear power, carbon capture and storage (CCS) and the further deployment of renewable energy sources, such as wind and biomass, as being central to reaching this target.

One area which still offers significant opportunities in terms of energy efficiency and carbon reduction is the built environment, with policy seeking to improve the performance of both new and existing buildings. Part L of the Building Regulations requires that all new homes be zero carbon by 2016 (and all nondomestic buildings to be zero carbon by 2019), while the ambitious Green Deal scheme allows consumers to receive energy efficiency improvements with no up-front costs (which are ultimately recovered by the installer through charges on the consumer’s now-reduced energy bill). This year saw the beginning of a large scale rollout of smart meters across the country, where 53 million units will be installed by 2019.
**Exemplar Case Study**

**NORTH WEST BICESTER**

As part of the government sponsored programme launched in 2007 to encourage the development of sustainable communities in England, North West Bicester will be the UK’s first eco-town and the first of the other successful bids (including the communities of Whitehill-Borden, St Austell and Clay Country and Rackheath) to be built. On an area of 21 hectares north of Bicester, Oxfordshire, NW Bicester will feature 6,000 new highly sustainable homes to become the UK’s largest zero carbon community. The only winning eco-town that will be built to the originally proposed stringent standards, the project will be divided into four phases, with an intended completion date of 2017.

The first phase, known as Exemplar, involves the construction of 393 zero carbon, highly energy efficient homes (in addition to 119 affordable homes for shared ownership or to rent, as well as a primary school, local shop, community centre and eco-pub in order to create a village feel in the new development. Homes will be built to Code for Sustainable Homes Level 5, and feature triple glazing, significant levels of insulation, rainwater harvesting and water recycling, in addition to 240 solar PV panels per property.

The community’s solar panels will collectively generate enough power for 550 homes, becoming the largest residential solar array in Britain. Heat and hot water will be provided by a gas-fired combined heat and power plant. The homes have also been designed to reduce the risk of overheating in anticipation of a changing climate. The development features 45% green space with a focus on natural landscaping and will include community allotments.

The project involves a holistic approach to sustainable communities, helping to foster sustainable behaviour among its residents. Sustainable transport options will be made convenient, with numerous charging points for electric vehicles, an electric car club, and a half-hourly bus service by the time the 500 home is occupied (which will be improved to a 15-minute service after the 200th home is occupied). The development has a target of cutting the number of journeys made by car to 50% (compared to 68% in central Bicester).

The first phase has been awarded the One Planet Living Status, joining a small group of global developments to achieve the prestigious benchmark and positioning NW Bicester as one of the greenest neighbourhoods in the world. With a focus on social sustainability in addition to environmental sustainability, the project will help boost the local economy and improve residents’ quality of life.

An exhibition house will be built in central Bicester to showcase new technology and building techniques used in NW Bicester.

**Low Carbon London**

Low Carbon London is a holistic approach to ensuring the low carbon future of the city. As the UK features greater sources of distributed energy, operators must find ways to better accommodate these sources while also keeping energy costs low for consumers. The £30 million project seeks to address the ambitious carbon target of reducing carbon emissions by 60% by 2035, based on 1990 levels.

Centrally to the issue of achieving low carbon in London, as in other cities, is consumer acceptance. As such, researchers have used the project’s deployment of 5,500 households, 1,100 of which include dynamic time-of-use tariffs to understand how flexible consumers are willing to be in terms of their energy consumption. Using questionnaires and in-depth interviews, the results will help shape the way the energy industry engages with domestic consumers and the deployment of energy efficient measures in homes. Already, the project has provided extensive information which has been assessed for the impact of smart meters on energy use.

**Sustainable Bristol**

As a result of its numerous project and initiatives to become the greenest city in the UK, and a leader in the shift to the low carbon economy, Bristol was named the European Green Capital in 2015. The city has committed to invest 300 million GBP for energy efficiency improvements and renewable energy by 2020. In 2012, the city established a local energy company to invest 140 million GBP in retrofitting homes and public building, helping to contribute to a 25% improvement in energy efficiency in homes.

The city is also home to a community-focused eco-town which has successfully helped to promote domestic retrofit in the city. By hosting numerous education events, Bristol Green Doors is meant to inspire homeowners to upgrade the energy performance of their homes. To facilitate uptake, the scheme supports Bristol’s residents in discussing their experiences in retrofit and promote the benefits as witnessed by those who have actually undertaken the work.

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**Case Studies**

**Low Carbon London**

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**UK’s Energy Profile**

Over a year the net carbon dioxide emissions from all energy use within the buildings on the eco-town development as a whole are zero or below.

**London’s Climate**

Community’s solar panels will collectively generate enough power for 550 homes, becoming the largest residential solar array in Britain.

The Government-led programme has provided 9.5 million GBP as part of the first phase of eco-town funding.

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**References**

AFRICA AND THE MIDDLE EAST

SOUTH AFRICA
EXEMPLAR CASE STUDY
1. Climate Proofing of Urban Communities, Johannesburg

CASE STUDIES
1. iShack, Stellenbosch

UNITED ARAB EMIRATES
EXEMPLAR CASE STUDY
1. The Sustainable City, Dubai

CASE STUDIES
1. Masdar City, Abu Dhabi
In 2013, South Africa began its transition to a low carbon economy at a scale much larger than previously undertaken, with the completion of the first solar park to be connected to the country’s grid. Though the 75MW park is expected to generate 135 GWh a year (enough to power 33,000 homes), the introduction of renewable energy in South Africa remains hindered by a grid infrastructure in need of modernisation.

However, the move into renewable power marks a considerable effort for the nation, as its large coal reserves, along with the numerous existing and planned coal powered stations, have helped it to become one of the most developed nations in Africa, with the largest economy on the continent in terms of GDP. With electricity prices expected to increase by 16% every year starting in 2013, it is hoped that the government’s public procurement programme titled Renewable Energy Independent Power Producer Programme (REIPPP), initiated in 2011, and the Integrated Resource Plan for Electricity 2010-2030 (with a target of installing 1 million solar hot water heaters in homes by 2030) will help improve the energy intensity of the economy.

South African cities are also facing future issues with large migration from rural settlements to urban centres, which is expected to occur rapidly over the short term. As cities grow and can provide basic services at lower costs (helping to improve overall quality of life), people will migrate, making sufficient and sustainable housing provision increasingly difficult. With 62% of the urban population of sub-Saharan Africa living in informal settlements, the solution in South African cities will need to be both innovative and affordable.
The holistic programme includes resident education, as well as monitoring and measurement, with the aim to climate proof the community and foster a sustainable human settlement. This includes community workshops conducted after installation as well as door-to-door educational visits to address maintenance and repair issues. The thorough stakeholder process undertaken during the project has helped to ensure community acceptance. Contractors on the project were required to train and employ 40 local people to help with project implementation, helping to provide useful skills for future employment. Local site management was also appointed to oversee the project and renewable energy and energy efficient technologies used on the project were manufactured by local companies.

Detailed surveys of the homes were undertaken before project implementation to collect details related to orientation, existing electrics and plumbing, as well as roof structure, to help with project design. Monitoring of energy and water use, as well as indoor temperature, has also been conducted before and after installation in order to correctly calculate the carbon savings of the scheme. By calculating carbon emission reductions, carbon finance can be raised in the carbon market, helping to fund further efficiency projects in Cosmo City.

Expected to save 58,641 tonnes of carbon emissions each year.

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Contractors required to train and employ 40 local people to help with project implementation, helping to provide useful skills for future employment.

Scheme is expected to save 59,000 homes of carbon emissions each year.
Almost all of the country’s drinking water is desalinated.

Despite being smaller than the US state of Maine, Dubai, United Arab Emirates, is the world’s 3rd largest oil exporter. Summer temperatures often reach over 50°C.

2.8 million barrels of crude oil were produced per day in 2012.

Abu Dhabi fund for development (ADFD) in concessional loans $41 million for renewable energy projects in developing countries.

Abu Dhabi has a renewable energy target of 7% by 2020.

Seen as an important leader and major trading centre in both the Gulf Region and the wider Middle East, the actions taken by authorities in the United Arab Emirates will dictate the sustainability initiatives undertaken in neighbouring countries. The UAE remains one of the 10 largest oil and natural gas producers in the world and has significant lower electricity rates than the rest of the world, both of which mean renewable energy has largely remained underutilised until more recently.

Despite high oil and natural gas reserves, an electricity mix entirely generated by fossil fuels, and a report by WWF which calculated that its citizens have the world’s largest carbon footprint, the UAE has set targets to reduce their carbon emissions and guarantee fuel security over the long term. Both Abu Dhabi and Dubai have set renewable energy targets, with plans to reach 7% and 5% generation capacity by 2020 respectively, while Dubai has also set a target to reduce energy demand by 30% by 2030. Aiming to diversify the economy away from fuel exports (as a result of aggressive government policy), the UAE is becoming a major leader in the development of clean energy technology, investing in important research focused on energy, water, advanced building materials and transport systems.

The Emirates Green Building Council was established in 2006, the first of its kind in the region. As a result, the UAE construction industry is gradually adopting green building practices, with a growing focus on building envelopes and a shift away from mostly glazed façades in order to improve energy efficiency. The Emirate of Abu Dhabi also introduced an indigenous building rating system, the Estidama Pearl Rating System, which applies to numerous building types including villas (homes) and multi-residential buildings.
With the aim to become the first Net Zero Energy city in Dubai, the Sustainable City is set to create a luxurious lifestyle in a mixed-use community without impacting the environment. Supported by the Government of Dubai Land Department, the 46 hectare community (which is 15 minutes from downtown Dubai) is expected to be home to 2,700 residents and features 500 townhouses and courtyard villas, as well as non-residential amenities including an eco-resort (hotel and spa) and sport and leisure facilities. Sustainable practices will be promoted within the community and beyond, with the establishment of the Sustainable Engineering and Research Institute within the development and its associated training centre.

The scheme features 600,000 square feet of solar panels, which will reach 10MW peak solar production. Installed throughout the development, as well as on individual houses, residents will be able to meet 60% of their energy needs from the panels installed on their roofs. Other features include space for urban agriculture and farming, extensive green space and amenities including an eco-resort (hotel and spa) and sport and leisure facilities. Sustainable practices will be promoted both within the community and beyond, with the establishment of the Sustainable Engineering and Research Institute within the development and its associated training centre.

The four phase masterplan has been carefully considered in order to include space for urban agriculture and farming, extensive green space and amenities including an eco-resort (hotel and spa) and sport and leisure facilities. Sustainable practices will be promoted both within the community and beyond, with the establishment of the Sustainable Engineering and Research Institute within the development and its associated training centre.

It is the aim of the developers that the community will be sustainable beyond its low environmental impact. In Dubai, a culture of buying and re-selling for short term financial benefits means communities are often transient in nature. It is hoped that the features of the Sustainable City will help to keep residents for the long term by creating a community that really benefits them. An additional incentive, which will help to promote ownership of the community, is the feature that all those who buy a townhouse will receive a share of the revenue generated by the community centre, shopping mall, 50,000 square feet of office space, 88 apartments for administrative staff, as well as the research and development centre, which will cover all service and community fees.

The developers do not see this community as a one-time project, but are really benefiting them. An additional incentive, which will help to promote ownership of the community, is the feature that all those who buy a townhouse will receive a share of the revenue generated by the community centre, shopping mall, 50,000 square feet of office space, 88 apartments for administrative staff, as well as the research and development centre, which will cover all service and community fees.

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ASIA PACIFIC

AUSTRALIA
EXEMPLAR CASE STUDY
1. Townsville Smart Cities Challenge
CASE STUDIES
2. Zero Carbon Moreland, Melbourne
3. Barangaroo Urban Regeneration, Sydney

CHINA
EXEMPLAR CASE STUDY
1. Tianjin Eco-city

HONG KONG
EXEMPLAR CASE STUDY
1. Zero Carbon Building, Hong Kong

JAPAN
EXEMPLAR CASE STUDY
1. Fujisawa Sustainable Smart Town
CASE STUDIES
2. Bloom Energy, Tokyo
With a high standard of living and cities which consistently rank globally as most liveable, it is of little wonder that Australia’s urban centres continues to grow by approximately 1.7% each year, particularly in the state of Queensland.

Much of Australia’s prosperity can be attributed to its diverse and abundant natural resources and energy sources including oil, coal and natural gas. However, despite the contribution of energy production and exports to Australia’s economy, the national, regional and city-scale governments have sought to improve their sustainability and resilience in urban areas. This is in part due to the growing occurrence of climate-related events felt in a number of Australian cities, including floods, bushfires, droughts and increased risk of sea level rise.\(^7\)

While Australia did not ultimately meet its 2012 commitment target for reducing its greenhouse gas emissions, the ratification of the Kyoto Protocol has led to additional national targets and programmes, including an expanded Renewable Energy Target to ensure 20% of Australia’s electricity is produced by renewable sources by 2020.\(^8\)

The Green Building Council of Australia developed the national rating system, Green Star, which was launched into 2003. Since then, over 600 projects in Australia have been certified. Additional sustainable building rating systems in the country include the government’s NABERS (National Australian Built Environment Rating System), which allows the assessment of homes with regard to energy and water use.

**KEY FACTS**

- **Country Population:** 22.5 million
- **Area:** 7.7 million km\(^2\)
- **Density:** 3 people/km\(^2\)
- **% of population in cities:** 89.2%
- **Electric power consumption per capita:** 10,712 kWh/yr
- **Motor vehicles per 1000 people:** 703
- **Electricity generated from renewables:** 10%
- **CO\(_2\) emissions per capita:** 16.9 tCO\(_2\)/yr
- **% of total energy used by residential sector:** 13%
- **Electricity generated from renewables:** 10%
- **Temperature Range:** -23°C to 51°C
- **Number of housing units:** 8 million
- **Population in megacities (over 1 million residents):** 60%

**Australia**

**Capital:** Canberra

- **Has 0.3% of the world’s population, but contributes about 1.5% of total greenhouse gas emissions**\(^9\)
- **Over 80% of the population live within coastal zones**\(^2\)
- **The world’s 9th largest energy producer and one of only three net energy exporters in the OECD**\(^3\)
- **The ecological footprint is estimated to be 7.5 global hectares per capita**
- **More than 50% due to greenhouse gas emissions**\(^4\)
- **In a low emissions scenario, the annual warming is projected to increase by:**
  - 0.8°C to 1.8°C by 2050
  - 1.0°C to 2.5°C by 2070\(^5\)
- **The energy demand is predicted to double over the next 40 years with corresponding increases in price**\(^6\)
Where does this energy come from?

Australia’s Energy Profile

Townsville’s Climate

Barangaroo Urban Regeneration

Exemplar Case Study

Townsville Smart Cities Challenge

Solar City has reduced maximum demand by 10.5% from the 2008-2009 peak at the beginning of the project.

Townsville Solar City has already saved 54,000 tonnes of CO2, 7% above the project’s 50,000 tonne target.

References

China continues to top numerous global rankings, as the world’s most populated country, the biggest energy consumer and producer, the largest emitter of global carbon emissions and the world leader in renewable energy production.

The Chinese government has placed a significant priority on expanding the number of renewable and natural-gas fired plans in the country as part of its 12th Five-Year Plan. The plan includes targets to reduce the country’s carbon-intensity by 17% by 2015. The Government is also seeking to encourage greater private investment in the nation’s energy market by streamlining the project approval process and loosening control of energy prices. The Five-Year Plan also includes details regarding the mass deployment of renewable energy, with targets including 100GW of wind, 35GW of solar and 13GW of biomass.

Beyond energy, there is a growing focus on green building in China, with the first LEED building in the country certified in 2005. By 2020, it is expected that green construction will account for 30% of all new construction. This is a significant number, as China surpassed the United States in 2010 as the world’s largest construction market. Overall, a lack of understanding of the potential costs savings associated with green building means the demand for energy efficient homes remains low, but rising air pollution in urban centres has helped improve awareness.

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Exemplar Case Study
TIANJIN ECO-CITY—

Start 2008  Finish 2020

Although one of many eco-cities currently being built around the world, Tianjin Eco-city has successfully moved beyond the concept stage, with the first residents having moved in by early 2012. The 32km² site (half the size of Manhattan), located 150km from Beijing and 40km from central Tianjin, is expected to be home to 350,000 residents by 2020.

A joint venture between the Chinese and Singapore governments, the £42 billion development is defined by a number of KPIs to be achieved by 2020, including:
- Carbon emissions: Limit to 150 tons per million USD GDP
- Proportion of green buildings: 100%
- Proportion of green trips (non-private vehicles): 90%
- Renewable energy use: 20%
- Water supply from non-conventional sources (recycled and desalinated): 50%
- Solid waste recycling rate: 60%

All buildings are being built to meet hybrid Chinese-Singaporean Green Building Evaluation Standard (GBES) regulations, which is based on the 3 Star Certification Programme in China. Buildings have been designed with a south-facing orientation in order to maximise passive heat, and include wall insulation and double glazing, green building features which are still rare in China. Smart controls include blinds which will automatically be drawn or lowered based on light and temperature levels within buildings.

A diverse range of renewable energy sources will be installed on site, including solar PV, solar hot water and wind turbines. The gateway to the city is marked by 5 large wind turbines which provide 5 GWh a year, while numerous solar panels will be installed along the boundary of Tianjin Eco-city, providing 6.6 MWh, enough to power 4,000 and 5,000 households respectively. Central to the scheme is the geothermal energy plant which provides 20,000 kW of cooling in the summer, 14,000 kW of heat in the winter and provides an electrical output of 1,500kW.

A focus has been put on green masterplanning and land use, creating a highly walkable and compact city with amenities, jobs and business parks close to residential areas. The scheme has also ensured the integration of green transport, encouraging the use of bicycles, public transport and walking.

Although the city’s sustainability goals may not seem as ambitious as other eco-towns, the project hopes to provide a framework which is affordable, adaptable and scalable and can be replicated across China. This means that the development has put a focus on maximising passive design features, with the aim to minimise additional construction costs despite being a sustainable development. Intended to be practical and actually work as a city, no behaviour or technology is banned (like cars have been in other developments), but alternatives are meant to be easy and convenient. Unlike other eco-cities, which have often been built on arable land or other ecologically important sites, Tianjin has been built on a former polluted area.

A flagship government-to-government project between China and Singapore and a strong example of country cooperation in creating sustainable cities.

CHANGQINGQIAO “TRINITY”

Located along the Hun River in Shenyang, China, the Trinity Project is located on a 70 hectare site located approximately 6 km from Shenyang city centre. This 8 km ‘linear city includes 210,000 square metres of residential, commercial and community facilities. The residential component ranges from urban villas to terraced houses and other housing typologies arranged around private green courtyards. The entire urban masterplan is comprised of an archipelago of three ‘villages’, each with its own local centre and unique character. With the intention of combining advanced environmental sustainability with high quality architectural design, the site will be home to three new residential districts with a range of styles. Formally a predominantly rural area dominated by temporary settlements, the new urban district is framed as a linear city which will follow the river and establish settlements on both sides, transforming the Hun River from a city edge into a ‘green’ corridor.

CHINA’S ENERGY PROFILE

Energy consumption by sector

RESIDENTIAL

INDUSTRIAL

COMMERCE

TRANSPORT

OTHER

Energy consumption as % of total energy consumption

TRANSPORT 15% 38% 15% 15% 15%

Industry 15% 35% 15% 15% 15%

Commerce 15% 25% 15% 15% 15%

Residential 15% 15% 15% 15% 15%

Other 15% 15% 15% 15% 15%

What renewable energy sources are available?

Biomass

Solar PV

Geothermal

Wind

100% of China’s renewable energy is from biomass.

CHANGQINGQIAO “TRINITY” 12

References

8.  Zero Carbon Compendium 2015 ASIA PACIFIC.
Though a leading financial centre both in Asia and worldwide, minimal natural resources and a reliance on imported goods in Hong Kong, including energy, has put a focus on energy security and the long-term sustainability of the island nation. As a Special Administrative Region of China, the country relies heavily on energy supply from the mainland, with 25% of its electricity imported. Low levels of domestic energy production means Hong Kong largely relies on fossil fuels for power, contributing to its large ecological footprint, one of the highest in the Asia-Pacific region. In fact, residents use 150 times the level of resources than the territory can provide, second only to Singapore.

High levels of air and water pollution are the result of coal-fired power stations and traffic, as well as the numerous factories that dot the neighbouring Pearl River Delta. As a result, a Clean Air Plan for Hong Kong was released in 2013, which outlined concrete policies, measures and plans to address these challenges.

Though leading globally in high-rise accommodation, there is still room for improvement, with building’s consuming nearly 90% of the city’s electricity, the majority of which is used for air conditioning. To tackle this, Hong Kong’s Green Building Council launched HK3030 in 2012 with the target of encouraging the reduction of electricity consumption of buildings by 30% from 2005 by 2030, while the nation’s first Green Building Week took place in September 2013.
Completed in 2012, the 1,400m² Zero Carbon Building marks an important turning point for city development in Hong Kong. A collaborative effort between the Construction Industry Council (CIC) and the Hong Kong government, the complex is meant to raise community awareness of sustainable living in Hong Kong.

The complex successfully combines passive and active elements to achieve zero carbon emission. Passive design features, which have helped to contribute to 20% energy savings compared to buildings built to current standard design, include a cross-ventilated layout, high-performance glazing, an optimised wall to window ratio and ultra-low thermal transfer. External shading devices include trellises, deep overhangs and vertical shading fins. Uniquely, the building features earth cooling tubes, buried underground, they provide naturally pre-cooled air for the building to use, helping to reduce the need for air conditioning.

The installed active systems have helped to reach a 25% energy saving, compared to similar buildings built to current design standard. Features include intelligent light management, high-volume-low-speed fans (which help reduce humidity and the overall duration of the use of air conditioning) and a regenerative lift (featuring a regenerative converter which can provide a feedback path for the energy generated from the braking mode of the motor). Of particular interest for wider Hong Kong is the inclusion of a dedicated bio-diesel (with biofuel from waste cooking oil) trigeneration system, providing cooling, heating and power, generating 143MWh of electricity each year. Importantly, the plant has a high efficiency rate of 75%, compared with 40% of conventional power plants.

The first zero carbon building in Hong Kong, the building also features 1,015m² of PV cells, which generate 87MWh of electricity each year. Overall, the site has helped to improve the surrounding micro-climate, with light reflecting paint and shades able to reduce the heat island effect, a major concern in Hong Kong. The entire site is monitored by 2,800 sensing points to control and monitor the performance of the building via the overall Building Management System.

The Zero Carbon Building Ltd, established to manage the building and the showcases to which residents can visit to understand key benefits of low and zero carbon design now administers the Hong Kong-based Carbon Labelling Scheme for Construction Products. Although voluntary, it is hoped that project such as the Zero Carbon Building and the Carbon Labelling Scheme will help to improve the demand and therefore supply of low carbon products in Hong Kong.

2,800 sensing points provide real-time control and monitoring via a comprehensive Building Management System.
Through helping other global economies in their progress toward low carbon (particularly in the Asia Pacific region) and a strong focus on improving domestic efficiency, Japan continues to be a world leader in environmental policy and the development of innovative energy technology including electronics and advanced solar photovoltaics.

Following the 2011 Fukushima nuclear accident, a top priority in Japan has been ensuring energy diversity, particularly in a country where there is limited natural energy resources and energy security for the future is also a concern. The future of nuclear in Japan remains uncertain, as a number of nuclear reactors remain closed. However, recent developments suggest that nuclear energy production is likely to continue, although with significantly greater safety measures in place. Already one of the biggest importers of liquid natural gas (LNG), the percentage of imports has increased by 30% since 2011. As a result of being resource poor, Japan’s government has put considerable effort into improving domestic energy efficiency, with a policy emphasis placed on improving the efficiency of appliances. The revision of the Act on the Rational Use of Energy in 2013 has introduced regulations which set efficiency requirements above those currently achievable by the best products on the market, with the aim to improve both efficiency and stimulate innovation among manufacturers over the next 10 years. Other initiatives have focussed on the comprehensive voluntary measures that allow for flexibility. While this has been successful among Japan’s industry, the housing industry is an area where a large considerable savings in terms of greenhouse gases and energy efficiency could be made.
Since 2011, the need for improved energy provision has been supported by the public demand to shift to renewable energy sources which are less vulnerable in the face of major disasters.

Fujisawa Sustainable Smart Town, a 19 hectare new brownfield development 50km southwest of Tokyo, has taken this demand to heart, creating a sustainable and resilient town which will provide 3,000 homes for 3,000 people. With an equal focus on smart infrastructure, as well as the design of user-friendly and well-designed spaces, the town aims to optimise performance in 5 areas in order to improve the quality of life for residents: energy, security, mobility, healthcare and community. The overall cost of the project is anticipated to reach 60 billion yen (700 million USD), and has now started on site. The town is expected to be run like a business, run by the corporation like entity Fujisawa Town Management Company, which hopes to successfully integrate all of the community’s stakeholders and ensure the on-going evolution of the town.

The homes themselves include a solar power generation system, as well as storage battery units, with the aim for the homes to be independent in the creation and consumption of energy. The long-term plan of the town is to ultimately group buildings together in their energy management, further increasing the community’s efficiency. The design of the homes incorporates a traditional approach to Japanese building, where passive features which maximise natural ventilation and daylight are utilised. The homes will also feature a super-insulated design and will feature geothermal heat utilisation. Energy efficiency will be maximised through a smart energy management and monitoring system, where appliances will be centrally controlled.

The project has a number of clear targets to which it is being built, including a carbon emission reduction of 70% compared to 1990 levels, with the homes expected to be virtually zero carbon. Water consumption will also be reduced by 30%, while renewable energy will provide 30% of the town’s energy requirements through PV panels installed on homes, town facilities and other public areas. There is a clear emergency plan called the ‘Community Contingency Plan’, which itself has its application at the town level.

The town’s developers intend for Fujisawa to provide a framework to help other cities develop sustainable towns in other areas of Japan and beyond.

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UK IN FOCUS

UK Carbon Emissions per capita (by region)

mitCO₂/capita

- 0.0 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- 4.1 - 5.0

Source: Stockholm Environment Institute
THE ROAD TO ZERO CARBON
Charting the UK’s journey from Kyoto to Zero Carbon and beyond

1990
BREEAM Launched

1998
Kyoto Protocol

2002
BEDZED

2006
Code for Sustainable Homes

2007
Brighton

2008
Zero Carbon Hub launched

2009
Climate Change Act

2010
Newcastle

2011
Bristol

2012
Zero Carbon Definition

2013
Zero Carbon Compendium

2014
First Code Level 6 Home

2015
Community Energy Strategy

2016
Peterhead Carbon Capture and Storage project begins. When completed, it will be the first CCS gas-fired power station in the world.

2019
Zero Carbon Buildings

2020
UK renewables at 15%

2050
UK renewables reduced by 80% compared to 1990 baseline.

UK IN FOCUS

Paves the way for similar environmental certification systems around the world.

UK signs the Kyoto protocol, created in 1997, committing to reduce, below its 1990 baseline, emissions of carbon dioxide which are generated mostly by electricity, coal, and steel plants.

The UK’s largest mixed-use carbon neutral development, setting new standards in sustainable building.

Introduced as a voluntary scheme, the code helped to place zero carbon development at the top of the industry agenda.

Is the most sustainable city in Britain, according to the Sustainable Cities Index. It tracked progress on sustainability in Britain’s 20 largest cities from 2007 to 2010 in terms of environmental performance, quality of life and future-proofing.

The Hub is becomes operational, helping to support the government’s target of delivering zero carbon homes in England from 2016.

Bristol beats Brighton to claim the top spot on the Sustainable Cities Index, thanks to its impressive increase in recycling and composting rates.

UK becomes the first country to set legally binding carbon targets.

Newcastle pushes Bristol and Brighton to second and third place on the Sustainable Cities Index, topping the environmental tables. It stays on top until 2010.

A zero carbon home is defined as a home achieving Level 6 of the Code for Sustainable Homes, which includes emissions from both regulated and unregulated energy.

NHBC Foundation, Zero Carbon Hub and PRP publish an international compendium of low carbon housing.

Bristol is named the European Green Capital for 2015, as a result of the city’s commitment to investing €300m for energy efficiency and renewable energy by 2020 and the achievement of significant reductions in energy use.

All new homes in the UK to be Zero Carbon.

All new non-domestic buildings to be Zero Carbon.

UK not only achieves its target below 1990 levels, but also achieves the biggest reduction in the European Union.

The government confirms that the target for 2016 is for all new homes to be zero carbon, but that the definition now excludes unregulated energy.

15% of UK’s energy consumption to come from renewable sources, including on- and off-shore wind, biomass heat and electricity, marine energy, ground and air source heat pumps, and renewable biowaste.

15% of UK carbon emissions down by 12.5%.

UK carbon emissions reduced by 34% compared to 2008 baseline.

UK carbon emissions reduced by 80% compared to 1990 baseline.

UK renewables at 15%

Building Regulations improved by 44% over 2002 standards.

UK carbon emissions reduced by 80% compared to 1990 baseline.

UK carbon emissions down by 12.5%.

UK not only achieves its target below 1990 levels, but also achieves the biggest reduction in the European Union.
The following graphic details the requirements for achieving zero carbon in the UK. The first three triangles outline the Zero Carbon Hierarchy and the approaches one can take to achieve zero carbon.

As described by the Zero Carbon Hub, there are three core requirements which must all be met for a home to qualify as zero carbon:

1. The fabric performance must, at a minimum, comply with the defined standard known as the Fabric Energy Efficiency Standard (FEES)
2. Any CO₂ emissions that remain after consideration of heating, cooling, fixed lighting and ventilation, must be less than or equal to the Carbon Compliance limit established for zero carbon homes
3. Any remaining CO₂ emissions, from regulated energy sources (after requirements 1 and 2 have been met), must be reduced to zero.

Requirement 3 may be met by either deliberately ‘over performing’ on requirements 1 and 2 so that there are no remaining emissions, or by investing in Allowable Solutions.

Additional Approaches to Achieving Zero Carbon

**Extreme Fabric**

Fabric performance to Passivhaus standards, less reliance on on-site low carbon energy technologies

**Extreme Low Carbon Technologies**

Approach focused on optimising emissions reductions from fabric and energy technologies (e.g. Code for Sustainable Homes Level 5) without needing Allowable Solutions
60 Low and Zero Carbon Developments in the UK

A collection of groundbreaking low to zero carbon projects by Passivhaus architects from all over the country.

- Includes the Sigma House, Kingspan Lighthouse, 20 BRE Innovation Park ZED development on a constrained urban site.
- Sustainable community UK’s first large-scale mixed use.
- Lancaster Co-Housing Project, Lancashire.
- First offsite constructed Passivhaus in the UK.
- Underhill House, Gloucestershire bills are only £100/year.
- Demonstration project where hot water and heating.
- Glasgow House, Glasgow.
- First rural Passivhaus development in the UK.
- Wimbish Housing, Essex.
- Code Level 5 and Passivhaus certified Welsh cottages
- The Crossway, Kent.
- Hills Peak, Inverness.
- Wooding Hous, Essex.
- Lime House and Larch House, Bibb Vale.
- First rural Passivhaus development in the UK.
- Ginger House, Glasgow.
- Demonstration project where hot water and heating bills are only £100/year.
- Underhill House, Gloucestershire.
- Hills Peak, Inverness.
- The Crossway, Kent.
- Lancaster Co-Housing Project, Lancaster.
- Seddied, London.
- BowZED, London.
- BRE Innovation Park includes the Sigma House, Kingspan Lighthouse, Barratt Green House, and Osborne demonstration house.

Source: (Cribb, A. and Hall J. (2009), Ecological Footprint of British city residents. Natural World Fund (NWF UK), Surrey, UK).
**Zero Carbon Compendium 2015**

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**BREEAM** The Building Research Establishment Environmental Assessment Methodology was established by the Building Research Establishment (BRE) in 1990 in the UK and has become the most widely used method of assessing and certifying the sustainability of buildings.

**Building Retrofit** Making changes to the systems inside the building or the structural envelope after its initial construction and occupation with the expectation of improving amenities for the building’s occupants and improving the environmental performance.

**Carbon capture and storage (CCS)** A process where waste carbon dioxide (CO2) is captured (typically from large fossil fuel power plants) and disposing it in underground geological formations (such as oil and gas fields) in an effort to reduce the amount of CO2 released into the atmosphere. Also known as carbon capture and sequestration.

**Carbon intensity** The amount of carbon by weight emitted per unit of energy consumed. Common measures of carbon intensity include, for example, a common measure of carbon intensity is the weight of carbon per megajoule of energy produced, or the amount of carbon emitted by a country per unit of GDP.

**Carbon Neutral** Achieving net zero carbon emissions by balancing a measured amount of carbon released with an equivalent amount of carbon removed from the atmosphere. Also known as carbon neutrality.

**Energy Intensity** Measure of the energy efficiency of a nation’s economy, calculated as units of energy per unit of GDP.

**Greenhouse Gas (GHG)** A gas in an atmosphere that absorbs and emits radiation within the thermal infrared range. The primary greenhouse gases in the Earth’s atmosphere are water vapour, carbon dioxide, methane, nitrous oxide, and ozone.

**kWh** A unit of energy equal to 1,000 watt-hours, or 3.6 megajoules that is frequently used as a billing unit for energy delivered to consumers by electric utilities.

**Kyoto Protocol** An international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets. Adopted in 1997, the Protocol came into force in 2005.

**LEED** The Leadership in Energy and Environmental Design was developed by the U.S. Green Building Council and is a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes and neighbourhoods.

**Low Carbon and Environmental Goods and Services** All economic activity across all sectors and supply chains that deal with all environmental issues ranging from traditional pollution clean-up to renewable energy to complex, emerging low carbon solutions.

**Microclimate** A local atmospheric zone where the climate differs from the surrounding area. Can refer to areas as small as a few square feet or as large as many square miles.

**Megawatt (MW)** Equal to one million (1,000) watts. Many events or machines produce or sustain the conversion of energy on this scale, including large residential or commercial buildings which may use several megawatts in electric power and heat.

**OECD** The Organisation for Economic Cooperation and Development is a group of 30 member countries that discuss and develop economic and social policy. OECD countries are democratic countries that support free market economies.

**Smart Grid** A modernised electricity supply network that uses digital communications technology to detect and react to local changes in usage in order to improve the efficiency, reliability and sustainability of the production and distribution of electricity.

**Zero Carbon** There are three core requirements which must all be met for a home to qualify as zero carbon:
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The Compendium is based on information gathered from a range of sources and contacts. While every effort has been made to ensure accuracy, we welcome any feedback and comments.

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