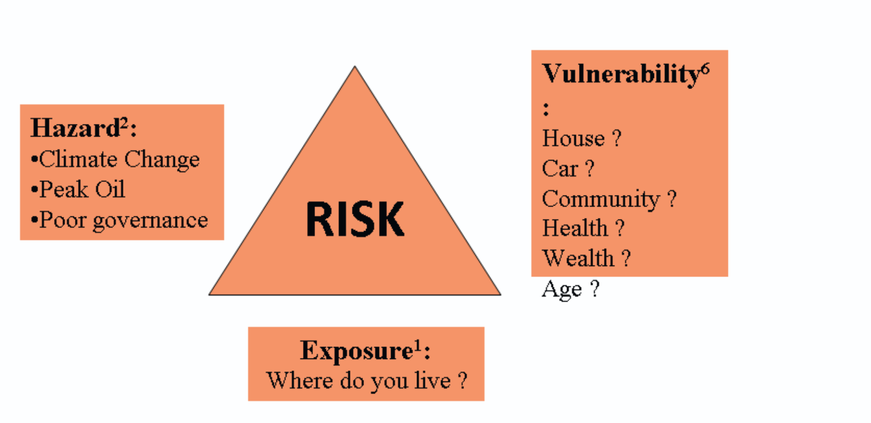
INTRODUCTION TO FOURTH EDITION

Since the third edition of *Ecohouse* was published in 2007 we have experienced an event that has changed all our lives: the collapse of the global economy in 2008. The Peak Oil pundits[1] always held that economic chaos would be unleashed once the global peak of oil production was passed. Some say that occurred in 2008. Brent crude is currently trading today at between US$105 and $120 a barrel and with world demand growing this price looks set to go on rising. Oil prices and economic instability seem to track each other fairly closely and both have become an established feature of our daily lives now.

Eleven years ago Benito Muller predicted in the introduction to the first edition of *Ecohouse* that by 2012 the gap between oil supply and demand would be clear. It seemed so far in the future then that I am sure we did not really comprehend its implications. The editorial message then from me was 'we the privileged must act altruistically to reduce our emissions and save the planet'. It seems a bit wishy washy given the potential impacts of what we face now. Now – I go on here to say to you – 'every person for themselves'. We are all at risk – look after Number One! But I believe the most effective way to do that is to look after those around you – so read on.

Those of you who have read our 2009 edition of *Adapting Buildings and Cities for Climate Change*[2] will be familiar with David Crichton's Risk Triangle. Look at it, and then look at it again – because this diagram is about your future. What risk do you personally face? Have you ever even thought about the issue?



I.1
The Risk Triangle
(source: David Crichton).

I have added three hazards to the triangle to begin with, climate change, peak oil and poor governance.

The exposure side of the triangle is self evident – where do you sit in relation to the hazard? If you own a house on the flood plain of Elgin in Morayshire in Scotland you are exposed to both flooding exacerbated by climate change and to poor governance because the Planners in that town are allowing more buildings to be built on the flood plain each year.[3] This is pushing more people into flood poverty every year as their homes become uninsurable and thus unsellable. This pushing of citizens into flood risk is happening to communities around the world.

Vulnerability comes in many forms and most of us reading this book would not have dreamed a few years ago that we are in fact very vulnerable ourselves to the growing risks of the twenty-first century. But how many of us now watch anxiously for when the next energy bill arrives? Many people, even relatively wealthy ones, in larger rural homes are apprehensive about what the next delivery of heating oil will cost – but not as apprehensive as they were in the freezing winter of 2010/11 in the UK when supplies never turned up at all for some because of excessive demand.

I am now vulnerable because of my own lack of foresight when I designed the Oxford Ecohouse. I did not envisage that one day I too would be old. I failed to see that one coming! I did not put a proper shower room on the ground floor as I so easily could have then. Chris Day has added a brilliant section in Chapter 4 of this fourth edition, on designing ecohouses with our 'whole life' in mind, in sickness and in health.

Physical vulnerability will eventually affect all of us, but another vulnerability is also becoming endemic. Financial insecurity is spreading, even through the middle classes, as the gap between the super rich and the 'others' widens. I will illustrate the drift with a single case study of the ordinary middle classes in Arizona, USA.

In April 2007 I had been working at Arizona State University with Harvey Bryan and the price of a barrel of oil was around US$65. I roughly calculated that the ordinary American couple, living in a standard 2000ft^2 home in Phoenix needed around US$70,000 a year to pay for their mortgages, their health, insurance, food, energy, credit card bills and other living expenses. If you doubled the price of energy that basic annual income requirement jumped to US$90,000 a year and this would include the effect of the rising cooling costs in a city where the heat island effect is pronounced.[4] If you lived in one of the 'Sustainable Communities' in the desert, that reflected the aspirations for an 'American Dream' lifestyle 30 miles out of town, then these costs could be up to US$20,000 a year more because the new house was 3–4000 ft^2, the mortgage higher, and you had to drive 30 miles to work in your SUV that you could not sell because everyone else was trying to sell theirs too and you were stuck with it. In July 2007 you may also have had to pay for fuel to truck water into your desert community because people found that they had been sold homes without enough water rights to provide for them all year.

By July 2008 the price of oil spiked at US$147 a barrel. Americans pay their bills monthly and in the wake of the soaring energy costs, at the pump and for the home, it was not only the 'poor' of Arizona who fell victim to this energy price shock, but many of the middle classes too. By the end of 2010 there were approximately 91,000 vacant homes in the Phoenix metro area, a year in which one in every 17 Arizona households got a foreclosure filing.

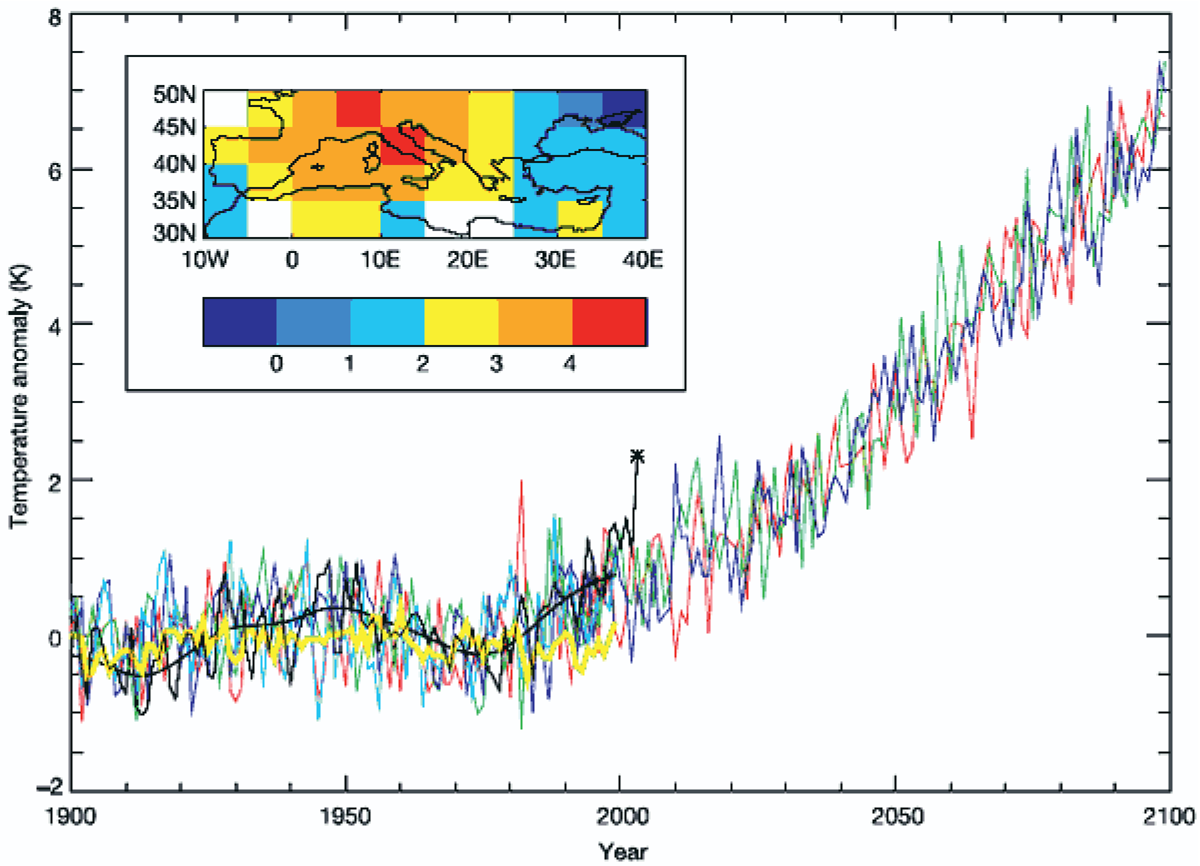
Arizona is a state that has been dominated by the interests of the house developers who bank-rolled the universities, the economy and the politicians. In 1975 the average middle class home being built was around 1500 ft^2 in size and by 2007 that figure had jumped up to 4000 ft^2 in some new desert communities. These homes had minimum insulation, often no shading, many were surrounded by bitumen or concrete yards with little planting and were saddled with a state-wide scarcity of, and high price for, water. It was a recipe for disaster. Young researchers were asking me – a visiting academic – why aren't 'they' telling these people they have no water rights? Search me!

The citizens of Arizona generally did not think they were poor before the summer of 2007. It was the golden state everyone was moving to. They thought they could afford the house, but no one told them the price of energy would double, or gas at the station, or they would have to pay for water. When it is 115°F (46°C) you cannot turn off the air conditioning in summer, especially when you live in a chipboard mansion in the unrelenting desert. Families had to eat, drive to work and pay their health care, so when the energy prices doubled in 2007 there, the mortgage was the first thing that was not paid. At first the poor, and then the middle classes began to default on their mortgages and Arizona became the No. 1 'Domino State' in America that took down the others, and the global economy followed in 2008.

The simple point here is that if the developers of Arizona, or the legislators of Arizona had seen this future and regulated for and built smaller homes, with solid walls, thermal storage, more insulation, shading, solar hot water systems and smaller air conditioning systems run on photovoltaics, then the Arizonans could have cooled their homes, eaten and paid their mortgages and remained in their homes. For the same build cost, with smaller homes, they could have reduced their monthly running costs by enough to let them ride out the spikes and to keep them safe through difficult economic times.

This has happened all over the world. Even in new 'sustainable' communities in rural Scotland some people found it almost impossible to keep warm in their own homes in the freezing conditions of the 2010/11 winter even if they could buy the oil in time. One couple I know who went through that winter in a new high spec home now have it on the market – just like the ones in Arizona – with no buyers in sight.

The time has come for all of us to take the challenge of decoupling our homes from the fossil fuel economy very seriously indeed. The solution is clear: to run our homes on free clean renewable energy, on our own roofs or in our own gardens. Reason: because then you never have to pay for it again. Nuclear power, offshore wind, big hydro and tidal energy sources are fine for industry but not for people in their own homes – because you have to pay whatever the generation companies ask for the energy – forever, plus shareholder profit. Rather than being free – 'big energy' will inevitably become more and more expensive year on year, and with it the perhaps more ominous spectre of more expensive and unaffordable food. If you own your own source of generation you are safe from the first risk but obviously not from the second.



RISK: PEAK OIL – REDUCED BY GENERATING YOUR OWN ENERGY

Then there is climate change. You need to live in a house that will keep you cool or warm in extreme weather – again simply to be safe. Just think of a world where the temperatures of the summer of 2003 (35,000 in Europe died during a single heatwave) is considered a cool one. That is predicted to be Europe in 2050. By 2030 every other summer may well be as hot as 2003. So design your homes to withstand such heat, and extreme cold and wind and rain. Don't end up in a chipboard mansion, miles from anywhere, in a blizzard, when the heating oil has run out, or in the scorching desert when you cant afford to run your air conditioner. Begin to protect yourself now.

If your home is highly exposed to a particular risk – like flooding or winds – move if you still can. Make your own home more resilient. The straightforward design lessons in this book are key to helping you reduce your own vulnerability to the risks around you and the risks ahead. My main pieces of climate-proofing advice to you now are:

1. Natural ventilation should be used for every room – with a sensible range of different opening window types to suit different functions in the home. That means natural daylight too. Get rid of machines wherever you can, or use only the most efficient ones.

I.2
June–August anomalies (relative to 1961–90 mean in K) over the region shown inset. Shown are observed temperatures (black line, with low-pass-filtered temperatures as the heavy black line), modelled temperatures for four HadCM3 simulations including both anthropogenic and natural forcings to 2000 (red, green, blue and turquoise lines), and estimated HadCM3 response to purely natural forcings (yellow line). The observed 2003 temperature is shown as a star. Also shown (red, green and blue lines) are three simulations (initialised in 1989) including changes in greenhouse gas and sulphur emissions according to the SRES A2 scenario to 2100. The inset shows the observed summer 2003 temperature anomalies in K).5

2. Building integrated renewables should provide as much of your heat, coolth and electricity as possible.
3. Thermal storage is important in your home – because when the lights do go out in the blizzard, or the heat wave, it will still keep you cool or warm – for a while at least.

Design your house to give you all of the above, as well as incorporating as many of the other design steps outlined in this book as you need to build a resilient home that can adapt to the requirements of a changing world over time.

RISK: CLIMATE CHANGE – REDUCE BY BUILDING A RESILIENT, ADAPTIVE HOME

Oh yes – and there is the 'everyone for themselves' issue. We have to think like that in the twenty-first century – to look after Number One, because for many of us top down politicians don't seem to be doing the job for us. To stay safe you are going to have to make sure that the community around you is safe as well. Your neighbours will be your first line of defence in dark times. During extreme events around the world we have seen time and time again that those who survive best, do so with the support of the people around them. For example if this means forming groups to stop irresponsible planners from putting more buildings on the flood plain and blighting more lives – then form a group – because a community divided into haves and have nots is an unstable one. There is no gated community, or council chamber, in the world that will stop a crowd when the man in the street has finally had enough. This has been a key lesson learnt since the last edition of *Ecohouse* was published in 2007:

MAJOR RISK: POOR GOVERNANCE – WE NEED TO SORT IT

Sue Roaf
2011-09-20

Notes

1 Groups such as the Association of Peak Oil (www.aspo.org) and the Oil Drum (www.theoildrum.com) have been very influential in promoting such ideas.
2 Roaf, S., Crichton, D. and Nicol, F. (2009). *Adapting Buildings and Cities for Climate Change*, Architectural Press, Oxford.
3 See: http://www.youtube.com/watch?v=ZuVf9MBMc8c
4 Urban Heat Island (UHI) is a metropolitan area which is significantly warmer than its surrounding rural areas due to the increased heat storage capacity of the materials of which a city is built, heat resulting from energy used in the city and the metabolic heat generated by people in the city.
5 Nakicenovic, N. and Swart, R. (2010). *Special Report on Emission Scenarios*, Cambridge University Press, Cambridge, UK.

INTRODUCTION TO THIRD EDITION

PASSIVE SURVIVAL HOUSING

Six years after writing the introduction to the first edition of *Ecohouse*, I sit in my Oxford study, looking out over the trees, and wonder that some still have their leaves on in early December. I am wearing a T-shirt in an unheated room and thinking, 'Oh my God, we were so right. It is all happening just as we said it would!' But the world is changing faster than I ever envisaged that handful of years ago.

We first published *Ecohouse* in 2001 and in that introduction we covered theoretical concerns over climate change and fossil fuel depletion. By the second edition of *Ecohouse*, published in 2003, these concerns were firming up with the emerging reality of more extreme climate events and growing publicity over the issue of 'Peak Oil'.

But even in the three years since 2003 so many alarming events and trends have been written on the faces of cities like New Orleans or the landscapes outside our own windows that we are all beginning to get an inkling that there is much worse to come. Even in America the cosy talk amongst the educated architects of 'Sustainable Buildings' has turned to discussions of how we design for 'Passive Survival' in our own homes, when the power fails and the storms menace[1]. People are beginning to take heed of the growing clarion calls for action in the face of the irrefutable evidence of a rapidly changing climate[2].

Four events in particular have penetrated through to the 'conventional wisdom' of the thinking public. The first was the effect of the European heatwave of the summer of 2003 that killed over 35000 people, of whom some 15000 alone lived in France. Many were the vulnerable elderly, living on the top floors of blocks with the traditional French, un-insinuated metal, roofs. So even trad-itional vernacular buildings were beginning to need adaptation to provide adequate shelter for their occupants in extreme weather[3], let alone the 'modern buildings' that typically rely on using large amounts of energy to stay comfortably cool or warm, even in temperate climates.

A heatwave also triggered the second event, the power failure that affected over 50 million people in the Eastern Seaboard of the United States of America in August 2003. In New York people had to evacuate most of the buildings in

1
The lights go out in New York in August 2003. How many would die if this happened in a blizzard? (Source: AP/Empics).

the city, because they had non-opening windows and air-conditioning systems in which the air for breathing ran out in under an hour, and internal temperatures surged within minutes. Again these buildings had failed to provide adequate shelter in extreme conditions. What was a unique 'New York' experience on a hot summer evening with people safely sleeping on the streets may, if that had happened during a snow storm in winter, have resulted in untold loss of human life.

The third event that shocked the world was the flooding of New Orleans by Hurricane Katrina in September 2005. It was not only the scale of the destruction that occurred to the buildings and the city that made the world hold its breath in horror, but the failure of the social support systems of the United States of America, supposedly the richest country on earth, to deal with the human tragedy that unfolded before our eyes.

The fourth factor has been the inexorable rise of oil and gas prices around the world, heralding the fact that we are beginning to run out of secure supplies of oil and gas[4]. In the last two years alone our gas and electricity bills have doubled in the UK, and over 1.2 million households of the 20 million in England alone have fallen into fuel poverty during that time (namely the old, the young and the poor). At the Conference on Oil Depletion at the UK Energy Institute[5] on 7 November 2006 Chris Skrebowski, a globally recognised expert, concluded that oil supplies will peak round 2010–2011 at around 92–94 million barrels per day. Speakers also voiced their alarm at the prospect of both oil and gas shortages in the UK, Europe and the rest of the world in the near future due to a range of supply problems[6].

A least we now have politicians around the world waking up to the need to act in the face of the growing economic impacts of climate change. On 30 October 2006 Sir Nicholas Stern published his *Review on the Economics of Climate Change*[7]. This was the first comprehensive UK review of the subject and clearly demonstrated that all countries will be affected by climate change, but Stern stressed that the poorest countries will suffer earliest and most. The review's major conclusions were that average temperatures could rise by 5°C from pre-industrial levels if climate change goes unchecked. Stern shows that warming of 3°C or 4°C will result in many millions more people being flooded. By the middle of the century 200 million may be permanently displaced due to rising sea levels, heavier floods and drought. Warming of 4°C or more is likely to seriously affect global food production, but by then growing areas of the world will be simply too hot to inhabit.

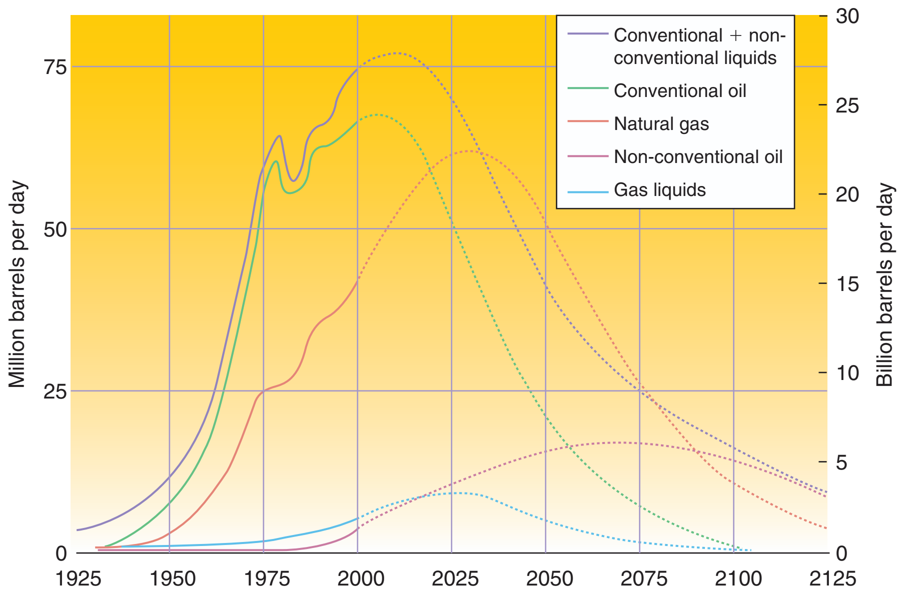
Warming of 2°C could leave 15–40% of the world's species facing extinction. The review reiterates that before the industrial revolution the level of greenhouse gases in the atmosphere was 280 parts per million (ppm) of CO_2 (equivalent); the current level is 383 ppm CO_2 and the level must be limited (by means, we maintain, of Contraction and Conversion policies and mechanisms[8]) to not exceed 450–550 ppm CO_2. Anything higher would substantially increase risks of very harmful impacts. But Stern claims that anything lower would impose very high adjustment costs in the near term and might not even be feasible. He states very clearly that climate change is the greatest and widest-ranging market failure ever seen.

Stern states that what we do now can have only a limited effect on the climate over the next 40 or 50 years, but what we do in the next 10–20 years can have a profound effect on the climate in the second half of this century[9]. What he does not deal with is the significance of buildings as generators of climate change. Buildings use over half of all the energy consumed globally and are responsible for over half of all the climate change emissions, yet year on year 'modern' fashionable buildings become more energy profligate.

The damage this is doing to our cities and businesses is dealt with in another London report, *Faulty Towers*[10], published in July 2006 by the inter-national architectural group 'Gensler'. The authors issue a stark warning to commercial property investors that 75% of property developers believe that impending legislation to grade the energy efficiency of buildings (in response to the EPBD, the European 'Energy Performance of Buildings Directive'[11]) will have a negative impact on the value and transferability of inefficient buildings when certification is imposed from 2007. The report claims that 'Property fund managers are effectively sitting on an investment time bomb. The introduction of energy performance certificates will shorten the lifespan of commercial buildings constructed before the new regulations, and we expect the capital value of inefficient buildings to fall as a result.'

This will happen with homes as well when the requirement for an Energy Certificate – to be produced on the point of sale of every house in Europe – kicks in during 2007[12]. This means that anyone trying to sell a house that is expensive to run will find it increasingly difficult to dispose of. Another potential blight on housing sales relates to homes on the flood plains that may no longer be eligible for flood insurance after 2007[13].

This book deals with the design and building of actual houses. Since it was published we have produced *Closing the Loop: Benchmarks for Sustainable Buildings*, in which we have tried to help people understand a wider range of the 'sustainability' issues relating to buildings including how to define and measure quality of life, community, transport, waste, air, land and water pollution, etc. If you are interested in these subjects it is a useful reference book[14].



2
Historical data to 2000, and projections thereafter, on when various fossil fuel reserve outputs will peak. Based on studies by a range of authors including Campbell and Laherrerre.4 (Source: Boyle, G., Everett, B. and Ramage, J. (eds). (2004). *Energy Systems and Sustainability*. Oxford University Press, p. 289).

In 2005 we produced a further, more shocking book, *Adapting Buildings and Cities for Climate Change*, in which were described, in detail, the ways in which the climate is changing, and how these changes will affect the design and performance of buildings and cities in an era of rising fossil fuel prices[3]. Writing this book made me thank God for my own safe secure ecohouse. I have just paid my quarterly gas bill, double what it was last year, but then again it is only £17.50! My bills will double in the next few years then double again and again. That is what the future will be like. Even then I will only pay around £150 for the quarter. What if you pay £300 a quarter for gas now? A quarterly bill for you in the future would be £2400. It would be impossible to pay. This is why everyone in the UK, indeed in the world, has to wake up now to the challenge of surviving in the coming years and decades in a world with more extreme weather and spiralling fossil fuel energy prices.

This is why we have included in the third edition of *Ecohouse* many more ways to exploit the clean, free, infinitely renewable energy around us to power our buildings, with new chapters on wind, hydro, ground source heat pumps, biomass and more on water conservation. We introduce more information on low embodied energy building materials and construction approaches and some fascinating new case studies.

What has become clear in the past three years of rapid change since the second edition was published is that we have the technology to survive – in fact we all had the necessary technology in the local shops in Oxford in 1995. What we desperately need now is the 'Eco-society' that will enable the neces-sary changes to happen in time to ensure that everyone, especially the vulnerable, can 'future-proof' themselves against what lies ahead. We urgently need to:

1. Adapt to mitigate our emissions until each of us only produces their fair earth share of greenhouse gasses, in every country, in line with the method of 'Contraction and Convergence', as set out by the Global Commons Institute[8].

2. Adapt our buildings so that we are able to survive in them through the worst that the climate can throw at us, even when the lights go out.
3. Adapt to increase the resilience of our communities to ensure that the fabric of our 'civilised' societies remains in tact through the changes ahead.

At the heart of all these 'adaptations' is the robust, resilient and safely located ecohouse, powered by renewable energy and embedded in a strong community. If you think that someone else is going to make all that happen for you, you are almost certainly wrong. It is up to you now to ensure that you, your family, your community your business, your society, your economy are all safe, because without all of them in tact it just may not be worth surviving through the coming decades of the twenty-first century.

And the time to start work on all of this is NOW, because we have around ten years before our actions cease to be important in the battle against climate change.

Sue Roaf
July 2007

The Moving Finger writes; and, having writ,
Moves on:
nor all your Piety nor Wit
Shall lure it back to cancel half a Line,
Nor all your Tears wash out a Word of it.
Omar Khayyam
Born: May 31, 1048 in Nishapur, Iran : Died: December 4, 1131

CONTRACTION AND CONVERGENCE: A QUESTION OF SURVIVAL

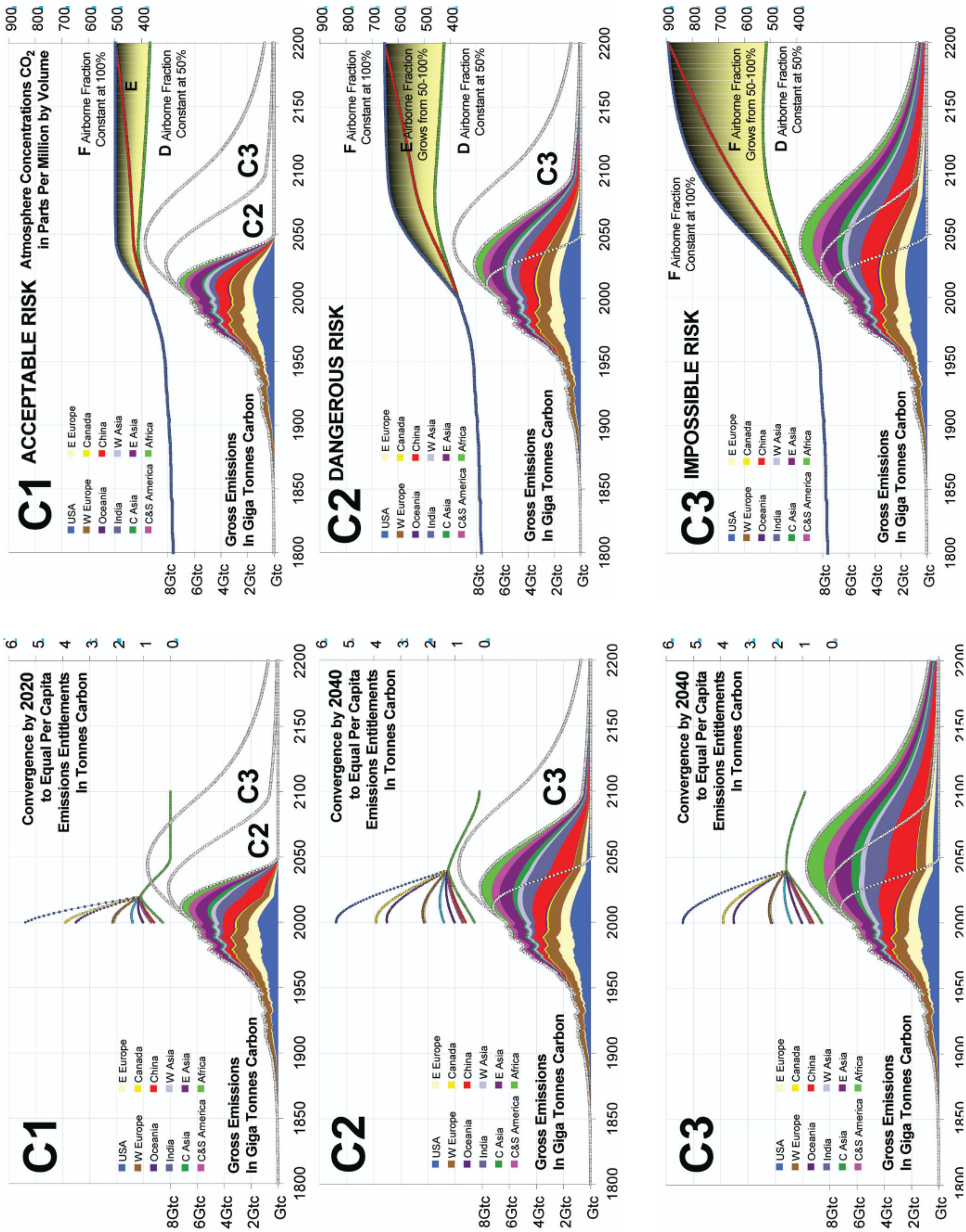
If we are to reduce our global emissions of CO_2, humanity will have to devise a way to work together towards a common understanding of what constitutes a fair Earth share of emissions per capita for everyone on this planet. 'The only game in town' to do that is currently C&C – the theory of 'contraction and convergence' (for a definition statement of C&C and support please go to http://www.gci.org.uk/briefings/ICE.pdf).

The six graphs shown in Figure 3 project scenarios for future rates of CO_2 stabilisation in the atmosphere. These are 'path-integrals', in other words carbon transferred to the atmosphere added up over time, in much the same way as water accumulates in the bath as water flows through the tap into the bath and, as the plughole gradually blocks it, progressively stops draining away.

These path-integrals have the underlying carbon consumption – as 'contraction and convergence' budgets – for carbon emissions shown as well. Chart four shows convergence accelerated relative to the rate of contraction for reasons of international reconciliation.

These follow the carbon-cycle modelling published by the IPCC since the Second (1995) and Third Assessments (2000), for

3 (facing)
Future CO_2 'path-integrals' – projecting 'aggravated rates of accumulation' of atmospheric CO_2 or accelerated rates of contraction and convergence (C&C) to avoid this (Source: Aubrey Meyer).


C1
Convergence by 2020 to Equal Per Capita Emissions Entitlements In Tonnes Carbon
Gross Emissions In Giga Tonnes Carbon
C1 ACCEPTABLE RISK
Atmosphere Concentrations CO_2 in Parts Per Million by Volume
F Airborne Fraction Constant at 100%
D Airborne Fraction Constant at 50%
C2
Convergence by 2040 to Equal Per Capita Emissions Entitlements In Tonnes Carbon
C2 DANGEROUS RISK
E Airborne Fraction Grows from 50-100%
C3
C3 IMPOSSIBLE RISK
USA
W Europe
Oceania
India
C Asia
C&S America
E Europe
Canada
China
W Asia
E Asia
Africa

1. 350 parts per million by volume (ppmv),
2. 450 ppmv, and
3. 550 ppmv.

These IPCC reference curves are shown by line D in each case against the emissions contraction budgets also quoted by IPCC.

In each of these four reference cases, the curves for atmospheric accumulation are projected using the C&C model to show the aggravated path-integrals of rates of CO_2 accumulation in the atmosphere into the future at:

1. a Constant Airborne Fraction (CAF) at 50 per cent as given with the IPCC determined rates of emissions contraction budgets and path-integrals for atmospheric accumulation – this is path 'D' in Figure 3.
2. 100 per cent CAF, in other words the theoretical maximum rate of atmospheric retention of ghg emissions from human sources – this is path 'F' in Figure 3 shown, and
3. a rate of ghg retention in the atmosphere that gradually increases from 50 per cent to 100 per cent over the next two centuries – this is path 'E' in Figure 3.

In other words the scenarios shown are 'pairs' of emissions budgets and atmospheric concentrations where the latter should have been stable (following IPCC given values), but can rise faster along paths 'E' due to sink increasing sink-failure and the consequent aggravated rate of concentration build-up.

C1 An emissions budget for 350 ppmv as determined by IPCC, may well rise through 500 ppmv [here called 'acceptable risk']
C2 An emissions budget for 450 ppmv as determined by IPCC, may well rise through 650 ppmv [here called a 'very dangerous risk']
C3 An emissions budget for 550 ppmv as determined by IPCC, 550 may well rise through 900 ppmv [here called an 'impossible risk'].

The justification for doing this relies on the data returned between 2000 and 2006 showing that the aggravated rate of emissions accumulation in the atmosphere is already occurring intermittently. The purpose of doing this is to highlight the much greater extent of risk with which we are already confronted, as the likelihood of aggravated rates of accumulation persisting into the future is real. The point of concern is that conditions of a runaway rise in climate change will take hold much sooner than previously foreseen, if preventive action is not urgently taken.

These 'aggravated rates of accumulation' are a fundamental strategic consideration as we try and determine a stable future over the many following decades when it:

1. hasn't yet occurred
2. is still caught in poor understanding and indecision about 'policy' to modify human fossil fuel consumption beyond 2012 when the irresolute Kyoto Protocol to the UNFCCC expires, and
3. operates under the increasingly challengeable assumption that there is still

time to avert dangerous rates of climate change from taking hold when some already take the position that it is all too late; in the analogy, the bath is inevitably now going to overflow.

The priority test to keep in mind for policy to this purpose is comparing path-integrals for:

1. the rate at which we cause the problem with our global emissions total where this rate is understood as the possible and likely rates of atmospheric accumulation and therefore
2. these rates against the rates at which we are organising globally to stop triggering dangerous rates of climate change (as for example with the Kyoto Protocol) by contracting our global emissions total fast enough to avoid this.

All this shows is that we can reasonably measure the rate at which we presently still continue to cause the problem much faster than we act to avoid it with the wholly ineffectual Kyoto Protocol. In its given time period of 2008–2012, the Kyoto Protocol will theoretically and at best have avoided emitting a few hundred million tonnes of CO_2 (measured as carbon) into the atmosphere. During the same period we will have added several billion tonnes of carbon to the atmosphere from emissions virtually business-as-usual.

As soon as we factor aggravated accumulation into this it is clear that the end result will be that by 2012 we will be more, not less, deeply committed to the accelerating rate at which we are causing the problem than the response rates of C&C that are necessary to avoid it.

Notes

1 Environmental Building News Vol. 14, No. 12: http://www.buildinggreen.com/articles/IssueTOC.cfm?Volume=14&Issue=12 or http://www.buildinggreen.com/press/passive-survivability.cfm

2 There have been a number of media exposes of the problems – perhaps the most influential has been the Al Gore film *An Inconvenient Truth.* This included a number of images from Mark Lynas's excellent book *High Tide: news from a warming world*, 2004, Flamingo Press, London. The science behind such works has also moved on rapidly and become more access-ible. For instance on climate change and its impacts see: www.ukcip.org.uk and www.ipcc.ch You do have to be careful using the internet though as there are many sites in cyberspace that are have their own agendas and some that are downright misleading. For the view of one who thinks it is already too late to act see: Lovelock, J. (2006). *The revenge of Gaia*. Penguin Publications.

3 Roaf, S., Crichton, D. and Nicol, F. (2005). *Adapting Buildings and Cities for Climate Change*. Architectural Press, Oxford.

4 For excellent discussions on the issues of Peak Oil see: www.peakoil.net, www.odac-info.org and www.energycrisis.com. For more insights into how Peak Oil estimates are arrived at see for instance: http://www.hubbertpeak.com/laherrere and Campbell, C.J. and Laherrère (1998). The End of Cheap Oil, *Scientific American*, March (http://dieoff.org/page140.htmn).

5 http://europe.theoildrum.com/story/2006/11/10/17234/128#more and http://www.odac-info.org

6 Sixth Report of the Joint Energy Security of Supply Working Group (JESS), April 2006, p.14. http://www.dti.gov.uk/files/file28800.pdf
7 www.sternreview.org.uk
8 For a full account of the theory of Contraction and Convergence see the website of the Global Commons Institute: http://www.gci.org.uk
9 http://environment.guardian.co.uk/climatechange/story/0,,1935211,00.html
10 www.gensler.com/faultytowers
11 See: www.epbd-ca.org/Medias/Pdf/15_CO_UK.pdf and http://www.eeph.org.uk/energy www.epbd-ca.org/Medias/Pdf/15_CO_UK.pdf and http://www.eeph.org.uk/energy
12 http://en.wikipedia.org/wiki/Energy_efficiency_in_British_housing#Home_Energy_labelling
13 See: the Association of British Insurers website for more information on this: http://www.abi.org.uk/flooding and if you want to check if your house is at risk of flooding see: http://www.environment-agency.gov.uk/subjects/flood/?lang=_e and fill in your postcode.
14 Roaf, S., Horsley, A. and Gupta, R. (2004). *Closing the Loop: Benchmarks for Sustainable Buildings*. RIBA Enterprises, London.

INTRODUCTION TO SECOND EDITION

Since we deposited the manuscript for the first edition of *Ecohouse* with Architectural Press in late 2000 a surprising amount has happened. For one thing, at a global level, the rain has changed! Countries around the world are suffering the worst floods in living memory, and it is not just the poor of Bangladesh and Vietnam whose homes and lives have been devastated by these unprecedented deluges. Britain, Europe and the United States have suffered catastrophic inundations and, frighteningly, the world is beginning to realise that it simply can no longer afford to undo the increasingly devastating impacts of climate change. Germany has recently admitted that it cannot now cover the true costs of the August 2002 floods. In December 2002 the UK insurance industry began withdrawing insurance cover from homeowners around Britain located in areas prone to flooding. Also in Britain, warnings have gone out that no development should now occur on flood plains, but the proposals for housing schemes below maximum flood heights still appear in planning offices around the country almost every day. This is madness – and the person who pays will be the unsuspecting homeowner!

One of the reviewers of *Ecohouse 1* questioned why we had included sections on wind-proofing buildings from storm damage. It seems only prudent in the twenty-first century to take every precaution one can against the power of the climate because we are just beginning to get a taste of what climate change may begin to do to our buildings, and our lives, over the ensuing decades. From now on, every building should be built to withstand strong winds and those in exposed areas should be hurricane-proof!

At the level of the building, growing concern is being expressed over problems associated with the 'modern' fully air-conditioned (AC) building, even by the Doyens of the AC industry. I predict that this type of building will turn out to be a late twentieth-century phenomenon. They will, sooner rather than later, be replaced, even in the hottest climates, with buildings that can be naturally ventilated either all year, or for as much of the year as possible. There are many reasons that will drive this change, apart from the rapidly rising cost of power-energy hungry AC systems. These include the fact that the heat the AC systems produce is making cities grow increasingly warmer, becoming 'urban heat islands' (something like the heat effect caused by freezers in the

1
Floodwaters from Hurricane Katrina cover a portion of New Orleans, Louisiana, illustrating the growing power of the climate to devastate ordinary lives (Source: Associated Press/ EMPICS).

local shop), and that the CO_2 emissions from AC systems have become one of the largest driving forces for climate change around the world. This change is strongly resisted by the related industries, services engin-eers and architects who simply do not know how to design passive buildings and/or get paid for doing so. It is only through major changes, such as climatic conditions, and more expensive fuel that these doubters will be shocked into evolving into the twenty-first century, but such shocks are already on the horizon and driving rapid changes in the built environment.

Perhaps the real driving force for the end of the great air-conditioning age is that of the health of building occupants. Worryingly, researchers are finding that the filters, ducts and plants for AC systems often produce much dirtier air than if one simply opened the window, even in the city (Clausen, G., Olm O. and Fanger, P.O., 2002, *The Impact of Air Pollution from Used Ventilation Filters on Human Comfort and Health*, Proceedings of the 9th International Conference on Indoor Air Quality and Climate, Monterey, vol. 1, pp. 338–343, www.indoorair2002.org). Air-condition systems can harbour potentially killer chemicals and bugs such as Legionella, moulds and particulates that are released back into the ducts from the filter, particularly when the weather changes; for instance, on getting warmer and wetter conditions in a warm front (Mauderly, J., 2002, *Linkages Between Outdoor and Indoor Air Quality Issues: Pollutants* *and Research Problems Crossing the Threshold.* Proceedings of the 9th International Conference on Indoor Air Quality and Climate, Monterey, vol. 1, pp. 12–13). Many internal ducts are not only seldom cleaned but also impossible to get at to clean, and to make matters worse actually give out toxic fumes from the plant, seals and ductwork itself. In addition, dirty duct air is then mixed with a cocktail of Volatile Organic Compounds: formaldehydes, moulds, fungi, dust mites and potentially toxic cleaning materials already inside rooms. This may explain why, in air-conditioned buildings, many more people succumb to Sick Building Syndrome (Bjorkroth, M., Asikainen, V., Seppanen, O. and Sateri, J., 2002, *Cleanliness Criteria and Test Procedures for Cleanliness Labelling of HVAC Components*. Proceedings of the 9th International Conference on Indoor Air Quality and Climate, Monterey, vol. 1, pp. 670–674). AC and ventilation systems that incorporate filters and long duct runs should be avoided at all costs, and of course furnishings and finishes in houses should be made of natural materials wherever possible. It is pretty easy to do once you know how.

Even in the hot humid tropics ingenious systems for using cold water pipe systems and night cooling systems could be a much more comfortable and healthier solution (see Case Studies 9 and 10 on the Lim and Surabaya houses) than subjecting yourself to the toxic soups of room air and cold shock so often experienced in overcooled and over-expensive to run buildings. The average American worker is absent from work on average for one day a month because of sick building syndrome! A figure that sounds incredible to us in the UK. Let us not forget that from here on energy, and particularly electricity, will only get more expensive, so that when you are building your new house, this is the time to future-proof yourself against not only the changing climate but also the inevitable rise and rise in the cost of powering that home and the health aspects that should, at no extra cost, be built into it. A good time to invest in opening window firms?

So what is the good news? Well, people's attitudes, as well as the market place, are actually changing fast; evidenced, for instance, by the surge of people investing in solar technologies for their homes. Nowadays, because of the very high demand for them, you wait some time to get a PV panel delivered to site in the UK! Ultimately, the driving force for such necessary changes will be shifting attitudes and mindsets of this generation. It is hard to believe that, in the face of all this growing evidence, we still succumb to the 'Easter Island Effect' and continue on a 'business as usual' approach towards the future. One good sign is that so many people have bought copies of *Ecohouse 1* and we would like to thank them for providing us with the opportunity to develop it into *Ecohouse 2*. They are the reason why Manuel, Stephanie and I have elicited the help of friends to revise many of the chapters for this edition and include new sections.

Manuel returned from his beautiful ecohouse perched on a mountain overlooking the lakes in Bariloche, Argentina, to help complete *Ecohouse 2*. Stephanie worked with us, from Florida, where she is at the Florida Solar Energy Centre and completing her own hurricane-proof ecohouse (see Case Study) on the Florida Keys, based on her Caribbean experience. This house is a great example of a pragmatic design that manages to incorporate not only the values of an ordinary American lifestyle, but also to minimise the envir-onmental impacts of doing so while optimising the comfort and well-being of its occupants. It demonstrates that ecohouse principles can be incorporated into the mainstream of the housing market, even in the United States.

What is new in *Ecohouse 2?* Well, Mike Humphreys deliberates on life in a Hobbit Hole! Fergus Nicol helps us to estimate the design challenges of making houses comfortable in different climates with his Nicol graph. Craig Simmons explains how ecological footprints work demonstrating too that it is the lifestyle of the building occupants that matters as much as getting the design right – a good lesson. Peter Warm tells us more about, well, keeping warm, with insulation. Chris Kendrick informs us with additions to the section on cold bridges and Paul Jennings tells us how to stop buildings from leaking. The famous Dr Dave Anderson, Washington toxicologist, explains how to turn yourself into a mould detective!

Manuel has updated the Passive solar chapter using the results of a Pilkington funded study completed with Chiheb Bouden of the Tunisian Solar Energy Centre. Chiheb modelled the thermal performance of the Oxford Ecohouse under a range of 'what if' scenarios to see how wrong or right we got the initial design. Chris Laughton, of the UK Solar Trade Association, has contributed his wisdom to solar hot water system design and Bruce Cross, who designed the Oxford PV roof, tweaked the Photovoltaic chapter. Nick Grant has also added his help to our chapter on using water wisely. Stephanie has added Porpoise Point Ecohouse (Case Study 20) which she designed herself while in Oxford, and a new one in the hot Mediterranean climate of Tunis (Case Study 22) was contributed by Chiheb. We also include the new cold climate healthy house in Vancouver (Case Study 21). In addition, I am exceedingly glad that, in the recent strong deluges, I had wide Dales storm-proof gutters which rapidly dealt with even the most torrential downpours.

You can see that developing *Ecohouse 2* has been an opportunity to meet old and make new friends alike. We have built on what we always knew was going to be an important book when we first started it, quite simply because we wrote it in answer to your questions, asked when so many of you first visited us here in Oxford.

Please contact us to let us know if there are subjects we have omitted and you would like covered, and if we have got anything wrong.

I hope that young students of architecture and engineering will also read this book, as well as designers and home builders. Encapsulated in the following rationale for ecohouse design are many of the lessons they will need to build any building, however large or small, in the twenty-first century. A project to design an ecohouse, even in the architecture or engineering school studio, is a good way to learn the basic lessons of twenty-first century design, and develop an individual approach to successful eco-design, for there never is one answer.

Do check the Architectural Press website to browse for details of our ongoing Student Ecohouse Design Competition at www.architecturalpress.com.

What is sure is that the buildings of this century will not be like those of the last century. The times, and the climate for design, are changing, and the dream of endless fossil fuel is coming to an end. A new design age is upon us.

Good luck with your own ecohouse designs!

Sue Roaf

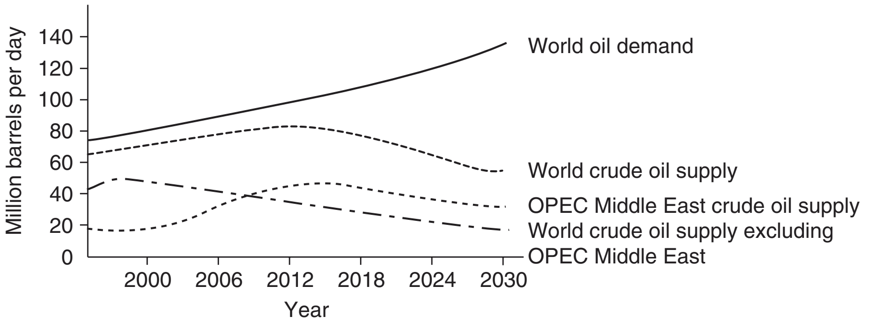
September 2002

INTRODUCTION TO FIRST EDITION

The first question to answer should be: what is an ecohouse? Eco-architecture sees buildings as part of the larger ecology of the planet and the building as part of a living habitat. This contrasts with the more common notions of many architects, who see a building as a work of art, perhaps on exhibition in a settle-ment or as 'frozen music' in the people-less pictures of glossy magazines. Some architects see the process of design as a production line with the building as a product to be deposited on a site, regardless of its particular environment or qualities. You will see from the case studies at the end of the book that ecohouses are closely connected to their site, society, climate, region and the planet.

Why bother making buildings connect in this way? Because the alternative is not acceptable and 'modern buildings' are literally destroying the planet. It does not help that the number of people on the planet is growing so rapidly (5.3 billion in 1990; 8.1 billion by 2020; 10.7 billion in the 2080s) or that we have increasingly sophisticated technologies to exploit the Earth's natural resources. But it should be widely known that buildings are the single most damaging polluters on the planet, consuming over half of all the energy used in developed countries and producing over half of all climate-change gases.

The shift towards green design began in the 1970s and was a pragmatic response to higher oil prices. It was then that the first of the oil shocks, in 1973, sent fossil fuel prices sky high and the 'futurologists' began to look at the life



1
World oil demand and conventional oil supply in millions of barrels per day (*Guardian*, 17 June 2000, p. 30).

history of fossil fuels on the planet and make claims about how much oil and gas were left. Their predictions were alarming and, 30 years on, we appear still to have abundant oil. However, their calculations on total reserves were fairly accurate and many of their predictions have yet to be proved wrong. From the features on gas, oil and coal below you can see that it is now estimated that we have left around 40 years of conventional oil reserves and 65 years of gas, at current rates of extraction. Recent studies (see Bartsh and Muller, 2000) point to 2012 as being when the oil shortages will really begin to bite hard and to start changing the face of society.

OIL: the estimates of total oil reserves have changed little in 20 years and the last big oil field discovered was in the North Sea in the 1960s. The output from the southern 48 States of America began to decline in the 1940s. The output from oil fields typically follows a form of bell-shaped curve, rising steeply to a plateau then falling sharply. Every day the world consumes around 70 million barrels of crude oil. To date, we have used around half of the total estimated oil reserves globally and it is thought that within a few years we will reach the peak of global oil production, after which time conventional oil production will decline.

The capacity for exploiting those reserves can be increased by technologies that allow more of the reserves to be extracted, for example by using pumped gas and water. Thus in the USA, UK and Norway, for instance, reserves are intensively exploited while in other areas, such as Saudi Arabia, Kuwait and Iraq, they are not. The term 'reserves' indicates the long-term potential of an oil field while 'capacity' describes what can be pumped from that field taking into consideration constraints such as the technical efficiency of the extraction process. An increase in the rate of recovery of oil from a field from 30 per cent to 60 per cent is the equivalent of doubling the proven recoverable resource.

Perhaps worst hit by the decline in oil reserves will be the fields in the USA and the North Sea, which will be badly affected by 2020. Issues of how to sustain current lifestyles in these regions, with declining oil reserves, unpredictable global oil prices and geopolitical conditions, should prove very interesting.

There is capacity for considerable expansion in oil production over the next few years to meet increased global demands from the various oil-producing countries. However, the capacity to increase supplies may well not actually meet the increasing demands. The cost of oil will depend on the match between demand and supply, the 'time lag' between synchronising these and the size of 'buffer' supplies that are currently largely held in the Gulf. Prices will rise when governments perceive a reduction in the size of the buffer, or anticipate that demands for oil are growing faster than investment in capacity expansion. The oil crises of 1973 and 1979 were caused by such a mismatch of demand and consumption. Recently the oil price on the global market has fluctuated from under US$10 a barrel to over US$30 a barrel. Our societies are highly dependent on oil, the price of which has not proven particularly predictable in the past.

The world does hold huge reserves of non-conventional oil that will be exploited when the scarcity of conventional reserves pushes the price of a barrel above $30 for long periods.

When making long-term predictions, analysts have to balance the capacity, or production, of a field against the size of its reserves and the onset of 'oil field

OIL: decline'. If, as some maintain, global production will plateau in around 2005 and we continue to increase our global demand as predicted, there is a strong likelihood of considerable volatility in oil prices in the future, as happened in the 1970s. No one is brave enough to stake their reputations on what oil will cost in 5, 10, 15 or 20 years but pundits suggest that by around 2015 global natural decline in conventional oil production will be noticeable, and may be considerable after around 2020. These declines can be compensated for by developments in non-conventional oil production but at a high cost to the consumer. One worry is that old oil fields in areas such as the Middle East and Venezuela are already showing signs of fatigue and may not yield their full potential of reserves. A rough figure given is that we may have around 40 years left of conventional oil reserves.

As Bartsch and Muller (2000) state in their recent book *Fossil Fuels in a Changing Climate*, 'It is not that we will not have enough oil to take us to 2020 but that the road is likely to be bumpy and subject to a number of economic and political shocks'.

GAS: reserves of natural gas are abundant and current estimates suggest that stocks could last for 65 years at current rates of consumption. Some countries rely on gas for over half of all the primary energy they use and the biggest increase in demand is for gas-powered electricity stations. Gas is a cleaner fuel for the generation of electricity than coal or oil and results in less CO_2 emissions per unit of delivered energy generated because gas-fired power stations are more efficient.

Two interesting characteristics of gas are that:

1 it is difficult to move over long distances without leakage and
2 most of it is located in countries where demand for it is lower.
For instance, in Europe there are around 3.2 trillion (3.2 3 1012) cubic metres of proven reserves of natural gas and the Europeans are consuming around 0.38 trillion cubic metres per year, which gives us at this rate just under 10 years of gas left in Europe. However, more reserves may be found. In the USA the situ-ation is more difficult with around 3.2 trillion cubic metres proven reserves left and 0.686 trillion tonnes being consumed a year. At this rate the USA has around 5 years of reserves of their own natural gas left. However, such countries are very aware of the limitations of their own reserves and import large quantities of cheap gas now, with a view to conserving their own stocks for the future. For example if the USA imports three-quarters of the gas they use every year at current rates their own stocks could last for 20 years.

Fortunately there are abundant reserves in other areas of the world of which 77 per cent are in the Middle East (39 per cent) and North Africa (38 per cent). It is estimated that globally there are reserves that will support demand for gas for the next 60 years at least. However, as local reserves of gas are depleted and countries have to buy more and more of their stocks from the global market they will have to pay the global market price. The rate of uptake of cleaner gas technologies, used to reduce CO_2 emissions, for instance, from power stations, will be influenced by the cost of gas, which will increasingly be dictated by the highest bidders. Prices will eventually rise significantly in countries where the fuel is now very cheap, such as the USA, but obviously will be less affected in countries such as Denmark where fuel prices have been kept high and energy efficiency is widely practised. The USA now consumes around 27 per cent of the world's gas (with 4 per cent of the world population) and is responsible for about 23 per cent per year of global gas production.

COAL: the main problem with coal is that it is a dirty fuel and contributes 38 per cent of CO_2 emissions from commercial fuels and is also a major source of sulphur dioxide and nitrous oxides emissions, as well as particulates and other emissions. Coal currently provides only 26 per cent of the world's primary energy consumption, very much less than in 1950 when this figure was 59 per cent. There are abundant reserves of coal in the ground estimated to be capable of lasting over 200 years. Over 50 per cent of the reserves are in the USA, China and Russia. The coal industry does have the additional problems of poor working conditions in some mines and the high costs of transport for the fuel. In France it is expected that all mines will be closed by 2005.

The costs of producing coal vary significantly. Internationally traded coal ranges in delivered price to the European Union (EU) of between US$30 and US$55 per tonne, which in terms of fuel oil is roughly equivalent to US$45–75 per tonne. This compares with the average spot price of fuel oil delivered to northwest Europe in 1997 of US$90–95 per tonne and between US$65 and US$70 per tonne in the first half of 1998. This indicates that coal is very competitively priced against oil but it does have a high environmental impact compared with fuel oil (medium impact) and gas turbines and natural gas combined-cycle power plants (low impact), which will limit its wider use globally in the future for environmental reasons.

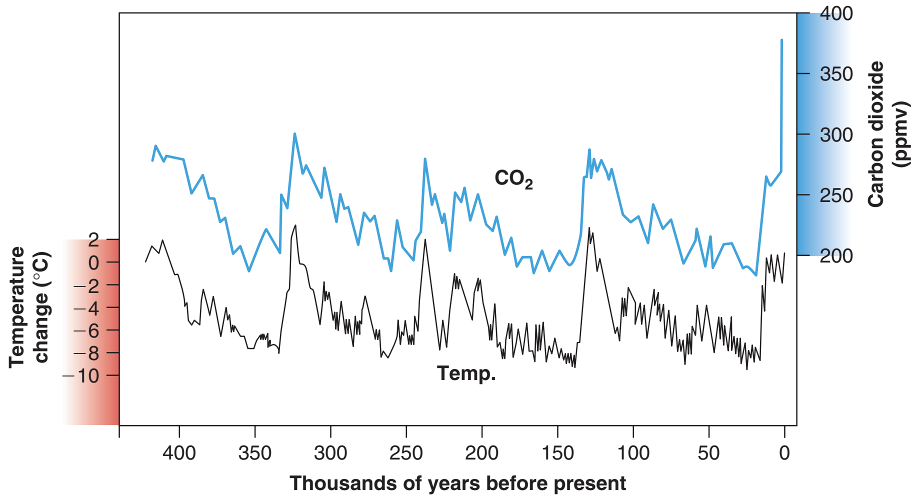
The oil crisis of the 1970s resulted in the rise of the solar house movement: homes built to use clean renewable energy from the sun. One such house can be seen in the case study in Tokyo. Such houses used passive solar and solar hot water systems with rock bed and ground storage systems to store heat between the seasons, and provided the foundations on which were developed the blueprints for the ecohouses of the twenty-first century.

In the 1980s came the next big shock – climate change. It was then that the rates of depletion in the ozone layer and the increase in greenhouse gases and global warming became apparent. The predictions made by the Intergovernmental Panel on Climate Change in 1990 have been borne out by the steadily increasing global temperatures over the 1990s, the hottest decade on record.

Just as people dismiss the fossil fuel depletion claims by saying that 'they were wrong in the 1970s about oil, you see we have not run out yet', so climate change predictions are simplistically rebuffed with phrases such as 'the climate of the world has always changed'. It is obvious from Figure 2 that this is indeed correct, but what is deeply worrying is the revealed rate and scale of change that is now happening.

The main greenhouse gas is CO_2 and the main source of CO_2 (ca. 50 per cent of all man-made emissions) is buildings. If we continue to produce greenhouse gases at current rates of increase in a 'business-as-usual fashion', predictions by the UK Meteorological Office indicate impacts will be substantial and by 2080 will include:

- a rise in global average temperatures of 3°C over the 1961–1990 average by 2080;
- substantial dieback of tropical forests and grasslands with resulting loss of CO_2 sink;
- substantial overall decreases in rainfall amounts in Australia, India, southern

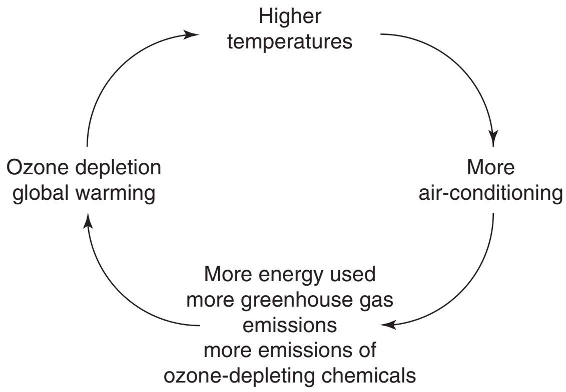


2
The correlation between historic carbon emissions and global temperature (Woods Hole Institute).

Africa and most of South America, Europe and the Middle East. Increases will be seen in North America, Asia (particularly central Asia) and central eastern Africa;

- an increase in cereal yields at high and mid-latitudes such as North America, China, Argentina and much of Europe. At the same time cereal yields in Africa, the Middle East and particularly India will decrease, leading to increases in the risk of famine in some regions;
- sea levels will be about 40 cm higher than present with an estimated increase in the annual number of people flooded from approximately 13 million today to 94 million in 2080. Of this increase 60 per cent will be in southern Asia, from Pakistan through India, Sri Lanka, Bangladesh and Burma and 20 per cent in Southeast Asia from Thailand, Vietnam, Indonesia and the Philippines. Under all scenarios sea level rises will affect coastal wetlands, low-lying islands and coastal lowlands;
- health impacts will be widespread and diverse. By the 2080s an estimated 290 million more people will be at risk from malaria, with the greatest risk in China and central Asia. Fewer people will die in winter in temperate cities and more will die in summer from heat-related problems (www.met.office.gov.uk/sec5/CR_div/CoP5/obs_pred_clim_change.html). Skin cancer rates will soar. In Queensland, where UV-B radiation is the highest, it is predicted that three out of every four people will get skin cancer. In America, in 1935 the chances of getting skin cancer were 1 in 1500, in 2000 the chances are 1 in 75 (www.geocities.com/Rainforest/Vines/4030/impacts. html).

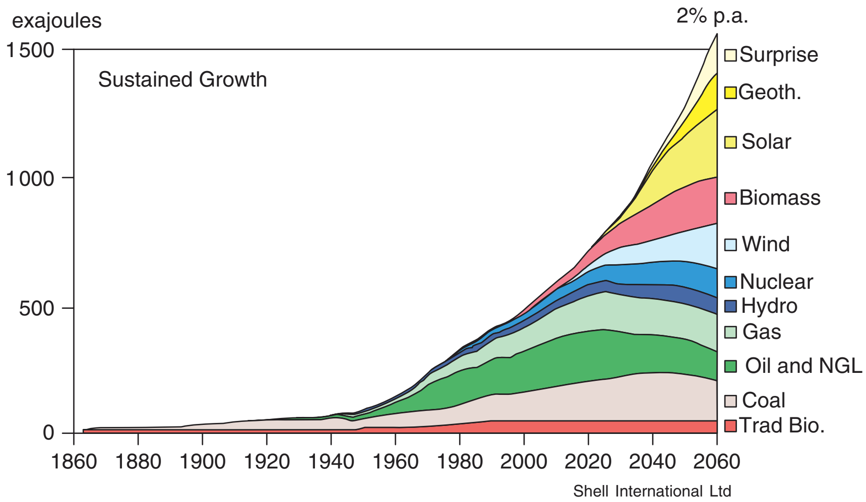
There are so many related impacts of greenhouse gas emissions that we only touch on them here. Yet we see them illustrated daily in newspaper art-icles on the extinction of species, the increase in number and intensity of floods and cyclones, water shortages and the starvation that results from droughts. What is certain is that we must act now to reduce CO_2 emissions globally and that one of the most effective sectors from which to achieve rapid reductions in emissions is buildings. Houses consume around half of all the energy used in buildings.



A recent Report by the Commission on Environmental Pollution in the UK states that if we are to begin to attempt to stabilise climate change we will have to introduce cuts in all CO_2 emissions of around 60 per cent. This means using 60 per cent less energy to run the home (http://www.rcep.org.uk/). This is actually not too difficult, as demonstrated in many ecohouses. For instance, the Oxford Ecohouse emits around 140 kg CO_2 per year while other, similar sized, houses in Oxford will produce around 6500 kg CO_2 per year. This is because the Oxford Ecohouse is run largely using renewable solar energy. This demonstrates how important solar technologies are for the 'Low Carbon Lifestyle'.

But what is the typical architectural response to the challenge of global warming? It is not to make the building do more of the work in providing better shelter against climate change, nor to use solar technologies, but to install air-conditioning, which is a key element in the vicious circle that is creating global warming.

Air-conditioning systems represent the greatest source of climate change gases of any single technology. In the USA, which has only 4 per cent of the world's population and yet produces around 25 per cent of the global CO_2 annually, over 40 per cent of electricity generated is used in air-conditioning systems. Energy efficiency is absolutely not an issue, in general, with the US architectural profession. Indeed, climate change is not an issue in the majority of architectural offices around the world who have systematically, over the last 30 years, shut the indoor climate off from the outdoor climate, so requiring air-conditioning to make the building habitable. Air-conditioning engineers have traditionally made their profits by putting as much plant as possible into a building. It is not uncommon for heating and ventilating engineers to insist on having fixed windows throughout a building, not least because the calculations for system performance are too difficult if an open-window scenario is adopted. So, many buildings have to be air-conditioned all year round while perhaps for only one, two or three months is the external climate uncomfortably hot or cold. In addition, many 'fashionable' architect-designed buildings contain excessive glass, overheat, create extreme indoor discomfort and can only be saved from becoming hellish environments by huge amounts of air-conditioning plant. When sensible engineers suggest that perhaps the building would be better without, for instance, the glass roof, architects have been heard to retort that engineers cannot understand great design ideas and they



3
A Shell prediction graph developed in the early 1990s on a 'sustained growth' scen-ario. It shows the gradual drop-off in fossil fuel supply, the increasing demand for energy and the growth of the renewable energy sector (Shell, UK Ltd, with thanks to Roger Booth).

should do what they are paid to do and not express opinions about the building's aesthetics.

The world needs a new profession of ecotects, or archi-neers or engi-tects, who can design passive buildings that use minimal energy and that what energy they do use comes from renewable sources if possible. It is the only way forward.

The scenario for future global energy consumption developed in the early 1990s by the Shell oil company demonstrates this well. Figure 3 shows how the demand for energy continues to grow exponentially while conventional fuel sources such as oil and gas begin to show significant reductions in output. The gap is filled by renewable energies such as wind and photovoltaic (PV, solar electric) energy. It was on the strength of such predictions that Shell and BP have invested huge amounts of money in the development of PV production and distribution companies.

By the decisions we make on the drawing boards in our comfortable offices the global environment is changed. The world is warming and the ozone layer thinning. Some time in the not too distant future building designers will be made to take into account their own global environmental responsibilities. This will be done through building regulations, fuel price increases and carbon taxes. The sooner we start to change architecture, from an appearance-driven process to a performance-driven art, the better prepared we will be to lay the building foundations of the post-fossil fuel age. The best place to start learning is with an ecohouse.

We have tried to bring together 'How to' information on key issues not well covered in other books. This includes developing technologies, thermal mass, ventilation, cold bridging, materials issues, passive solar design, photovoltaics, cyclone design and grey water systems. The book is not a comprehensive guide to all aspects of low-energy or ecological building. Many subjects have been very well covered in other books; for example, passive solar design (Mazria, 1979; Yannas, 1994), low-energy house design in the UK (Vale and Vale, 2000), materials (Borer and Harris, 1998; Berge, 2000) and timber-frame houses (Pitts, 1989, 2000; Talbott, 1993). We also think that house buyers can choose many elements for their house pragmatically, with a little help from their local building supplies store. For instance, what is the best glass for their windows, based on what is locally available, compared performance data and what they can afford.

We do incorporate the wisdom learnt from ecohouses around the world in the case studies. These are not ordinary houses. The majority are built by architects for themselves and often by themselves, not for clients. They express, in their varied forms, the local climates, resources, culture and the tastes of their designers, as well as the design ethos of the times in which they were built.

The temptation to 'innovate' can often lead us unwittingly into problems, but from them we learn. For example, the early solar houses often overheated because, in the rush to utilise free, clean solar energy, the dangers of the sun were underestimated. The best modern buildings do have excellent solar control and yet it is astounding to see how many still employ glass roofs and walls that not only can cause severe discomfort to people inside but also can result in huge bills for compensatory cooling systems. Some people never seem to learn. Clients should avoid such designers.

Today photovoltaics are already cost-effective in virtually all countries for off-grid systems. In far-sighted countries, such as Japan and Germany, there are already over 10000 installed domestic PV systems in use. In Britain (where £900000000 was spent on the Millennium dome at Greenwich) there are about ten installed grid-connected PV systems on houses. To adapt an old Yorkshire expression, some people are 'all front parlour and no Sunday lunch' when it comes to sustainability and sensibly investing in the future for our children.

It is incredible to note that in many parts of the world including Britain, the challenges of trying to reduce the catastrophic impacts of buildings on the environment are still left to individuals. The challenges ahead seem so enormous that it is difficult to see what we, as individuals, can do. But it was Confucius who said that if each person solved the small problems over which they have control then the larger problems would disappear.

Why are such important issues as the impacts of climate change and fossil fuel depletion ignored by politicians when our species is so obviously at an ecological watershed? We are only one species on the planet, yet we are multiplying exponentially; every day we destroy other species and their ecological niches and, in many parts of the world, we are even destroying our own peoples and their habitats. This was historically demonstrated on Easter Island where the population destroyed all the trees on the island and had to flee to survive, or die. This is happening around us today. Will it be obvious to us that we are the cause, when the first of the Small Islands disappear altogether when sea level rises? Will we register that fact?

Species can adopt symbiotic, parasitic or predatory lifestyles, and they can also literally commit community suicide. There is potentially much to be learnt about how we can develop through the study of ecology, by comparing our behaviour with that of other species on the planet.

ECOLOGY is defined as the study of the interactions of organisms and their physical and biological environment. Organisms have the ability to control the movement of energy and material between their internal and external environments. They adapt in order to use the water, energy, heat, light and resources available in different environments and climates to sustain life in the multiplicity of ecosystems on the planet.

Competition between species is a driving force that can lead to evolutionary divergence between species, to elimination of species and also, more positively, to a co-evolution and the development of mutually supportive relationships. Evolution requires adaptation, not only to adjust to the changing circumstances of climate and environment, but also to changing populations and resources.

The theory of evolutionary ecology begins with Charles Darwin in the late nineteenth century. He regarded the environment as the key agent of 'selective mortality' without mentioning the relationship of birth rate to the survival of species. In 1930 Ronald Fisher's classic book *The Genetical Theory of Natural Selection*, dealt with the importance of population growth rates but this subject was largely marginalised until 1966 when the theory of the 'life histories' of popu-lations became popular. This theory states that adaptation is largely the making of compromises in the allocation of time and energy to competing demands. It introduced the idea that very different 'life history' adaptations are favoured under conditions of high and low population densities in relation to the carrying capacity of the environment. At high densities, selection favours adaptations that enable populations to survive and reproduce with few resources and hence demands 'efficiency' in the way resources are used. At low densities, adaptations promoting rapid population increases are favoured, regardless of efficiency. Natural selection adjusts the amount of time and resources expended not only in accordance with changes in the environment but also with the life history of a population.

So how would this affect us? In times of ecological threat animal species respond in a variety of ways, from becoming spiteful to being altruistic. Ecologists would perhaps expect selfish behaviour to prevail to the exclusion of altruism because it is the selfish behaviours that increase the reproduct-ive success of the dominant species or individual.

Growth, however, is a survival strategy for species with a life history at a low-density phase. At high densities, populations must employ strategies of efficiency to survive. Human beings are unique in the history of the world because of the sheer scale of the impacts we have had on the global environment and in particular on the Earth's atmosphere, and our ability to comprehend, and alter, them.

If we are to survive the challenges ahead of us in the twenty-first century, with some semblance of normality retained, we will have to effect fairly radical changes in what we, as individuals, expect from the infrastructures of our own ecological niches, our houses and settlements, and society. To do this we will have to behave fairly altruistically, not only towards our own families, friends and neighbours but also to the larger family of our fellow human beings. Altruism is not unknown when bonds of loyalty are stretched to encompass larger and larger groups. Humans seldom question that, in times of war, they are asked to die for their country. This they do ultimately to protect their families, through whom their genes are perpetuated.

When faced with the twenty-first century challenges it is the global nature of human being's environmental impacts that make it imperative to see our kin as all the people of the world. If not, few of us will survive. There are no safe islands in the twenty-first century. Europe knows that if the countries of northern Africa suffer from repeated severe droughts it is to Europe that the ravaged populations of these regions will flee. The same is true of America, Mexico and Latin America. The history of humans is one of diasporas, the dispersions of peoples. If there are more people and fewer resources, such movements will surely affect each of our everyday lives?

Buildings are only part of our habitat. Buildings are intimately linked to the local, regional and global environments that are all part of our 'Ecological Niche'. It is the responsibility of our generation to begin to adapt our buildings to ensure that we can stabilise climate change, that we can live without fossil fuels and that we do not unsustainably pollute the environment. Only by so doing can we ensure the survival of our own habitats.

This cannot be so difficult because people survived on the planet for millennia without the miracle fuels of oil and gas. Traditional buildings have much to teach us about how to design regionally appropriate structures.

We can change fast enough. We can mix the wisdom of the master builders, new knowledge, materials and renewable technologies to create ecobuildings, the New Vernacular, to minimise the environmental impacts of buildings. We can now measure those impacts with the new methodologies for counting the envir-onmental costs of buildings. We do need a new type of designer, part architect, part engineer, and to get rid of heating and cooling machines where possible or power them with renewable energy. What you will read in the first section of the book shows that all of this is possible and, in the second section, that it is already being done in many of the case study ecohouses from around the world.

Sue Roaf

August 2000