ZERO CARBON COMPENDIUM

Who's doing what in housing worldwide

NHBC FOUNDATION
Housing research in partnership with BRE Trust

ZERO CARBON HUB

PRP
responsive, intelligent, enduring **design**

Zero Carbon Compendium
Who's doing what in housing worldwide

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Who's doing what in housing worldwide

FOREWORD

Nick Raynsford
Chair, NHBC Foundation

Paul King
Chair, Zero Carbon Hub

Climate change is the biggest threat we face globally, but all too often it appears abstract and disconnected from our daily lives. And yet, across the globe, as in the UK, our own homes account for between 20% and 25% of all man-made CO_2 emissions. For many governments, cutting emissions from housing is now seen as central to their ability to meet national and international emissions reduction targets. A wide range of approaches and policies directed at housing, both existing and new, are being developed with the aim of enabling low-carbon living. Some of these are well developed and already provide powerful examples which are informing international thinking.

This Compendium is the first synthesis of international activity in this field, providing a unique snapshot of how 15 different countries are demonstrating leadership in low carbon technology, culture change, policy development and change management. For each country, headline energy consumption and climatic data has been assembled to provide context. This is accompanied by an analysis of progress against national aspirations and policy targets for emissions reductions. 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 rapid and challenging performance improvements for new homes are expected with the target of delivering zero carbon from 2016, there is an obvious need to learn key lessons from overseas. While every country has unique domestic circumstances, this Compendium urges us not to reinvent the wheel or ignore critical insights which have been gained over time – now considered to be our most depleted resource in the fight against global warming.

While the global market can bring powerful international perspectives to our decision making, we rarely have the time to step back and gain an appreciation of the broad progress that is being made across the world. This Compendium both helps provide that perspective and enables us to appreciate the significant contribution being made by our own housing sector and policy makers to international progress on low carbon housing.

We must build a wider appreciation of the global importance of low and zero carbon housing in tackling climate change. This Compendium makes a valuable contribution to that important objective.

Nick Raynsford

Paul King

ABOUT THE NHBC FOUNDATION

NHBC FOUNDATION

Housing research in partnership with BRE Trust

The NHBC Foundation was established in 2006 by the NHBC in partnership with the BRE Trust. Its purpose is to deliver high-quality research and practical guidance to help the industry meet its considerable challenges.

Since its inception, the NHBC Foundation's work has focused primarily on the sustainability agenda and the challenges of the government's 2016 zero carbon homes target. Research has included a review of microgeneration and renewable energy techniques and the groundbreaking research on zero carbon and what it means to homeowners and housebuilders.

The NHBC Foundation is also involved in a programme of positive engagement with government, development agencies, academics and other key stakeholders, focusing on current and pressing issues relevant to the industry.

Further details on the latest output from the NHBC Foundation can be found at **www.nhbcfoundation.org**

NHBC Foundation Advisory Board

The work of the NHBC Foundation is guided by the NHBC Foundation Advisory Board, which comprises:

Rt. Hon. Nick Raynsford MP, Chairman

Trevor Beattie, Corporate Director for Strategy, Policy, Performance and Research at the Homes and Communities Agency

Dr. Peter Bonfield, Chief Executive of BRE

Professor John Burland CBE, BRE Trust

Imtiaz Farookhi, Chief Executive of NHBC

Neil Jefferson, Chief Executive of the Zero Carbon Hub

Rod McEachrane, NHBC Director (retired)

Geoff Pearce, Group Director of Development and Asset Management at East Thames Group

David Pretty CBE, Chairman of the New Homes Marketing Board

Richard Simmons, Chief Executive of CABE

Professor Steve Wilcox, Centre for Housing Policy, University of York

ABOUT THE ZERO CARBON HUB

Established in 2008, the Zero Carbon Hub supports and reports to the 2016 Taskforce which is chaired by the Housing Minister and the Executive Chairman of the Home Builders Federation.

It is a public/private partnership established to take day-to-day operational responsibility for co-ordinating delivery of low and zero carbon homes. This purpose will be fulfilled by monitoring, co-ordinating and guiding the zero carbon programme and engaging organisations active in low and zero carbon homes.

To do this the Zero Carbon Hub is developing five integrated workstreams: energy efficiency, energy supply, examples and scale up, skills and training and consumer engagement.

- Creating confidence during change
- Reducing risk and clearing obstacles
- Developing practical guidance

For more information visit
www.zerocarbonhub.org

The work of the Zero Carbon Hub is directed by its Management Board which comprises:

Paul King, Chairman

Neil Jefferson, Chief Executive of the Zero Carbon Hub

David Adams, Director, Zero Carbon Hub

Trevor Beattie, Homes and Communities Agency

Imtiaz Farookhi, NHBC

Mike Freshney, HBF/Robust Details Ltd

Bob Ledsome, Communities and Local Government

Ray Morgan, Local Government Association

John Tebbit, Construction Products Association

ABOUT PRP

PRP is a progressive multi-disciplinary architectural practice with 45 years' experience in the built environment across the UK, Eastern Europe, Middle East and Asia. PRP's services include architecture, urban design, landscape design, planning, interior design, environmental and project management.

PRP is an industry leader in the design and delivery of sustainable places and buildings where people love to live, work and play. Passionate about place making, PRP's portfolio spans the residential, specialist housing, mixed use, commercial, retail, health, education and leisure sectors.

Employing over 270 staff in seven offices across the world. PRP's offices are located in London, Manchester, Milton Keynes, Surrey, Edinburgh, Moscow and Abu Dhabi.

PRP is committed to R&D, continually seeking new issues to investigate and projects to study, keeping abreast of European and world wide housing approaches to help inform UK best practice.

PRP's multi-disciplinary sustainability team includes architects, environmental engineers and assessors, energy engineers, project managers and cost and sustainability consultants.

For more information, visit
www.prparchitects.co.uk.

CONTENTS

INTRODUCTION

The 1997 Kyoto Protocol (born out of the World Summit in Rio de Janeiro 1992) was the world's first collaborative initiative to try and reduce carbon emissions on a global scale. Buildings, housing in particular, play a major part in the emissions of the world's developing and rapidly-developing nations and as such have been the subject of increased regulation since the early 90's.

The UK's 2016 building regulations agenda for England, with its 'roadmap' to a 'zero carbon standard', is one of the world's most ambitious programmes in terms of renewable energy and carbon reduction.

PRP were asked to provide a snapshot view of the position other countries around the world have taken in addressing the carbon emissions in their respective residential sectors. The main purpose of this Compendium is to help provide an international context to housing developments in the UK, particularly with regards to the progression of the zero carbon definition, following the recent Communities and Local Government Consultation on Zero Carbon Homes and Non-domestic Buildings, released in December 2008.

We selected fifteen country case studies for this research. Each country has been assessed against a framework of questions and presented in a standard format for easy comparison. These case studies provide information on the geographic, climatic, and statistical indicators for each country as well as a brief review of each country's approach to low- and zero-energy housing. Each includes an overview of policy and incentives to achieve environmental targets, mandatory requirements in terms of building energy and design, and an exemplar project that features good practice, innovation and the potential for deployment on a medium to large scale.

We knew a comparative study would prove to be difficult as factors of lifestyle, climate and carbon intensity of national grids have a significant impact on carbon emissions. For example, a country often experiencing -10 degrees C in winter, such as Austria or Canada, requires more heating energy overall compared to those of temperate countries like France or the UK. A country running mainly on nuclear power would have lower carbon emissions overall compared to a country running mainly on coal. This would influence the carbon emissions of that country whilst not necessarily reflecting improvements in building energy efficiency. Any statistical data must always be analysed with the local socio-political context in mind.

The UK's 2016 building regulations agenda for England, with its 'roadmap' to a 'zero carbon standard', is one of the world's most ambitious programmes in terms of renewable energy and carbon reduction.

This Compendium aims to create a better understanding of the issues surrounding the achievement and delivery of zero carbon housing, improve the quality of the debate, and set out a basis for better international comparisons and collaboration. This document clearly sets out comparable data across an interesting set of case studies, perhaps highlighting the need for a harmony of approach with regards to assessing building performance, and providing the start for a more detailed evaluation of specific criteria related to energy and emissions on an international level.

The comparison of measures and policies across the countries also assists in putting UK policy in an international context and serves as a useful tool in the coming years, as we move towards achieving our carbon reduction goals.

ZERO CARBON HOUSING WORLDWIDE

Energy Efficiency Standards

Most of the countries in our study have well-established energy efficiency standards built into their building regulations and building codes, some dating back to the 1970's, which were developed as a response to the 1973 oil crisis. Over the years these minimum standards have progressively improved and developed, along with a set of aspirational standards that set the scene for innovative solutions to low-energy homes and consequently inform the evolution of regulatory standards.

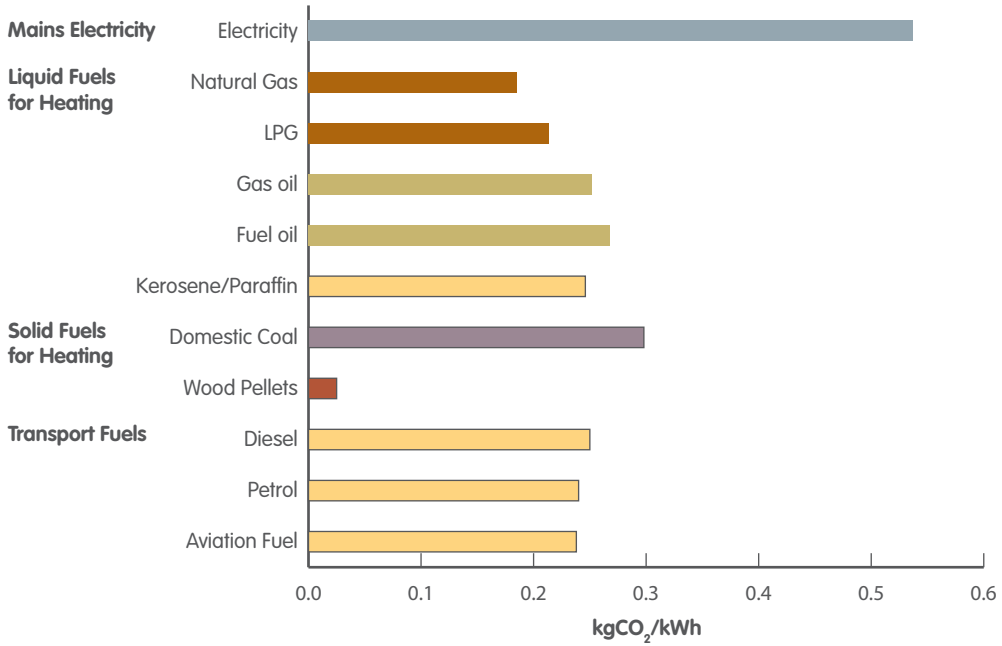
CO_2 or kWh?

The countries in this Compendium all have a carbon reduction programme based on established Kyoto targets. Among our set of case studies, the UK's dominant use of CO_2 instead of kilowatt-hours as a metric for measuring energy performance of buildings in its building regulations sets it apart from the rest. The use of CO_2 in the UK means that our metrics reflect the carbon intensity of our national grid, where electrical energy is twice as carbon intensive as heating energy, as shown in Figure 1.

Figure 2 shows a comparison of CO_2 emissions per unit of energy between the countries discussed in this Compendium, and it is clear that each country's carbon intensity is different. This means that statistical figures for CO_2 per household do not necessarily reflect energy efficiency and lifestyle, but are rather the result of the composition of that country's national grid.

Figure 1a

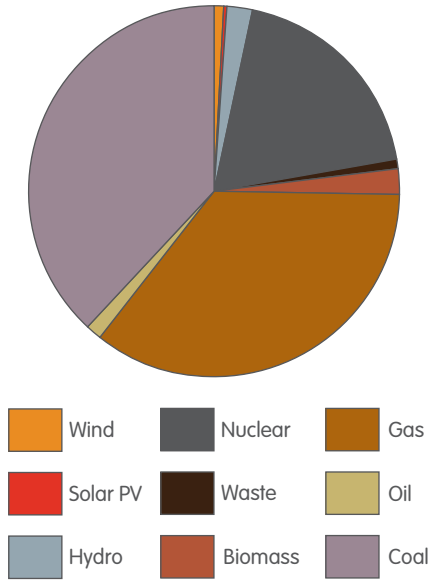
Carbon Emissions per unit of Energy (UK), different fuels ($kgCO_2$/kWh)



Data sources: UK BERR, Carbon Trust, IEA

Figure 1b

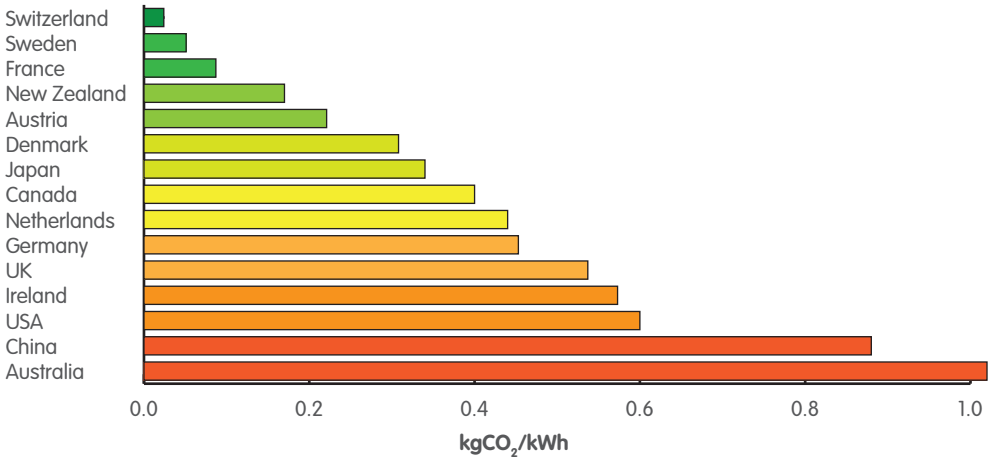
Electricity Production by Source, UK



Data source: UK BERR

Figure 2

Carbon Emissions per unit of Energy, different countries ($kgCO_2$/kWh)



Data sources: CarboNZero, Japan Times, earthfuture.com, UK BERR, US EIA, Tsinghua University, AGO and GHGprotocol.org

In the case of the UK, our use of CO_2 as a metric means, for example, that a comparison of the effectiveness of energy efficiency improvements in the UK with its predominantly gas- and coal-powered grid and France, with its nuclear power-dominated grid, is not as straightforward as one would think.

Defining Net Zero

When the other countries talk of net zero over a year or over the building's lifetime, they refer to regulated energy and sometimes also the embodied energy. Achieving overall lower emissions through behavioural change and domestic appliance use is recognised as important, but it is left to other sectors and to the decarbonising of the energy grid itself.

Here in the UK the proposed definition for Zero Carbon Homes could potentially retain the meaning that 'Net Zero' will include not only regulated energy but also unregulated energy - energy consumption arising from appliances, as the current definition already stipulates. This inclusion of unregulated energy means that the role of behavioural change and consumer awareness will become more significant in the years to come.

Standards for Low-to-Zero Carbon

Save for the UK's Code for Sustainable Homes Levels 5 and 6, the German 'Passivhaus' standard is probably the most stringent currently-established building standard that exists. Sweden has made this standard mandatory for all buildings - in Germany there are over 2,000 Passivhaus buildings and a number of German cities have now adopted it as a mandatory standard for building on publicly-owned land. The number of completions of Passivhaus dwellings in Austria and Switzerland also number in the thousands.

The UK has only a handful of completed Code Level 4, 5 and 6 homes. This Compendium shows how prototypes have been encouraged through research programmes and special development projects on a larger scale over many years in the period leading up to market acceptance. The UK still lags behind in its support for exemplar development on a large scale.

Many of the Passivhauses and low energy schemes have been monitored, so there is therefore a substantial body of monitored data on mainland Europe made available, originally through the CEPHEUS Project and more recently, from many of the certifying agencies such as Minergie and Passivhaus. No such available data bank exists in the UK and not knowing how we are performing is a barrier to awareness and improvement. Some standards incorporate post-occupancy evaluation for up to 3 years as part of the certification.

With respect to costs, some national standards, such as Minergie in Switzerland, have a requirement to show cost effectiveness. Buildings must lie within 10% of base costs to qualify for the Minergie certification. This has helped dispel the misconception that delivering enhanced standards is not economically feasible.

UK Leadership

Through BREEAM, which has been the inspiration if not the basis for a number of international 'green' building standards, the UK has been a leader in the field of developing aspirational codes which have helped the building industry worldwide move forward beyond minimum targets set by building regulations.

The UK undoubtedly leads in terms of vision, with over 25 major policies and measures for energy efficiency in buildings and renewable energy technology established within the last five years.

In terms of the drive towards a zero-carbon future in housing, the UK is not alone in its aims for a net 'zero energy' house. France is actually aiming for a 'plus energy' house by 2020, and currently a lot of countries have established programmes that push

the agenda for the research and delivery of zero-energy housing, including the United States ('ZEB'), Australia (NATHERS 10-star), Canada (NZE Housing), Japan (Zero Utility Cost Houses), and the German speaking countries ('nullenergiehaus'). The definitions vary, however, and none except the UK currently attempt to account for both regulated and unregulated energy.

Energy Supply

Understanding that reducing distribution losses is a significant route to lowering overall carbon emissions (generally accepted that up to 20-25% savings in CO_2), a number of countries (Denmark, Sweden) have made it mandatory where possible to connect to district systems. Others, such as Switzerland, have financial incentives for energy producers to encourage decentralised energy production.

From the study it is clear that in countries where significant improvements in energy performance have been achieved, information, national infrastructure and financial incentives have gone hand in hand with new policy, paving the way for policy success and widespread market acceptance. Successful partnerships between policy makers and industry, and more importantly, with the public, are essential to the advancement of national programmes for housing energy efficiency.

Some countries, such as Denmark, Austria and Switzerland have committed to a low-carbon future without nuclear energy. Sweden in particular, in response to the Chernobyl disaster, has since reversed what was originally a strong drive for nuclear expansion and has since established aims towards a nuclear-free grid.

From the study it is clear that in countries where significant improvements in energy performance have been achieved, information, national infrastructure and financial incentives have gone hand in hand with new policy, paving the way for policy success and widespread market acceptance.

Building Regulations and the Code for Sustainable Homes

In the UK, the primary energy consumption of a house built to Part L 2006 standards would be around 200 kWh/m^2.a, equating to roughly 38 kgCO_2/m^2.a. To put this into perspective, the primary energy consumption of a Passivhaus would be 78 kWh/m^2.a, or 15 kgCO_2/m^2.a, close to half that of a UK home built to current standards.

The Code for Sustainable Homes is a mandatory rating system for new homes that sets minimum standards for energy and water use, and uses a 1 to 6 star rating system to indicate the overall sustainability performance of a new home.

Code Level 3 is comparable to the current requirement for compliance with German building regulations, which specify a primary energy load of 130 kWh/m^2.a of regulated energy, with an annual heating demand of 60 kWh/m^2.a.

In terms of airtightness, the current Part L regulations require 10 m^3/m^2/hr at 50Pa, while in Germany the requirement is for 3 m^3/m^2/hr at 50Pa. Germany's planned 2010 revision estimates a 30% improvement on current standards, while the 2009 revision is set to include a commitment to meet 15% of heating, hot water or cooling energy demand from renewables. This obligation can be waived if the building is able to achieve an equivalent reduction in energy consumption using building fabric improvements. In the UK, the 2010 revision for Part L is targeting a 25% improvement on current standards, equivalent to current Code Level 3 standards.

This equivalent reduction policy is now being adopted in some UK local authorities as a replacement to the 'Merton Rule' which left no choice for housebuilders and often did not result in optimal solutions.

In Austria, all government-funded housing, including social housing as well as owner-occupiers with grant funding, will have to meet an ambitious heating standard of 36 kWh/m^2.a for single-family homes, and 20 kWh/m^2.a for multi-storey residential dwellings by 2012, a range which lies somewhere in between Code Levels 4 and 5.

These aspirational standards for Austria are comparable to the current building standard in Switzerland, where the heating load is 38 kWh/m^2.a and the total primary energy consumption is around 125 kWh/m^2.a. The Minergie standard, which is set at a 60% improvement on building regulations, would therefore be 22.7 kWh/m^2.a, and is a mandatory requirement in a number of Swiss cities at present.

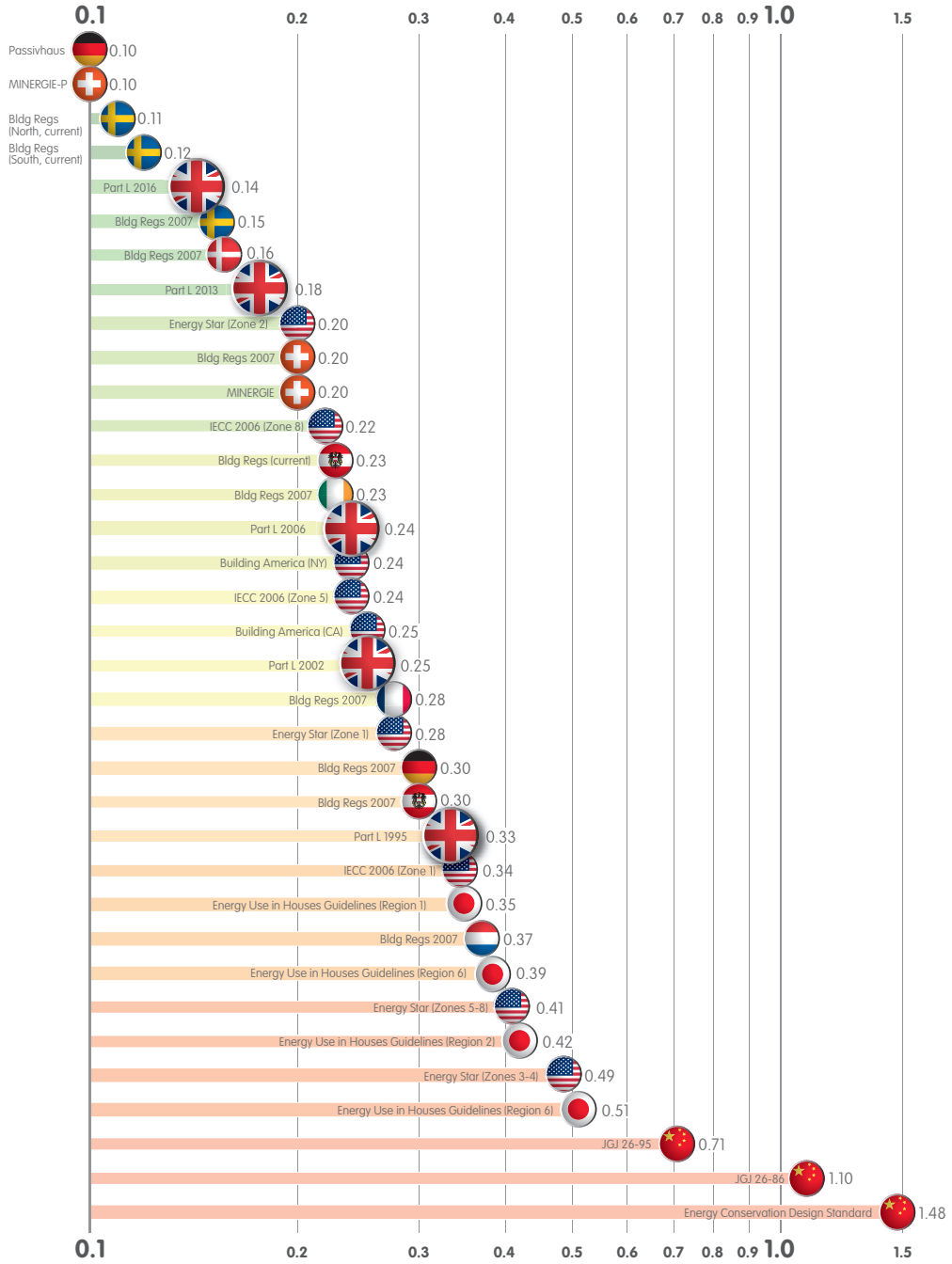
Sweden's building regulations are probably the highest standard that exists at the moment for building fabric and energy performance, with U-values in the range of 0.12-0.14 W/m^{2}K depending on location, and a heating load equivalent to Passivhaus standards at 15 kWh/m^{2}a. Their window U-value requirement at 0.7 W/m^{2}K is also one of the most stringent, and is lower than the requirement for wall insulation in concrete construction in Japan. The energy performance of a house built to Swedish building regulations standard is in the region of 110-130 kWh/m^2.a.

Figure 3 shows the relative fabric requirements for UK homes throughout its different revisions - the insulation backstops for the 1995 revision lie in between USA's IECC for Zone 1 and Austria's current building regulations, while the 2002 revision is comparable to current French building regulations and USA's aspirational Building America standards for California.
The backstops for the current 2006 revision are not significantly different from the 2002 revision, and are comparable to USA's aspirational Building America standards for New York, and Ireland's current building regulations.

The planned 2013 revision brings the standard up to current Swiss and Danish building regulation standards, while the 2016 revision brings UK fabric performance within the range of current Swedish building regulations.

The UK's current Part L (2006) requirements for thermal performance and energy efficiency fall behind those for Germany, Austria, Switzerland and Sweden at present, but it is also worth bearing in mind that these countries with stricter standards also experience colder winters which justifies these stricter standards. That being said, our milder climate should mean that we require less energy to heat our homes here in the UK, and yet we struggle to bring our heating energy consumption down to levels normally achieved in colder climates.

Figure 3
Averaged U-values for floors, roofs and walls (W/m^{2}K)



GUIDE TO THE CASE STUDIES

The following case studies illustrate recent developments in zero carbon housing worldwide. The aim was to give a taste of how the issues are being tackled in these different countries, to highlight differences in approach as well as similarities to our own local context.

The research focused on the following aspects of zero carbon housing design and delivery. These concepts appear as icons on each case study page, to indicate whether that particular country has established measures or mandatory standards, or shown innovation or exemplary performance in that particular area.

Government Policies & Measures

This icon indicates that national-level government policies and legislative measures are in place that support and promote low- and zero-carbon housing. This would include laws, national programmes and international committments.

Building Regulations

This icon indicates that the country has a set of mandatory building codes in place that set standards for building energy efficiency and, in some cases, carbon performance. This is often accompanied by a calculation methodology to demonstrate compliance.

Energy Certificates

This icon indicates that a system for building labelling and energy certification has been established in that country, as an effort to make energy performance data transparent and accessible to the public.

Aspirational Standards

This icon indicates that a well-established aspirational environmental standard, one that sets performance criteria beyond the minimum requirements set by building regulations.

Financial Instruments & Trade-offs

This icon indicates the use of financial measures to offer incentives or support for low- and zero-carbon housing. This may also include financial offsets to assist in the fulfillment of carbon reduction requirements.

Passive Design

This icon indicates that passive design features - for example, daylighting and natural ventilation - are a feature or mandatory requirement in the country's building codes, or are a significant component of compliance with the aspirational standard.

Building Envelope

This icon indicates that specific requirements for fabric performance - for example, U-values and airtightness - are a feature or mandatory requirement in the country's building codes.

Energy Efficient Equipment

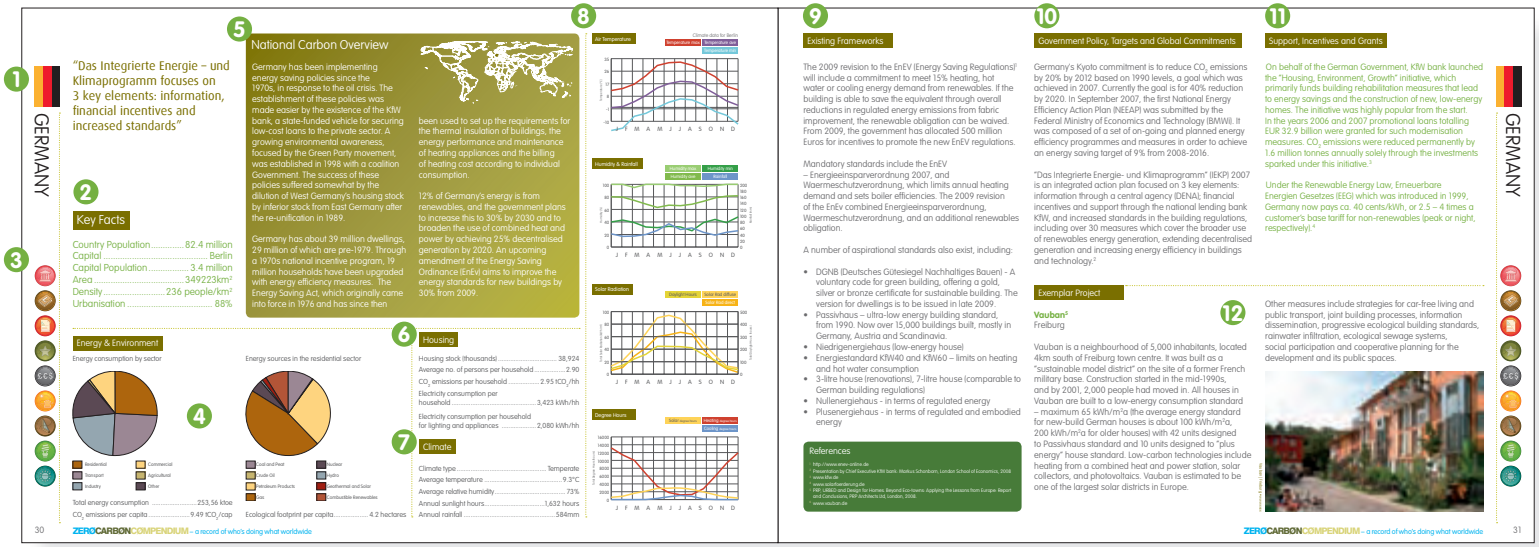
This icon indicates that the country's building codes include requirements for energy efficient equipment, whether it be for lighting, appliances or mechanical equipment.

LZC Technology

This icon indicates that a low- or zero-carbon technology is a requirement or compliance option in the country's building codes, or that these technologies feature prominently in the country's strategy for achieving carbon reduction commitments.

Innovative Systems

This icon indicates that innovative systems, such as building management systems or smart meters, are a requirement or compliance option in the country's building codes, or that these systems feature prominently in the country's strategy for achieving carbon reduction commitments.



❶ **Flag** and **Name of Country**

❷ **Key Facts** including demographic data on population, area, density and level of urbanisation.

❸ **Icons** indicating established measures, innovation or exemplary performance for each issue.

❹ **Energy and Environment** statistics, including sectoral energy consumption, mix of energy sources, carbon emissions and ecological footprints per capita.

ktoe - kilo tonnes of oil equivalent
tCO$_2$/cap - tonnes of CO$_2$ per capita

❺ The **National Carbon Overview** sets the scene for the case study, providing a background for the country's domestic energy and housing situation, and information about its recent history that may have shaped government policy and strategy today.

❻ **Housing** statistics, including housing stock figures, persons per household and data pertaining to carbon emissions and energy consumption per household.

tCO$_2$/hh - tonnes of CO$_2$ per household
kWh/hh - kilowatt-hours per household

❼ **Climate** summary figures for average annual temperature, humidity, sunlight hours and rainfall.

❽ **Climate Graphs** for the most populated city, illustrating the annual variations in temperature, humidity, rainfall, daylight hours, solar radiation, and solar, heating and cooling degree-days - indicating different heating and cooling energy requirements.

❾ **Existing Frameworks** describes established mandatory and aspirational building standards that may be applied to domestic buildings.

❿ **Government Policy, Targets and Global Commitments** describes the country's global carbon reduction commitments, and gives an overview of current strategies and government programmes that drive and inform the promotion of low- and zero-carbon housing.

⓫ **Support, Incentives and Grants** contains information about financial incentives, grants and funding towards energy efficiency and carbon emissions reduction in the domestic sector.

⓬ **Exemplar Project** contains a description and image of a low- or zero-carbon house or housing development built or developed in that country, chosen primarily for its low-carbon performance, but also for its overall combination of sustainability measures and its potential applicability to larger-scale urban settings.

AUSTRALIA

'Before the introduction of national energy efficiency regulations for houses in 2003, less than one percent of Australian houses achieved NatHERS 5 stars. Many well designed houses are now being built with ratings over 6 stars'

Key Facts

Country Population.....21.6 million
Capital .....Canberra
Capital Population.....327,700
Area .....7.6 million km^2
Density.....2.83 people/km^2
Urbanisation 91%

National Carbon Overview

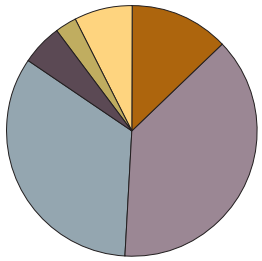
Australia is the world's sixth-largest country, roughly 80% larger than all the EU-25 countries put together. The country is rich in mineral resources, including coal, oil and natural gas.[1] In terms of climate change, Australia's emission intensity is very high due to the widespread use of coal and the presence of numerous energy-intensive industries.

Australia's approach to addressing climate change is technological, and it is seeking to develop new technologies that will provide economic progress with reduced emissions. In terms of renewables, Australia has a successful renewable support scheme and some of the lowest prices for renewables internationally.

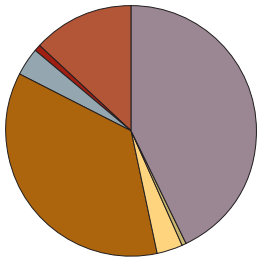
House energy rating through the Nationwide House Energy Rating Scheme (NatHERS) uses computer simulations to assess the potential thermal comfort of Australian homes on a scale of zero to ten stars. Houses built in 1990 average about 1 star on the NatHERS scale. Before the introduction of national energy efficiency regulations for houses in 2003, less than one percent of Australian houses achieved NatHERS 5 stars. Many well designed houses are now being built with ratings over 6 stars.[2]

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption .....77,726 ktoe
CO_2 emissions per capita .....18.65 tCO_2/cap
Ecological footprint per capita.....7.80 hectares

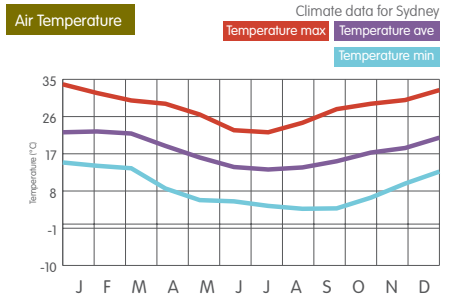
Housing

Housing stock (thousands) 7,596
Average no. of persons per household 2.50
CO_2 emissions per household .....5.44 tCO_2/hh
Electricity consumption per household .....7,419 kWh/hh
Electricity consumption per household for lighting and appliances .....4,401 kWh/hh

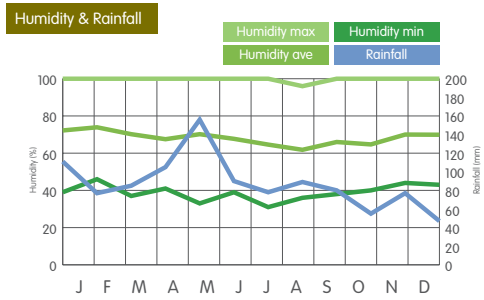
Climate

Climate type .....Equatorial, Arid, Warm Temperate
Average temperature .....17.9°C
Average relative humidity.....67%
Annual sunlight hours.....2,038 hours
Annual rainfall 1,044mm

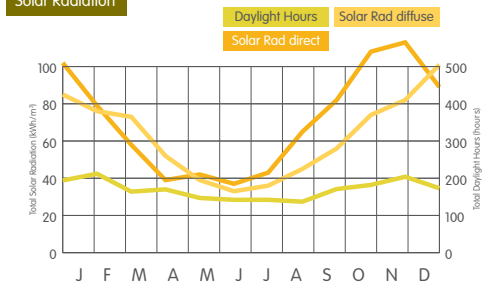
Air Temperature



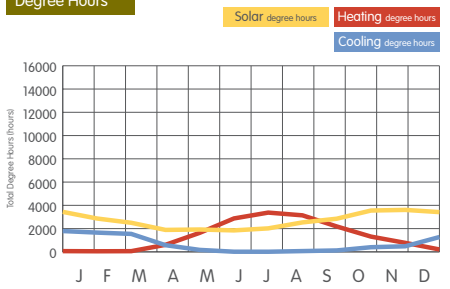
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

In January 2003, measures to increase energy efficiency were introduced into the national Building Code of Australia (BCA). The latest revision is the BCA 2006 Energy Efficiency Provisions for Housing. These measures have now been adopted in all states and territories. The Code was developed to achieve a specified level of energy efficiency under the NatHERS ratings scheme. The major components for evaluation include home layout, construction elements, window orientation and shading, and climate suitability.

The Green Star rating system was launched by the Green Building Council of Australia in 2003. This voluntary, national scheme assesses the environmental impact of buildings at design or construction stage based on nine categories, with credits to assess a building's attributes under Management, Indoor Environment Quality, Energy, Water, Materials, Transport, Land Use & Ecology, Emissions and Innovation. The rating system is available for offices, education and healthcare facilities, multi-unit residential developments, retail centres and industrial premises. Green Star ratings are only available for developments achieving Four Star (Best Practice), Five Star (Australian Excellence) and Six Star (World Leadership).[3]

The National Australian Built Environment Rating Scheme (NABERS) is a national performance-based rating system for existing office buildings and homes administered by the NSW Department of Environment and Climate Change (DECC). NABERS rates a building on the basis of its measured operational impacts on the environment, awarding a star rating from one to five.[4]

References

1. Energy Policies of IEA Countries: Australia 2005 Review, International Energy Agency, 2005
2. NatHERS website, www.nathers.gov.au (last updated December 2008)
3. Green Building Council of Australia, www.gbca.org.au
4. National Australian Built Environment Rating Scheme, www.nabers.com.au
5. Carbon Pollution Reduction Scheme: Australia's Low Pollution Future – White Paper. Australian Government Department of Climate Change, 2008
6. Energy Efficient Homes Package, Australian Government Department of the Environment, Water, Heritage and the Arts, 2009
7. New Zero-Emission Home for Australian Families, CSIRO, 2008

Government Policy, Targets and Global Commitments

In the Australian government's white paper, it reiterated its commitment to meet a long-term target of a 60% reduction in GHG emissions by 2050 based on 2000 levels, as well as to reduce GHG emissions by 5-15% below 2000 levels by 2020.[5] The National Appliance and Equipment Energy Efficiency Program (NAEEEP), established in 1992, aims to reduce energy demand through efficiency in appliances and equipment. This program covers minimum energy performance standards (MEPS) and energy labelling systems. Another programme, the Solar Cities programme, enables trials for smart metering and innovative approaches to energy pricing. The Housing Industry Association (HIA) runs a voluntary scheme called Green Smart, which focuses on educating builders, designers, product manufacturers and consumers in the field of sustainable building. They advise on environmental management, household and construction waste reduction and measures for reducing water and energy consumption.

Exemplar Project

Australia's Zero Emission House (ZEH)[7]
Melbourne, Victoria

The ZEH is a four-bedroom detached house which embodies the vision of being a zero-emissions house that Australian families can afford. The project, a collaboration between the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and a consortium of government and industry partners, aims to build a home that does not release any CO_2 as a result of producing or consuming energy on-site. The new house is expected to use up to 70% less energy than a traditional home of a similar size, and will reduce energy consumption through careful building design, considering the climate, hot water supply, heating and cooling as well as appliances. The house will incorporate an energy management system, and will be occupied by tenants for a year.

Support, Incentives and Grants

The government provided AUD 40.4 million from 2000-2005 for the Photovoltaic Rebate Program (PVRP) to encourage the long-term use of PV technology. Rebates of up to AUD 4,000 per household were made available, as well as a component for developers to apply for funding to install PV on new-build. The take-up on this incentive has been quite low however – even with subsidy, the installations are still very expensive.

The Energy Efficient Homes package offers financial assistance for insulating homes and rebates for homes which install solar hot water systems.[6] Most Australian jurisdictions provide rebates for solar hot water systems, namely Queensland, Victoria, SA, WA and ACT, all offering different amounts. The scheme is designed to harness the large amount of solar energy that Australia receives and to ultimately replace electric water heaters which account for a large amount of Australia's greenhouse gas emissions.

Zero Emission House | Melbourne • Henley Property Group

AUSTRIA

'The number of Passivhaus homes rose to a market share of 4% in 2006 from almost zero in 2000. By 2007 there were 2,000 Passivhaus buildings in Austria'

National Carbon Overview

Austria has one of the highest percentages of rental properties in Europe at 40% (80% in Vienna). Present initiatives in the Austrian housing market are focused on the promotion of sustainable buildings, including cost-effectiveness, occupant acceptance, and faster market penetration. The market deployment of sustainable housing is supported both by research programmes and financial support from the Austrian federal and provincial governments.[1]

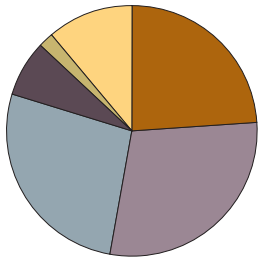
From 1990-2006, overall household energy efficiency in Austria improved by 23%, mainly due to the increasing number of homes with good insulation. In 1999, the government began a Haus der Zukunft, or 'Building of Tomorrow' programme to support trend-setting research and development projects and the implementation of exemplary pilot projects. This initially ran from 2000-2005 and resulted in huge market awareness, technological innovation and cost surety. The number of Passivhaus homes rose to a market share of 4% in 2006 from almost zero in 2000. By 2007 there were 2,000 Passivhaus buildings in Austria. Austria has 2.5 times more Passivhaus buildings per 1 million inhabitants than Germany. Due to the success of this program, the Austrian Research promotion Agency (FFG) launched in October 2008 a tender for 'Haus der Zukunft PLUS' to explore dwellings that generate energy in sufficient quantity to offset their CO_2 emissions over their lifetime.

Key Facts

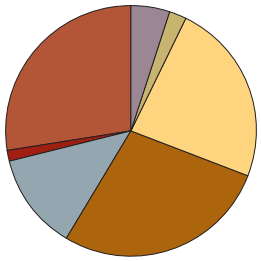
Country Population ..... 8.17 million
Capital ..... Vienna
Capital Population ..... 1.6 million
Area ..... 82,444 km^2
Density ..... 99 people/km^2
Urbanisation 67%

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption ..... 27,972 ktoe
CO_2 emissions per capita ..... 8.11 tCO_2/cap
Ecological footprint per capita ..... 5.0 hectares

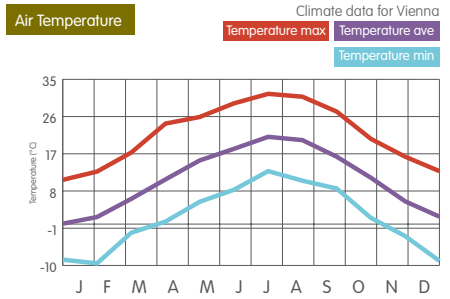
Housing

Housing stock (thousands) 3,302
Average no. of persons per household 2.40
CO_2 emissions per household ..... 5.06 tCO_2/hh
Electricity consumption per household ..... 4,395 kWh/hh
Electricity consumption per household for lighting and appliances ..... 1,961 kWh/hh

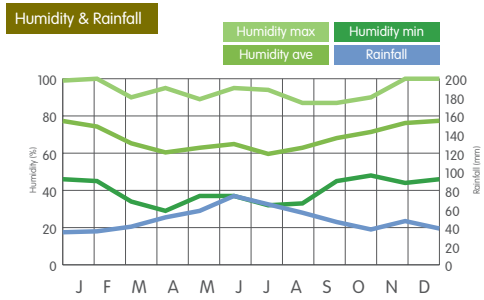
Climate

Climate type ..... Warm Temperate
Average temperature ..... 10.70°C
Average relative humidity 67%
Annual sunlight hours ..... 1,771 hours
Annual rainfall ..... 145 mm

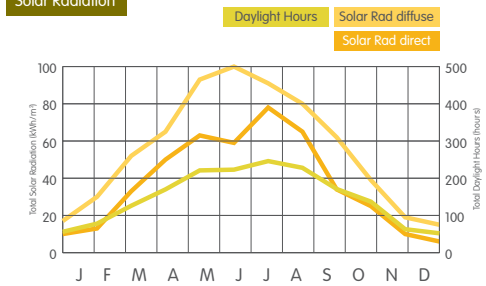
Air Temperature



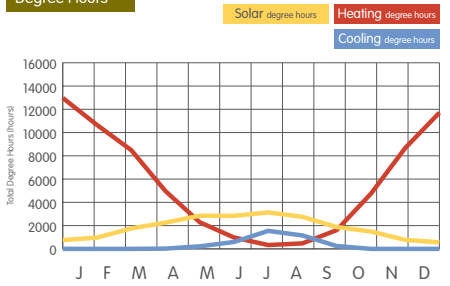
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

Due to the distribution of responsibilities according to the constitutional law from 1929, there has never been one single building law in Austria, but at least nine different systems, each consisting of a building law and related orders. The Österreichisches Institut für Bautechnik (OIB The Austrian Institute of Construction Engineering) is a private association founded by the nine Austrian states. In 2007, a sophisticated calculation system was developed, amalgamating these nine building codes. This methodology is included in the 'OIB-Guidelines', which are based on a set of 11 'ÖNORM' (Eco) standards.

IG Passivhaus Austria is the certified standard for new and existing low energy buildings. These houses have higher energy efficiency throughout the life-cycle of the building, use renewable energy sources, sustainable raw materials, are materials-efficent, and have increased focus on user needs and services whilst remaining cost-effective in comparison to conventional building methods. There are five categories under this standard:

- Passivhaus residential with heating load <10 W/m^2
- Passivhaus residential with an energy requirement <15 kWh/m^2.a.
- Residential buildings with an energy requirement of 15-20 kWh/m^2.a.
- Passivhaus special purpose buildings.
- Refurbishment of existing buildings with Passivhaus components.

References

[1] Austrian Federal Ministry of Transport, Innovation and Technology
[2] Reinhard Jellinek, 'Energy Effiency And CO_2 Emissions in Austria', SAVE Odyssee data base, EVA Austrian Energy Agency, 2003
[3] H Krapmeier, 'Living Comfort without Heating', CEPHEUS, 2002

Government Policy, Targets and Global Commitments

Austria's Kyoto Protocol commitment is to reduce GHG emissions by 13% by 2012 based on 1990 levels. The Austrian Action Plan is the driving force for policy in meeting this target. Per capita emissions are already low, due to the widespread use of hydropower and biomass energy. From the Austrian perspective, nuclear energy is incompatible with the principles and priorities of sustainable development and offers neither a cost-effective nor viable option in the fight against the anthropogenic greenhouse effect.

By introducing '15A agreement', the government hopes to address the issue of rising GHG emissions in the domestic sector. The newly adopted regulations will come into force in early 2009, and from 2012, houses built with government housing subsidies (both for social housing but also owner-occupied dwellings) will have to meet ambitious heating standards: 36 kWh/m^2.a for single-family homes, and 20 kWh/m^2.a for multi-storey residential buildings.

Support, Incentives and Grants

Austria is a federal republic which consists of nine federal states (Laender). Besides the National Housing Promotion Act for sustainable housing, the states have policies for energy efficient design and offer specific financial support for biomass, solar and heat pump systems to consumers, who can also claim rebates for purchasing energy-efficient appliances.

The Austrian Federal Law on Environmental Support, which is now 15 years old, is considered an international example of an efficient and effective funding instrument in the environmental sector. In some federal states, the investment in renewable energy technology is seen as a means of securing a future economy.[2] There have been promotional and fiscal incentives for access to real data, information dissemination, as well as training for industry partners and fiscal support for higher performing buildings (Low-energy housing credits) and products.

Exemplar Project

Residential Apartments[3]

Salzburg, Hallein

Located in a small town 15 km south of the provincial capital, Salzburg, Hallein was part of the pan-European CEPHEUS project. The scheme consists of 31 apartments, divided into 2 blocks orientated south-east and south-west. All units have south-facing balconies, serving as solar shading, which are thermally broken from the external envelope. Access via stairs and external covered walkways are also thermally separated from the highly-insulated dwellings. The reinforced concrete frame and floors provide thermal mass, and the external timber-framed walls have a U-value of 0.11 W/m^{2}K.

Decentralised whole house ventilation with heat recovery is provided in each dwelling. Residual heating is not provided through the air supply as the client was unsure of market acceptance - a centralised wood pellet boiler provides heat through conventional heating instead. Warm water is provided by a centralised 2,000-litre buffer tank heated by a solar thermal system with top-up from the biomass boiler. Waste heat from a central domestic freezer room is also fed into this tank.

Heat Energy – 13.90 kWh/m²a, Heat load – 9.00 W/m², Airtightness – 0.58@50pa.

Hallein | Salzburg • Ignacio Martinez

CANADA

'Canada is a net exporter of energy, and therefore supply security is not a highly significant issue. Environmental awareness, however, is high – the effects of a warming climate have affected many parts of the country'

Key Facts

Country Population ..... 35.5 million
Capital ..... Ottawa
Capital Population 812,129
Area ..... 9 million km^2
Density ..... 3.9 people/km^2
Urbanisation 79%

National Carbon Overview

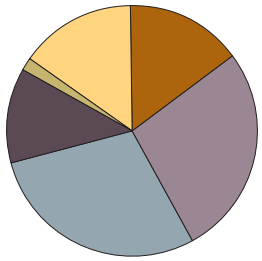
Canada's consumption of primary energy and electricity per capita is among the highest in the world, despite having the second-largest installed hydroelectricity capacity in 2002. This is due to a combination of high outputs from energy-intensive sectors, a very cold climate, high living standards, and sprawl, resulting in significant residential and commercial heating demand and large travel distances.[1] Canada is the second-largest country by area in the world, with a third of the population living in three of the largest cities – Toronto, Montréal and Vancouver.

Canada is a net exporter of oil, natural gas and electricity, therefore energy supply security is not a highly significant issue. Environmental awareness, however, is high – the effects of a warming climate have affected many parts of Canada through reductions in sea ice and glacier cover, melting of permafrost, heat waves in the south, severe drought on the prairies, ice storms in the east, flooding, forest fires and pest infestations.

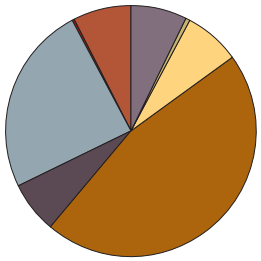
Canada is aspiring to high standards of energy efficiency in homes through its Energy Star for New Homes initiative, and has committed significant government funding towards supporting homeowners in upgrading the energy performance of existing homes.

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption ..... 201,513 ktoe
CO_2 emissions per capita ..... 17.03 tCO_2/cap
Ecological footprint per capita ..... 7.10 hectares

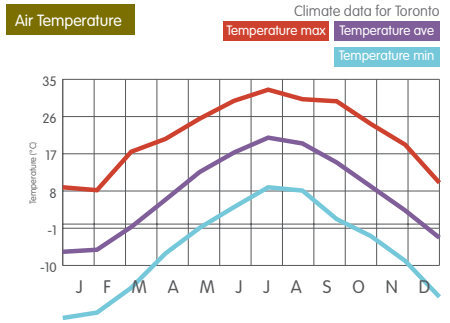
Housing

Housing stock (thousands) 13,273
Average no. of persons per household 2.60
CO_2 emissions per household ..... 7.24 tCO_2/hh
Electricity consumption per household ..... 10,334 kWh/hh
Electricity consumption per household for lighting and appliances ..... 4,664 kWh/hh

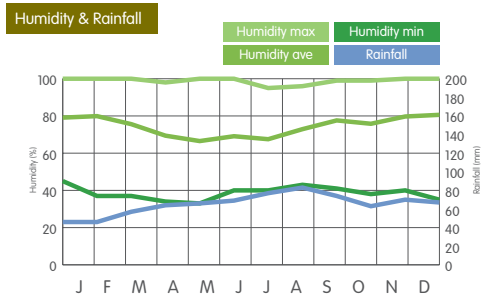
Climate

Climate type ..... Warm Temperate, Snow, Polar
Average temperature ..... 7.20°C
Average relative humidity 74%
Annual sunlight hours ..... 2,223 hours
Annual rainfall ..... 145 mm

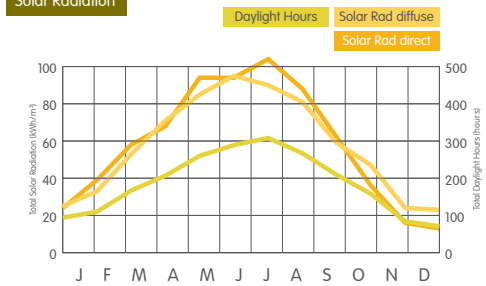
Air Temperature



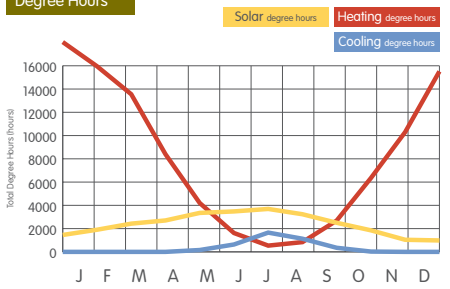
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

The Canadian Office of Energy Efficiency (OEE) uses a combination of information programmes, partnerships, standards and regulations, namely the National Building Code of Canada (NBC) and the Model National Energy Code (MNEC) of 1997, to improve energy performance in the housing sector.[2]

The MNEC was developed by the federal government. However, at that time building codes were the responsibility of the individual provinces and the Code was not adopted by all of them, resulting in a patchwork of codes as the model code was adopted in varying degrees. In July 2008, the Council of Energy Ministers endorsed an improved National Energy Code for Buildings that would have the potential to reduce energy demand in Canada by almost 25% of current energy use by 2030.[3] The new energy efficiency component is to be phased in starting in 2010, with full standards to be released in 2012.

Aspirational standards include the following:

- The Energy Star for New Homes, introduced in 2005, sets high standards for energy efficiency (approximately 30% above the level set for minimum building code standards).
  See www.energystarhomes.gc.ca.
- The LEED Canada for Homes rating system (part of the LEED Canada Initiative). See www.cagbc.org.
- Net Zero Energy Home Coalition – private coalition for the promotion of homes that supply the grid using renewable energy sources.
  See www.netzeroenergyhome.ca.

References

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[2] Energy Policies of IEA Countries – Canada: 2004 review, International Energy Agency, 2004.
[3] Energy Ministers' Conference: Collaborating on Canada's Energy Future, Government of Canada, 2007.
[4] CMHC Equilibrium Sustainable Housing Demonstration Initiative – Project Profile: Riverdale NetZero, Canada Mortgage and Housing Corporation, 2008.

Government Policy, Targets and Global Commitments

Canada's energy policy focuses on a balance between environmentally responsible production and use of energy, growth and competitiveness of the Canadian economy, secure and competitively priced energy, and the protection of infrastructure. The ratification of the Kyoto protocol in 2002 committed the Canadian government to reduce GHG emissions by 6% from 2008–2012 based on 1990 levels, with a framework set out via the Climate Change Plan for Canada. The government relies on policy instruments to overcome barriers such as inadequate information and economic constraints. These instruments include leadership by example, information and awareness programmes for energy efficiency, voluntary initiatives, financial incentives and building regulations. Natural Resources Canada (NRCan) has been promoting energy efficiency and renewable energy in Canada over the past decade. They offer support to owners of single-family homes, including detached, semi-detached and low-rise multi-unit residential buildings.

Support, Incentives and Grants

As of 2004, the Canadian government had committed $3.7 billion to climate change-related activities, including funding for foundations working on climate science, demonstrations of environmental technologies, and the development of new emissions reduction technology.

EnerGuide for Houses (EGH) was set up to provide Canadian homeowners with personalised expert advice on energy performance, particularly for undertaking renovation and maintenance projects. Homeowners able to demonstrate an improvement in the house's EGH rating pre- and post-renovation would qualify for a non-taxable grant for 10-20% of the retrofit cost. Under this programme, over 79,000 houses were evaluated and labelled and more than 30,000 grants totalling $24 million were awarded.

Exemplar Project

Riverdale NetZero Project[4]

Edmonton, Alberta

Riverdale is a new semi-detached two-storey duplex in Edmonton, featuring healthy living features, reduced energy use, net zero energy production, resource conservation, low environmental impact, and commercial viability.

The predicted annual energy requirement is less than the annual energy production from on-site renewables, which include passive and active solar heating systems and photovoltaics. The homes are highly insulated and airtight, with higher amounts of thermal mass and reduced heating requirements. Appliances are high efficiency, and energy consumption requirements for the homes are predicted to be 24% of that for a standard Canadian house. Surplus electricity is fed back into the grid. Other environmental features include low-VOC materials and finishes, daylight and passive solar design techniques. Thermal comfort is maintained via a thermostatically-controlled, forced-air heat distribution system and a heat recovery ventilator to control humidity and distribute fresh air throughout the house. Space and water heating is provided by an active solar thermal heating system.

Riverdale NetZero | Edmonton • The Riverdale NetZero Project

CHINA

'By 2015, half of all the buildings in China will be less than 15 years old'

National Carbon Overview

As one of the world's most rapidly developing economies, China's energy policies have a significant impact on global energy supply and the environment. The drive for energy efficiency in China's residential sector was in response to severe summer power shortage due to the increased affordability and use of air-conditioning[1], which for many was representative of improved living standards. In response to this problem, an energy labelling system for air-conditioning units and refrigerators was introduced and became mandatory in 2005.

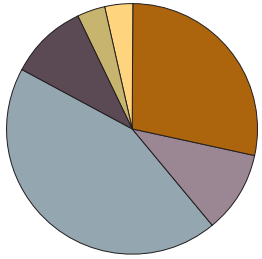
The world's largest construction market, China is home to half of the new buildings built around the world every year. The nation spends up to 45% of its total energy on the manufacture and transport of building materials, construction of homes and offices, and on heating and cooling[2]. If the current rate of construction continues, it will be impossible for China to provide enough energy to operate all of these buildings properly, without a combination of energy conservation measures and renewable energy infrastructure. This rate of growth also means that by 2015, half of all the buildings in China will be less than 15 years old, in stark contrast to the situation in Europe, where most of the dwelling stock is already in existence. The energy standards for these new-builds are however far behind in terms of European standards – four times more energy is required per m^2 for heating and cooling in China compared to Europe.[3]

Key Facts

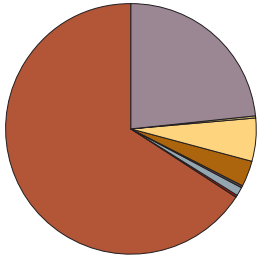
Country Population ..... 1.3 billion
Capital ..... Beijing
Capital Population ..... 16.3 million
Area ..... 9.3mil. km^2
Density ..... 139 people/km^2
Urbanisation 37%

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption ..... 1,201,846 ktoe
CO_2 emissions per capita ..... 4.41 tCO_2/cap
Ecological footprint per capita ..... 2.10 hectares

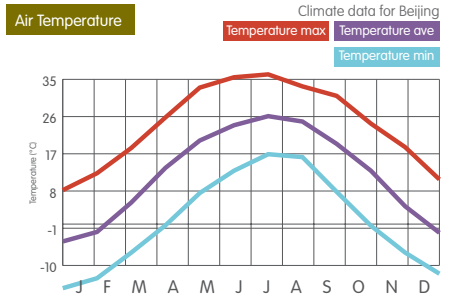
Housing

Housing stock (thousands) 374,053
Average no. of persons per household 3.36
CO_2 emissions per household ..... 3.80 tCO_2/hh
Electricity consumption per household ..... 478 kWh/hh
Electricity consumption per household for lighting and appliances ..... no data

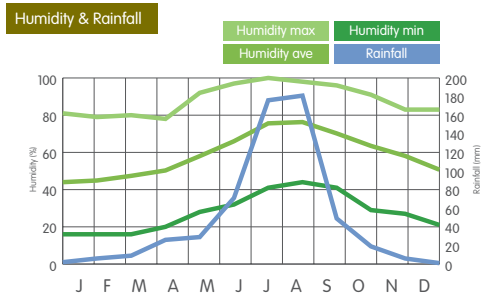
Climate

Climate type ..... Arid, Warm Temperate, Snow, Polar
Average temperature ..... 11.90°C
Average relative humidity 57%
Annual sunlight hours ..... 2,749 hours
Annual rainfall 578mm

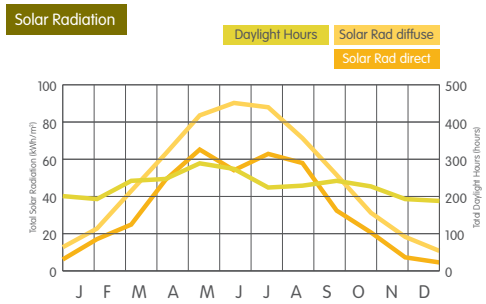
Air Temperature



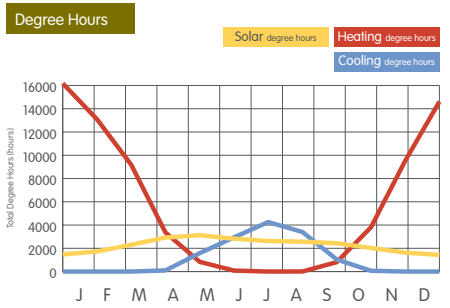
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

Since 1986, China's Ministry of Commerce has issued energy-saving codes for China's different climates as part of the effort to develop codes and standards for different building types in China's four main climates. The codes required relatively higher levels of insulation in the walls and roof, lighting energy limits, and double-glazing and insulated window frames in certain climates. Higher efficiencies were also established for heating, ventilation, and air conditioning (HVAC). However, by the end of 2000, only 5% of all new construction had met the standards. Today's revised standards call for increased enforcement, and by 2010, more than one-third of new buildings will be required to cut energy consumption by up to 50% - 20% from thermal insulation and 30% from building systems and management.[4] By 2020, all the new buildings will be expected to reduce energy use by 65%.

Building Energy Efficiency (BEE) Design Standard:

- JGJ 26-95 Residential Energy Code (Energy Conservation Design Standard for New Heating Residential Buildings).
- JGJ 134-2001 Design standard for energy efficiency of residential buildings in hot summer and cold winter zone.
- JGJ 75-2003 Design standard for energy efficiency of residential buildings in hot summer and warm winter zone.

The three JGJ standards will soon be merged into one national standard – The Design Standard for Energy Efficiency of Residential Buildings.

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[2] Natural Resources Defense Council (NRDC) China Clean Energy Project
[3] 'Energy Efficient Construction in China', dena GmbH - German Energy Agency Construction in China Project
[4] Hui, S (2000). Building Energy Efficiency Standards in Hong Kong and Mainland China, Proc 2000 ACEEE Summer Study on Energy Efficiency in Buildings, USA
[5] www.arup.com

Government Policy, Targets and Global Commitments

In line with the Five-Year Plan of China, state-funded units are required to make annual energy-saving plans and reduce energy consumption. The plan aims to reduce China's total emissions by 10% via clean fuel demonstration projects, energy efficiency standards, an energy labelling system, formulating efficiency incentives and introducing measures for publicising energy efficiency. In its proposed 'alternative oil strategy', Beijing has called for a doubling in renewable energy generation to 15% by 2020, including major installations of wind power and biomass.

The Chinese government has promoted energy-efficient technologies in buildings as a strategy for easing the energy crisis. China plans to reduce the energy consumption of residential and public buildings by 50% through the technical reform of heat-supply systems, renewed efforts in promoting building energy efficiency technology and the renovation of existing buildings in the cold northern regions.

Support, Incentives and Grants

China's Renewable Energy Law, implemented in 2006, designates renewable technologies as a priority area for energy development and research. It requires power grid operators to purchase renewable energy from registered producers, and also offers financial incentives, including a national fund, discounted lending, preferential loans with subsidised interest and tax benefits for renewable energy projects. The law aims to increase the use of solar and wind power in China to 10% in 2011, as well as increase biomass usage.

Exemplar Project

Dongtan Eco-City[5]
Shanghai, China

Dongtan was to be an ecologically friendly development with zero-GHG emission transit and complete self-sufficiency in water and energy. The development was heralded as pioneering work leading to a more sustainable future. Unfortunately the project has fallen behind schedule and the future of the project is yet unclear.

Compared to a 'business as usual' development model, Dongtan aimed to have 60% smaller ecological footprint, 66% reduction in energy demand, 40% energy from bio-energy, 100% renewable energy for buildings & transport, waste to landfill down by 83%, and virtually no carbon emissions. The building design strategy for achieving these objectives was to specify high thermal performance, use energy efficient equipment and promote mechanisms to encourage building users to save energy. Energy would be supplied via a combined heat and power plant running on biomass (rice husks), a wind farm, biogas extracted from municipal waste and sewage, and building-integrated electricity generation (photovoltaics and micro-turbines).

Dongtan East Village | Shanghai • Arup

DENMARK

'Today Denmark is one of the leaders in energy efficiency in the EU, being virtually self-sufficient in energy, a net exporter of oil and gas, and having the lowest energy intensity[1] among the member countries'

Key Facts

Country Population ..... 5.4 million
Capital ..... Copenhagen
Capital Population ..... 1.2 million
Area ..... 42394km^2
Density ..... 127.69 people/km^2
Urbanisation 85%

National Carbon Overview

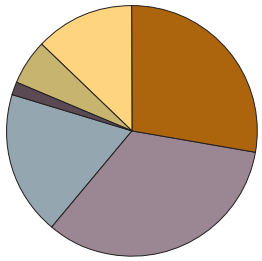
Today Denmark is one of the leaders in energy efficiency in the EU, being virtually self-sufficient in energy, a net exporter of oil and gas, and having the lowest energy intensity[1] among the member countries. Thirty years ago it was very different – the 1970's oil crisis had a severe impact on the Danish economy – Denmark was highly dependent on imported energy, importing as much as 99% of all the energy used. Today, the government's ambitious energy efficiency programme has established stringent building and appliance codes, public service campaigns, high taxes on energy, and a public sector that sets efficiency examples.

Approximately half of all dwellings are connected to a district heating network in which the heat is produced from decentralised CHP, running mainly on biomass and waste (42%), natural gas, and, to a limited extent, oil and coal.

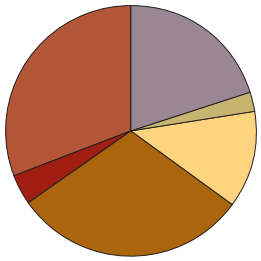
Renewable energy accounts for over 15% of Denmark's gross energy consumption, and is composed of a mix of solar, wind and biomass. Denmark was the first in the world to establish offshore wind. Denmark aims to cut gross energy consumption by 2% by 2011 and 4% by 2020 compared to 2006 levels. By 2011 renewable energy is expected to provide 20% of the country's total energy demand.

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption ..... 15,927 ktoe
CO_2 emissions per capita ..... 9.38 tCO_2/cap
Ecological footprint per capita ..... 8 hectares

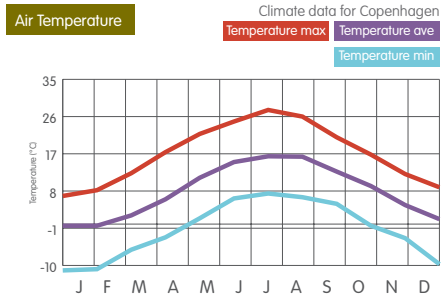
Housing

Housing stock (thousands) 2,602
Average no. of persons per household 2.20
CO_2 emissions per household ..... 5.65 tCO_2/hh
Electricity consumption per household ..... 4,231 kWh/hh
Electricity consumption per household for lighting and appliances ..... 3,130 kWh/hh

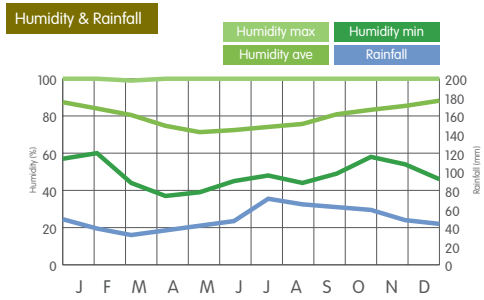
Climate

Climate type ..... Warm Temperate
Average temperature ..... 7.90°C
Average relative humidity 80%
Annual sunlight hours ..... 1,649 hours
Annual rainfall ..... 145 mm

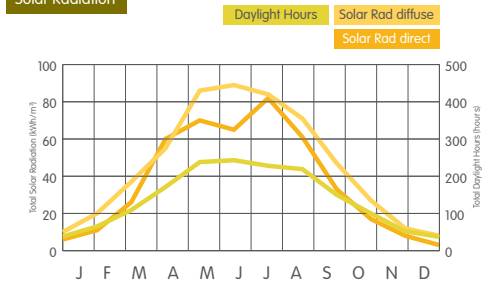
Air Temperature



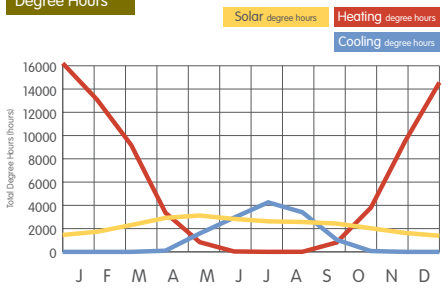
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

Mandatory requirements for dwellings are set out in the Danish Building Regulations for Small Dwellings (BR-S 98). These impose stricter energy performance requirements in accordance with current Danish action plans for an increased 25% energy saving in new buildings, compared to pre-January 2006 requirements. An energy performace target is the main requirement for all types of buildings heated to at least 15°C. For all types of buildings the new energy requirements include two classes of low energy buildings. Class two has an energy demand of 75% or less compared to a normal house, and class one, 50% or less. Low-energy buildings may be exempted from connecting to public networks with natural gas or district heating, which is otherwise obligatory in some areas.[2]

There are plans to impose stricter building standards (25% energy savings) in 2010, followed by an additional 25% in 2015 and another 25% in 2020. Denmark has also set a target that all new housing should meet Passivhaus standards by 2020.[3]

A version of BREEAM is currently being developed for Denmark.

Government Policy, Targets and Global Commitments

Under the Kyoto Protocol and the EU's subsequent Burden Sharing Agreement, Denmark has undertaken to reduce greenhouse gas emissions by 21% from 2008-2012, based on 1990 levels.[4] This is one of the most ambitious reduction targets undertaken by any country in the world.

Denmark's new energy strategy 2025, released in June 2005, identifies three major challenges: energy security, climate change and economic development. Current government policies focus on cost-effective and market-based solutions. In 2006, an Action Plan for Renewed Energy Conservation committed electricity, natural gas and oil companies to achieve specific energy-saving targets by initiating savings among their customers. Similar targets for district heating customers are being developed. The 2005 EU Energy Performance of Buildings Directive (EPBD) was also instrumental in the implementation of energy labelling for buildings and setting new standards for maximum heating energy consumption.

Support, Incentives and Grants

25 million DKK per year has been allocated for wave and solar power research, and a substantial sum over 2 years has also been set aside to promote the replacement of oil-fired furnaces with heat pumps, as well as subsidies for renewable energy technologies.[5]

Energy prices and taxes are among the most important determinants of energy consumption and have been successfully used to promote energy savings in Denmark. From 1990-2005, revenues from 'green' taxes increased by 161%.

Denmark's Climate Policy Objectives and Achievements paper[6] makes reference to grant funding schemes for private wind turbines, expansion of electrical generation capacity using wind turbines, decentralised co-generation of heating and power, the use of biomass for electricity production, energy savings in businesses, the conversion of old dwellings to cogenerated heat and power and solar heating, heat pumps, and biomass.

Exemplar Project

Skotteparken Egebjerggard
Ballerup

Skotteparken is an experimental building project aimed at a 60% saving on heating and hot water use, as well as a reduction in energy and water consumption. The dwellings are solar-heated and low-energy, achieved through a combination of extra insulation, low-emission glazing, heat recovery, solar water heaters, district heating from CHP, local heat and water metering, an energy management system, and rainwater collection. The project received the 'World Habitat Award' in 1994 for impressive ecology in housing and it has also been chosen by the UN as one of the 100 best practice examples in the world.

Skotteparken | Ballerup • Koj Andersen

References

[1] Energy intensity is defined as energy use per GDP, measured in toe/MEUR.
[2] Søren Aggerholm. Implementation of the EPBD in Denmark: Status August 2006, European Communities, 2006
[3] Henrietta Lynch. A Case for Passivhaus, Building Design (BD) magazine, 2008.
[4] Denmark's Climate Policy Objective & Achievements, Danish Ministry of the Environment, 2005
[5] Denmark commits to overall energy reduction, Ministry of Foreign Affairs of Denmark, www.denmark.dk, 2008.
[6] Denmark's Climate Policy Objectives & Achievements: Report on Demonstrable Progress in 2005 under the Kyoto Protocol.' Danish Ministry of the Environment, 2005.

FRANCE

'Of particular significance is the agenda for technological change to ensure that the majority of buildings will have 'positive' energy by 2020'

National Carbon Overview

French consumers enjoy some of the cheapest energy prices in the OECD and the country has one of the lowest levels of greenhouse gas emissions (GHG) per unit of GDP in the world. The government has been commended for its focus on energy security. As of 2004, France also had the most renewable energy production of any EU country, 98% of which comes from hydropower and biomass, and the second-largest integrated system of nuclear power plants in the world, accounting for 41% of the total primary energy supply.

In the construction sector, voluntary environmental certification has given way to a range of regulatory codes aimed at reducing the country's greenhouse gas emissions by 75% by 2050 and to provide 21% of electricity from renewable sources by 2010. In France, new regulations apply nationwide from the outset, despite the challenge of meeting the requirements of eight different temperature zones. The 2005 review of the thermal standards of the building code brought about an anticipated average energy savings of 15% compared to 2000 standards.

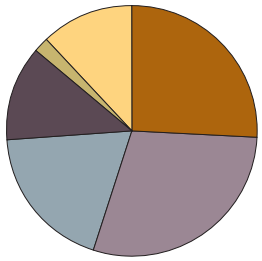
Of particular significance is the agenda for technological change to ensure that the majority of buildings will have 'positive' energy – producing more energy than they consume – by 2020, with a third of all new building offering low, if not neutral, energy consumption within five years.[1]

Key Facts

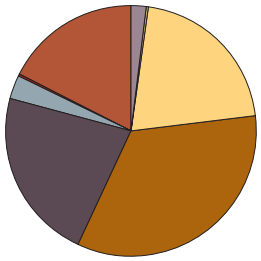
Country Population	60 million
Capital	Paris
Capital Population	2.1 million
Area	545630km^2
Density	110 people/km^2
Urbanisation	76%

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption	173,952 ktoe
CO_2 emissions per capita	5.79 tCO_2/cap
Ecological footprint per capita	4.90 hectares

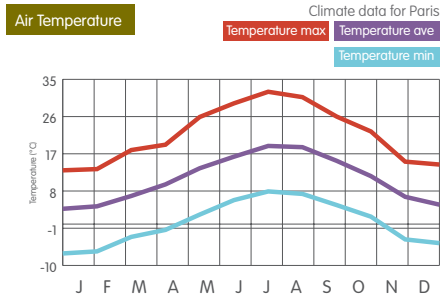
Housing

Housing stock (thousands)	29,495
Average no. of persons per household	2.30
CO_2 emissions per household	3.25 tCO_2/hh
Electricity consumption per household	5,359 kWh/hh
Electricity consumption per household for lighting and appliances	2,319 kWh/hh

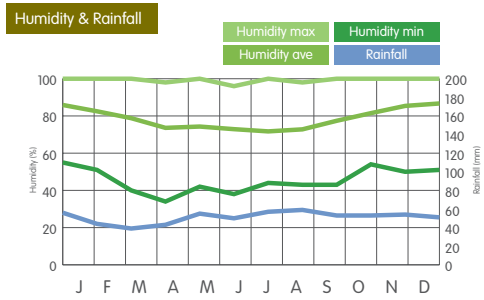
Climate

Climate type	Warm Temperate
Average temperature	10.90°C
Average relative humidity	79%
Annual sunlight hours	1,750 hours
Annual rainfall	608 mm

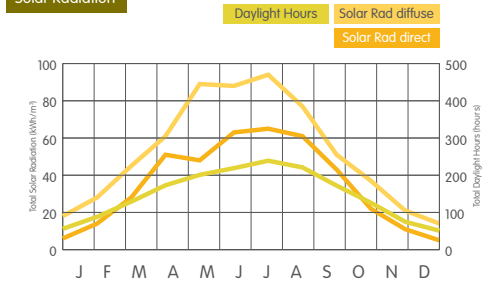
Air Temperature



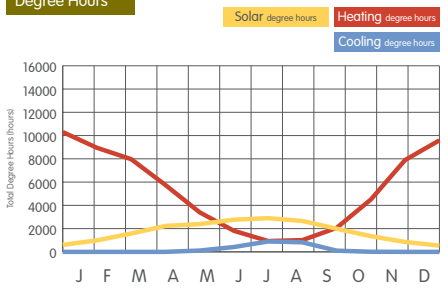
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

The Thermal Regulation (RT2005) introduced stringent regulations for thermal insulation and heating systems from 2000, with a new revision released in 2006. The regulation also aims to reduce the use of air-conditioning and limit the use of electricity for heating, cooling, domestic hot water, lighting and ventilation. For each type of building and climatic zone, RT2005 sets out a maximum consumption in kWh/m^2 of primary energy, in contrast to the UK approach of assessing energy using direct energy usage and CO_2. The building is assumed to be compliant if it is lower than the maximum and reference values for CEP (coefficient of primary energy consumption). The calculation procedure includes climate, orientation, siting, passive solar techniques and solar protection, indoor climate, renewable energy sources and natural lighting. Within the RT 2005 framework there are five additional levels of compliance: HPE, HPE EnR2005, THPE, THPE EnR2005, and BBC2005, or Effinergie standard.

The Effinergie standard requires energy consumption to be <50 kWh/m^2.a, multiplied by a factor between 0.8 to 1.3 depending on the altitude or climate zone. This includes heating, hot water, ventilation, lighting and air-conditioning.[2]

The Haute Qualité Environnementale (HQE, 'High Environmental Quality') is a green building standard based on the principles of sustainable development set out during the 1992 Earth Summit. It includes criteria for a wide range of environmental impacts, as well as energy.

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[2] Carassus J. 'The Effinergie Energy Efficient Building Concept', 2008
[3] Energy Efficiency: Policies and Measures Database, International Energy Agency (IEA)
[4] Barrier, Jean-Yves. 'Salvatierra Building in Rennes, France', in Sustainable architecture and urbanism, eds Gauzin Müller D and Favet N, Birkhäuser, 2002
[5] Bulteau V, Cantin R and Guarracino, G. 'Very low energy buildings: Analysis of Two Case Studies in France', in 2nd PALENC Conference and 28th AIVC Conference Proceedings, 2007.

Government Policy, Targets and Global Commitments

Under the EU burden-sharing agreement, France has committed to keeping its emissions at 1990 levels until 2012. The French government has set a target for decreasing GHG emissions by 75% by 2050 based on 1990 levels, as well as maintaining energy consumption at 2003 levels by 2015 and building up to 10,000 MW of wind power by 2010. The current large share of GHG-free power generation mainly via nuclear energy actually means that the scope for emissions reduction is limited, making the reduction of GHG emissions one of the greatest challenges facing France today.

To reach the 2015 energy consumption stabilisation goal, France has introduced the Tradeable White Certificate (TWC) scheme, an innovation which awards certificates to consumers or suppliers that use energy more efficiently, with mandatory requirements for a pre-determined number of certificates for certain energy suppliers.

Support, Incentives and Grants

In 2006, the French government announced the creation of a €10bn fund for offering low-interest loans to domestic energy conservation projects. Called the LDD, or Livret de Développement Durable, these are available through banks - 2% of the funds were allocated to energy conservation loans in 2005, rising to 5% in 2009 and 10% thereafter. These loans can be used for the installation of energy efficient boilers, thermal insulation, thermal regulation equipment, renewables, wood or biomass-based space and water heating equipment, & heat pumps.

From 2005, tax credits were also offered for primary residences, for purchases of low-temperature boilers (until Dec 2008), condensation boilers, thermal insulation and heating regulation devices, heat pumps, biomass or wood boilers, voluntary energy audits, and heating systems based on cogeneration or renewable energy sources. The amount of tax credit varies – homes constructed before 1977 get an increased amount.[3]

Exemplar Project

Salvatierra Apartments

Rennes, Beauregard, France

These apartments were part of a set of case studies for the CEPHEUS (Cost Efficient Passive Houses as European Standards) project, which investigated the validity of the German Passivhaus standards on a European Scale. The largest of the case studies in the CEPHEUS project, the development has 40 two- to six-room solar-optimised apartments. Other features include a compact form, airtight building envelope, argon-filled double glazing, natural materials, non-hazardous finishes, two-way ventilation with heat recovery via heat exchanger, additional air intake heating by urban heating plant, and solar hot water heating. The timber-framed walls with hemp insulation have a U-value of 0.21 W/m^{2}K. Heating energy consumption was estimated [4] at 14.9 kWh/m^2.a with a total energy consumption of 40kWh/m^2.a. The actual energy performance[5] was 41 kWh/m^2.a for heating (107 kWh/m^2.a total) – still a low-energy building but not ultra-low (Passivhaus) standard.

Salvatierra Apartments | Rennes • Coop de Construction

GERMANY

'Das Integrierte Energie – und Klimaprogramm focuses on 3 key elements: information, financial incentives and increased standards'

National Carbon Overview

Germany has been implementing energy saving policies since the 1970s, in response to the oil crisis. The establishment of these policies was made easier by the existence of the KfW bank, a state-funded vehicle for securing low-cost loans to the private sector. A growing environmental awareness, focused by the Green Party movement, was established in 1998 with a coalition government. The success of these policies suffered somewhat by the dilution of West Germany's housing stock by inferior stock from East Germany after the re-unification in 1989.

Germany has about 39 million dwellings, 29 million of which are pre-1979. Through a 1970s national incentive program, 19 million households have been upgraded with energy efficiency measures. The Energy Saving Act, which originally came into force in 1976, has since been used to set up the requirements for the thermal insulation of buildings, the energy performance and maintenance of heating appliances and the billing of heating cost according to individual consumption.

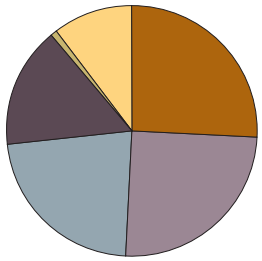
12% of Germany's energy is from renewables, and the government plans to increase this to 30% by 2030 and to broaden the use of combined heat and power by achieving 25% decentralised generation by 2020. An upcoming amendment of the Energy Saving Ordinance (EnEv) aims to improve the energy standards for new buildings by 30% from 2009.

Key Facts

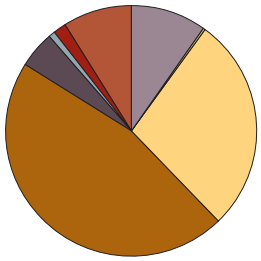
Country Population ..... 82.4 million
Capital ..... Berlin
Capital Population ..... 3.4 million
Area ..... 349223km^2
Density ..... 236 people/km^2
Urbanisation 88%

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption ..... 253,56 ktoe
CO_2 emissions per capita ..... 9.49 tCO_2/cap
Ecological footprint per capita ..... 4.2 hectares

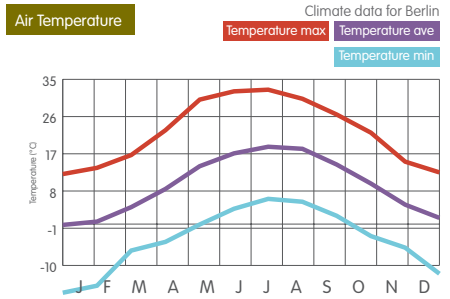
Housing

Housing stock (thousands) 38,924
Average no. of persons per household 2.90
CO_2 emissions per household ..... 5.71 tCO_2/hh
Electricity consumption per household ..... 3,423 kWh/hh
Electricity consumption per household for lighting and appliances ..... 2,080 kWh/hh

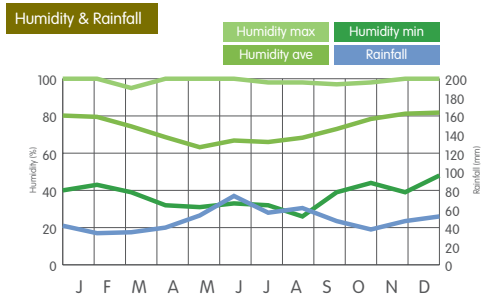
Climate

Climate type ..... Temperate
Average temperature ..... 9.3°C
Average relative humidity 73%
Annual sunlight hours ..... 1,632 hours
Annual rainfall 584mm

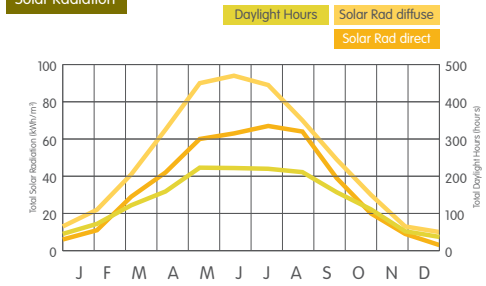
Air Temperature



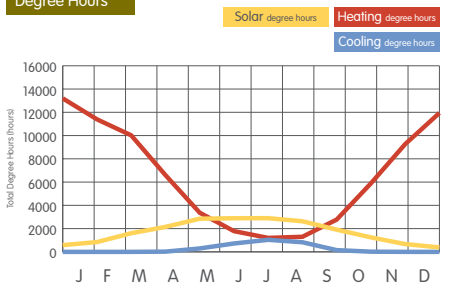
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

The 2009 revision to the EnEV (Energy Saving Regulations)[1] will include a commitment to meet 15% heating, hot water or cooling energy demand from renewables. If the building is able to save the equivalent through overall reductions in regulated energy emissions from fabric improvement, the renewable obligation can be waived. From 2009, the government has allocated 500 million Euros for incentives to promote the new EnEV regulations.

Mandatory standards include:

- EnEV – Energieeinsparverordnung 2007, and
- Waermeschutzverordnung - limitation of annual heating demand and boiler efficiency standards.

The 2009 revision of the EnEv combined these two standards with an additional renewables obligation.

A number of aspirational standards also exist, including:

- DGNB (Deutsches Gütesiegel Nachhaltiges Bauen) - A voluntary code for green building, offering a gold, silver or bronze certificate for sustainable building. The version for dwellings is to be issued in late 2009.
- Passivhaus – ultra-low energy building standard, from 1990. Now over 15,000 buildings built, mostly in Germany, Austria and Scandinavia.
- Niedrigenergiehaus (low-energy house).
- Energiestandard KfW40 and KfW60 – limits on heating and hot water consumption.
- 3-litre house (renovations), 7-litre house (comparable to German building regulations).
- Nullenergiehaus - in terms of regulated energy.
- Plusenergiehaus - in terms of regulated and embodied energy.

References

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[6] www.vauban.de

Government Policy, Targets and Global Commitments

Germany's Kyoto commitment is to reduce CO_2 emissions by 20% by 2012 based on 1990 levels, a goal which was achieved in 2007. Currently the goal is for 40% reduction by 2020. In September 2007, the first National Energy Efficiency Action Plan (NEEAP) was submitted by the Federal Ministry of Economics and Technology (BMWi). It was composed of a set of on-going and planned energy efficiency programmes and measures in order to achieve an energy saving target of 9% from 2008-2016.

'Das Integrierte Energie- und Klimaprogramm' (IEKP) 2007 is an integrated action plan focused on 3 key elements: information through a central agency (DENA); financial incentives and support through the national lending bank KfW, and increased standards in the building regulations, including over 30 measures which cover the broader use of renewables energy generation, extending decentralised generation and increasing energy efficiency in buildings and technology.[2]

Support, Incentives and Grants

On behalf of the German government, KfW bank launched the 'Housing, Environment, Growth' initiative, which primarily funds building rehabilitation measures that lead to energy savings and the construction of new, low-energy homes. The initiative was highly popular from the start. In the years 2006 and 2007 promotional loans totalling EUR 32.9 billion were granted for such modernisation measures. CO_2 emissions were reduced permanently by 1.6 million tonnes annually solely through the investments sparked under this initiative.[3]

Under the Renewable Energy Law, Erneuerbare Energien Gesetzes (EEG) which was introduced in 1999, Germany now pays ca. 40 cents/kWh, or 2.5 – 4 times a customer's base tariff for non-renewables (peak or night, respectively).[4]

Exemplar Project

Vauban[5]
Freiburg

Vauban is a neighbourhood of 5,000 inhabitants, located 4km south of Freiburg town centre. It was built as a 'sustainable model district' on the site of a former French military base. Construction started in the mid-1990s, and by 2001, 2,000 people had moved in.[6] All houses in Vauban are built to a low-energy consumption standard – maximum 65 kWh/m^{2}a (the average energy standard for new-build German houses is about 100 kWh/m^2.a, 200 kWh/m^2.a for older houses) with 42 units designed to Passivhaus standard and 10 units designed to 'plus energy' house standard. Low-carbon technologies include heating from a combined heat and power station, solar collectors, and photovoltaics. Vauban is estimated to be one of the largest solar districts in Europe.

Other measures include strategies for car-free living and public transport, joint building processes, information dissemination, progressive ecological building standards, rainwater infiltration, ecological sewage systems, social participation and cooperative planning for the development and its public spaces.

Vauban | Freiburg • URBED

IRELAND

'Ireland has the youngest dwelling stock in the EU.'

National Carbon Overview

On the basis of energy usage per dwelling in 2006, Ireland was 27% above the average for the UK, and in 2005, was 36% above the EU-27 average. Ireland's residential sector is responsible for 23% of total final energy consumption, the second largest energy sector after transport. Just under 50% of the current housing stock was built before the first thermal insulation requirements were established in 1979. 28% of the total housing stock has been built since 1996 – these buildings should be more energy efficient due to the increased stringency of the Building regulations. The most common house type is the detached house, at 43% of the total. According to the European Housing Review 2008,[1] Ireland has the youngest dwelling stock in the EU.

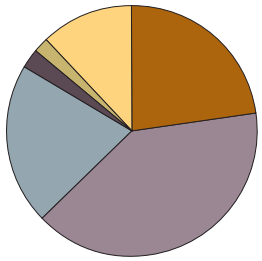
The number of private households has been increasing since 1961. Average floor areas have been increasing as well – from 130 m^2 in 1990 to 161 m^2 in 2007. The number of persons per household has been declining, although by international standards it is still high – 2.81 persons per household compared to Germany's 2.1 and UK's 2.4. These lifestyle factors all combine to increase Ireland's carbon emissions – the average Irish Dwelling in 2005 emitted 47% more CO_2 than the average UK dwelling.[2] Additionally, in terms of its fuel mix, Ireland has a high proportion of oil and coal use at 38% and 17% of the total, respectively, with minimal district heating and use of wood. Ireland maintains a statutory prohibition of nuclear generation.

Key Facts

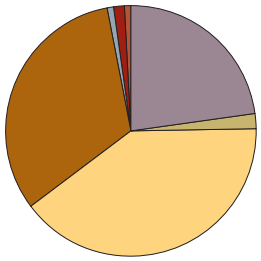
Country Population	3.9 million
Capital	Dublin
Capital Population	860,000
Area	68,890km^2
Density	57 people/km^2
Urbanisation	59%

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption	13,396 ktoe
CO_2 emissions per capita	10.57 tCO_2/cap
Ecological footprint per capita	6.30 hectares

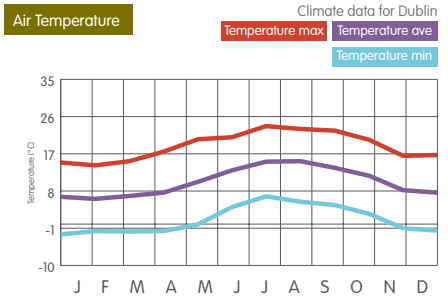
Housing

Housing stock (thousands)	1,387
Average no. of persons per household	2.90
CO_2 emissions per household	6.98 tCO_2/hh
Electricity consumption per household	5,205 kWh/hh
Electricity consumption per household for lighting and appliances	2,458 kWh/hh

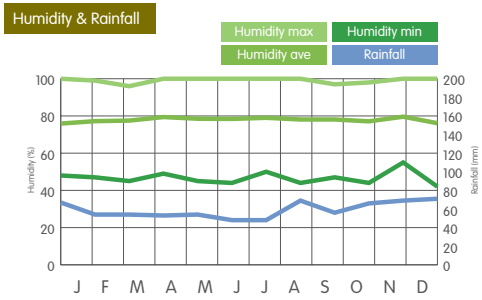
Climate

Climate type	Warm Temperate
Average temperature	10.20°C
Average relative humidity	78%
Annual sunlight hours	1,614 hours
Annual rainfall	711 mm

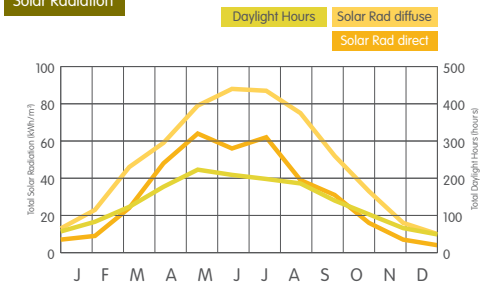
Air Temperature



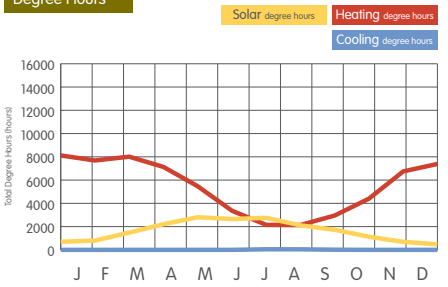
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

Irish building regulations SI 854 (Part L, 2007) and SI 872 (EPBR, 2005) cover the following energy aspects:

- Limitation of heat loss through building fabric
- Limitation of CO_2 emissions
- Space heating and hot water supply systems controls
- Hot water storage, pipe and duct insulation

The official calculation methodology is called the Dwellings Energy Assessment Procedure, or DEAP. This procedure is a standardised method for assessing the design and construction of the dwelling to come up with an estimate of its typical annual energy requirement and the associated CO_2 burden. This assessment then generates a Building Energy Rating, or BER. The 2007 revision of the regulations aim to achieve an improvement in energy performance and reduction of CO_2 emissions by 40% in new dwellings compared to current standards. A review of these regulations is set for 2010, with a view to improving energy performance by 60% compared to current standards.

References

[1] European Housing Review 2008. European Housing Review, www.rics.org.
[2] Energy in the Residential Sector: 2008 Report, Sustainable Energy Ireland Energy Policy Statistical Support Unit, 2008.

Government Policy, Targets and Global Commitments

Since 2005, there have been a number of major policy developments, including an energy white paper, a programme for government, and the EU Energy End-use Efficiency and Energy Services Directive. These set out the following targets for the coming decades:

- Energy efficiency to improve by 9% by 2016 through national policies and measures.
- 20% improvement in energy efficiency by 2020
- 33% renewable energy for national electricity consumption by 2020
- 12% renewable energy for heating by 2020

Ireland's first National Energy Efficiency Action Plan, or NEEAP, sets out the country's proposed actions for meeting these objectives, and includes a sector-by-sector discussion of existing and committed actions together with energy and CO_2 savings estimates for each action.

Support, Incentives and Grants

The Low Carbon Housing Programme, established in 2008, is the successor to Sustainable Energy Ireland's (SEI) House of Tomorrow Programme. It supports the development of new low-carbon and energy efficient housing by providing capital grants to developers. Projects have to satisfy a set of specific minimum requirements covering energy ratings, energy and CO_2 performance coefficients, renewable energy generation, insulation standards, appliances, heating systems, water, and other issues.

Under the National Home Energy Saving Pilot Scheme, householders can pay EUR 100 towards the cost of a Building Energy Rating (BER) assessment, with the rest of the cost subsidised by Sustainable Energy Ireland (SEI). In the pilot scheme the government will then cover up to 30% of the recommended measures, to a maximum of EUR 2,500. Other grant schemes are currently in force which encourage biofuels, CHP, biomass heaters and domestic renewable heat.

Exemplar Project

Galway Passive House

Galway, Ireland

Built in 2005, Galway Passive House is the first fully passive timber frame house in Ireland. The manufacturer, Irish-based Scandinavian Homes, Ltd, claims that it is possibly the world's first standardised and factory-made passive house. Assembling the 2,500 sq.ft. house was quick – six days after the foundation work started, the pre-manufactured house arrived at the site and within two days, the shell had been erected and the roof fully felted. In true Passivhaus tradition, the house is airtight and requires practically no heating apart from one 900W electric heater built into a heat-recovery ventilation unit. Underfloor heating is provided by water pipes embedded into the foundation with hot water provided by solar water collectors. During the winter months, an electric heater built into the 300-litre water tank will supplement the supply.

Galway Passive House | Galway • Scandinavian Homes Ltd

JAPAN

'Roughly one out of seven newly built houses in Japan is a prefabricated house'

National Carbon Overview

In 2004, total 1,160,083 houses were newly built in Japan. Among them, 159,000 houses (13.7%, roughly one in seven)[1] were prefabricated.[2]

Japan launched a 70,000 PV-roof market incentive program in 1994 that initially covered 50% of PV installation costs, becoming the first country to introduce federal subsidies for residential PV systems. This strategy catapulted Japan to be world leader in installed PV capacity and PV cell manufacturing. These incentives were gradually phased out, leaving behind a thriving industry, with the cost of PV reduced by over 75% during the course of the program. Japanese PV companies manufactured 60% (or 400 MW) of global PV modules in 2003, and 55% of it was destined for the local market. Of the local market, the residential sector has the greatest share at 85%.[3]

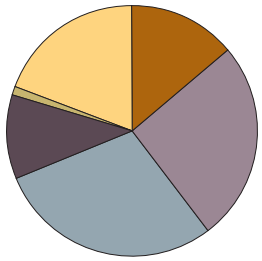
Nuclear power has a central role in Japanese energy policy, both in terms of energy supply and climate change. The long-term goal is ultimately to reduce CO_2 emissions by 60% - 80% by 2050. Four policies set the path towards achieving this target: the development of innovative technologies and dissemination of existing advanced technologies; framework-building for lower country-wide carbon emissions; active roles to be played by local regions; and citizen involvement in reducing emissions.[4]

Key Facts

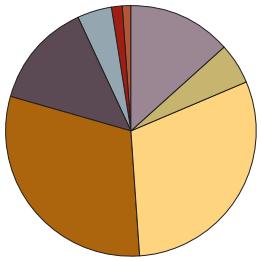
Country Population ..... 127 million
Capital ..... Tokyo
Capital Population ..... 12 million
Area ..... 374,744km^2
Density ..... 340 people/km^2
Urbanisation 79%

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption ..... 351,787 ktoe
CO_2 emissions per capita ..... 9.27 tCO_2/cap
Ecological footprint per capita ..... 4.90 hectares

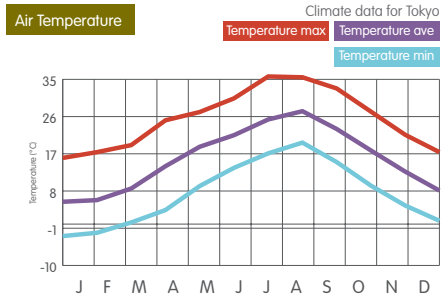
Housing

Housing stock (thousands) 40,971
Average no. of persons per household 2.80
CO_2 emissions per household ..... 4.24 tCO_2/hh
Electricity consumption per household ..... 5,512 kWh/hh
Electricity consumption per household for lighting and appliances ..... 4,689 kWh/hh

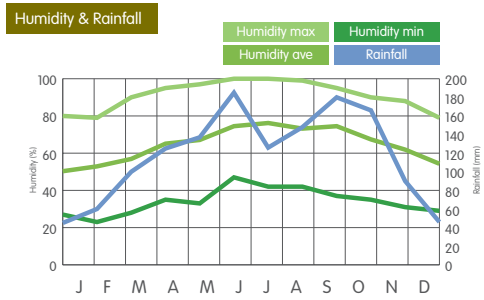
Climate

Climate type ..... Warm Temperate, Snow
Average temperature ..... 15.70°C
Average relative humidity 63%
Annual sunlight hours ..... 1,813 hours
Annual rainfall ..... 1,406 mm

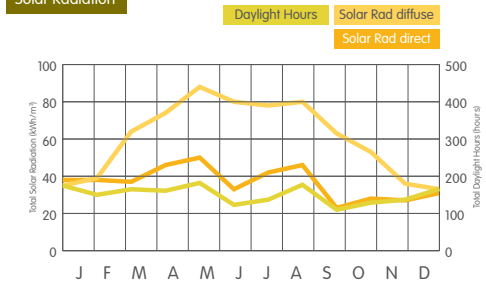
Air Temperature



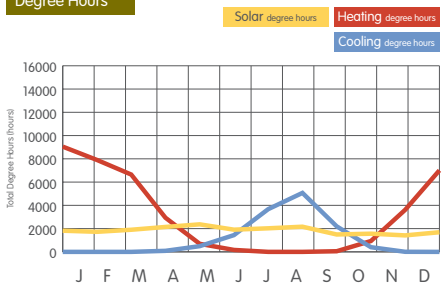
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

Energy efficiency standards for new dwellings were first introduced in 1980, in the form of the Energy Conservation Standard (ECS), with revisions in 1992 and 1999. The latest standards for insulation were predicted to save 20% of energy use for airconditioning, but in 2001, only 8% of new buildings met these requirements. One system for voluntary certification was the Housing Performance Indication System (HQAL). Approximately 90,000 buildings have implemented the HQAL standard since its establishment in 2000.

Japan has also adopted the international Energy Star Programme for energy-efficient appliances. Loans are offered by the Development Bank of Japan for adopting these technologies.

Voluntary environmental building standards include CASBEE-Home v.2007.9, with CASBEE-City (low carbon) under development. CASBEE is defined by Building Environmental Efficency (BEE), which rates the relationship between Q (environmental quality) and L (environmental load).

Government Policy, Targets and Global Commitments

Under the Kyoto protocol, Japan has committed to reducing CO_2 emissions by 6% between 2008-2012 based on 1990 levels. The path towards achieving this target has been set out in the government's 'New Guideline for Measures to Prevent Global Warming', published March 2002. Japan has developed an impressive range of policies to address its rising emissions. These include the 'Top-Runner' Programme, energy efficiency labelling, new technologies (e.g. energy management systems), voluntary energy performance standards and portfolio standards for renewables.

In 2006, the government announced a target for energy saving measures to be implemented in 40% of households by 2015. In 2008, a similar target for solar panels to be installed in 30% of households by 2030 was set.

Support, Incentives and Grants

Currently individual billing and metering is applied in all buildings – the government is planning to introduce computerised Home Energy Management Systems (HEMS) for providing real-time energy consumption and cost, and increasing awareness and energy efficiency. Subsidies in the form of low-interest loans are available for the purchase of more efficient homes. Combined heat and power (CHP) generation is also promoted through a generous taxation and financial support system. Tax incentives are also being offered for the installation of energy efficient equipment.

Exemplar Project

Kanagawa Hybrid Z
Kanagawa, Japan

Misawa Homes, which released the world's first zero-energy prefabricated house in 1998, announced the completion of a model 'Next Generation Zero Energy' House in Asahikawa City. This house features improved materials for insulation, airtightness, passive solar heating in winter, and solar shading in summer. Insulation standards are twice as efficient as required by the national government's energy-saving standards. To achieve a 'better than zero' annual energy balance, the design includes the following technologies: a heat pump system for cooling and heating water, a wall-mounted panel-based air-conditioning system which uses chilled or heated water, and a 9.5kW PV system covering the whole roof.[5] Previous models include the 'Hybrid-Z', 'Misawa Homes Z', 'Hybrid Chikujin-no-ie' and 'Hybrid Jiyu-kukan' homes.[6]

Kanagawa Hybrid Z | Tokyo • Misawa Homes

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[2] Japanese Prefabricated Construction and Suppliers and Manufacturers Association, 2005
[3] Charron R. A Review of Low and Net-Zero Energy Solar Home Initiatives, CanmetENERGY (NRCan), 2008
[4] Prime Minister Yasuo Fukuda, in a speech to the Japan Press Club entitled 'Japan as a Low-carbon Society', 2008
[5] www.misawa.co.jp
[6] Roaf S, Fuentes M and Thomas S. Ecohouse: A Design Guide, 2007.

NETHERLANDS

'The current thinking is that a CO_2–free society is only possible with heat pumps - in combination with renewable electricity, good insulation, housing design and quality, and clear and transparent process management'

Key Facts

Country Population	16 million
Capital	Amsterdam
Capital Population	747,290
Area	33,883km^2
Density	481 people/km^2
Urbanisation	90%

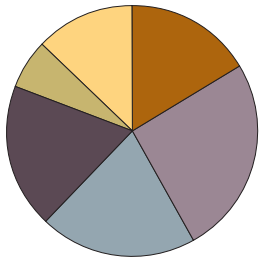
National Carbon Overview

During World War II, 95,000 of Holland's two million dwellings were completely destroyed, 55,000 were seriously damaged, and a further 520,000 were slightly damaged. An accelerated programme of housing construction began in the 1950s, and by 1985, nearly four million dwellings had been built. Today, around 70,000 new dwellings are built every year. In terms of energy efficiency, households improved their energy efficiency by more than 25% from 1990-2006, brought about mainly by an improvements in heating efficiency.

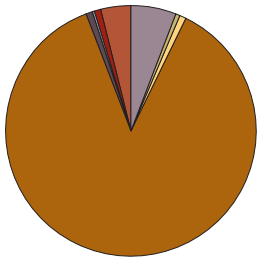
According to SenterNovem, an agency of the Dutch Ministry of Economic Affairs in charge of promoting sustainable development and innovation, low energy houses are in the market introduction phase, and that the main barrier to their introduction is the general low quality of buildings in the Netherlands in terms of thermal insulation and airtightness.[1] There is currently a strong push from SenterNovem to couple heat pump development to the emerging low-energy housing market, and the current thinking is that a CO_2-free society is only possible with heat pumps - in combination with renewable electricity, good insulation, housing design and quality, and clear and transparent process management.[2]

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption	61,250 ktoe
CO_2 emissions per capita	10.45 tCO_2/cap
Ecological footprint per capita	4.40 hectares

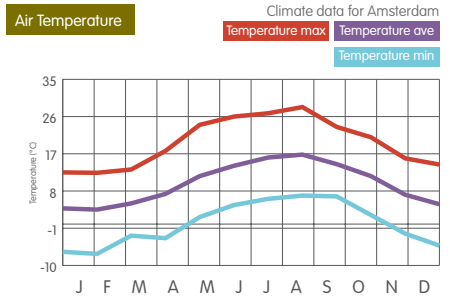
Housing

Housing stock (thousands)	6,914
Average no. of persons per household	2.30
CO_2 emissions per household	3.36 tCO_2/hh
Electricity consumption per household	3,190 kWh/hh
Electricity consumption per household for lighting and appliances	2,280 kWh/hh

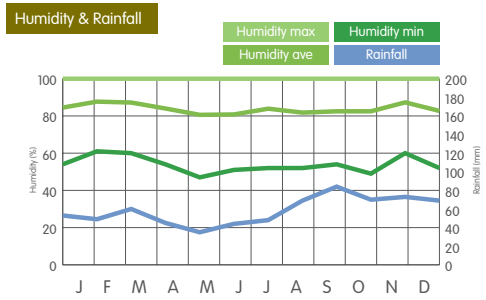
Climate

Climate type	Warm Temperate
Average temperature	9.70°C
Average relative humidity	86%
Annual sunlight hours	1,494 hours
Annual rainfall	697 mm

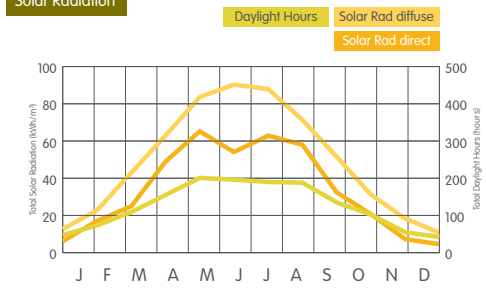
Air Temperature



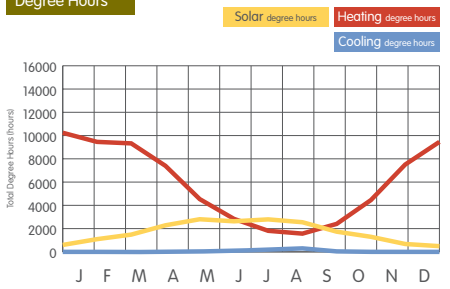
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

The Dutch building law comprises the Building Decree on Energy, Articles 70, 71 & 71a, and the Energy Performance Standard NEN 5128 for residential buildings. These set performance standards for energy efficiency of new buildings and major renovations of existing buildings via the Dutch Energy Performance Standard. Since the standard is performance-based, it allows flexibility in achieving compliance, the focus is on total energy performance and not on stand-alone solutions.[3] This was done to ensure that standards and regulations are able to adapt to the development of innovative systems, and so that regulations do not limit the development of new technologies.[4]

The Compass programme, covering the Dutch built environment, is a SenterNovem instrument for achieving the CO_2 reduction goals as set out in the Kyoto agreement. Programmes include providing advice on energy performance and energy saving measures, the introduction of housing energy labels, the development of the EPCheck tool for checking and improving the calculation for the EPC, providing support and tools for implementing the EPBD and providing assistance to housing associations.

In terms of voluntary assessments the Dutch Green Building Council has chosen to adopt BREEAM as the building assessment tool for the Netherlands.[5]

References

[1] Kleefkens, O. Economical Heating & Cooling Systems for Low Energy Houses, IEA HPP Annex 32, 2008.
[2] Low Energy Houses in the Netherlands, Annex 32. SenterNovem presentation, 2008.
[3] van Ekerschot, Francis and Heinemans, Marjolein. Implementation of the EPBD in The Netherlands: Status and planning in June 2008, European Communities, 2008
[4] Strategies and Policies – The Netherlands, Network of International Society for Low Exergy Systems in Buildings, www.lowex.net
[5] Kennett S. Dutch to adopt BREEAM, in Building magazine, October 2008.
[6] Dutch Ministry of Housing, Spatial Planning and the Environment, 'Energy and Sustainability in Housing', www.vrom.nl
[7] Energy Efficiency Profile: Netherlands, www.odyssee-indicators.org, 2008
[8] Nieuwenhuijzen, J. German-speaking countries have a substantial head start: Lacking 'price incentives' holds back sustainable building and renovations, Real Estate Journal, October 2008.

Government Policy, Targets and Global Commitments

From 1995, Dutch policy has set energy performance standards for new dwellings using the Energy Performance Coefficient (EPC). These standards have improved energy efficiency in new dwellings by over 50% since they were implemented. Energy labelling for appliances was introduced in 1996, and more recently, energy performance certificates have also been introduced as part of compliance with the EPBD directive.[6]

In 2007, the Clean and Efficient (Schoon en Zuinig) programme set ambitious targets for 30% reduction in GHG emissions, 20% share of renewables in the energy mix, and improvements in energy efficiency of 2% per year until 2020. Through the More with Less programme (Meer met Minder), the Dutch government established voluntary agreements with key partners in the housing, energy and construction sectors, with an aim of reducing energy consumption in buildings by 100 PJ by 2020.[7]

Exemplar Project

Zero Energy Housing

Etten Leur, The Netherlands

Etten-Leur, by BEAR Architecten, is a demonstration project with 43 houses, with a target for 50% reduction in energy consumption compared to the 2000 Dutch Building Code. The remaining 50% of the power required is supplied by an energy-generating roof. Techniques include passive solar energy, high insulation standards, high performance windows, a heat recovery system, heat pump and ground aquifer, photovoltaics on the roof, and a low-temperature radiant heating system.

During the summer, heat is stored in the ground for winter use. The 'energy roof' consists of 45 m^2 of PV panels per house that are raised to form an overhang over the houses, which creates a ventilating effect that improves the system's performance. By doing this, house orientation can be independent of the solar PV systems.

Support, Incentives and Grants

Countries like Germany and Austria have built a substantial head start in energy-efficient building and renovations, but the Netherlands is lagging behind despite the availability of the technology – this stagnation appears to be caused by the lack of incentives for energy efficient building.[8] Improved standards have certainly improved the standards of build quality, however most of the funding in the Netherlands is being directed towards sustainable energy generation, and not housing.

Etten-Leur • The Sustainable Building Support (SBS) Centre

NEW ZEALAND

'The New Zealand Business Council for Sustainable Development have reported that more than a million homes are not adequately insulated'

Key Facts

Country Population ..... 4.1 million
Capital ..... Wellington
Capital Population 179,463
Area ..... 268,021km^2
Density ..... 15 people/km^2
Urbanisation 86%

National Carbon Overview

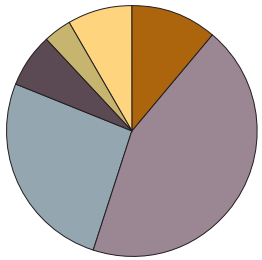
New Zealand exports a large amount of the world's crude oil, natural gas and coal, and a high percentage of New Zealand's electricity generation is produced by renewable technology, primarily hydropower and geothermal power. At the end of 2008, 54% of electricity production was from hydropower, and a total of 67% of electricity was produced by renewables.

The government is keen to upgrade the sustainability of the country's existing and future housing. A variety of measures have been implemented to improve the housing sector, including reconfiguring the housing stock, undertaking community renewal programmes, implementing 'Healthy Housing' solutions, modernising state housing to appropriately defined standards and conducting regular maintenance on existing housing. Additionally, the government is currently developing the Auckland Strategy to respond to a significant population growth in the area.[1]

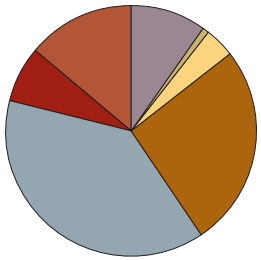
The New Zealand Business Council for Sustainable Development have reported that more than a million homes are not adequately insulated[2], and that more than 410,000 homes could be making their occupants sick.[3]

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption ..... 13,133 ktoe
CO_2 emissions per capita ..... 8.81 tCO_2/cap
Ecological footprint per capita ..... 7.80 hectares

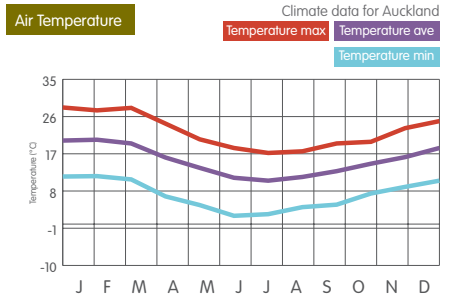
Housing

Housing stock (thousands) 1,600
Average no. of persons per household 2.56
CO_2 emissions per household ..... 2.22 tCO_2/hh
Electricity consumption per household ..... 8,647 kWh/hh
Electricity consumption per household for lighting and appliances ..... 3,055 kWh/hh

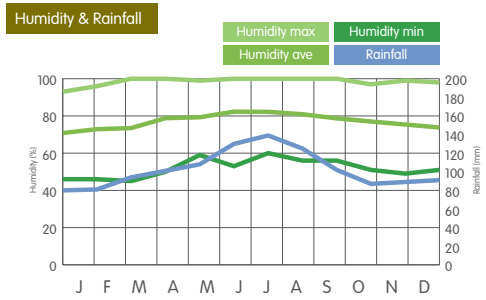
Climate

Climate type ..... Warm Temperate
Average temperature ..... 15.3°C
Average relative humidity 78%
Annual sunlight hours ..... 2,038 hours
Annual rainfall ..... 1,222 mm

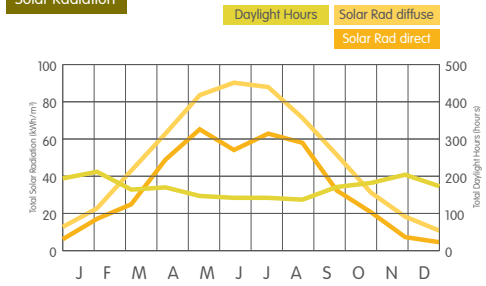
Air Temperature



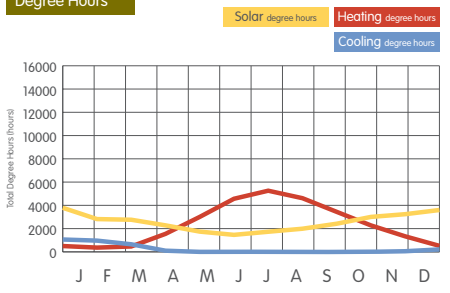
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

The Building Code of New Zealand provides general building standards. These are set to be amended to provide minimum benchmarks for energy efficiency and overall building performance. The New Zealand building regulations include a section on energy efficiency, defining mandatory regulations for hot water and HVAC, building insulation, solar water heating, and lighting.

A review of the current Building Code has been mandated by the Building Act (2004) but is not expected to be implemented until 2009 at the earliest.

Additionally, the government has produced the voluntary Home Energy Rating Scheme (HERS) for home energy efficiency based on energy efficiency and energy performance. The New Zealand Green Building Council (NZGBC) and property industry have developed the Green Star NZ rating system, which is designed for a range of building types, including industrial, office, and education buildings, as well as the interior fitouts of office buildings. Green Star rating tools are developed and released according to market demand. A residential rating tool is currently in development for release in late 2009, which will be merged with the government's HERS scheme.

Government Policy, Targets and Global Commitments

New Zealand's obligation under the Kyoto Protocol is to reduce its greenhouse gas emissions to 1990 levels on average over the 2008-2012 commitment period, or take responsibility for any emissions over these levels.

In 2006, New Zealand's emissions levels[4] had already increased by 22%, and the Country has now set a long-term goal of '50 by 50' - reducing New Zealand's net emissions to 50% of 1990 levels by 2050.

It is the New Zealand government's intention to table the country's policy on a 2020 target at the Bonn climate change negotiations in August. It is hoped that this policy will help to achieve global agreement at the Copenhagen Conference in December.

The 'New Zealand Energy Efficiency and Conservation Strategy' has been developed[5] to promote energy efficiency.

Support, Incentives and Grants

The EnergyWise Scheme is a government-funded programme available for energy efficiency improvements to homeowners for the installation of insulation and clean and efficient heating under the Warm up New Zealand: Heat Smart programme.

The $323 million 'Warm Up New Zealand' programme provides government grants for heating and insulation to home owners with houses built before 2000. A home owner can get $1,300 towards insulation. Repayments can then be paid through council rates, bank mortgages and power companies. The government plans to help provide 180,000 homes with insulation over the next four years.

The New Zealand Electricity Commission offers subsidies for efficient lighting products following the launch of the New Zealand government's Efficient Lighting Strategy, aiming to reduce lighting energy consumption by 20% by 2015.[6] Education programmes (see www.rightlight.govt.nz) are part of this strategy.

Exemplar Project

Otago Eco-House

Otago Coast, New Zealand

Otago Eco-House | New Zealand • Ecobob Ltd

Sustainable architecture expert Professor Robert Vale once said that New Zealand's housing stock was '40 years behind European cutting edge eco-houses' and that they were 'scarily cold, badly insulated, had huge expanses of single-glazed glass, and a nightmare to heat.'[7] Admittedly, the majority of the housing stock does need improvement, but there have been efforts to build sustainable housing – the emphasis tends to be towards 'eco-house' as opposed to 'zero-energy' and the use of passive solar rather than Passivhaus techniques. One such example is an 'eco-friendly house' on Otago Coast, completed in 2003. Sustainable features include the use of low-embodied energy materials and strawbale construction. The home is off-grid and uses good levels of insulation, double glazing, a solar PV system, wood-fired central heating, exposed thermal mass, energy efficient appliances, and wind energy. It also has an energy management system that tells the occupants how much they use and where the energy comes from.[8]

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4. New Zealand Ministry for the Environment, Net Position Report 2009: New Zealand's projected balance of Kyoto Protocol units during the first commitment period, New Zealand government, 2009.
5. The New Zealand Energy Efficiency and Conservation Strategy (NZEECS), Energy Efficiency and Conservation Authority (EECA), www.eeca.govt.nz.
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SWEDEN

'Today, Sweden has the highest proportion of renewable energy in the EU.'

National Carbon Overview

Sweden has about 3.8 million households at an average size of 2.2 persons per household, and roughly 30% of the population live in cities. There are four housing sectors in Sweden: owner occupiers, private tenants, social tenants, and housing cooperatives.[1] In 1990, owner-occupied dwellings accounted for about 40% of the housing market, while social and private tenants each accounted for 20%, and cooperatives accounted for about 15%.

In comparison to other OECD countries the Swedish per capita electricity consumption is very high, due to a high share of energy intensive industry and electricity use for household heating.[2] Despite this, per capita emissions are very low, due to extensive use of hydropower and biomass energy. Up until the 1996 Chernobyl incident, Sweden had a strong policy on expanding nuclear power, with 12 new plants commissioned in the 80's. Since 1990, however, the policy has been reversed in favour of decentralised energy generation and renewable fuels. The proportion of renewable energy used in Sweden has increased from 34% in 1990 to 43 % in 2006, and today it has the highest proportion of renewable energy in the EU.

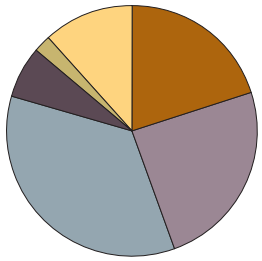
The housing stock in Sweden is relatively new: three-quarters of the stock was built after 1940. About a quarter of the housing in the three largest cities was built as part of the Million Programme (1965-1974), which aimed to construct a million dwellings over ten years.

Key Facts

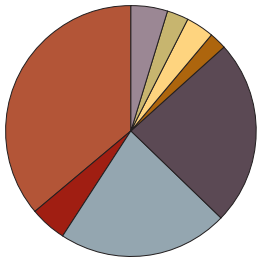
Country Population	8.9 million
Capital	Stockholm
Capital Population	770,889
Area	410,935 km^2
Density	21 people/km^2
Urbanisation	83%

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption	34,986 ktoe
CO_2 emissions per capita	5.46 tCO_2/cap
Ecological footprint per capita	5.10 hectares

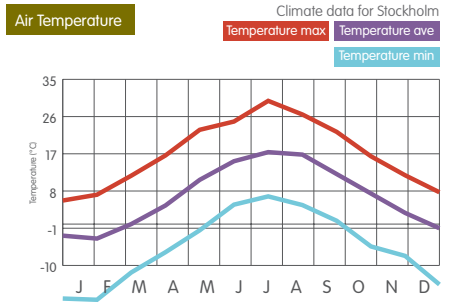
Housing

Housing stock (thousands)	4,380
Average no. of persons per household	2.00
CO_2 emissions per household	2.42 tCO_2/hh
Electricity consumption per household	9,631 kWh/hh
Electricity consumption per household for lighting and appliances	3,331 kWh/hh

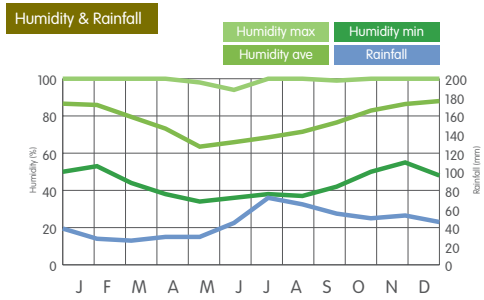
Climate

Climate type	Snow
Average temperature	6.70°C
Average relative humidity	78%
Annual sunlight hours	1,821 hours
Annual rainfall	539 mm

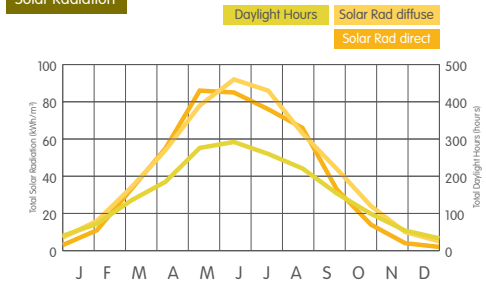
Air Temperature



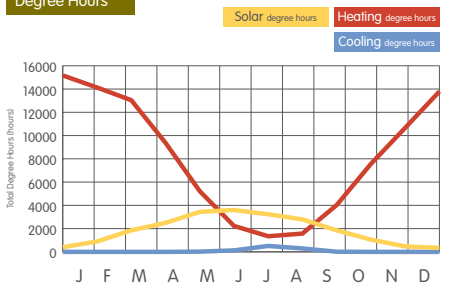
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

Sweden has pursued energy efficient design since the 1970's, with differing mandatory standards for north and south due to climatic variation. Today, their performance standards are among the highest energy efficiency requirements in the world, with U-values of 0.13-0.14 W/m^{2}K for the south and 0.12-0.13 W/m^{2}K for the north, and a total energy performance (all regulated energy) of 110 kWh/m^2.a in the south and 130 kWh/m^2.a in the north.

Sweden's current mandatory regulations, the National Board of Housing Building and Planning Regulations, are already in line with Passivhaus standards, and as such no further voluntary codes are deemed necessary. These specify maximum heating, domestic hot water and cooling electricity requirements, average and elemental U-values, thermal bridging standards, airtightness, solar shading and ventilation system efficiencies.

Government Policy, Targets and Global Commitments

Sweden's Kyoto commitment is to reduce GHG emissions by 13% by 2020 based on 1990 levels. Emissions from the household and services sector decreased from 1990-2006, mainly because of the switch from oil to district heating. Methane emissions from solid waste disposal also decreased due to rising gas collection. Successful national policies have been put in place to reduce energy demand and to encourage decentralised energy generation from alternative sources.

Sweden has set 16 Environmental Quality Objectives (EQOs) that are to be reached by 2020, with the overall goal of passing on an environmentally sound society onto the next generation.[3]

The aim of current revisions to building regulations is to lower the energy use in residential and commercial buildings to below 1995 levels. In June 2006, it was decided that the energy use in residential buildings should decrease by 20% by 2020.[4]

Support, Incentives and Grants

Low energy development has strongly been driven by CO_2 taxes and high oil prices. These have also increased the adoption of alternative renewable fuel technology. The overall fiscal energy structure in Sweden (including environmental taxes on electricity and heating oil, high performance construction standards, financial incentives, public procurement and R&D efforts) has provided a sufficient framework for breaking the normal barriers to market adoption. This has been helped by proactive municipalities at local level, along with bigger construction companies rising to the challenge of meeting the more stringent building standards.

In 2007, an energy efficiency campaign was launched, demonstrating technical solutions to improve daily energy efficiency in Swedish homes. The 2006 Energy Declaration of Building Act include support for the purchase of energy-efficient windows and biomass boilers for up to 30% of the cost.

Exemplar Project

Hammarby Sjostad
Stockholm, 1990-2010

This car-free community of 11,000 dwellings and 25,000 residents was designed with a view to cutting the environmental impact of the whole development by 50% compared to typical 1990's development. The 'Hammarby Model' is the integrated strategy which governs the environmental solutions for Energy, Water, Sewage, and Waste.

The high building standards (similar to Passivhaus) and the use of local energy generation and district heat from waste incineration, biofuels and sewage heat recovery have increased energy efficiency. Stormwater and sewage water is collected and recycled, and a vacuum system for refuse collection, sorting and disposal has enabled an efficient waste to energy conversion. With its comfortable and vibrant public realm, Hammarby has become one of Europe's most enlightened communities in terms of market acceptance of a low carbon society.

Hammarby Sjostad | Stockholm • Andrew Mellor, Pop

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[1] Kemp, P, 'Sweden' in 'Housing Policy in the EU Member States, working document, European Parliament, 1996.
[2] OECD Working Group on Innovation and Technology Policy, 'Innovation and the Environment', 2000.
[3] 'Sweden: Achieving Results for Sustained Growth', OECD, 2007.
[4] Energy Efficiency in Buildings: Low-Energy and Passive Houses Spreading in Sweden, in 'Smart Climate Solutions: Seven International Success Stories, Gaia Consulting Oy for the WWF, 2008.

SWITZERLAND

'Switzerland has been self-sufficient and able to export energy in the summer, with one of the lowest energy per capita values in the developed world.'

Key Facts

Country Population	7.4 million
Capital	Bern
Capital Population	320,000
Area	39,770km^2
Density	187 people/km^2
Urbanisation	67%

National Carbon Overview

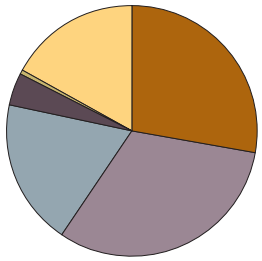
In 2000, Switzerland had one of the lowest owner-occupancy rates in Europe, at 35%. For the private householder, the purchase of a home is usually a long-term decision and they are therefore willing to invest in improvements with a longer-term view. The highest proportion of dwellings consist of privately-owned rental stock at 57%, with 22% run by institutional investors, and approximately 8% owned by cooperatives.

A long history of housing cooperatives has produced consistently high standards. Between 2001 and 2003, 23% of all new housing was cooperative housing. In 2008, 1000 new homes were built by cooperatives in Zurich alone[1] and they normally work with leading architects to achieve outstanding architectural and ecological quality.

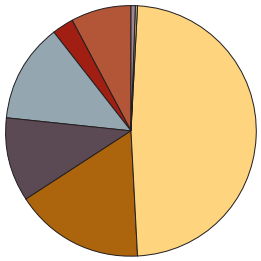
Switzerland has significant energy generating capacity, with large scale hydroelectric among its portfolio of energy sources. The country has, up until recently, been self sufficient and able to export energy in the summer months, with one of the lowest energy per capita figures in the developed world. This is largely due to the fact that it has a relatively small industrial / manufacturing industry compared to other countries. More recently it has become a net annual importer. Targets have been set for 10% renewable generating capacity by 2030, and the phase-out of nuclear energy.

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption	22,244 ktoe
CO_2 emissions per capita	5.24 tCO_2/cap
Ecological footprint per capita	5.00 hectares

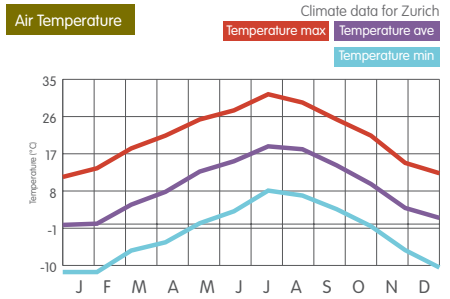
Housing

Housing stock (thousands)	3,710
Average no. of persons per household	2.30
CO_2 emissions per household	3.00 tCO_2/hh
Electricity consumption per household	4,904 kWh/hh
Electricity consumption per household for lighting and appliances	no data

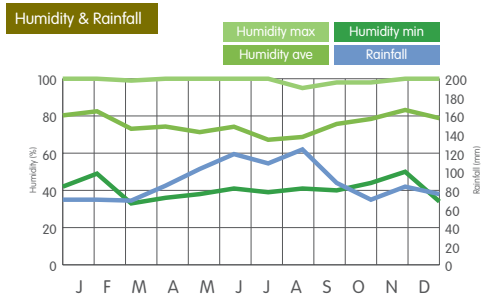
Climate

Climate type	Warm Temperate
Average temperature	8.90°C
Average relative humidity	75%
Annual sunlight hours	1,435 hours
Annual rainfall	145 mm

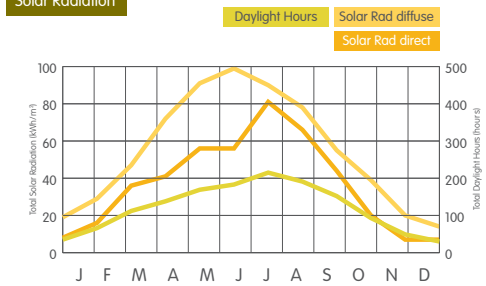
Air Temperature



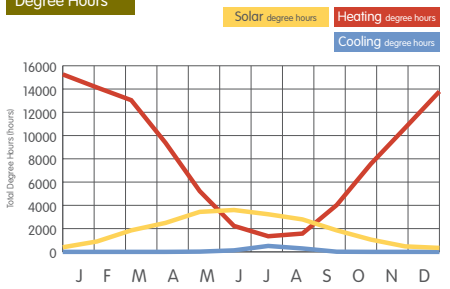
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

MuKEn is the alignment of the individual regions' (Cantons) building regulations into a single national regulation. The improvement of building energy performance is the priority in the new 2008 revision.

The Swiss Association of Architects and Engineers (SIA) have also released standards for Thermal and Electrical Energy in Buildings.

The Swiss MINERGIE standard is a registered quality label for new and refurbished low-energy consumption buildings. The standard is granted to buildings that provide high-grade, airtight building envelopes, with energy efficient ventilation systems. Energy consumption is the main indicator for performance. Dwellings must achieve an annual energy consumption of below 42 kWh/m^2.a for heating – a 20% improvement compared to building regulations. Since its inception, 12,000 buildings have been MINERGIE certified.

MINERGIE-P is the ultra-low energy equivalent of the MINERGIE standard, which demands a decrease in heat demand by 80%. MINERGIE-Eco is another enhancement that includes broader environmental issues, such as health and materials. The standards used for MINERGIE-P are comparable to Passivhaus standard.

Government Policy, Targets and Global Commitments

Under Kyoto, Switzerland has committed to an 8% reduction in CO_2 emissions by 2012 based on 1990 levels. In March 2007, the Electricity Supply Act was passed with a view to increasing renewable energy supply to 10%.[2]

The two main objectives of Swiss energy policy are to promote the use of renewable resources and to encourage efficiency. To date, there has been little change in GHG emissions since 1990 levels, though Switzerland already has by far the lowest NOx and SO_2 emissions per capita.

To meet their targets for CO_2 reduction, there is a commitment to reduce emissions by 1.5% per year. This will achieve 50% saving by 2050. For 2020 they are targeting a 21% reduction. In addition, they intend to buy overseas carbon credits thereby compensating for any residual fossil emissions and achieving carbon neutral status.

Support, Incentives and Grants

There is a large and varied array of subsidies and grants distributed through the regional Cantons, which have defined the improvement of the building fabric as their highest priority (thermal performance of walls, floors, windows and roof) along with energy efficiency in building services. Secondly the aim is to increase awareness in the residents and to change behavioural patterns. Thirdly, they have set out to promote the use of waste heat and renewable forms of energy. In the use of renewable energy, each of the Cantons define their own priorities.

There are widespread information initiatives, along with lump sum contributions to energy saving measures, as well as a national feed-in tariff to support the installation of renewable energy technology. The Swiss have the highest feed-in tariff in the world.

Exemplar Project

Residential building[3]
Brunnenhof, 2007

This scheme, Zurich's first Minergie-Eco registered building, is for 72 generously planned homes, from 3-bedroom to 6-bedroom apartments. Working with an artist, the facades play on colour with moving screens to offer privacy and adjustable shading to the south facing balconies.

As with all new developments in Zurich, the scheme had to meet the MINERGIE Standard for energy efficiency: the building is constructed to U-values of 0.2 W/m^{2}K, cold bridging through balconies is minimised and 20% less fossil energy is used compared to a building regulation compliant scheme. The underfloor heating and domestic hot water is supplied by district heating and the overall costs do not exceed 10% of base line costs. In addition, the designers considered the environmental impact of all aspects of the project from fabrication through operation to decommisioning and the scheme is the first Minergie-Eco registered project in Zurich.

Brunnenhof | Zurich • Georg Aerni

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1 www.ICA.coop
2 http://www.bfe.admin.ch/index
3 Wohnsiedlung Brunnenhof, Bautechnologie II und IV, Professur für Bauphysik ETHZ, Prof. Dr. Bruno Keller, 2007

UK

'The UK has been a pioneer in many aspects of energy policy and has been used as a model by other countries following its path'

Key Facts

Country Population ..... 61 million
Capital ..... London
Capital Population ..... 7.4 million
Area ..... 241,590km^2
Density ..... 252 people/km^2
Urbanisation 90%

National Carbon Overview

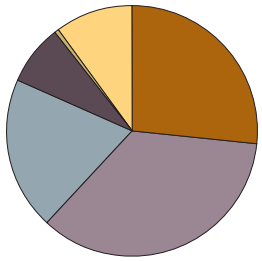
The UK government has set a target for reducing GHG emissions by 80% by 2050 based on 1990 levels. The process of achieving this target is especially challenging for the UK, owing to the wide range of age and condition of the UK housing stock. The government's National Energy Efficiency Action Plan (NEEAP) also sets a target to reduce emissions from the residential sector by 31% by 2020.

Over 27% of the UK's CO_2 emissions come from the residential sector. 82% of the energy used in households is for space or water heating. Less than a third of all housing stock in Great Britain had central heating in 1970. Thirty years later, the proportion had risen to 89%.[1]

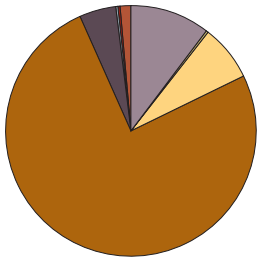
The UK has been a pioneer in many aspects of energy policy and has been used as a model by other countries following its path. It was the first country to announce a major long-term CO_2 emissions target, and was also one of the first countries to develop a certificates obligation programme for renewable energy. In England, the proposals for improving energy efficiency in the housing sector, as set out in the recent Zero Carbon Consultation, are very ambitious and put forward several innovative ideas for implementation, including the concept of 'allowable solutions' which may include energy efficient appliances, advanced building control systems, energy exporting, contributions to low-carbon infrastructure, upgrading of nearby housing stock, off-site renewables, and financial investments.

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption ..... 158,731 ktoe
CO_2 emissions per capita ..... 8.72 tCO_2/cap
Ecological footprint per capita ..... 5.30 hectares

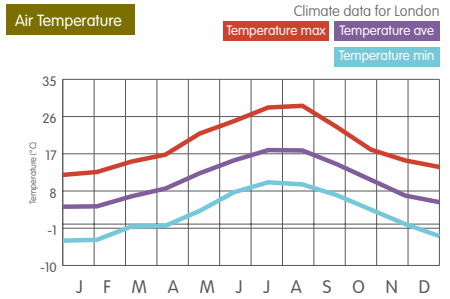
Housing

Housing stock (thousands) 25,953
Average no. of persons per household 2.40
CO_2 emissions per household ..... 5.99 tCO_2/hh
Electricity consumption per household ..... 4,588 kWh/hh
Electricity consumption per household for lighting and appliances ..... 2,815 kWh/hh

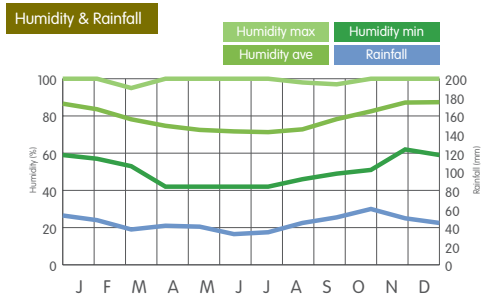
Climate

Climate type ..... Warm Temperate
Average temperature ..... 10.40°C
Average relative humidity 79%
Annual sunlight hours ..... 1,579 hours
Annual rainfall ..... 543 mm

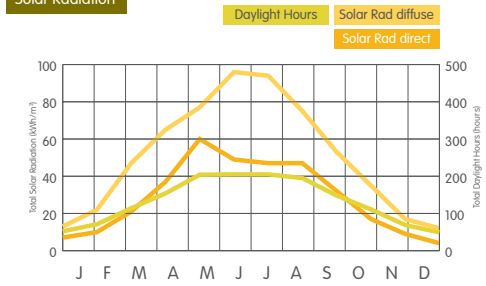
Air Temperature



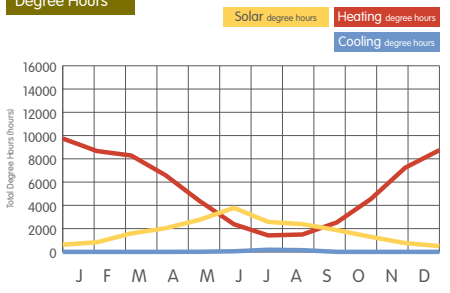
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

The 1965 building regulations introduced the first limits on the amount of energy wasted due to building fabric losses, expressed as a U-value. These limits were tightened as a result of the 1973 oil crisis, and in 2006, regulations in England and Wales were significantly tightened further as a result of the 2003 Energy White Paper. The 2006 regulations introduced the calculation for the Dwelling Carbon Dioxide Emission Rate (DER), calculated using the government's Standard Assessment Procedure (SAP) for Energy Rating of Dwellings.

Relevant regulations for the countries of the UK are:

- England/Wales – Approved Documents, Part L – Conservation of Fuel and Power
- Scotland – Building Standards, Section 6 – Energy Use
- Northern Ireland – Technical Booklets, Technical Booklet F – Energy Use

The Code for Sustainable Homes[2] (launched in 2006) is a voluntary standard which was developed from the BRE Ecohomes system, and was introduced to drive a step-change in sustainable home building practice. It awards a rating from 1 to 6, based on 9 sustainability criteria which include energy and CO_2 emissions. A Code Level 1 home represents a 10% improvement over building regulations standards, while a Code Level 6 home would be equivalent to a zero-carbon home, or a 150% improvement, as it includes not only regulated energy but also energy used for household appliances. In March 2008, the government announced that a Code rating would be required for all new homes from May 2008.

References

[1] Energy Consumption in the United Kingdom, BERR, 2002
[2] Code for Sustainable Homes: A step-change in sustainable home building practice, Department for Communities and Local Government, 2006.
[3] Energy saving grants and offers, Energy Savings Trust, http://www.energysavingtrust.org.uk/What-can-I-do-today/Energy-saving-grants-and-offers,2008
[4] Bioregional, BedZED monitoring data, www.bioregional.com, 2008

Government Policy, Targets and Global Commitments

The UK is committed to reducing its GHG emissions by 12.5% from 2008-2012 as part of the Kyoto Protocol. The Climate Change Act, published in 2007, originally set the target of reducing emissions by 60% by 2050, and in 2008, this target was increased further, to 80%.

The Energy Efficiency Commitment (EEC) required electricity and gas suppliers to achieve targets for demand reduction in households via upgrades to insulation, low-energy lightbulbs, high efficiency appliances and boilers. The principal driver for energy efficiency in existing homes is the Carbon Emissions Reduction Target (CERT), which came into effect in 2008 and expands on the EEC efforts through the promotion of microgeneration measures, biomass community heating and CHP.

The Energy Act of 2008 contains the legislative provisions required to implement UK energy policy, the key elements including the following: carbon capture and storage, renewables, and smart meters.

Support, Incentives and Grants

To support the move towards zero carbon homes, the UK government announced stamp duty exemptions for all new homes meeting the zero-carbon standard, from 1st October 2007.

The Low Carbon Buildings Programme (LCBP), launched in 2006, provides funding for microgeneration technologies. The programme will run until 2010, with grants totalling £10.5 million. Grants are also available from energy suppliers for energy efficiency measures and renewable energy technologies, as part of the Carbon Emissions Reduction Target (CERT) programme.

The UK government funds schemes providing up to £2,700 to households on certain benefits to improve their heating and energy efficiency. These schemes are called Warm Front (England), Warm Homes (Northern Ireland), Warm Deal (Scotland) and the Home Energy Efficiency Scheme (Wales).[3]

Exemplar Project

Beddington Zero Energy Development (BedZED)
Wallington, South London, UK

BedZED is the UK's largest eco-village, and comprises 100 homes, community facilities and workspaces for 100 people. Residents have been living at BedZED since 2002. The heating requirements of a typical BedZED home are around 10% that of a typical home, and the whole development works on a low-energy-emission concept, covering not only the housing units but also exploring car-free concepts, water efficiency, and materials. The houses make full use of passive solar gain, use triple glazing and high levels of thermal insulation.

Monitoring studies conducted in 2003 found that heating requirements at BedZED were 88% less than the UK average, with 57% less hot water consumption, 25% less electrical power consumption (with 11% from solar panels) and mains water consumption was reduced by 50%.[4] A combined heat and power plant, fuelled by wood chips from waste timber, meets most of the energy demand.

The design principles of BedZED have now been realised in six Code Level 6 certified houses in Upton in Northhamptonshire.

BedZed | London • Bill Dunster

USA

'The US is the largest provider of funding for research into new technologies, including CCS, biofuels, nuclear power, fuel efficiency, wind energy and PV.'

National Carbon Overview

In 2007, there were over 128 million housing units in US, including rented apartments, seasonal cottages, suburban single-family houses, and manufactured homes.

63% of American homes contain three or more bedrooms, 65% have a garage, and 86% have air-conditioning.[1] More than one-third (36%) of these are in urbanized suburbs, while 11% are in 'rural' suburbs. Of the fifteen countries in this Compendium, the USA has the highest CO_2 emissions per capita and electricity consumption per household. The population density of the US is relatively low, and the country is dependent on fossil fuels for almost all of its energy supply.[2]

In the area of energy R&D, the US is a world leader in many technologies, and has contributed greatly to the development of new and advanced energy technology. Today, it is the largest provider of research funding for new technologies in the world, driving the development of carbon capture and storage, biofuels, nuclear power, vehicle fuel efficiency, wind energy and photovoltaics.

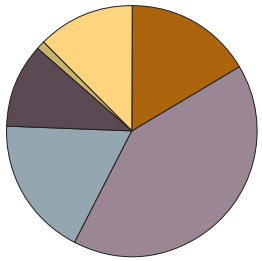
The US Zero Net Energy Buildings Outreach and Action Plan (2000) aims to facilitate the construction of 100,000 affordable net Zero Energy Solar Homes (ZESH) by 2020. The US DOE's Building Technology Program aims for the acceptance of low energy and net zero energy homes in the marketplace by 2020.

Key Facts

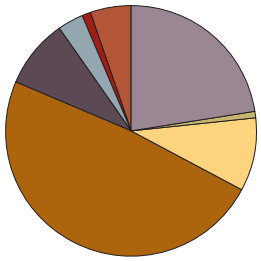
Country Population	293 million
Capital	Washington DC
Capital Population	6.3 million
Area	9.1 million km^2
Density	31.98 people/km^2
Urbanisation	77%

Energy & Environment

Energy consumption by sector



Energy sources in the residential sector



Total energy consumption	1.5 million ktoe
CO_2 emissions per capita	19.15 tCO_2/cap
Ecological footprint per capita	9.40 hectares

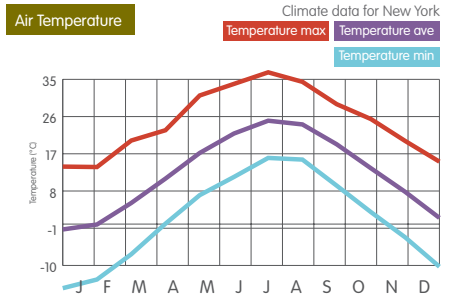
Housing

Housing stock (thousands)	117,211
Average no. of persons per household	2.60
CO_2 emissions per household	8.38 tCO_2/hh
Electricity consumption per household	11,336 kWh/hh
Electricity consumption per household for lighting and appliances	7,272 kWh/hh

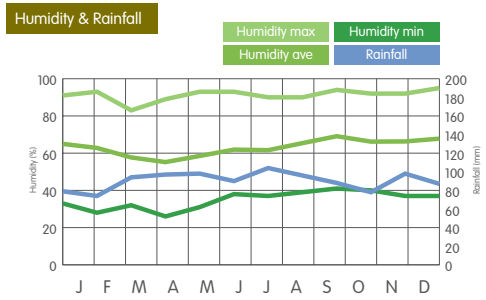
Climate

Climate type	Arid, Warm Temperate, Snow
Average temperature	12.10°C
Average relative humidity	62%
Annual sunlight hours	2,500 hours
Annual rainfall	1,082 mm

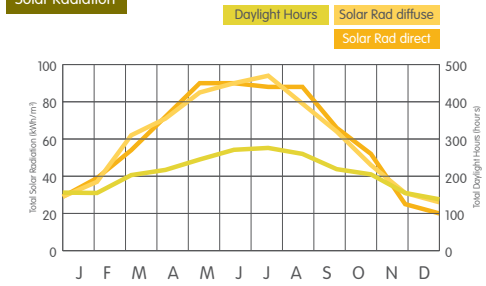
Air Temperature



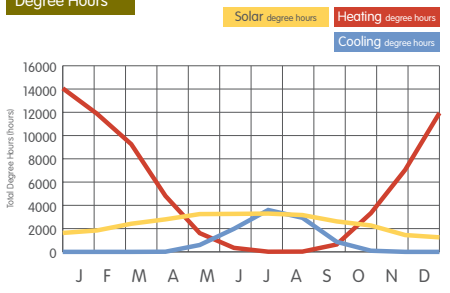
Humidity & Rainfall



Solar Radiation



Degree Hours



Existing Frameworks

Existing building code standards are based on the American National Standards Institute (ANSI), American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), and Illuminating Engineering Society of North America (IESNA) standards and the 2009 International Code Council (ICC) International Energy Conservation Code (IECC). The IECC is a model building code, and each state can select which edition it will adopt as part of their laws. The 2009 edition offers a 15% improvement in energy efficiency over the 2006 edition.

The Building America program[3] aims to develop cost-effective solutions that reduce the average energy use of housing by 40-100%. The ultimate objective would be that its research activities would lead to the development of net zero energy homes. The EnergySmart Home Scale, or E-scale, estimates the annual energy usage of a home compared to a typical new home. Energy Star labels are also available for homes – to earn the label the home must be at least 15% more energy efficient than the 2004 International Residential Code (IRC).

The Leadership in Energy and Environmental Design (LEED) rating system was launched by the US Green Building Council (USGBC) in 1998. To date, LEED has certified over 14,000 projects all over the world. It provides a suite of standards for environmentally sustainable construction, including energy, water, materials, air quality and innovation.

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[2] Energy Policies of IEA Countries: The United States – 2007 Review, International Energy Agency, 2007 Review.
[3] www1.eere.energy.gov/buildings/building_america/
[4] http://www1.eere.energy.gov/buildings/challenge/index.html
[5] Building America Best Practices Series Case Study: Clarum Homes – Vista Montana, US Department of Energy, 2007.

Government Policy, Targets and Global Commitments

The US government has set up an initiative called the 'Builders Challenge'[4] to the housebuilding industry, to build 220,000 high-performance homes by 2012. Qualifying homes have to achieve 70 or better on the EnergySmart Home Scale (E-scale). The current administration, via the Obama-Biden comprehensive New Energy for America plan, have committed $150 billion over the next ten years to catalyse private efforts for building a clean energy future, put 1 million plug-in hybrid cars on the road by 2015, ensure that 10% energy generation comes from renewable energy by 2012, up to 25% by 2025, and reduce GHG emissions 80% by 2050.

In 2007, the Department of Energy (DOE) established requirements for federal buildings (including multi-residential and low-rise residential buildings) which aim to address energy efficiency by improving energy performance by at least 30% compared to prevailing building codes.

Exemplar Project

Vista Montaña Zero Energy Community[5]

Watsonville, California

Vista Montaña, developed by Clarum Homes, is California's largest 'Zero Energy' Home Community, with 177 single-family homes, 80 townhouses and 132 apartments. The development, a part of the Building America programme, opened in August 2003 and sold out in the first year.

Every home in the development has a 1.2-2.4kW PV system installed and a selection of energy efficiency measures including a tankless on-demand water heater, a high efficiency furnace, foam-wrapped building envelope, increased insulation, a radiant roof barrier, advanced HVAC technology, tightly sealed ducts and low-e windows. Other sustainable features, such as water-conserving fixtures, and sustainable building materials, are also included. The homes are designed to reduce energy bills by up to 90%. Clarum's Enviro-Home™ brand signifies a home that combines state-of-the-art energy efficiency and renewable energy with environmentally sustainable materials.

Vista Montana | California • Consol Inc.

Support, Incentives and Grants

The Energy Policy Act of 2005 facilitated the provision of tax incentives and loan guarantees for energy production of various types, including tax breaks for making energy conservation improvements to their homes.

American consumers can avail themselves of several energy tax incentives, including:

- Home Energy Efficiency Improvement tax credits – for purchase and installation of specific products, e.g. energy-efficient windows, insulation, doors, roofs, and domestic heating/cooling equipment.
- Residential Renewable Energy tax credits – for installation of solar electric systems, small wind systems or geothermal heat pumps
- Federal Tax Credits for Energy Efficiency – for energy efficient home improvements, solar energy systems, fuel cells, small wind energy systems, plug-in hybrid electric vehicles, and new energy efficient homes.

15 COUNTRIES, 7 THEMES: LESSONS LEARNED

Driven by Change

Every country in the case study has had its own energy and environmental issues to deal with and problems to solve:

'Canada is a net exporter of oil, natural gas and electricity, therefore energy supply security is not a highly significant issue. Environmental awareness, however, is high – the effects of a warming climate have now affected many parts of Canada'

'Today Denmark is one of the leaders in energy efficiency in the EU, being virtually self-sufficient in energy, a net exporter of oil and gas, and having the lowest energy intensity among the member countries'

Denmark was one of the hardest hit by the 1973 oil crisis and it has bounced back to become one of the exemplars for national energy efficiency and generation. In Canada, the effect of climate change on its fragile environment has been used to catalyse environmental initiatives that have been welcomed by the general public.

Strong political leadership is essential in order to provide solid ground for ambitious targets and national aspirations.

Aspirations

The UK and France have both set high and admirable aspirations for the future:

'The UK has been a pioneer in many aspects of energy policy and has been used as a model by other countries following its path'

'…of particular significance (in France) is the agenda for technological change to ensure that the majority of buildings will have 'positive' energy by 2020'

A combination of solid aspirations, strong government policy and implementation and widespread acceptance and commitment by the private sector should leave the UK well-placed to achieve its aspirations for zero carbon housing by 2016. Nowhere else in the world are people talking about zero carbon for both regulated and unregulated emissions as a mandatory target to be met by the housebuilders alone. Delivering zero carbon homes needs a comprehensive multi-sectoral solution.

Future Growth

The state of the UK's existing housing stock has always been at the forefront of any discussion about low-to-zero carbon housing. But for three of our case studies, the problem is quite the opposite – Ireland, China and New Zealand have either a relatively young housing stock, or have a lot of housing stock that has yet to be built in the run-up to 2050:

'By 2015, half of all the buildings in China will be less than 15 years old'

'Ireland has the youngest dwelling stock in the EU'

'The New Zealand BCSD have reported that more than a million homes are not adequately insulated'

China, in particular, is at a turning point where the adoption of an American model for housing development could have devastating effects on global carbon emissions.

'63% of American homes contain three or more bedrooms, 65% have a garage, and 86% have air-conditioning'

Ireland and New Zealand both have issues regarding the quality of their housing stock and are currently trying to expedite the establishment and implementation of building standards and energy-efficient building, but efforts are still in their infancy compared to countries like Germany, Denmark and Sweden.

What are the UK's own 'growth areas', and are there any issues that we can start looking at now so that they do not become problems in the future? In the UK we need to deliver 240,000 new homes a year – building these to a very high standard will help us achieve our targets and drive innovation and industry towards higher standards that will then make technologies available for existing stock.

Energy Supply

State-funded infrastructure projects for renewable energy have thrust Denmark, Sweden and Switzerland into pole position in terms of national carbon emissions reductions.

'Today, Denmark is one of the leaders in energy efficiency in the EU, being virtually self-sufficient in energy, a net exporter of oil and gas, and having the lowest energy intensity among the member countries'

'Today, Sweden has the greatest share of renewable energy in the EU'

'Switzerland has been self-sufficient and able to export energy in the summer months, with one of the lowest energy per capita figures in the developed world'

Energy generating capacity is a very important driver for progress and is essential to achieving energy self-sufficiency. The establishment of a dialogue between the energy and housing sectors is necessary, to understand the issues surrounding supply and delivery.

Acceptance and Diffusion

Many other countries in this study have shown a high degree of success with regards to public and private acceptance of low energy housing standards. Take the examples of Australia and Austria:

'Before the introduction of national energy efficiency regulations for houses in 2003, less than 1% of Australian houses achieved 5 stars. Many well-designed houses are now being built with ratings over 6 stars'

'The number of passive houses rose to a market share of 4% in 2006 from almost zero in 2000. By 2007 there were 2,000 Passivhaus buildings in Austria'

It would be worth taking a deeper look at their efforts in promoting these techniques and initiatives and seeing how we can apply them towards achieving UK aspirations.

Clear Strategies

Simple, clear and focused strategies for dealing with the issues of energy and climate change can help consolidate efforts and engage the public:

'Das Integrierte Energie- und Klimaprogramm' (in Germany) focuses on 3 key elements: information, financial incentives and increased standards'

'The current thinking (in the Netherlands) is that a CO_2-free society is only possible with heat pumps, in combination with renewable electricity, good insulation, housing design and quality, and clear and transparent process management'

Frameworks for achieving zero-carbon can easily become too onerous and complex, and the key is to simplify, to structure government initiatives using clear-cut strategies and visions that have a robust technical base.

Technology

Technological innovation is moving very quickly, and any strategy and vision must be flexible enough to accommodate these technologies, as well as provide support for their development:

'Roughly one out of seven newly-built houses in Japan is a prefabricated house.'

'Today, the USA is the largest provider for research funding for new technologies in the world, driving research into carbon capture and storage, biofuels, nuclear power, vehicle fuel efficiency, wind energy and photovoltaics'

The role of innovation and research cannot be stressed enough as it forms an integral part of decarbonising the national grid, developing controls for appliances and energy use, and delivering alternative carbon-free transport. Any upcoming standards or certification schemes must be able to embrace these new technologies. Programmes should also be geared towards the diffusion and market acceptance of emerging technologies that may well be the key to our zero-carbon future.

CASE STUDY SUMMARY

	Australia	Austria	Canada	China	Denmark	France	Germany
Government Policies and Measures	White Paper	Austrian Action Plan	Climate Change Plan	Five-Year Plan	Energy Strategy 2025	TWC Scheme	NEEAP, IEKP
Building Regulations	NatHERS	OIB Guidelines	NBC, MNEC	JGJ Standards	BR-S	RT2005	EnEV
Energy Certificates							
Aspirational Standards	Green Star, NABERS	Passivhaus	R-2000, LEED, Net Zero Energy		Passivhaus, BREEAM	Effinergie, HQE	DGNB, Passivhaus
Financial Instruments and Offsets	Energy Efficient Homes + PVRP	Federal Law on Environmental Support		Renewable Energy Law	Energy prices and green taxes, grants	LDD loans, tax credits	KfW initiatives, feed-in tariff
Passive Design Standards							
Building Envelope Standards							
Energy Efficiency Standards				AC systems			
Low-to-Zero Carbon Technology	Solar hot water, PV	Biomass, solar and heat pumps	Net Zero Energy Home Coalition	Solar, wind, biomass	District heating, CHP (biomass + waste), wind	Nuclear, hydro, biomass, heat pumps	Renewables obligations
Intelligent Systems							

Ireland	Japan	Netherlands	New Zealand	Sweden	Switzerland	UK	USA
Energy White Paper, NEEAP	Global Warming Guideline	EPC, Meer met Minder	NZ EECS	National EQOs	Swiss Energy Policy	Climate Change Act, EEC, CERT, Energy Act	New Energy for America plan
SI Regulations	ECS	EPN	Building Code	SBN, ELAK, NR	MuKEn, SIA	Part L	IECC
				Building Regulations are already at aspirational standard!			
	HQAL, Energy Star, CASBEE	BREEAM	Green Star, NABERS		MINERGIE	BREEAM, CSH	LEED, Building America
	tax incentives, subsidies			environmental taxes, incentives	subsidies, grants, feed-in tariff	Allowable Solutions, LCBP, exemptions	research funding, tax incentives
			lighting	windows, systems	building services	lighting, boilers, appliances	windows, equipment
Low Carbon Housing Programme	Prefab solar houses, CHP, PV	Schoon en Zuinig programme	LCET research fund	renewable fuels, biomass	highest feed-in tariff in the world	microgen, biomass, CHP, district heating	solar, wind, geothermal
	HEMS, subsidies					smart meters	hybrid cars, fuel cells

ZERO CARBON TIMELINES

Figure 4
Current Zero Carbon Timeline, England, UK
2009-2050

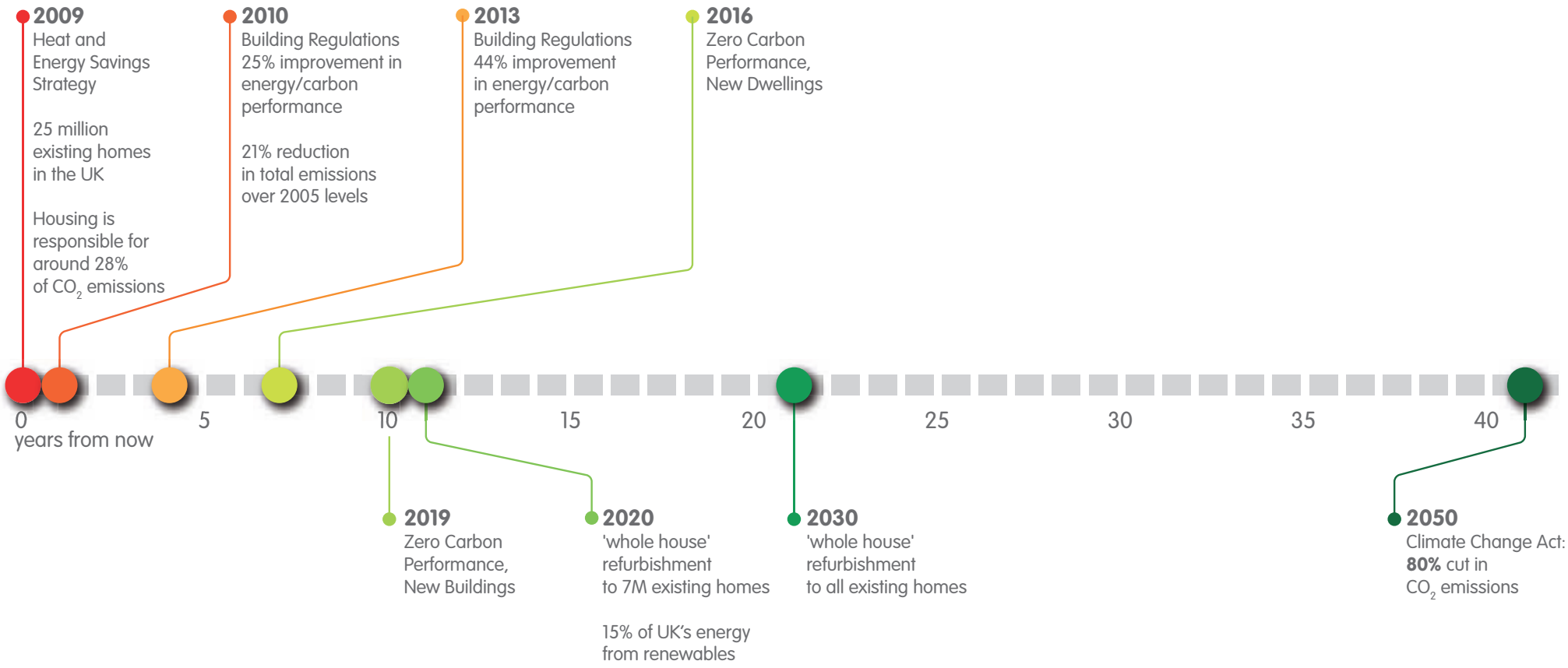
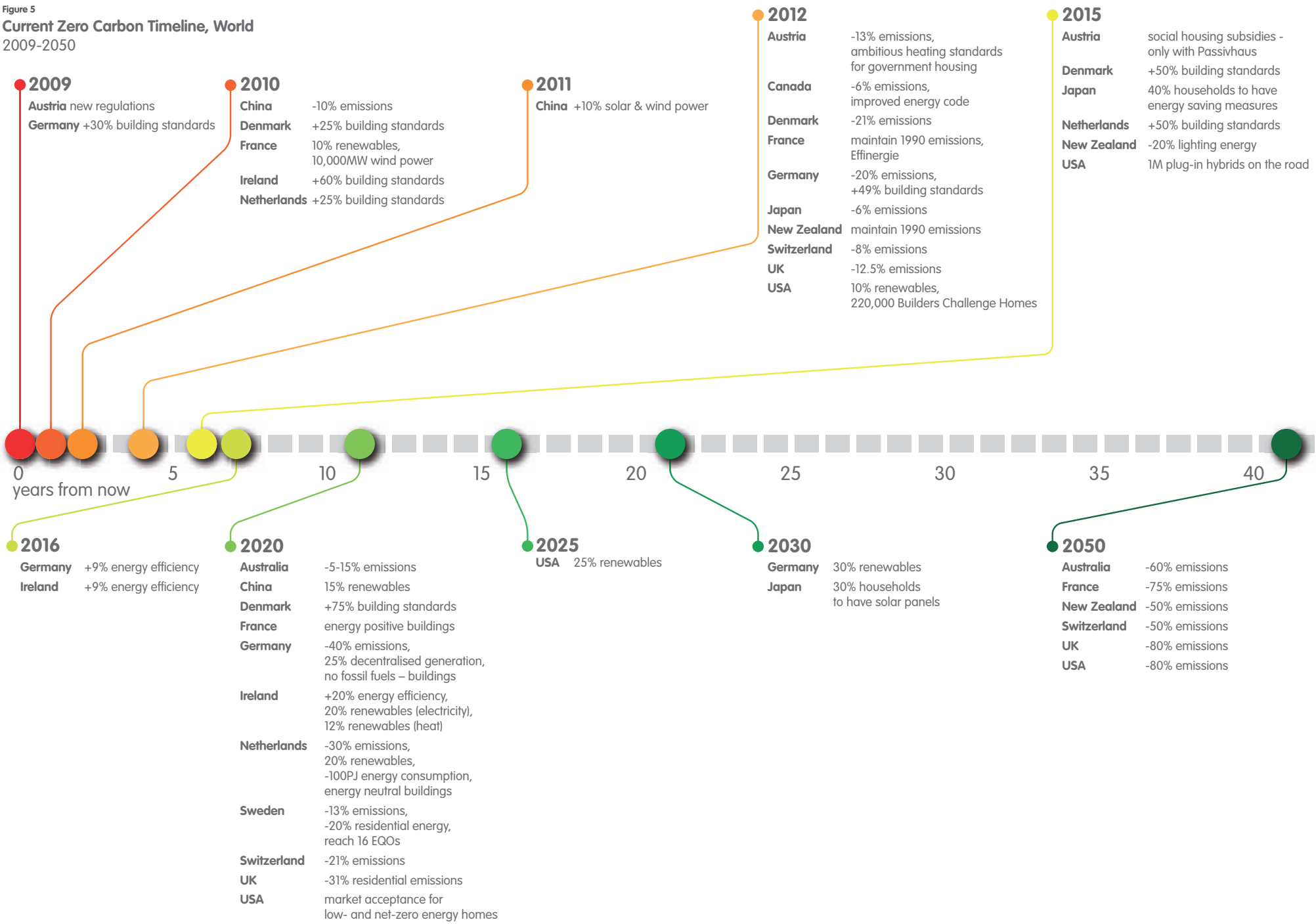


Figure 5

Current Zero Carbon Timeline, World

2009-2050



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