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Architecture and Urbanism
11:08

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Feature:
Arup and Sustainable Buildings

专辑：
奥雅纳——可持续建筑的挑战

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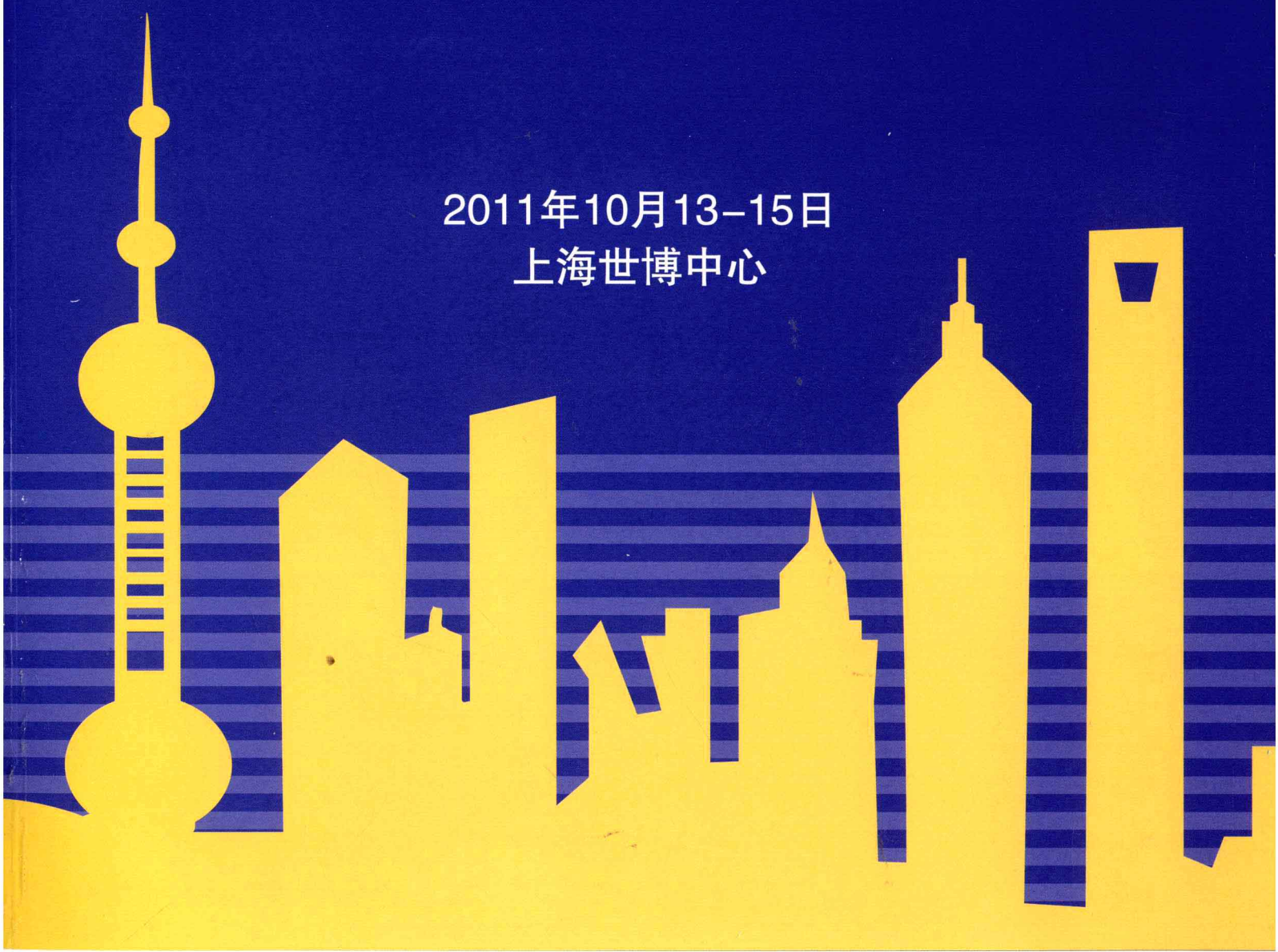

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Arup and Sustainable Buildings

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Cover: Graphic symbols showing 6 objectives of Arup's Designing Sustainable Buildings strategy.

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Feature: Arup and Sustainable Buildings

SOM Awarded Commission for Eco-Urban Community in Vietnam

SOM 设计越南生态城市社区项目

Skidmore, Owings & Merrill, LLP (SOM) has been awarded the Master Plan commission for Golden Hills, an Eco-Urban Community in Danang, Vietnam. The plan has been commissioned by Trugnam Group, a Vietnamese company specializing in real-estate, construction, and hydro-electric power. The project site covers an area of 375 hectares along the Cu De River at the northern edge of the City of Danang. The plan incorporates a wide range of uses organized into a series of distinct districts, including a series of residential neighborhoods, a Village Center, a Business District, and an Education, Sports and Leisure District. Located at the mouth of the river, the design addresses the site's critical flood risk environment through a series of forward-looking storm water strategies which preserve existing watercourses and the natural landscape of the site. A series of new terraced levels will integrate development into the site and enhance both existing and future landscapes to ensure flood protection during various critical storm events, including 1 in 10-year, 1 in 100-year and 1 in 200-year storms. In addition to taking into account tidal flooding and sea level rise in the South China Sea, the plan further incorporates international best practices for on-site storm water management.

日前，斯基德莫尔－奥因斯－梅里尔建筑师事务所（SOM）获得了越南岘港黄金山生态城市社区总体规划的项目委托。项目方楚格南集团是一家专营房地产开发、建造业和水力发电的越南企业。该项目地处岘港市北部边缘的古德河沿岸地区，占地 375 公顷，涵盖多种用地性质，综合设计为一系列特色突出、风格鲜明的分区，包括住宅区、社区中心、商务区以及文教体育休闲区。由于基地坐落在河口地带，面临洪泛风险，因此设计方案采用一系列前瞻性防洪策略，保存现有自然河道及景观。此外，新开发项目用地规划为一系列阶梯台地，旨在营造有利地形环境，从而能够有效防范和抵御各种严重的暴雨洪涝，包括十年一遇、百年一遇和两百年一遇的险情。除了考虑到南中国海的涨潮和海平面上升带来的影响，该项目还进一步针对暴雨天气，应用了国际最先进的雨水现场管理措施。

MVRDV Wins Competition for China Comic and Animation Museum in Hangzhou

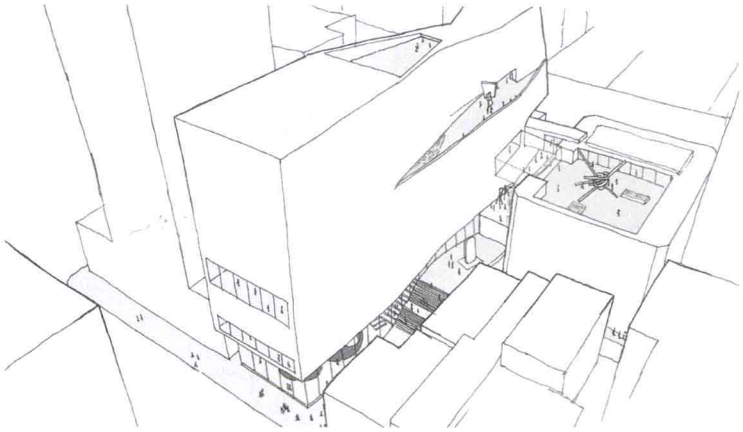
MVRDV 赢得中国杭州动漫博物馆项目设计竞赛

The Hangzhou urban planning bureau has announced MVRDV as the winner of the international design competition for the China Comic and Animation Museum in Hangzhou, China. MVRDV's winning design refers to the speech balloon: a series of eight balloon shaped volumes create an internally complex museum of 30,000 m^2. Part of the project is also a series of parks on islands, a public plaza and a 13,000 m^2 expo center. Construction is envisioned to start in 2012, and the total budget is 92 million euros. The balloon shape allows for versatile exhibitions; the permanent collection is presented in a chronological spiral whereas the temporary exhibition hall offers total flexibility. The museum will contain a multitude of interventions such as ground storage, natural ventilation and adiabatic cooling, all focused towards an excellent energy efficiency rating. The aerodynamic design results in even wind pressure and a lower need for air-conditioning, and the box in box construction of the bubbles permits different conditions inside the building.

杭州市规划局宣布，中国动漫博物馆项目国际设计竞赛由 MVRDV 建筑师事务所最终胜出。获奖方案以动漫中常见的对话气泡框为主体意象——建筑外观如同八只气泡框汇聚一处，总面积 30000 m^2，内部空间层次复杂。方案内容还包括一组岛屿公园、一处公共广场和一座面积为 13000 m^2 的展览中心。工程预计 2012 年动工，投资高达 92 亿欧元。气泡状的建筑内部空间便于举办各种不同类型的展览；其中，常设展厅按时间排序串连成螺线形参观路线，而临时展厅的布置则完全灵活机动。该项目将采用包括地层蓄热、自然通风和绝热冷却在内的多项节能措施，旨在实现高能效建筑等级达标。室内通风经由空气动力学设计，风压均匀，降低了空调使用率。各气泡体块相对独立，有如“盒中套盒”，因此建筑内部可分别营造出不同的环境条件。

This page, top: Bird's eye view of SOM's Eco-urban Community. This page, middle: View of terraced levels. This page, below right: Bird's eye view of MVRDV's museum in Hangzhou. p. 6, top: Sketch of proposed design for SFMOMA by Snøhetta. p. 6, middle: Portrait of ARO. p. 6, bottom: Winy Maas at the French Legion Award presentation. All images on pp. 5–6 except as noted courtesy of the architects.

本页，上：SOM 建筑师事务所设计的生态城市社区鸟瞰图；中：阶梯式台地；右下：MVRDV 建筑师事务所设计的杭州动漫博物馆鸟瞰图。
6 页，上：斯诺赫塔建筑师事务所设计的旧金山现代艺术博物馆（SFMOMA）方案草图；中：ARO 建筑师事务所三人肖像；下：威尼·马斯在“法国军团荣誉勋章”颁奖仪式上致词。（陈霜译）



Snøhetta Chosen for $250-Million SFMOMA Expansion

斯诺赫塔建筑师事务所获选设计预算达 2.5 亿美元的旧金山现代艺术博物馆扩建工程

Oslo/New York-based Snøhetta in collaboration with SFMOMA and EHDD of San Francisco have unveiled the preliminary design for the over 225,000 sq ft expansion that will double the museum's exhibition and education space. The new building that will run contiguously along the back of the current building will both transform the museum and enliven the city by opening up new routes of public circulation around the neighborhood and into the museum. On its east side, the building will feature a sweeping facade and an entrance in an area that is currently hidden from public view and largely unused. This will be achieved through the creation of a mid-block, open-air, 18 ft-wide pedestrian promenade. The promenade will feature a series of stairs and landings terracing up to an entry court that extends from the new east entrance, providing additional public spaces. The building also introduces a facade on Howard Street that will feature a large, street-level gallery enclosed in glass on three sides, providing views of both the art in the galleries and the new public spaces. Completion is projected in 2016.

斯诺赫塔建筑师事务所总部设在奥斯陆和纽约。不久前，该事务所与旧金山现代艺术博物馆（SFMOMA）及 EHDD 建筑设计公司联合揭幕了 SFMOMA 扩建工程的初步设计方案。该扩建项目建筑面积超过 225 000 ft²（1 ft=30.48 cm），可将博物馆现有的展览与教育空间增加一倍。新建筑沿现有博物馆背面延展，并计划在周边街区内开辟新的公共通道，同时增设博物馆入口，从而改造博物馆各项设施，并激活周边城市空间。东侧采用弧形立面，将目前公众视线之外的隐蔽区域开放设置为东入口，中央位置处新建一条露天入口长廊，宽 18 ft（1 ft=30.48 cm），供行人使用。入口长廊的设计别具特色，由一系列台阶和平台拾级而上，与入口庭院相连通，营造出更多公共空间。临霍华德街的大型画廊，地坪与街面同高，采用三面玻璃幕墙。人们可从室外看见画廊内的艺术展品和新建的公共空间。扩建项目预计于 2016 年完工。

announcements

Winy Maas Receives French Legion of Honor

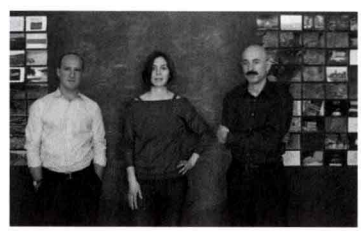
威尼·马斯荣获法国军团荣誉勋章

Winy Maas has received the highest French decoration Chevalier de la Légion d'Honneur by the French Ambassador to the Netherlands Mr. Jean-François Blarel at the French residence in The Hague. MVRDV's daring projects are distinguished by an understanding of contemporary needs that respect the demands of the present-day developments with flexibility and innovation in regards to the issues the modern metropolis faces. MVRDV is strongly engaged in France in a range of projects: the participation in Atelier du Grand Paris, with large scale urban plans for Bordeaux and Caen and a number of architecture projects in Paris and Dijon, among which is a zero energy office building in Paris, ZAC Gare de Rungis. Le Monolithe, a mixed-use building in Lyon was recently completed.

威尼·马斯日前在法国驻荷兰大使让－弗朗索瓦·布拉海勒先生的海牙官邸接受颁发了法国军团荣誉勋章中最高等级的骑士勋章。MVRDV 建筑师事务所的设计方案大胆前卫、卓尔不群，蕴含着对当前时代需求的了解和尊重。其方案针对现代大都市面临的各种问题，充分体现出灵活性与创新性。MVRDV 在法国积极从事各类设计实践：他们加入“大巴黎研讨会”，承接了波尔多和卡昂的大规模城市规划项目以及若干位于巴黎和第戎的建筑项目，其中包括坐落于巴黎汉基车站开发区的零能耗办公楼。“勒莫那里斯”商住大楼近日在里昂竣工。

Cooper-Hewitt Unveils 2011 National Architecture Design Award Winner: Architecture Research Office

库珀·休伊特国家建筑设计奖 2011 年度得主揭晓：ARO 建筑师事务所



The Architecture Design Award, which recognizes work in commercial, public or residential architecture, is given to Architecture Research Office, a New York-based firm led by Stephen Cassell, Adam Yarinsky and Kim Yao. Its work spans from strategic planning to architecture and urban design. From a prototype for 1,000 sq ft low-income sustainable housing to a proposal to reinvent the role of ecology and infrastructure in New York, ARO uses design to unite the conceptual and the pragmatic within a strong, coherent vision.

该奖项针对商业建筑、公共建筑或住宅建筑中的优秀作品予以嘉奖。本年度大奖授予 ARO 建筑师事务所。该事务所总部设在纽约，由斯蒂芬·卡塞尔、亚当·雅林斯基和金姆·伊奥主持领导。事务所承接项目涉及战略性规划、建筑设计和城市设计多个领域。从建筑面积为 1000 ft² 的低收入住宅可持续性原型到纽约市生态环境与基础设施的重建规划方案，ARO 以其强大而连贯的设计理念为基础，在设计项目中将理念构想与实践操作统一结合起来。

exhibitions

2011 International (Shanghai) Planning & Architectural Design Exhibition

2011 上海国际规划与建筑设计展览会

Shanghai Expo Center
October 13–15

With sustained development of China's urbanization, every year tens of millions of people migrate from the countryside into cities and towns to purchase residences. The continuance of urbanization and the construction of large infrastructures makes China become the world's largest construction market. And this market is still growing. The huge construction market creates excellent market opportunities for domestic and international survey, design, planning and architectural design companies. This fair will attract Chinese and global exhibitors in the fields of urban planning, architectural design, landscape design, engineering design and commercial decoration etc. It will build a comprehensive platform for exhibitors and decision makers, decision participants, professionals from fields of urban land planning, real estate developing companies, urban infrastructure, public building construction etc.

随着中国城市化的持续发展，每年有上千万人口由农村转入城市和城镇购房居住。随着城市化进程的持续推进和大量的基础设施建设，中国成为世界上建筑市场最大的国家，并且这个市场规模仍然在持续扩大。中国巨大的建筑市场为国内外勘察设计、规划与建筑设计企业创造了绝佳的市场契机。

此次展会将吸引来自中国和世界各地的城市规划、建筑设计、景观设计、工程设计、商业装饰设计等领域的展商，并为展商与城市国土规划、地产开发商、城市基础建设、公共建筑建设等领域的决策者和参与决策者及专业人士构建一个全面的交流平台。

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Feature:

Arup and Sustainable Buildings

专辑：

奥雅纳——可持续建筑的挑战

The built environment exerts a major influence on society and our surroundings, and today one of the most important concerns of architectural design is the realization of sustainability. By now, it is rare to see it discussed without the words green or environmentally friendly.
However, it is not easy to clarify what we have to do, and how, to achieve sustainability in the built environment.

This issue features Arup and sustainable buildings. With more than 90 offices in over 30 countries, Arup is one of the world's leading professional services firms. It is known as a pioneer in environmental engineering as well as in structural engineering. Arup is not only well versed in assessment methods such as LEED® in the USA, BREEAM in the UK, Green Star in Australia, and CASBEE in Japan, but has also developed its own methodology for the realization of sustainability. Arup's 'Designing Sustainable Buildings' strategy has six objectives, involving carbon, water, materials, climate change, community and the environment, and operations. These six objectives are provided to the client and shared with the design team on every project. In his essay Alistair Guthrie explains the strategy and outlines the methodology in detail. The graphic symbols beside the title of each project in this issue were visualized by Arup in order to show the six objectives and the degree of achievement of the 'Designing Sustainable Buildings' strategy. (See p. 14 for how to read the symbols.)

This issue introduces about 50 works as case studies categorized by building type. Most have been completed over the last ten years. This issue also features three essays: one on the concept of total design proposed by Ove Arup, the founder of Arup, and its reflection in the work of the firm; another on integrated urbanism, dealing with masterplan proposals for communities and wider areas; and another on architecture for the ecological age, which looks forward to the city of 2050. There is also a glossary on sustainable building at the back of the issue.
We hope that this issue will provide the reader with concrete and practical insights into sustainable design. a+u would like to express our appreciation to Alistair Guthrie and Arup staff from all over the world for their cooperation. *(a+u)*

建筑环境对我们的社会和生活具有重大影响，而如何实现可持续发展是当前建筑设计中最重要的课题之一。时至今日，当人们探讨和谈论建筑时，几乎不可能不提及“绿色”或“环保”的字眼。然而，为了实现建筑环境的可持续性，我们应该做什么？如何去做？要表述和理清这些议题并非易事。

本期专辑介绍了奥雅纳工程咨询公司及其可持续建筑设计实践。奥雅纳身为全球领先的工程咨询服务机构之一，旗下拥有 90 多个办事处，遍及全球 30 多个国家，以环境工程和结构工程领域的先驱而闻名。奥雅纳不仅熟知各种绿色建筑评估系统，例如美国的能源与环境设计标准 LEED®、英国的建筑研究院环境评估法 BREEAM、澳大利亚的“绿星”环保评级和日本的建筑环境效能综合评估系统 CASBEE，而且还自行开发出一套可持续建筑设计的方法体系。奥雅纳的可持续建筑设计策略涵盖 6 项战略目标，涉及碳排、水耗、材料应用、气候变化、社区建设与环境和实际运作等方面。奥雅纳将这 6 项设计策略提供给所有的项目委托方，并与项目设计团队共享。阿利斯泰尔·加思里在论文中阐释了奥雅纳的设计策略，并逐条概述了设计方法。奥雅纳将其 6 大战略目标具象化设计为一组专用图标。本期收录的所有项目都在名称旁边标注有该图标，并在上面一一标识出各项战略目标的实施程度。（图标的识读参见 15 页。）

本期共收录了约 50 个可持续建筑项目，分门别类进行个案研究。其中大多数项目已于过去十年间竣工完成。本期刊登了三篇论文：一篇专题介绍由奥雅纳创始人奥韦·奥雅纳提出的“全方位设计”的概念以及这一概念在奥雅纳项目中的应用；一篇针对社区或范围更大的地域区块的总体规划问题，着重探讨“综合城市化设计”的概念；另外一篇以生态化建筑为主题，展望 2050 年的城市风貌。本期末尾还辑录了一篇可持续建筑用语表。我们希望读者能够通过本期专辑进一步具体而深入地了解和认识“可持续建筑设计”。a+u 在此谨向阿利斯泰尔·加思里以及世界各地的奥雅纳工作人员致以谢意，感谢他们的热忱合作。 （编者）

Essay:

The Challenge of Sustainability

Alistair Guthrie

论文：
走向可持续建筑
阿利斯泰尔·加思里

The challenge of sustainability was eloquently summed up by G H Bruntland in 1987 as: "Meeting the needs of the present while not compromising the ability of the future to meet its own needs".

As society develops it tends to use the earth's resources in a one-way process which does not consider what is left for future generations. It works on the principle that they will find their own solutions with what resources remain. This is our greatest challenge.

Sustainable solutions are those which tend to reverse this trend and try to consider the future impacts of today's actions.

The built environment is not only the largest user of natural resources, aggregates, cement, timber, metals, energy but has possibly the biggest influence on sustainable living for a large section of the community. The resources used every day at home, leisure and work depend on the design of our buildings and the planning of our urban centres and transport systems.

How is the built environment sector responding to these challenges? It is vitally important that we continue to lay down infrastructure and erect buildings that are fit for purpose, not just for the immediate future but which will still be performing well in 50 years time. The developing world particularly needs to build new infrastructure which meets these challenges rather than repeats the mistakes of the past. But this is not enough. There has to be a rapid realisation that if we rely only on new construction to meet levels of reusability, energy and water consumption that are sustainable, we will not meet the pressing challenge of climate change or provide improvement in living standards. So refurbishing and renovating our existing buildings and infrastructure is essential as it can provide long-term fit-for-purpose accommodation with minimum use of new materials and deliver significant reductions in energy consumption.

At Arup we have long realised that sustainability in the built environment is about total holistic design. Each part of the construction project, each element of the design interacts with each other and it is only as we consider the whole, and its impact on the local environment and society, that we can evaluate its future performance. We have for many years organised our offices, design studios and project teams to facilitate this necessary interaction, by locating engineers and designers from different disciplines together. This has helped us provide integrated design to many of the world's seminal buildings. We have also developed a method of whole project or site assessment called SPeAR which seeks to evaluate before and after scenarios for developments. The output shows graphically the change from the existing conditions to the proposed projects measuring its sustainability with a wide range of parameters.. But latterly we have wanted to take this a step further and get all our building designers thinking about sustainability in a way that would make a difference to every project. This thinking does not just happen – it must be actively encouraged. To this end, when I took on the role of sustainability leader for buildings in Arup, I developed a simple methodology which we call our 'Designing Sustainable Buildings' strategy. This was developed using a method called backcasting which determines ideal outcomes and then works out how to move towards them.

We held an internal workshop to canvas opinion on how we could help ourselves, the client and the rest of the design team achieve more sustainable outcomes in our work. We all decided that measuring outcomes using assessment methods such as LEED®, BREEAM or Green Star was admirable, and to be encouraged, but not sufficient. We needed to focus each project on a clear sustainability strategy at the outset and get all the parties thinking about how it might be achieved. It needed to be inspirational, strategic, visionary and imaginative, as well as technically correct and economically feasible. At the workshop we decided that we should not set arbitrary targets for sustainability indicators such as how much better it was than a previous benchmark but we should measure our projects as far as possible against an absolute in line with the idea of backcasting. So for carbon we set a target that we should aim for all our projects to be carbon neutral, in operation over a yearly cycle. This is a target that can be measured and it is universal in its application. We developed six similar objectives involving carbon, water, materials, climate change, community and the environment and operations. At the outset of every project we provide our client and the design team with a strategy of how we would design their project within the natural capacity of the planet using these six objectives. We offer to "provide creative and viable strategies that will enable our clients to imagine how it is possible to move towards fully sustainable buildings".

The six objectives can be summarised as follows:

1987 年，布伦特兰提出了“可持续发展”的概念，其定义表述言简意赅而且生动形象：“既能满足我们现今的需求，又不损害子孙后代满足其未来需求的能力。”

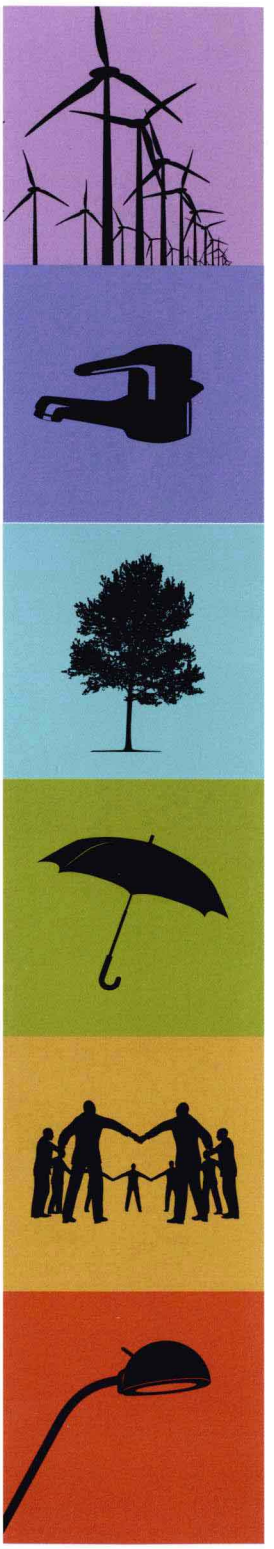
现代社会的发展模式趋向于单向性地消耗地球资源，却不考虑留给未来世代什么样的资源和环境。其思想基础是：无论当代人留下什么残山剩水，后世子孙届时只能自谋生路。然而，这种发展模式对人类社会的发展危害极大。

可持续发展正致力于扭转单向性资源消耗的趋势，尽可能充分考虑现阶段的人类行为对未来的地球环境会产生什么影响。

建筑环境对自然资源、石材、水泥、木材、金属和能源的消耗量最大；不仅如此，建筑环境更可能对广大公众的可持续生活产生深远影响。建筑物的设计、城市中心区域的规划和交通系统的规划决定了人们每天在家庭、休闲和工作中所消耗的资源量。

那么，规划设计领域的从业人员应如何应对这些挑战呢？首当其冲的任务是，在新建基础设施和房屋楼宇时，我们不仅要满足现阶段及近期的功能需求，而且应力图保证它们将在未来 50 年内依然性能良好。当前，发展中国家亟需全面新建基础设施，他们更应该从可持续发展的视角出发进行规划设计，而不应重复西方国家过去的错误。然而，这仍然不足以应对挑战。我们需尽早意识到：如果仅仅在新建项目中实现再生利用以及能耗与水耗的可持续性，那么我们仍将无法缓解气候变化的紧迫危机，也无法提高生活水准。因此，对既存建筑和基础设施的整修和翻新是至关重要的，既能够满足长期的功能需求，同时又将材料消耗降至最低限度，并显著减少能源消耗。

在奥雅纳公司内部，我们早已达成一点共识——建筑环境的可持续性必须以综合的整体性设计为出发点。建设项目的所有组成部分都彼此作用，设计方案中的所有元素都相互影响；我们应将每个项目都作为综合整体来考虑，并兼顾它对当地环境和社会的影响，唯其如此，才能正确评估其未来的性能表现。多年来，我们在办事处、设计工作室和项目团队的人员配备和组织结构上，尽量让不同学科领域的工程师和设计师组队共事，目的正在于催化项目各环节之间必要的相互作用。这一措施促进奥雅纳公司研发完成了诸多国际开创性建筑的综合



Six objectives
6 项战略目标

1. Carbon neutral

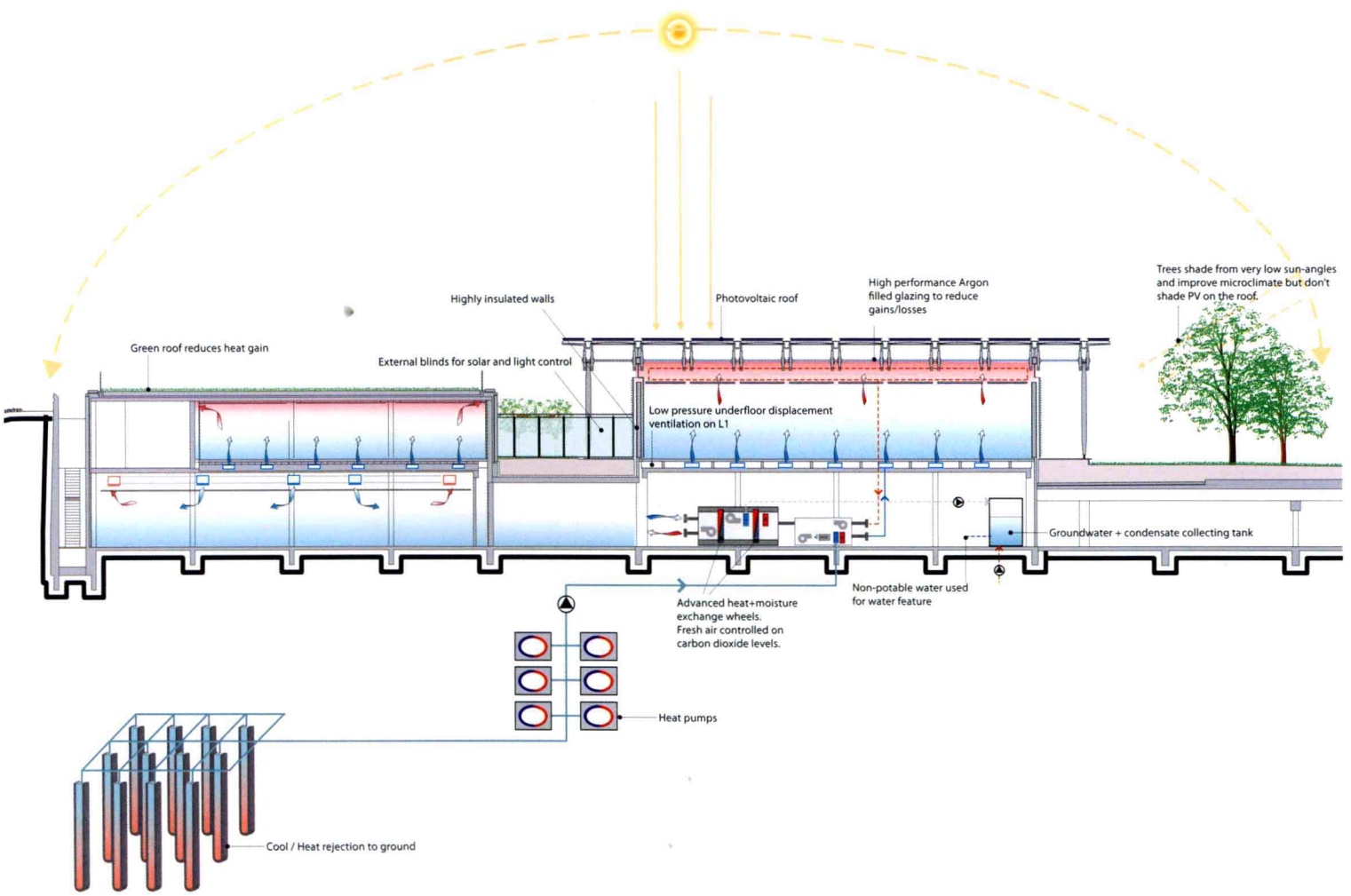
Designing a building to balance the total carbon inputs and outputs over the course of a year. The strategy would include three basic steps:

Firstly, this would include designing the building envelope to minimise summer cooling load. Strategies include the shape and mass of the building, external shading of windows, high thermal inertia structure, opening windows where appropriate. The winter heating load would be reduced by improving the insulation of the walls and windows. The windows would be designed to optimise the natural daylight.

Secondly, use energy efficient equipment including lighting, ventilation, heating and cooling. An energy efficient building envelope gives more options for energy-efficiency equipment.

Thirdly, having reduced the energy requirement to a minimum, use renewable or low-carbon supply sources such as photo-voltaics, biomass boilers, combined heat and power plants (CHP), or heat pumps combined with ground heat and cool storage. These can either be stand-alone on the building or part of a wider district or city plan for shared power and energy.

The Kimbell Museum extension in Fort Worth, Texas, is a good example. At the first meeting with the architect and client we offered to help them imagine what a truly sustainable building might look like. This included a strategy for carbon-neutral galleries. They fully embraced the idea and the project is on course to have carbon-neutral gallery spaces. To reduce carbon, we designed roof-mounted louvres that combine daylight control with solar shading and photo-voltaic energy collection. The daylight control allows them to operate without elective light for much of the year and the photo-voltaic panels generate energy which offsets the rest of the lighting load and the air conditioning load. We used the ground around the building to store excess heat in summer and to reuse it for heating in the winter.



The Kimbell Museum extension, Fort Worth, Texas, USA. Environmental strategy.

金贝尔博物馆扩建项目，美国，德克萨斯州，沃思堡。环境策略。

设计方案。此外，我们还开发出一套项目或基地总体评估的方法体系：可持续项目评估程序 SPeAR（Sustainable Project Appraisal Routine），用于评估项目的建成前后状况。我们通过一系列范围广泛的参数指标将“可持续性”进行量化，以图表方式将评估结果表现出来，从而显示出项目从现状到规划后可能发生的变化。后来，我们希望能更上一层楼，使全体设计师都能意识到可持续性对每一个项目的影响。但这种意识不可能自然生成，我们必须积极鼓励和引导。为此，我在奥雅纳主持可持续设计工作期间，采用“回溯法” 领导研发出了一套简明的方法体系，命名为“可持续建筑设计策略”。所谓“回溯法”是指预先设定理想目标，然后返回推导，研究如何能达成目标。

我们专门举办了公司内部研讨会，集思广议，为如何促进设计师、业主和整个设计团队取得优异的可持续性方案寻求思路。最终我们一致认为，采用诸如 LEED®、BREEAM 或 Green Star 的量化指标体系虽然令人赞赏、值得鼓励，却有所不足。我们更需要从每一项目的初始阶段便专注于一套明确的可持续发展策略上，敦促项目各方都积极参与思考。这种方法体系应该富于启发性、战略性、前瞻性和想象力，同时又必须技术正确、经济可行。在研讨会上，我们主张，不以主观臆断的态度给可持续性指标设定目标值，比如要求项目在某项指标上必须提高多少量；但是我们应该遵循回溯法的原理，尽可能地比照最优标准来衡量我们的项目方案。例如，针对碳排放问题，我们制定的目标是所有项目都以一年为运行周期，达到碳中和。这个目标既可衡量，又普遍适用。类似地，我们制定了 6 项战略目标，分别涉及碳排、水耗、材料使用、气候变化、社区和环境以及实际操作等方面。在每一项目的初始阶段，我们便向项目业主和设计团队提出 6 项战略目标，阐述如何把设计方案控制在地球的自然能力范围内。我们的宗旨是“提供创新而且可行的设计策略，为项目方描绘出如何迈向全面可持续建筑的远景蓝图”。

奥雅纳的 6 项可持续发展战略目标分别概述如下。

1. 碳中和

设计建筑时，我们力求保证其碳排放与碳吸收每年在总体上达到平衡。该设计策略包括三项基本步骤。

首先，建筑围护结构的设计应使夏季制冷能耗最小化。具体措施包括对建筑形状、建筑体量、外部遮阳设施、高热惰性内部结构和开窗位置进行优化。通过改善墙体与窗户的隔热性能，建筑的冬季供暖能耗也得以降低。窗户的设计应优化自然采光。

其次，采用节能高效的照明、通风、供暖和制冷设备。节能的建筑围护结构可为各类节能设施提供更多选择。

第三，在将能源需求降到最低限度之后，还应进一步采用可再生或低碳的供能设备，例如太阳能光电板、生物质锅炉、热电联产技术（CHP）或地热蓄冷两用热泵。此类设备既适用于建筑单体，也可应用在城市区域乃至城市整体的电力和能源总体规划之中。

德克萨斯州沃思堡的金贝尔博物馆即为一例优秀个案。在与建筑师和项目方的首次会谈中，我们便提出了概念方案，向他们描绘出一座高度可持续性的建筑。方案将碳中和策略运用于展厅。建筑师和项目方深表赞同。于是，如方案所设计，展厅被建成了碳中和建筑。其天窗将太阳能光电采集与可控遮阳的自然采光功能整合一体，以利于减少碳排放。每年大部分营业时间内，天窗能够保证展厅室内自然采光而无需动用电力照明，太阳能光电板所产生的电能可用于抵消人工照明和空调电力所对应的碳排量。建筑物四周的地面在夏季将多余的热量储存起来，至冬季再释放出来用于供暖。

2. 用水自给自足：收集和再生

大多数建筑中，水的主要用途有两类：厕所冲洗和园艺灌溉。这两类用水都无需达到饮用水的纯度和清洁标准。可持续建筑宜采用现场收集和储存雨水的策略，将之用于厕所冲洗和园艺灌溉。

英国康沃尔郡的伊甸园项目（见 18 页）所在地水资源紧缺，但其可用自然水源却足以满足园艺要求（包括灌溉和喷湿），并可用来冲洗厕所。只有饮用水和餐饮用水无法由现场水源供应。

收集的地表水和雨水先存入地下储水箱，然后再泵送到配水系统。生态温室内的喷湿用水对纯度要求较高，以防止在植物表面造成矿物质沉积。因而，喷湿用水最好利用从植物群落表面采集而来的雨水。这部分雨水被采集并输送到基地高处的储水箱，再通过重力作用从储水箱流到分布在植物群落各处的喷嘴。伊甸园项目中，3700 万公升地表水用于灌溉和冲厕，1300 万公升的再生雨水用于喷湿，而自来水消耗量仅为 1300 万公升。

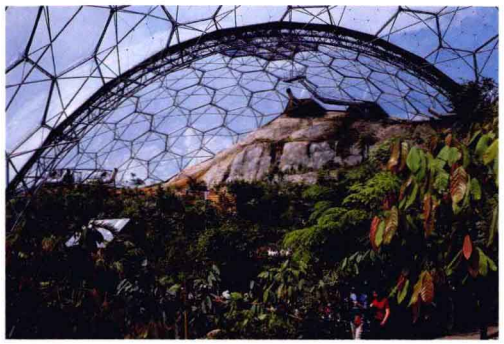
3. 环保型建筑材料

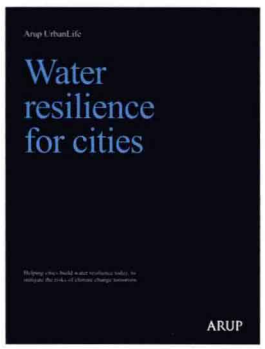
建筑材料资源有限。所有新建项目都应考虑采用回收材料和低碳材料。举例而言，废旧铝材易于回收，但从矿石中提取和生产铝却需要耗费大量的能源。又如，生产混凝土时可采用再生骨料和粉煤灰水泥作为替代成分。天然材料（如木材、石材）一般都可以回收，具有低能耗再利用的潜力。

也许，最具再生潜力的是多功能建筑或适于改变用途的建筑。在设计阶段，我们应充分考虑到灵活适用性；建于 20 世纪的码头仓库便可作参考，它们在现代被广泛改建为性能优异的住宅、办公室、餐厅和工作室。

采用可持续性建材的项目示范可以加州科学院（见 32 页）为例，

2. Self sufficient by collecting and reusing water





Above: The Eden Project, Cornwall, UK, 2001. Photo by Graham Gaunt. Left: Cover of the Water resilience for cities.

上：伊甸园项目，英国，康沃尔郡，2001 年；左：《城市供水应变能力》一书封面。

The major uses of water in most buildings are WC flushing and irrigation of landscape, neither of these requires pure, clean drinking water. Every building needs to consider a strategy for collecting and storing rainwater on site and using it to meet WC flushing and irrigation needs.

The Eden Project in Cornwall, UK (p. 18), is an example of where water conservation is a big issue but available natural resources more than adequately provide for all of the project's horticultural requirements (including irrigation and humidification), and for the flushing of toilets. The only water not provided from on-site sources is a potable supply for drinking and catering.

Water sourced from the ground springs and collected rainwater is stored in an underground tank before being pumped into the water distribution system. Humidification sprays in the biomes require a high level of water purity to prevent deposition of minerals on the plant surfaces. The best source for this water was found to be the rainwater collected from the surface of the biomes. It is collected and pumped into storage tanks at the top of the site. From here, the water supplies are propelled by gravity to the misting nozzles located among the plants in the biomes. The Eden Project uses approximately 37 million litres of groundwater for irrigation and toilet flushing, 13 million litres of re-used rainwater for humidification, and only 13 million litres of tap water.

3. Built using sustainable materials

Above: California Academy of Sciences, San Francisco, California, USA, 2008. Photo by Taisuke Inatsugu / Shinkenchiku-sha. Below: Recycled denim insulation. Photo courtesy of RPBW, Stefano Goldberg - Publifoto.

上：美国加州科学院，美国，加利福尼亚州，旧金山，2008 年；下：回收牛仔布保温材料。

New construction materials are a finite resource. Each building project needs a strategy that considers the use of recycled materials and materials with a low-carbon footprint. For example, aluminum is easy to recycle, but requires considerable energy for its extraction. Concrete can be made with recycled aggregates and fly-ash cement. Natural materials such as wood and stone can generally be recycled and potentially use lower amounts of energy to make them usable.

Perhaps the most recyclable buildings are those which can be used and reused for different purposes. It would be good to think that we could design buildings that are as adaptable to different uses as the last centuries' dockside warehouses, which now make excellent housing, office, restaurant and workshop spaces.

An example of a new building designed using sustainable materials is the California Academy of Sciences, located in Golden Gate Park, San Francisco, CA, USA (p. 32). The building is constructed almost entirely from locally sourced, recycled and renewable materials, including sustainably harvested timber, fly ash as a cement substitute (50% in the foundations and 25% in the slabs) and recycled denim insulation. Demolition materials from the old building were recycled to reduce the waste by-product of the project.

4. Climate change

Climate change is a reality – we can be sure that it will happen, but exactly what will result is necessarily an informed prediction. It is important to apply climate change scenarios to our new building designs so that we can assess how they will cope with increasing temperatures and changes in rainfall patterns. Decisions can then be made on how we can adapt them to remain usable and comfortable for occupants in the future. A building that can adapt will retain its value and minimise risk to the business.

For the Bryghusprojektet located on the harbour front in Copenhagen, Denmark, we examined a number of climate change scenarios and scenarios for future sea level rise. As a result, all entrances to the building will be located above the predicted 500-year flood level as determined by the climate change scenarios. The building will also be designed so that the heating and cooling systems could be easily adapted or retrofitted to cope with the predicted rise in external temperature.

Bryghusprojektet, Copenhagen, Denmark. Rendering by OMA/ Realdania.

布里格胡西项目，丹麦，哥本哈根。

5. A positive contribution to the community and the built environment.

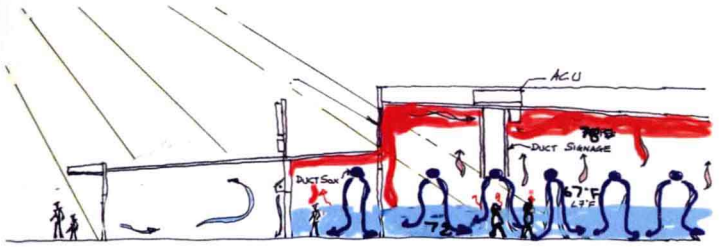
Our strategy prompts us to consider how our building projects impact on the wider community.
Every project has the potential to make a positive contribution. The following description of a new school in Wales, UK shows how careful design can make a real difference in the community.

Few missed the dilapidated old Bettws Secondary School building when it was demolished. Thanks to the best of passive design and modern technologies, the replacement building that emerged as Newport High School uses 25% less energy than required by Building Regulations. Its facilities can be enjoyed by the whole community, with adult education classes in the community hall and excellent sporting facilities open to public use outside school hours, including a 25 m pool and two flood-lit outdoor pitches.

The old school building was set back from the road, making it easy prey for vandals. By contrast, the new school building is designed to be secure, fronting onto a well lit road, with active security measures in place to the rear.

Right: Newport High School, Wales, UK, 2009. From top: Aerial view (image courtesy of HLM Architects), facade, gym opening to public. Photos by Girts Gailans.

右：新港中学，英国，威尔士，2009 年。上起：航拍图，正立面，面向公众开放的体育馆。



Wal-Mart, McKinney, Texas, USA. From top: Sketch of displacement air strategy; garden center with PV roof, interior store view. Photos by Chris Costea.

沃尔玛超市，美国，德克萨斯州，麦金尼。上起：空气置换策略示意图，屋顶安装有太阳能光电板的花园，超市室内。

6. Sustainable in operation

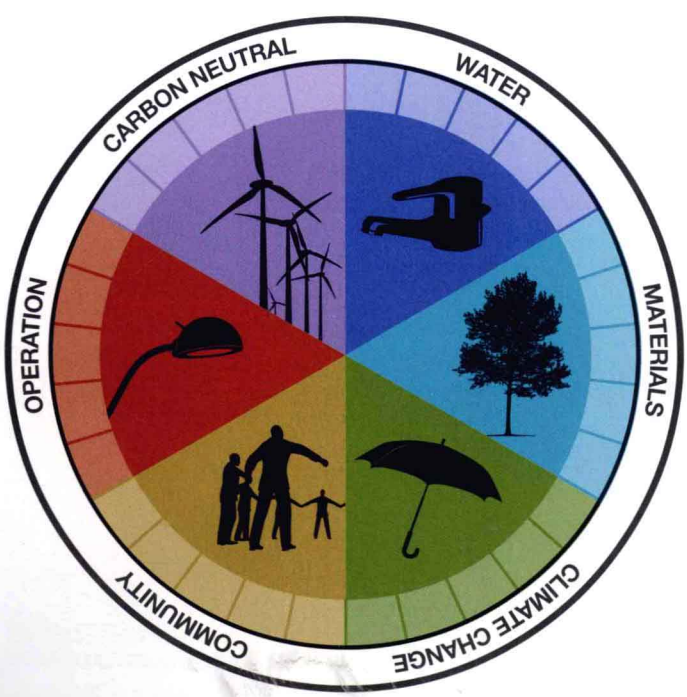
Our building designers need to consider how their designs will improve comfort, usability and productivity. How the design strategies for energy reduction will be achieved in practice is a key issue. For example, in an office, how will we get the occupants to turn off the lights and computers when they leave at night, or should we simply automate it? It is very instructive to prepare a user manual early on in the design process.

We conducted a project for Wal-Mart looking at two stores to see how design elements could impact their energy use in operation.

Retailing giant Wal-Mart builds around 300 new outlets each year in the USA alone. In 2003 it appointed Arup as lead design consultant for two experimental stores in McKinney, Texas, and Aurora, Colorado. Wal-Mart's ambition was to achieve a 50% reduction in energy use by 2009, and the stores were intended to test technologies and products that can save energy, conserve natural resources and tackle pollution, while providing a better environment for both customers and staff.

LED lighting in food cabinets resulted in less heat production and more efficient refrigeration. A displacement ventilation system replaced the traditional high-level system that conditions the entire space, which is over 6 m high. And sliding doors on cabinets for mid-temperature refrigerated products, such as bacon and cheese, resulted in significant energy savings.

We now apply our 'Designing Sustainable Buildings' strategy throughout our global building design practice and it is beginning to make a difference to the outcome of our projects. We have loosely graded the projects featured in this publication, using the graphic symbol shown here to indicate how well we believe we have met our six objectives to date in designing them.



Graphic symbol showing 6 objectives of Arup's Designing Sustainable Buildings strategy.

The outer coloured circle of the graphic symbol is a darker colour if we judge that the project is close to the "Designing Sustainable Buildings" targets. For example if in the blue water segment the outer band is all dark blue then we have fully met the goal of being self sufficient in water. If it is only partially dark blue we have gone some way towards meeting this goal.
The marking of a project in this way is not at the moment based on measurement but represents our opinion of how well it meets the six objectives.
The projects included have been chosen to represent a broad mix of geographical regions and project types and as such not all the projects with good sustainable credentials have been included. *(Alistair Guthrie)*

Alistair Guthrie is a Director and Leader of global buildings sustainability at Arup. He is a Professor of Environmental Design in the School of Built Environment Nottingham University. He joined Arup in 1979 and has been involved in the design of arts & culture, education, commercial and transport buildings worldwide. His particular expertise is the application of building physics and micro climate design in finding sustainable solutions to the built environment.