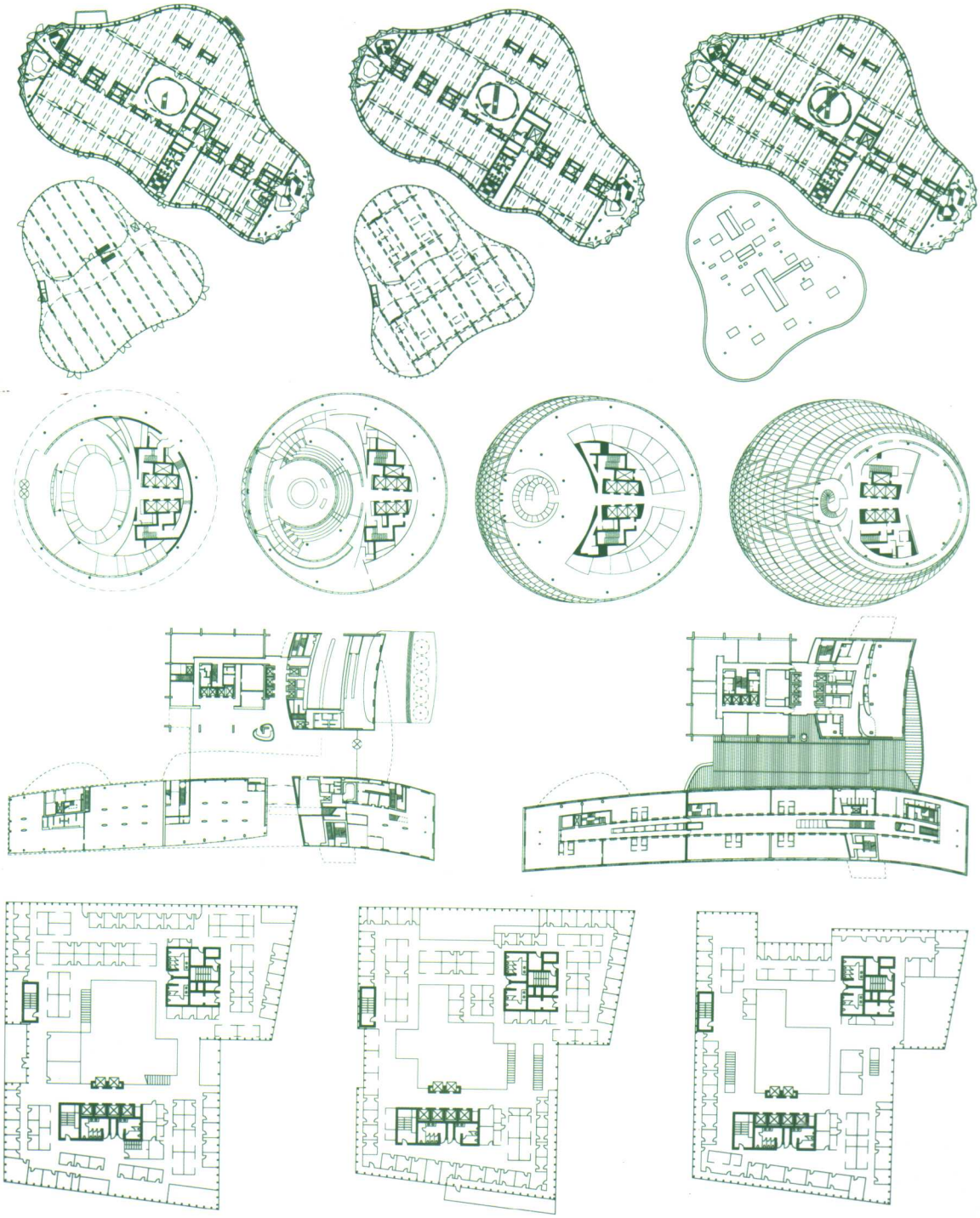
可持续建筑设计实践
DESIGN FOR SUSTAINABILITY

纪雁／（英）斯泰里奥斯·普莱尼奥斯 编著　Edited by Yan Ji and Stellios Plainiotis



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可持续建筑设计实践

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建筑历史的演化、建筑技术的进步在一定程度上也是人类为改善生存条件对自然进行改造的持续不断的过程。现代科学技术与现代工业的发展为这种改造提供了更多的信息和手段，使人类可以建造完全独立于自然系统之外，不受自然规律干扰的舒适的建筑内部环境。但人工化的舒适通常依赖于空调、照明和通风等高能耗设施，且舒适性的提高又往往以能耗的增加为前提，这种发展模式带来了当前全球性的环境和能源危机：大量的废气排放、温室效应、气候变异、资源枯竭，进而威胁到人类自身的生存与安全。环境问题已经成为21世纪全球关注的焦点之一。

随着全球经济的持续发展、发展中国家的快速城市化进程、城市居民生活水平的不断上升以及对室内舒适度的更高要求，建筑耗能占全社会能源消费量的比重还将继续保持上升，每年由于新建和改建建筑，消耗大量林木、砖石和矿物材料，消耗大量能源，带来土地的侵蚀、植被的退化、物种的减少和自然环境的恶化。同时建设中还存在土地资源利用率低、水污染严重、建筑耗材高等问题。如何处理人与自然的关系，实现可持续发展是本世纪人类所面对的巨大挑战。

设计和建造可持续的建筑已逐渐成为当今建筑界的一个重要潮流。出现了越来越多的以可持续设计为核心竞争力的建筑事务所，以往的著名建筑师和事务所也向可持续方向转型，一些已经成为这一设计领域的领军人物，如福斯特、霍普金斯、罗杰斯、班尼士－班尼士及合伙人事务所等。高水准的建筑设计水平、可持续设计的理念以及与之相对应的技术手段成为作品赢得声誉的三个主要方面，如罗杰斯的劳埃德船级社总部大厦、班尼士－班尼士及合伙人事务所的GENZYME中心等。因此，在建筑设计领域，评价一个作品不再只求建筑外表好看而已，是否对能源和环境进行关注将越来越成为赢得项目的关键所在。

欧洲的可持续建筑设计水平居于世界领先地位，这不仅得益于国家性强制法规的日益严格与完善，针对可持续技术的专门研究机构研究成果日益成熟，建设行业高度产业化的支持，同时也是教育科研机构非常重视和支持可持续发展，加上许多非营利的民间组织积极向公众普及和推广环保节能概念的成果。欧洲最早看到了技术和工业的消极面，可持续发展的概念在欧洲已经延伸至考虑平衡的问题，正在寻求有利于大自然，与自然和谐共存的理念和技术。

我国自上世纪80年代至90年代末的近20年间经历了以经济发展为重心的快速建设时期，进入21世纪以来，可持续发展，即科学发展观的新理念正迅速成为中国未来发展和建设的主导思路。在建筑领域，国家宏观的建筑节能政策、各个城市和部门制定的新的相关节能管理条例；国内主要建筑设计院所正积极转变思路，开始环保节能建筑的设计尝试；建筑专业教育机构也开始把建筑节能设计作为学科发展的重要突破点之一。自本世纪以来，一系列有关绿色环境和可持续发展的国际研讨会也在许多城市举行，节约能源、环境保护和可持续发展的意识正在深入社会生活。目前一些范例性的节能建筑已经完成，如清华大学的超低能耗示范楼、上海建科院建筑环境研究中心办公楼等将成为节能设计的范例。这些都预示了中国可持续设计时代的到来。

基于以上情况和思考，纪雁和斯泰里奥斯·普莱尼奥斯编纂了这本当前国际著名设计机构近期的重要

案例。纪雁在伦敦大学学院获得可持续设计方向的硕士学位，并在美国从事建筑设计实践，是获得美国绿色建筑协会LEED认证的建筑师，同时也具有国内的设计经验；斯泰里奥斯·普莱尼奥斯在英国格林威治大学获得博士学位，专门从事环境模拟方向的研究工作，是一位在环境科学领域活跃的年轻学者。这本书介绍了在建筑设计中引入可持续设计的一些基本原则与方法，通过对21个可持续建筑案例的介绍与分析，展示了国外建筑设计机构、设计师和工程师对可持续建筑的理解与取向，以及他们如何采用适用于特定环境的可持续设计的方法——从对自然环境简单的被动式利用到综合各种高科技成果的系统性设计，在兼顾建筑美学和内部空间的同时最大限度地合理利用多种自然和环境资源，创造富有创意的可持续建筑。同时，本书也介绍了近年来中国当前对节能与生态型建筑的探索性试验。

从本书所选的案例中，也可以看出，在推广和宣传可持续设计中有三点是值得注意的：

一是可持续设计具有较高的技术含量，但这并不意味着运用的技术越多越好，越高科技越好，而运用得当才是关键。本书所展示的可持续设计的实践项目并不是为了提供模仿的样板。对可持续建筑而言，环境的特殊性对设计项目起到决定性作用，尤其对中国而言，幅员辽阔所造成的多样性的气候条件和地理环境为设计师开发利用自然资源提供了很好的创作机会，应该在设计过程中否定对机械系统的依赖性，用尊重环境的设计逻辑和多学科的累积经验为改善建筑质量不断寻找独特和创新的设计手法，在设计的过程去重新发现自然的质量，重拾对光、太阳和风的感知。

二是要注意技术性与传统的设计美学和设计逻辑的合理结合，应避免片面强调技术性，而出现以牺牲建筑设计品质为基础的可持续建筑。技术是重要的，但不是本质性的东西，对建筑师而言，建筑永远是设计的本体，而可持续设计是将可持续发展的理念转化成一种可操作的具体的设计策略。

三是可持续设计不是建筑设计的附加或补充物，而是和建筑设计相融合的整合设计的过程，这需要业主、建筑师和各个专业的工程师从选址、方案构思到项目实施全过程的紧密合作，只有这样才能有效发挥可持续建筑的社会和经济效益。

自哥白尼以来，人类知道自己并不是宇宙的中心，渴望未来的人类也不会在瞬间过渡到未来，未来需要我们用不懈的努力和执着来实现。在全球化时代，可持续发展的核心是人类的生态伦理和社会伦理，人类要与养育人类的地球共同进化，实现共生。人类要尊重地球，要以控制自身发展的方式，以控制全球范围的社会组织和生产组织的方式尊重地球。法国科学家克洛德·阿莱格尔在《城市生态，乡村生态》一书的结尾中写道："人类自从在非洲森林旁边出现以来就为了生存而与自然搏斗。人类从大自然中'盗取'了火、挖走了金属；人类改造了它的土壤、整治了它的空地、开采了它的地下矿藏、污染了它的大气。现在人类必须明白，开采时代结束了，展现出来的是一个管理与保护的时代。对抗的年代过去了，展现出来的是和睦的年代。"本书的目的就是实现和睦的时代。

2006年6月21日

Foreword

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To some extent, the evolution of the architectural history and the advancement of the architectural technologies are also the continuous process in which human beings struggle to alter the nature for better living conditions. The development of modern science, technology and industry has provided this alteration with more information and means, making it possible to build comfort internal environment inside the architecture completely independent of the natural system, without any disturbance from the nature's law. However, the artificial cosiness often depends upon facilities that consume plenty of energy, such as air conditioning, illumination and ventilation, etc. the energy consumptions increasing with the improvement in cosiness. This kind of development mode has eventually brought forth the global environmental and energy crisis at present: substantive exhaust emission, greenhouse effect, climate variation, resource exhaustion, all of which have posed threats to the survival and security of human beings. Environmental issues have become one of the global focuses in the 21st century.

Along with the continuous development of global economy, rapid urbanization process in developing countries, constantly improving living standards of city dwellers as well as the higher and higher requirement for indoor cosiness, the proportion of architecture consumed energy in the consumption of the entire society will continue to rise. Every year, a great volume of energy together with a great number of woods, bricks and minerals have been spent on the new buildings and rebuilt ones, leading to soil erosion, vegetation degeneration, species decrease and environmental deterioration. Meanwhile, issues like low land resource utilization, severe water pollution and high building material usage, etc. exist in the process of construction. How to deal with the relationship between human and nature and realize sustainable development, this is a huge challenge facing human beings in this century.

Designing and building sustainable architecture have gradually become one of main streams in today's architectural design. More and more architecture firms have emerged with the sustainable design capacity as their core competition strength. Reputed architects and firms of the past have also redirected toward sustainability, some of which have become the leaders in this sphere, including Norman Foster, Michael Hopkins, Richard Rogers, Behnisch, Behnisch & Partner, etc. Three major respects with which the work has won its fame are first-class architectural design quality, sustainable design concept and the corresponding technical approaches. The Lloyd's Register of Shipping by Rogers and the Genzyme Centre by Behnisch, Behnisch & Partner are fine examples. Hence, in the field of architectural design, good outlooks are no longer the evaluation standard, the keys have shifted increasingly to the attention on energy and environment.

Europe is leading the world in sustainable architectural design, thanks to the increasing strictness and completeness of the mandatory regulations at the national level. In addition, The recent research achievements of specialised research institutes on sustainable design is approaching maturity day after day, efforts have been made to support high degree of industrialization; educational and research institutes have attached great importance and offered generous supports to sustainable development; as well as many non-profit civil organizations have proactively promoted and publicized the concept of environmental protection and energy saving in the public. As the first continent which has seen the side effects of technology and industry, Europe is now pondering over the issue of balance, which is the extension of the sustainable development concept, seeking a kind of concept and technology that is beneficial to the nature and allows balanced coexistence with the nature.

Over almost two decades from 1980s to the end of 1990s, our country has experienced a period of rapid construction with the focus on economic development. Since we crossed the threshold of 21st century, the new concept of sustainable development, or the scientific development approach, is rapidly shaping the dominant way of thinking in China's development and construction for the future. In view of architecture, the state has formulated macro policies on architectural energy saving, based on which various cities and sectors have made regulations on energy saving management respectively. Major domestic architectural design institutes are working proactively for a shift in the way of thinking, beginning with new attempts on the design of architectures featuring environmental protection and energy saving. Education institutions specialised in architecture have also started to make architecture energy saving design as one of the important breakthrough points in the discipline development. Since this century, a series of international symposiums on green environment and sustainable development have been held in many cities. The awareness of energy saving, environmental protection and sustainable development is going deep into the social life. By far some model architectures featuring energy saving have been completed, such as the Demonstration building with ultra-low energy consumption in Tsinghua University, the SRIBS Eco-Office & Laboratory Building, etc. All of this has indicated the arrival of the sustainable design era in China.

Based on the above mentioned circumstances and contemplation, Yan Ji and Dr.stellios Plainiotis have compiled this book of recently important cases by famous international design institutes. Yan Ji has acquired her master's degree in the direction of sustainable development in the University College London, and is engaged in the architectural design practice in U.S. She is a LEED accredited professional by USGBC, also having considerable domestic design experience. Dr.Stellios Plainiotis is a Researcher Environmental Scientist, with postgraduate degrees in sustainable architecture and virtual environments from the University College London and Ph.D. in Air Pollution Dispersion Modelling from the University of Greenwich, London, UK. This book has explained some basic principles and methods of introducing sustainable design into architectural design. With referral to and analysis of 21 cases on sustainable development, it represents the understanding and choice of foreign architecture design firms, designers and engineers on sustainable architecture, as well as how they adopt the environment-specific approach of sustainable development - from simple and passive utilization of nature to systematic design, taking comprehensive consideration of various hi-tech means, optimise the reasonable utilization of a multitude of natural and environmental resources while taking the aesthetics and internal space into account, so as to create the innovative and sustainable architecture. Meanwhile, this book also briefed on China's explorative experiments on energy saving and ecological architecture in recent years.

From the selected cases in this book, we can also conclude three noticeable points in the promotion and publicity of sustainable design:

First, sustainable design has high technological contents, but this doesn't mean "the more and higher technologies to use the better", rather, appropriate utilization is the key. The sustainable design projects demonstrated in this book are not intended to serve as examples for imitation. As far as sustainable architecture is concerned, the particularity of environment plays the determinant role in the project design. Especially for China, the variety of climate conditions and geographic environments existing on the vast territory has provided excellent opportunities for designers to create by exploring and utilizing the natural resources. In the design process, the dependence on mechanical system should be avoided. Unique and innovative design techniques shall be constantly explored with the design logic of respecting environment and the accumulated experiences of various disciplines to improve the construction quality, to rediscover the quality of nature and to refocus on the perception of the light, the sun and the wind.

Then, attention should be paid to the reasonable integration of technology with traditional design aesthetics and logic, avoiding the unilateral emphasis on technology, which would result in the so called sustainable architecture at the expense of the architectural design quality. Technology is important, though not essential. As for as architects are concerned, the architecture is always the main body of design, while sustainable design will convert the sustainable development concept into an applicable and detailed design strategy.

Finally, sustainable design is not the attachment or supplement of architectural design, but an integrated design process with the architectural design. This requires close cooperation of the landlord, the architects and engineers of each specialty in the whole process from site selection, scheme formation to the project implementation. Only in this way can the social and economic benefits of sustainable architecture be brought into full play.

As has been realized since the time of Copernicus, humans are not at the centre of the universe. Nor can they transit into the future in the blink of an eye, no matter how much they long for it. The future remains to be created with unremitting efforts and perseverance. In the era of globalisation, sustainable development should be based on ecological and sociological ethics, in which humans evolve and develop in harmony with the earth that feeds them. Humans should pay respect to the earth, by way of controlling their own development as well as the social and production organizations worldwide. As French scientist Claude Allègre pointed out at the end of his book, *Ecologie des villes, écologie des champs*, human beings must be aware of the fact that the era of contending with nature has gone when humans survive by struggling against the nature: to reform it, to exploit it, and to pollute it. An era of harmonious coexistence is unfolding itself. And this book is aimed at the realization of the coexistence of humans and the nature.

June 21st, 2006

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可持续建筑设计的理念与方法

Sustainable Design: Concepts and Strategies

1 可持续性与建筑

建筑的主要目的之一是为居住或使用者的活动提供一个健康舒适的环境。由于现代人大部分时间都是在室内度过，室内环境质量就变得至关重要。建筑的能效、安全性、室内空气质量、热舒适度、采光和声学特性不仅影响着居住或使用者的健康，也影响着他们的生活质量和工作效率，从而影响到整个社会的经济效益。

在建筑的设计、施工和使用中引入可持续理念，不仅能从根本上改善建筑的质量，而且还有利于创建更加健康的社会、增加建筑的吸引力，并且因此而提高经济效益。

普遍使用并在国际上被接受的可持续理念是："在满足当代人日益增长的需求的同时，不会牺牲未来人类满足自己需求的能力"。利用可持续的设计方法设计的建筑可以定义为：建筑的建造和使用能够最大限度地减少对居住者健康、舒适度和工作效率等方面的影响，同时减少能耗、污染等环境影响。可持续建筑的建设场地、建筑材料、建筑设计和设备系统等都需要经过整合设计来实现最优化的经济效益和环境保护。

1.1 能源与环境

可持续建筑要求建筑在诸如能源利用方面不对环境施加不必要的负担或风险。要了解提高建筑能效的重要性，最关键的就要了解能源的作用以及能源利用对环境的影响。

能源

能源可分为可再生能源与不可再生能源。

1）可再生能源

1 Sustainability and the Buildings

One of the main purposes of buildings is to provide a healthy and comfortable shelter for the occupants' activities. As people today spend most of their time indoors, aspects such as energy efficiency, safety, quality of indoors air, thermal comfort, lighting, and acoustics of buildings, affect the occupants' health, comfort and productivity, and the financial efficiency of societies.

Buildings designed for sustainability can be defined as those buildings that are constructed and operated in such a way that have their overall negative impact on the occupants (in terms of health, comfort and productivity) and on the environment (energy use, pollution) minimised.

The site, the construction materials, the design and the systems of sustainable buildings are integrated in such a way that they optimise the performance in an economically profitable and environmentally friendly model of development, while enhancing the occupants' health, comfort and productivity.

1.1 Energy and the environment

Sustainable development concepts applied to the built environment suggest that buildings should not cause unnecessary load or risk to the environment, for example in the form of energy use. Understanding the role of energy sources and the impacts of their use on the environment is critical for understanding the need of energy efficiency in buildings.

Modern civilisation has been based on man's increasingly effective harnessing of energy resources. Energy sources can be divided into sustainable (renewable) and non-sustainable (non-renewable). Since the middle of the last century, there has been an excessive increase in the global demand for energy, as a result of global population growth and industrial development. The utilisation of fossil fuels such as oil, natural gas, and coal has powered the industrial development and most of the transportation needs of the

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可再生能源也称作可持续能源，是不破坏自然资源的能源，包括太阳能、风能、地热能、水能和生物质能等。

太阳能直到近几年才被机械系统作为直接的能源供给方式，然而被动式太阳能技术在建筑上的应用却已有悠久的历史。如今，太阳能能够被直接用于采暖和采光，或者通过太阳能光电板，一种含有大面积p-n结二极管的半导体设备，将光能转化为电能。

地热能是来自地球深处的可再生能源，它起源于地球的熔融岩浆和放射性物质的衰变，能够用来产生电力或热能。

2）不可再生能源——化石燃料

虽然能源消耗的增加通常是一个国家发展的主要指标或是生活质量提高的标志，但我们对化石燃料的依赖也带来了许多问题。随着全球能耗的持续增长，不仅化石燃料的供应会最终枯竭，并已造成了众多的经济和社会问题，包括全球气候变暖和空气污染；化石燃料的开采和运输对土地造成破坏；酸雨造成环境恶化；水质污染以及对国外能源的日益依赖造成国家安全成本的增加等。

大量的化石燃料从地下采出或泵出，然后进行加工、输送和储存。这些化石燃料一旦从储藏地采出，环境影响就出现了。煤矿开采改变了地形地貌，引起水土流失，造成酸性水蔓延；勘探和钻探石油可能会扰动地层，破坏海洋水生环境；燃料的运输也会影响环境，如石油泄漏等。

气候变化与京都议定书

1896年，瑞典科学家Svante Arrhenius最先发现，人类活动加重了温室效应。传统的化石燃料燃烧发电排放出大量的人为温室气体(GHG)。温室气体就如同温室的玻璃，能够吸收红外线并在大气层积聚热量。大气层中温室气体的累积引起全球平均温度升高，从而扰乱

industrialised countries.

Energy

1) Sustainable energy

Sustainable Energy Sources (SES), also called Renewable Energy Sources (RES) are sustainable means of energy as they don't deplete natural resources. Sustainable energy sources include solar power, wind energy, geothermal energy, hydro (water) energy and biomass. SES capture their energy from existing on-going flows of energy such as wind, sunshine, flowing water, biological processes, and geothermal heat flows.

Solar power as a direct energy source has not been used in mechanical systems until recent human history. However, it has been passively used for many centuries as an energy source through architecture. Today, solar power can be directly captured for heating and daylighting or can be converted into electricity by photovoltaic cell systems (panels). A photovoltaic cell is a semiconductor device consisting of a large-area p-n junction diode, which in the presence of sunlight generates electrical energy.

Geothermal energy derives from radioactive decay in the core of the planet. It can be used to generate electricity or to produce heat.

2) Fossil fuels

Although excessive use of energy is usually a primary indicator of a country's development or a higher quality of life, a number of problems are attributed to our reliance on fossil fuels. As global energy use continues to expand, it becomes more and more apparent that not only the supply of fossil fuels has a finite end, but also that they cause economic and social difficulties. These include global warming, human health problems caused by air pollution, damage to land from mining and transportation of fossil fuels, environmental degradation caused by acid rain, water pollution and national security costs such as dependency to foreign energy sources.

Fuels are mined or pumped from the ground, refined, transported and stored. Environmental impact occurs since the process of removing fossil fuels from their source. Exploring and drilling for oil may disturb land and ocean habitats,

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1. 可再生能源是一种不破坏自然资源的可持续能源 | Renewable Energy Sources (RES) are sustainable means of energy because they don't deplete natural resources

2. 新西兰一地热发电厂的冷却塔 | Cooling tower for a geothermal power plant in New Zealand. *Photography: Allan Kilgour*

3. 尽管能源消耗是国家发展的一个指标，但是对化石燃料的依赖也带来了许多问题 | Although use of energy is an indicator of a country's development, a number of problems are attributed to our reliance on fossil fuels. *Photography: Jane M Sawyer*

4. 英国建筑研究所环境楼的垂直立面上安装了太阳能光电板，太阳能光电板由薄膜非晶硅太阳能电池制成 | Photovoltaic panels in the New Environmental Office, BRE, Watford, UK. Utilising thin film amorphous silicon cells, BRE seeks to explore issues associated with the integration of photovoltaics into vertical walling. *Photography: Marina Vieira da Silva*

气候，造成海水水平面上涨，并将造成其他无法预测的后果。1997 年在日本京都举行了关于全球气候变化的国际会议，使得世界各国认识到急需采取行动减少污染和能源消耗来解决环境问题。

表 1 各行业 CO 和 NO_x 排放量，按 tg CO/ 年和 tg NO_2 / 年计

地区	气体种类	家用燃料	工业用燃料	交通运输	电力
华中	CO	12.65	3.95	6.29	0
	NO_x	0.13	0.5	0.59	0.98
	CO/NO_x	165.6	13	17.5	0
华南	CO	8.66	4.35	11.66	0
	NO_x	0.16	0.75	0.99	0.74
	CO/NO	90.1	9.54	19.29	0

资料来源：Yuxuan X. Wang、Michael B. McElroy、“亚洲的 CO 和 NO_x 排放：从低空飞行器和中国监测站测得的数据”，《地球物理研究学报》，Vol. 109，D24304，doi：10.1029/2004JD005250，2004。

1.2 可持续建筑的效益

在建筑工程中引入可持续设计原理可以带来多种效益，包括提高资源及能源利用效率、增进居住者的身心健康、增加楼宇舒适感、提高运输效率以及促进地方经济与社区发展，总体上为未来社会创建一个环境、社会和经济可持续发展的远景。

环境效益

可持续建筑可以通过选择更环保的建材，更有效地利用自然资源等手段减少建筑对环境造成的负面影响，从而带来环境效益。

社会效益

可持续建筑能够为建筑的居住或使用者以及社会带来多种效益，

whilst coal mining modifies landscapes, creates erosion of earth and facilitates acid runoff. Enormous quantities of fossil fuels are moved every year from production areas to where they are used and their transportation also has environmental impacts such as oil spills.

Climate change and the Kyoto Protocol

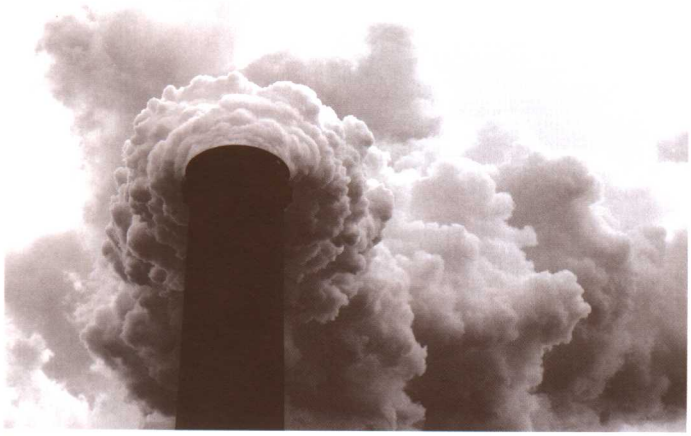
Swedish scientist Svante Arrhenius in 1896 was the first to observe that human activities contribute to the atmospheric greenhouse effect. Conventional combustion of fossil fuels for power generation contributes to a large proportion of man-made greenhouse gas (GHG) emissions. GHGs act like a greenhouse's glass, absorbing the infra-red radiation and trapping the heat in the atmosphere.

Greenhouse gases accumulated in the atmosphere result in a rise of the global average temperature which will disrupt the climate, cause seas to rise and lead to other unpredictable consequences. The International Conference on Climate Change held in 1997 in Kyoto, Japan, challenged governments to improve their national environmental performances in terms of reducing pollution and energy demand.

Table 1: CO and NO_x Emissions, in tg CO/yr and tg NO_2/yr by Sector

Region	Species	Domestic Fuel	Industry	Transport	Power
Central China	CO	12.65	3.95	6.29	0
	NO_x	0.13	0.5	0.59	0.98
	CO/NO_x	165.6	13	17.5	0
South China	CO	8.66	4.35	11.66	0
	NO_x	0.16	0.75	0.99	0.74
	CO/NO	90.1	9.54	19.29	0

Source: Yuxuan X. Wang and Michael B. McElroy, "Asian emissions of CO and NOx: Constraints from aircraft and Chinese station data", JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 109, D24304, doi:10.1029/2004JD005250, 2004.



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包括：

● 通过提供更具吸引力的生活和工作空间，提高人们的满意度和工作效率；

● 有利于居住或使用者的身心健康；

● 通过使用本地资源，支持地方经济的发展；

● 减少对进口能源的依赖；

● 通过提高资源利用效率和废物的回收利用，保护了邻里环境。

经济效益

大多数实例表明可持续建筑的初始建设造价可能较高，但是在建筑的整个使用期内，通过降低运行成本来产生较大的经济效益。运行成本的降低主要来自于能耗及维护费用的减少。

除此之外，上述的环境和社会效益对建筑营运商而言，都可以转变为经济效益。建筑使用者工作效率的提高幅度不易量化，然而，随着工资成本的上升，在节约方面的经济潜力是很明显的。即便是对员工身心健康和工作效率方面很小幅度的改善，都能为雇主节省巨额开支。

2 可持续设计的方法

2.1 环境响应型设计与建设策略

可持续建筑在设计、施工和运行过程中有多种策略与方法。最初的场地规划是确保建筑总体环境绩效的关键，诸如设计、建材、朝向、景观、地形地貌及周围植被等因素都将对建筑未来的使用与性能表现产生重大影响。设计过程中需要考虑的基本因素包括（图 8）：

● 建筑居住或使用者的健康、舒适和安全性都与室内环境条件

1.2 Benefits of sustainable building projects

Sustainable design principles incorporated into building projects can offer various benefits including resource and energy efficiency, healthier and more comfortable buildings, transportation efficiency, strengthened local economies and communities and generally an environmentally, socially and economically sustainable vision for the future.

Benefits to the environment

Sustainability concepts can minimise the overall pressure on the environment by reducing waste, pollution, dependence on virgin materials, and dependence on disposal facilities.

Occupants' and social benefits

Sustainability concepts applied to buildings can offer many social benefits including:

* Enhanced satisfaction and productivity by providing more attractive places for living and working.

* Improved health and comfort for the occupants.

* Support to local communities by using local resources that protect the local economy.

* Less dependency on foreign energy sources (e.g. the price of fossil fuels).

* Protection of the neighbourhood through efficient use of resources and recycling schemes.

Economic benefits

Although in most cases sustainable buildings involve additional construction costs, major economic benefits can be derived from reduced operating costs over the lifetime of the buildings. Such reductions include reduced energy consumption and lower maintenance costs. Additionally, each of the above described social and environmental benefits can translate into a bottom line financial benefit to the building operators. The impact of improved occupants' productivity is not easily quantifiable; however the economic potential

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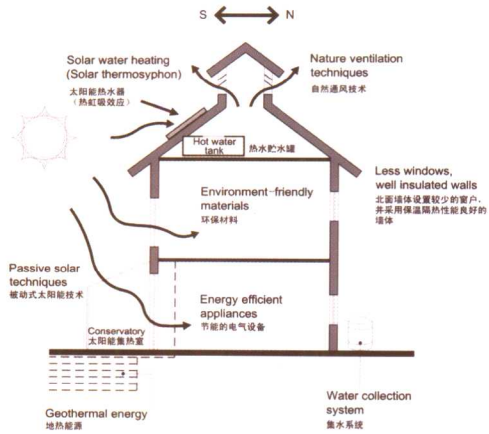

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5. 位于美国俄亥俄州一燃煤发电厂内冒着浓烟的烟囱 | Smokestack at coal burning power plant in Conesville, Ohio, USA. *Photography : Kenn W. Kiser*

6. 可持续建筑能够提供多种社会效益，如通过有效地利用资源和回收利用计划等保护社区环境 | Sustainable architecture offers various social benefits including protection of the neighbourhood through efficient use of resources and recycling schemes. *Photography: Jamie Choy*

7.由于现代人大部分时间都是在室内度过，建筑的能效以及室内环境质量等因素将会影响到居住或使用者的健康与工作效率，从而影响到整个社会的经济效益 | As people today spend most of their time inside buildings, aspects such as energy efficiency and Indoor environmental quality affect occupants' health and productivity and as a result the financial efficiency of societies. *Photography: Wolfgang Richter-Kirsch*

8. 可持续设计过程中需要考虑的基本因素 | The basic considerations

如温湿度、空气质量、噪声控制及高效照明等有关；

● 场地规划：保护场地内的自然和社会特征、建筑采用合适的位置与朝向和保护场地内的植被。最理想的是利用场地内能获得的自然资源，最大限度减少冬季和夏季的能源需求；

● 提高资源利用效率：通过利用被动式太阳能技术来采暖与制冷，通过采用自然采光和自然通风以及利用高效电子照明和电气设备来提高能效；通过使用环保材料以及优化对水资源和废弃物质的管理等来提高资源利用效率。

响应于环境的场地规划

对任何可持续建筑而言，在进入建筑设计阶段之前，设计小组直接参与对场地的选择是非常重要的。场地规划的主要目的是，识别场地的环境特性，确定该场地是否能够通过所设想的使用与研究方法使建筑更好地融入其中，从而优化建筑的使用性能。

1） 选址、植被和景观

响应于环境的场地规划能够最大限度减少建设项目对环境和社区的负面影响，保护好场地内现有的植被，甚至可以帮助社区振兴。场地内的微气候，诸如温湿度和主导风向等环境因素、地区性的地形地貌、遮阳效果及天然植被等都可以在很大程度上影响建筑的性能以及对环境技术的选择。

对于任何一个新建项目，应优先考虑对市区或郊区已开发场地的改造或重建，而不去占用未被破坏的自然土地。适当的地形地貌可以在夏日提供遮阳，在冬天有利于阳光的照射。地形还会影响气流形式与室内的空气湿度。如果建筑坐北朝南，北面隐蔽于山坡而南面朝向太阳，那么南坡即为有利地形。

树木和植被不仅能够美化景观，同时，也可以通过阻挡冬季寒

for savings is apparent with the current rise of salaries. Even small improvements in employees' health and productivity achieved through enhanced health, comfort and decreased absenteeism may count for considerable savings for the building operators.

2 Sustainable Design Strategies

2.1 Environmentally-responsive design and construction strategies

Sustainable building involves a variety of strategies during the phases of design, construction and operation of building projects.

Initial site planning is a key issue for the future performance of the building and factors such as the selection of building materials, the design, orientation, and landscaping, the topography and the site's vegetation all have a great impact. The basic considerations include (Fig.8):

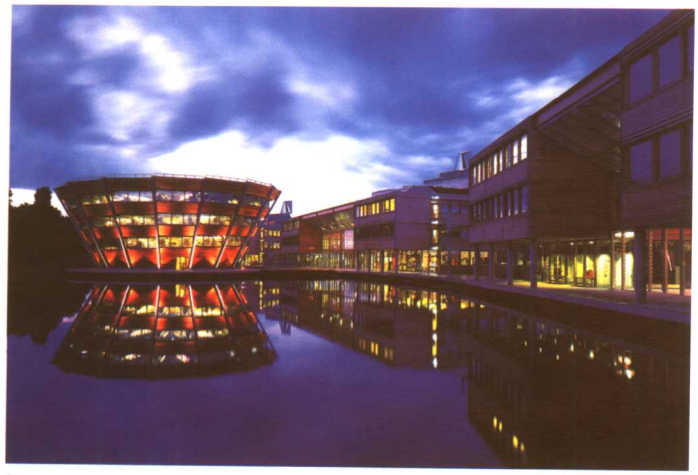
* Indoor Environmental Quality: Occupants' health, comfort and safety, all linked to the indoor conditions such as temperature, humidity, air quality, noise control and effective lighting.

* Site planning: preservation and protection of the natural and social features of the site, appropriate building location and orientation and vegetation. Ideally, sustainable site planning utilises the natural features available at the site to minimise the energy requirements for heating, cooling and ventilation.

* Resource Efficiency: Energy efficiency accomplished by utilising passive solar heating and cooling, daylighting, natural ventilation and the use of efficient lighting equipment and appliances. Efficiency in resources by using environmentally friendly materials and appropriate water and waste management etc.

Environmentally-responsive site planning

For any sustainable building project, prior to the design phase it is of high



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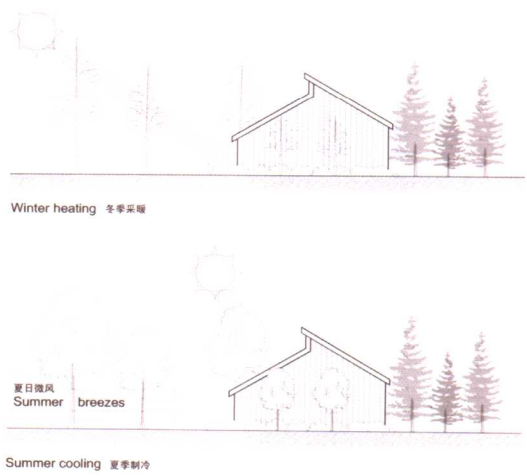

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9. 英国诺丁汉大学莱比丽新校区的场地规划策略集中表现为最优化建筑朝向与景观视线，并且在场地内提倡步行原则 | The site strategy for the Jubilee Campus of the University of Nottingham, UK focuses on optimising orientation and views of the landscape and giving priority to pedestrians over cars. *Photography: Martine Hamilton knight*

10. 建筑南向的落叶树木使得冬季阳光能够穿堂入室，而在夏日为建筑提供必要的遮阳；北向的常青树木在夏日为北面提供遮阳，在冬季阻挡寒风 | Deciduous trees on the south side of a building allow winter sunlight to get through while providing shade in summer when it is needed

风遮挡夏日骄阳而提高建筑整体的环境效应（图10）。保护基地内的当地树种和植被相比于移植其他地方的树种具有更好的成本效益，所以应予以优先考虑。在进行种植时，要优先种植天然生长于当地生态系统中的树木与植物，保护当地生物的多样性与特征。

所选基地毗邻公共交通以及商贸区同样也非常重要。同时也应该考虑所在区域现有的基础设施和服务体系，例如，供水、供电以及垃圾管理等情况。

基地周围潜在的有害污染源、空气质量、高噪声不仅对人的健康与舒适感产生影响，同时也会影响建筑整体的建造费用，如需要使用造价昂贵的玻璃窗以及隔声材料来降低噪声对室内的影响，空气污染源将会影响在建筑中使用自然通风的机会等。

2）建筑朝向

建筑的朝向非常重要，关系到是否有利于建筑使用者的健康、舒适和建筑节能。可持续建筑中采用的自然采光、被动式太阳能采暖技术和自然通风策略都与建筑朝向有关（图11，12）。

在北纬地区，墙面和窗户朝东和朝南优于朝西与朝北，因为北窗易受冬季寒风袭击，而毫无遮挡的西窗在夏天会使过多的太阳辐射进入室内。

因此，在冬天最大限度地利用太阳能的典型做法就是设计好朝向，使墙面和窗户尽可能朝南。使得南向表面在晴朗无云的冬日可以从上午9点至下午3点无阻挡地接受太阳辐射。建筑平面的角度可以在南偏东30°至南偏西30°之间变化。如果窗户安装在西墙上，应当安装适当的夏日遮阳措施，最大限度减轻潜在的室内过热问题。如果场地盛行夏季风，那么建筑的朝向应针对夏季主导风向采用自然通风和制冷技术。

importance for the design team to be involved in the site related decisions. The main purpose of sustainable site planning is to identify the environmental characteristics of the site in order to decide whether it is appropriate for the proposed use and research ways to better integrate the building within the site to optimise its performance.

1) Location selection, vegetation and landscaping

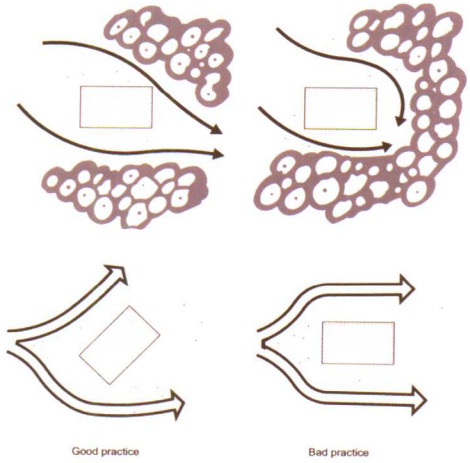
Environmental responsive site planning can minimise the negative impacts of the project on the environment and on the community character, preserve the existing vegetation and may possibly assist in revitalising urban areas. Environmental characteristics such as the site's microclimate (temperature, humidity and prevailing winds), regional-topography, shading and natural vegetation significantly affect the performance and the choice of environment techniques.

In any case, the redevelopment and regeneration of an urban or suburban site should always be considered and preferred to penetrating virgin/natural land.

Topography can add protection from summer sun, while providing shelter for winter sun exposure. It can also influence the air movement and affect the indoor air humidity. A south slope can be beneficial if the building is sheltered into the hillside from the north side while exposing the south facade to the sun.

Trees and vegetation not only aesthetically improve the landscape but can also enhance the overall energy efficiency, by protecting from cold winter winds and providing shading for summer cooling (Fig.10). Preserving local trees and vegetation on the site instead of removing and replacing them is more cost-effective and should always be preferred. When planting is required, native varieties and life that already exists in the local ecosystem should be preferred, to protect the biodiversity and the local character.

Accessibility to public transportation and proximity of the site to businesses and commercial operations are very important for reducing the emissions



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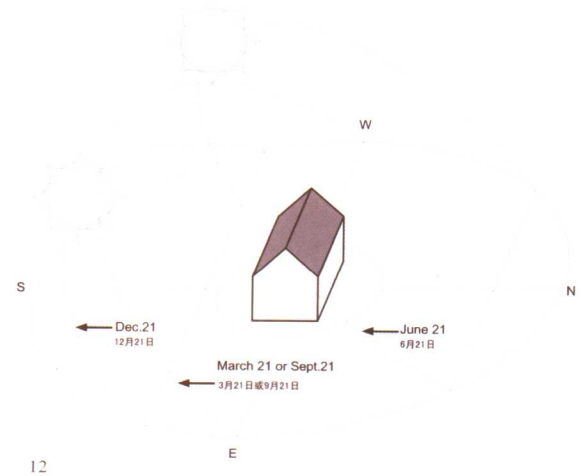

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11. 建筑相对于主导风向的朝向以及建筑周边植被的茂密程度都将影响自然通风的效果 | Orientation to prevailing winds and vegetation affects the opportunities for natural ventilation

12. 对位于北半球的建筑，其南向立面以及竖向的玻璃窗将在太阳高度角很低的冬天使得室内接受到更多的太阳辐射 | In the Northern hemisphere, southern orientation and vertical glazing receives much more solar gain in the winter, when the sun is much lower in the sky

建筑围护结构

建筑围护结构的作用就是将建筑室内与室外环境分隔开（图13）。建筑围护结构由外墙，屋顶，地基（地下室地面）和窗户等要素组成。围护结构自身就是建筑采光、采暖和制冷系统的一部分。密闭良好的建筑围护结构有利于控制温度和湿度，减少建筑的能耗（图14）。

建筑围护结构与下列元素相关：

- 温度：利用围护结构的保温隔热性能帮助控制室内温度；
- 空气：通过围护结构进排风口的通风控制来调节室内空气；
- 水：围护结构能够防雨雪和潮气；
- 噪声：利用围护结构的隔音性能来保证室内声环境；
- 光：通过围护结构透明和不透明表面的结合将自然光引入室内；
- 人员及其他生物体：围护结构能够提供安全、私密性和卫生。

1）保温隔热材料

保温隔热材料是可持续建筑围护结构的关键部分，它是指那些可以用来减缓热量传递的材料。目前有多种保温隔热材料，每种材料又具有不同的保温隔热性能，它们可以用“R－值”来表示。R值代表了材料阻挡热量通过自身的能力。对于在不同气候条件下建造的建筑，推荐使用不同“R－值”的保温隔热材料来达到有效的保温隔热性能。

材料的隔声性能是指一种材料能够减少声音在空气中传递的能力。质量大、密度高和密封性能好的材料一般都能提供较好的隔声效果。

2）窗户

and energy usage due to transportation. Moreover, the infrastructure and services of the area should be considered, such as water, energy supply and waste management.

Possible existence of harmful pollutants, quality of air and high noise levels not only affect the opportunities for health and comfort but also the overall construction cost (e.g. expensive glazing and sound insulation required to reduce noise levels, or air pollution sources affecting the chances for natural ventilation strategies).

2) Orientation

A building's orientation has enormous impact on its ability to optimise the opportunities for health, comfort and energy efficiency. Natural lighting (daylighting), passive solar heating, and natural ventilation strategies are all linked to the building's orientation (Fig.11, 12).

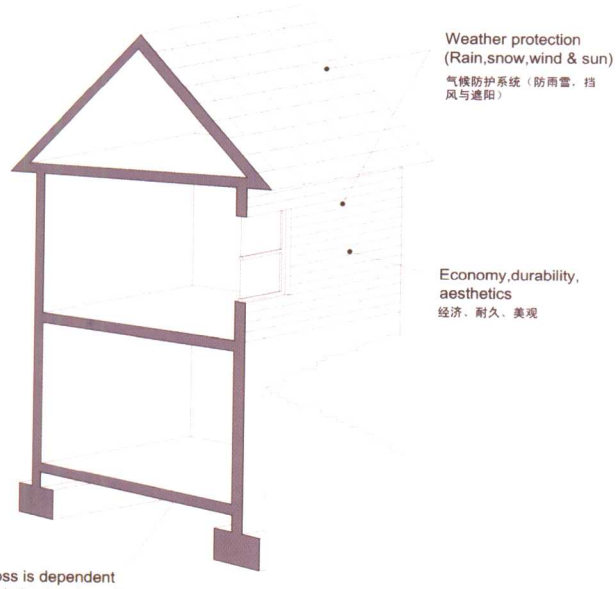
In the northern hemisphere, walls and windows facing south and east perform better than those facing north and west. This is because harsh winter winds hit the northern windows, while unshaded west windows permit the unwanted heat in summer to penetrate the interior.

Therefore, a good practice for taking advantage of the beneficial solar gains in winter is to apply an orientation that maximises the south-facing surfaces such as walls and windows. On clear winter days the south-facing surfaces should receive unblocked sunlight from 9:00 to 15:00. The southern orientation can vary from 30° east to 30° west. In cases where windows are applied on the west facing surfaces, good summer shading should be applied, to minimise potential overheating problems.

If a site has prevailing summer breezes, the building should be orientated in such a way that it can take advantage of natural ventilation and cooling techniques.

Building envelope

The building envelope performs as a barrier between the interior of buildings and the outdoor environment (Fig.13). The building envelope is the combination of the following elements: exterior walls, roof, foundations



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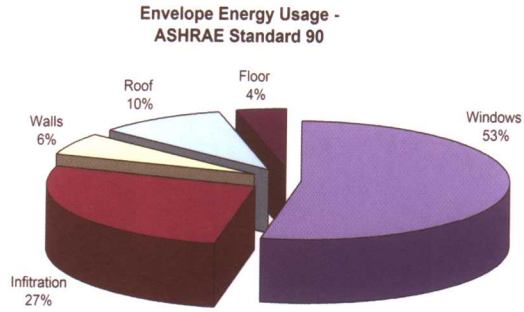

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窗户和其他一些玻璃外立面能够为建筑室内提供通风、噪声控制、自然采光、安全性以及保证室内外的视线沟通。窗户对建筑围护结构的能效有巨大影响，因为建筑中近一半的能量流失是通过窗户。窗户的性能通常是通过以下几个因素来测量：

- U－值，代表透过窗户组成材料的热传导量；
- 太阳辐射得热系数（SHGC）；
- 可视光透光率，指光线穿透玻璃的能力；
- 其他因素，如窗玻璃层之间是否存在氩气以及是否采用低辐射镀膜(low-e)玻璃等。

3） 地基与地下室地面

对地基和地下室楼板进行正确的保温绝热处理对于提高围护结构的能效有非常重要的影响。绝热的地基楼板能够防止热量、废气进入室内也可以避免土壤传递的潮气。

4） 墙面和屋面

位于炎热气候区域的建筑，外墙可以喷涂反射率高的墙面漆并且安装墙面遮阳设施。为减少制冷负荷，东墙和西墙的墙面遮阳措施最为重要；对那些终年需要制冷的建筑，南墙的遮阳也非常必要。因此在新建建筑的设计中可以考虑结合建筑的形式元素对墙面和窗户进行遮阳处理，而对于已建成的建筑，绿化遮阳似乎更可行。

屋面在可持续的建筑围护结构中也很重要。屋面能够在白天吸收太阳辐射并在夜晚将热量反射回天空。在炎热地区，超过75%的屋顶表面都应采用高反射率的材料，如白色涂料，或是具有高辐射率的材料。屋顶同样也可以种植草皮、花朵甚至树木，从而提供多种效益。种植的屋面可以提供更好的保温隔热性能和隔声性能，并且可以在炎热季节降低太阳辐射的吸收，减少雨水的流失。

(basement floor) and windows. The building envelope is itself part of the building's lighting, heating, and cooling system. A tight building envelope can provide good thermal and moisture control and support reductions in building energy use (Fig.14).

The basic function of the building envelope is to separate the interior from the external environment, as related to:

* temperature (thermal insulation)

* air (ventilation control)

* water (rain, snow, moisture-control)

* noise (sound insulation)

* light (combination of transparent and non-transparent surfaces to insert and distribute sun-lighting)

* human and other biological organisms (safety, privacy, health).

1) Thermal insulation

Thermal insulation is a key aspect for a sustainable building envelope and refers to any material that is used for its ability to slow the heat transfer throughout its body. Many types of thermal insulating materials exist, each having different thermal insulating properties, usually measured in "R-values". The R-Value of a material rates the resistance to heat flow throughout its body. As expected, in each different climate, thermal insulation of a different "R-Value" is recommended for achieving an effective thermal insulation.

Sound insulation refers to the ability of a material to reduce airborne sound. Improved sound insulation is generally offered by high-mass, dense and well sealed materials.

2) Windows

Windows and other glazed external surfaces provide ventilation, noise control, natural daylight, security and allow views connecting interior and outdoor spaces. Windows have a major impact on the energy efficiency of the building envelope as they are responsible for half of the overall heat losses in most buildings. Their performance is usually measured by: