Council on Tall Buildings and Urban Habitat
CTBUH
Research Paper
ctbuh.org/papers

Title:	**3 Environments, 3 Programs, 3 Solutions**
Authors:	Paul De Santis, Principal, Goettsch Partners Travis Soberg, Associate Principal, Goettsch Partners
Subjects:	Architectural/Design Sustainability/Green/Energy
Keywords:	Climate Sustainability Wind
Publication Date:	2012
Original Publication:	CTBUH 2012 9th World Congress, Shanghai
Paper Type:	1. Book chapter/Part chapter 2. Journal paper 3. **Conference proceeding** 4. Unpublished conference paper 5. Magazine article 6. Unpublished

© Council on Tall Buildings and Urban Habitat / Paul De Santis; Travis Soberg

3 Environments, 3 Programs, 3 Solutions
三种环境，三个项目，三种解决办法


Paul De Santis


Travis Soberg

Paul De Santis & Travis Soberg

Goettsch Partners
224 South Michigan Ave.
Chicago, Illinois
60604 USA

tel (电话): +1 312.356.0600
fax (传真): +1 312.356.0601
email (电子邮箱): pdesantis@gpchicago.com;
tsoberg@gpchicago.com
www.gpchicago.com

Paul De Santis is a principal and senior project designer at Goettsch Partners. With 14 years of experience, he serves as the lead designer on the majority of the firm's work in China. Traveling frequently between the firm's Chicago and Shanghai offices, Mr. De Santis directs designs for large-scale office, hotel and mixed-use projects. Recent work in China includes the 40-story Nexus Center office tower in Beijing; the 66-story mixed-use Park Hyatt Guangzhou; the 37-story Grand Hyatt Chengdu at Chicony Plaza mixed-use development; and the 92-story Tianjin R&F Guangdong Tower, which will be one of China's tallest buildings at 468 meters.

Paul De Santis：美国GP(Goettsch Partners)事务所董事兼高级项目设计师，拥有14年丰富的工作经验，作为首席设计师负责公司目前大多数中国的项目。频繁来往于芝加哥公司总部和驻上海办事处之间。De Santis先生负责了许多大型办公楼，酒店及综合性建筑项目的直管工作。目前在中国参与工作的项目有40层的北京SOHO嘉盛中心，66层的综合性大楼广州柏悦酒店，成都群光广场旁37层的成都君悦酒店和即将以468米成为中国最高高楼之一的92层天津R&F广东大厦。

Travis Soberg is an associate principal at Goettsch Partners, as well as the firm's director of sustainable design. Mr. Soberg brings 18 years of professional experience and has worked on some of the firm's most prominent projects. With the growth and expansion of the firm's international work, Mr. Soberg currently leads and coordinates many projects in China, including large-scale commercial office, hotel, and mixed-use developments. His recent work in China includes the 92-story, 295,000-square-meter Tianjin R&F Guangdong Tower; the 44-story, 100,000-square-meter Grand Hyatt in Dalian; and a 66-story, 175,000-square-meter mixed-use tower that features the Park Hyatt Guangzhou.

Travis Soberg：美国GP(Goettsch Partners)事务所副董事，同时主管公司可持续设计的工作。Soberg先生已有18年的专业经验并参与了公司一些最杰出的项目。随着公司国际事务的增多与扩大，Soberg目前领导并协调许多中国的项目，这包括大型的商务办公楼，酒店以及综合性建筑。目前参与了92层、295,000平方米的天津R&F广东大厦，44层、100,000 平方米的大连君悦酒店和66层高、175,000平方米具有综合性特色的广州柏悦酒店。

Abstract

The effects of climate change, increased population, and lack of natural resources are global issues. As the world continues to consolidate into regional urban centers, the role of cities in providing solutions to these issues becomes more pronounced. Yet, are the same solutions appropriate in one city also applicable in another? What role does the local climate, culture, or economy play into the formulation of sustainable solutions for these global metropolitan regions? Three buildings with three different environments are analyzed to consider the three unique solutions developed for each project. A critical assessment of the impact local conditions have on tall buildings, the role of cities in generating sustainable solutions for climate change, population growth, and resource depletion can be evaluated; ultimately leading to a more sustainable future.

Keywords: Chicago, Dalian, Abu Dhabi, Urban, Sustainable, Wind

摘要

气候变化，人口增长以及自然资源缺失已然成为全球性问题。随着世界不断向区域的城市中心地区聚合，城市需对这些问题提出解决方案的急迫性也日渐明显。但相同的解决方案能适用于不同的城市吗？对于那些全球的大都市地区，局部气候、本土文化和地方经济在可持续性解决方案的构想到底又起到了什么样的作用？本文通过分析三座不同环境下的建筑，构思了三种截然不同的解决方案。只有在地方条件对高层建筑的影响能准确评估，针对气候变化、人口增长及资源枯竭提出的可持续发展方案中，城市的作用能被正确估量才能最终进入一个更持续发展的未来。

关键词：芝加哥，大连，阿联酋，城市，可持续，风力

The Role of Cities in a Time of Climate Change

Over the last 20 years global urbanization has increased at a rapid rate, fueled by the shift from rural to urban populations of developing countries. This migration is supported by the fact that urbanization stimulates economic growth and vice versa. In fact, no country has reached middle-income status without industrialization and urbanization (The World Bank, 2009). The World Bank further estimates that as a country grows from low-income to lower-middle-income, its urban population rises from 10% to 50% (Brookings Institute, 2012). The regional economy of a metropolitan area benefits from the concentrated labor, infrastructure, and consumers of the region while its businesses benefit from the proximity, specialization, innovation, and economic growth of the metropolitan area. For a region therefore to be prosperous, it is necessary to consider the effects of urbanization and evaluate the sustainability of that urbanization process.

It has been estimated that the world's urban population is increasing at a rate of four times greater than that of its rural population (World Resources Institute, 2012). Between 1990 and 2025 alone, it's expected that the

都市在气候变化时期的角色

在过去的20年中，发展中国家人口从乡镇转移到都市，并以极快的速度推动全球都市化。这种迁移实质上是由都市化对经济发展的刺激所带动，反之亦然。实际上，没有一个国家不通过工业化和都市化而可达到中等收入水平（世界银行，2009年）。据世界银行进一步估计，作为一个从低收入增长为中等偏低收入的国家，都市人口从10%上升到50%。(布鲁金斯研究所,2012年)大都市的区域经济从集中劳动力，基础设施，以及该地区的消费者中受益，与此同时，商业也从大都市中的邻近化，特殊化，革新化和经济发展而受益。因此一个地区要繁荣，就有必须考虑都市化所带来的影响和评估都市化过程的可持续性。

据估计，世界各地的都市人口在以四倍于农村人口的速度增长(世界资源研究所，2012年)。仅在1990年和2025年之间，世界各地的都市人口预计将会增加一倍（同上），在许多国家创造了前所未有的都市化。同时也表明这些城市中心占全球能源消耗量的75%和温室气体排放量的80%(道德曼，2009年)，这似乎预示着都市化加快了气候转变的步伐。然而，按人均计算分析，城镇居民所产生的碳排放量与同一个国家内的其它地方相比要小很多(同上)。因此，这是合乎逻辑的假设，通

world's urban population will double (ibid), creating unprecedented urbanization in many nations. It has also been estimated that these urban centers are responsible for 75% of global energy consumption and 80% of greenhouse gas emissions (Dodman, 2009), seemingly indicating that urbanization facilitates the advancement of climate change. However, when analyzed on a per capita basis, urban residents tend to generate a substantially smaller volume of carbon emissions than residents elsewhere in the same country (ibid). It is therefore logical to assume that, through the efficiencies of urbanization, cities and their urban development can play a part in the solution to climate change if thoughtfully implemented.

That is not to say that the solutions for climate change have a universal answer which will apply in every metropolitan area. Instead, every city and every site must be considered individually to understand the unique opportunities available to create sustainable development. Although the world's urban centers are defined by a universal building typology, truly sustainable urban development can only be achieved when the attributes of each location are fully considered and a holistic design solution is achieved. As international architects of tall buildings, we are faced with these challenges on a daily basis. But, by embracing the unique considerations of each project, tall buildings can be a driver for sustainable development and a part of the solution to global climate change.

Dalian, People's Republic of China

The city of Dalian is located on the Liaodong Peninsula, along China's northeastern seaboard, and is bordered by the Bohai and Yellow seas. Dalian's climate is considered humid continental but heavily moderated by the surrounding seas with four distinct seasons ranging in temperature from -4°C in the winter to 24°C in the summer. Prevailing winds are strong and consistent year round, originating from the north in the winter and across the sea from the south through the summer.

The Grand Hyatt Dalian is a 100,000 square meters, 44 story hotel and apartment tower which occupies a slender wedge shape parcel fronting directly on to the Yellow Sea. To the north and east the project is bordered by the 45,000 square meters Xinghai Square, the largest municipal square in China. To the west sits a residential complex of low-rise residential villas and, at the northwest corner, three high-rise towers with views to the sea. The siting is significant in that it will forever provide clear and unobstructed exposure to the south, east, and north due to the neighboring sea and public square. Initial site studies indicated that by justifying the tower to the eastern edge of the site, the project not only enjoyed better views but also allowed the existing residential towers to maintain their direct site lines of the bay.

In fact, the view analysis to the surrounding context was the key catalyst to the initial massing and articulation of the project. To ensure all guest rooms and residences could capture the dramatic southern views of the sea; an elongated triangular massing was developed for the tower (see Figure 1). The guest rooms and residences form the east, south, and west façades of the building while the elevators and main corridor are justified to the north of the center core. This layout not only gave all units a spectacular view along the coast, but it also gave expansive views back to the city across Xinghai Square from the moment the guest steps off of the elevator.

While the unobstructed north and south exposures lend unparalleled views and light to the project, they also subject the tower to consistent and strong winds from the south in the summer and the north in the

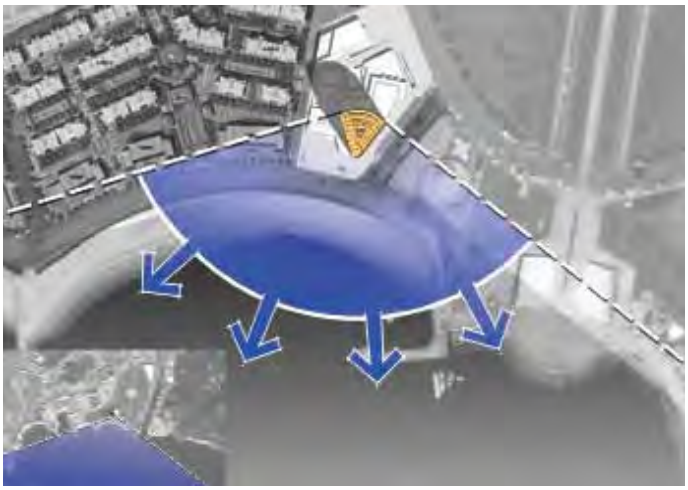

Figure 1. Dalian project site showing Xinghai Square to the north and the Yellow Sea to the south (Source: Goettsch Partners)
图1. 大连君悦酒店项目总平图，北面为星海广场，南面是黄河（资料来源：Goettsch Partners）

过都市化的效率，城市和其都市化发展如果谨慎地实施，可对解决气候变化问题起到一定的作用。

这并不是说，对气候变化的解决方案有一个适用于每一个大都市区域的通用答案。相反，每一个城市和每一个区域都必须被分别考虑以了解其创建可持续发展的独特机会。虽然全球的中心城市是由一个通用的建筑类型学所定义，但真正实现可持续都市发展则需要充分考虑每个地域的特性以及一个全面的设计解决方案。作为设计高层建筑的国际建筑师，我们每天都在面对这些挑战。但是，通过包括对每个项目进行具体的考虑，高层建筑可有助于推动可持续发展并成为解决全球气候变化方案的一部分。

大连，中国

大连位于辽东半岛，沿中国东北部海岸线，濒临渤海和黄海。大连是大陆性湿润气候，但极易受周围的海域影响；大连四季分明，温度范围从冬季的4℃可达夏季的24℃。盛行风在一年中风力强劲且持续不断，冬季从北边夏季从南边经过海面。

大连君悦酒店是一个拥有100,000平方米，44层的酒店和公寓塔楼，细长楔形的场地朝南直接连接黄海南部的海滩。其北部和东部毗邻45,000平方米的星海广场，即中国最大的市政广场。其西部坐落着低层住宅别墅的住宅综合体，在其西北角是三栋海景高层塔楼。酒店的选址极为重要，由于邻接海域和公共广场，其南面，东面，和北面则需要保留一览无余的视野。初步地块研究表明，将塔楼设在东部边界不仅使其享有更好的景观视野，而且可保留现有的住宅塔楼在地块内拥有完整的海岸线。

实际上，对周围环境的景观分析是本项目最初建筑体量和流线设计的关键契机。为了确保所有客房和住宅都能享受南部引人注目的海景；塔楼被设计成拉长的三角形（见图1）。客房和住宅设在塔楼东，南，西三面，而电梯和主要走廊设在核心筒以北。这一布局不仅为每个单元住户提供壮丽的海岸风景，同时也使客人在走出电梯的那一刻起，看到横穿星海广场的整个城市景观。

尽管畅通无阻的南北方位为项目带来无可比拟的景观和充足的光线，但也使塔楼承受夏季从南部和冬季从北部吹来阵阵强风。初步表明，其风速是造成主大堂内有不舒适感受的原因，因此需要为酒店客人提供有遮挡的落客区。然而，通过一个更精确的研究表明，由于其独特的选址，建筑预计会在南北方向经受持续的强风。与其他塔楼情况相似，在建筑转角处风速最高，由于塔楼的弧形几何形状， 其东北和西北角处的风速则格外强劲（见图2）。

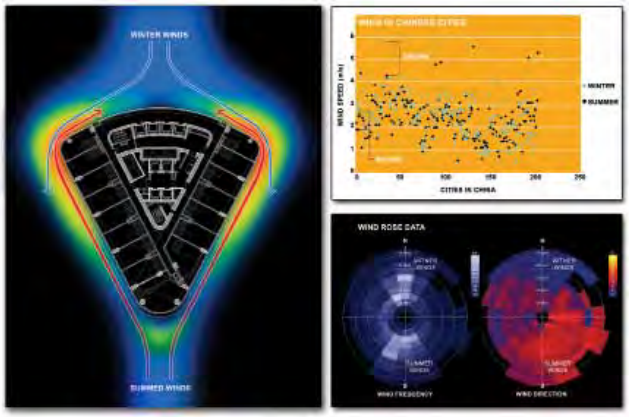

Figure 2. Dalian wind analysis (Source: Goettsch Partners)
图2. 大连风力风向分析（资料来源：Goettsch Partners）

winter. Initial indications were that wind speeds would be significant enough to create uncomfortable conditions in winter at the main lobby, requiring a sheltered drop-off for hotel guests. However a more precise study indicated that, due to its unique siting, the building would experience consistently high winds in a predictable north-south direction. As with most towers, the corners were found to have the highest wind speeds, with the northeast and northwest corners experiencing additional acceleration due to the curving geometry of the tower mass (see Figure 2).

Once the predictability of the wind was understood, the potential to harvest it for energy generation became an important opportunity for the project. Vertical axis turbines (VAT's), which were manageable in cost, size, and scale, were incorporated linearly along the northeast and northwest corners of the tower. With a 3.5 meter floor-to-floor height, the turbines could be supported from the corners of the façade by extending the horizontal metal sunshade out at every other floor, creating a unified expression between the shades and turbines. In this manner, 21 turbines on each corner could be integrated into the tower façade design; providing a total of 300 linear meters of VAT's in an urban setting (see Figure 3).

Manufacturers of VATs were identified and studied to understand what products were available in the Chinese market and whether or not the return-on-investment made economic sense using a simple payback analysis. Criteria were then established for evaluating the available turbine products:

- Manufactured to a quality standard befitting of a 5-star hotel
- Low-maintenance
- Noise and vibration free
- Bird-safe
- Locally manufactured
- Architecturally enriching and integral to the project design

Three manufacturers were found, each with their own proprietary technology which met all of the established criteria. In order to evaluate the effectiveness of each VAT, the turbines were analyzed based on a series of estimated metrics for each system:

- Start-up wind speed
- Weight of unit
- Total system cost
- Total annual kWh produced
- Projected payback period

一旦理解风的可预知性，采集风力以产生能量的可能性为该项目提供了一个重要机会。垂直轴风力涡轮机（VAT），因为其造价，尺度和比例适宜，沿东北和西北外墙转角与建筑呈直线地结合。在3.5米层高中，水平向金属遮阳板从外墙转角处每两层向外延伸支撑涡轮机，形成遮阳板和涡轮机之间的统一表达。以这种方式，每转角处有21个涡轮机与塔楼外墙设计结合，在城市环境中提供了总长为300自然米的垂直轴风力涡轮机（见图3）。

识别与研究垂直轴风力涡轮机的制造商以了解中国市场上有哪些产品可供选购，并且使用简单的投资回报分析来衡量投资回报的经济意义。以下是为评估现有市场上的风力涡轮机产品而定的标准：

- 产品质量标准与五星级酒店相称
- 低维修
- 无噪音和振动
- 鸟类安全
- 当地制造
- 建筑上对项目设计有增补及完善

找到三家厂商，每一家有自己的专有技术，并且满足所有既定的标准。为了评估每个垂直轴风力涡轮机的成效，在一系列估算指标基础上对涡轮机每个系统进行了分析：

- 启动风速
- 单元重量
- 总系统成本
- 生产的年度总kWh
- 预计回报期

在风力分析的基础上，估计垂直轴风力涡轮机95%的时间在转动，80%的时间在发电。初步估计显示，总长300自然米的风力涡轮机每年可以生产高达2.4百万kWh。按大连所使用的平均电力成本0.84rmb/kWh计算，系统投资回报期为12至26年之间，可产生建筑所需的3%能量。

Figure 3. Rendered perspective of Grand Hyatt Dalian showing integrated VAT locations (Source: Goettsch Partners)
图3. 大连君悦酒店垂直轴风力涡轮机渲染效果图（资料来源：Goettsch Partners）

阿布扎比，阿拉伯联合酋长国

阿布扎比，阿拉伯联合酋长国位于波斯湾的南部边界。其气候被认为是亚热带，夏季平均气温超过40° C，湿度水平可达到80

Based on the wind analysis, it is estimated that the vertical axis turbines will spin 95% of the time, generating power 80% of the time. Initial estimates revealed that 300 linear meters of turbines could produce up to 2.4 million kWh annually. Using an average cost of electricity in Dalian of 0.84rmb/kWh it was determined that the payback period would be between 12 and 26 years for the system, generating up to 3% of the energy required for the building.

Abu Dhabi, United Arab Emirates

Abu Dhabi is located on the southern edge of the Persian Gulf in the United Arab Emirates. Its climate is considered sub tropic with summer temperatures averaging above 40°C and humidity levels reaching 80–90%. Due to the high humidity, little diurnal cooling occurs in the evening hours, keeping the thermal temperature of the region elevated throughout the summer. Humidity is constant throughout all seasons. Temperatures cool off in the winter, averaging in the mid-20°C range. Sandstorms frequently blanket the city from May to July.

Immediately adjacent to the existing city center, Sowwah Island is being developed as an extension of the mainland through a series of inter-connecting bridges. Symbolically occupying a point on the island where the land mass curves in to form a small bay, Sowwah Square serves as the anchor for the entire development. The program for Sowwah Square required 270,000 square meters of class A office space and a central stock exchange building comprising 22,500 square meters. The master plan dictated that the office functions be divided into four towers and frame a formal backdrop to the central stock exchange building (see Figure 4). The orientation of each office tower was predetermined by the master plan, based on the premise of the formal planning around the stock exchange as opposed to optimal orientation with respect to a solar analysis.

With the orientation of the towers unchangeable, it became even more critical for the exterior façade design to serve as a multi-functioning veil which protected the buildings while simultaneously providing the features of a modern office tower. In no short order, Sowwah Square's exterior façade needed to provide natural daylight to the office interiors, shield the building from seasonal sand storms, reduce the heat transfer through the exterior wall, reduce energy consumption used to cool the interior space, and provide long-term quality for the life of the building. To accomplish these goals, a unique system of external façade shading solutions was developed which respond directly to the solar orientation, not the building orientation, and allow the interior spaces to remain shaded year-round, regardless of solar exposure (see Figure 5). The systems were divided into three types: south façades, east/west façades, and the central mass.

For the south facing faç ades, a series of external glass sunshades were developed which passively shade the building from direct exposure. The glass shades are optimally spaced one meter apart vertically in order to block year-round solar exposure while preserving views to the exterior for both standing and sitting occupants inside. Each shade extends 750mm from the exterior face of glass and is composed of two layers of 8mm low-iron glass with a laminate bond between. Embedded within the laminate layer is a PET film with a two-color dot pattern impregnated in the film. By utilizing a dot screen pattern within the glass shades, visible light transmittance reaching the façade is reduced by 55%, dramatically reducing the direct solar load on the low-E coated glass from 506wh/m2 to 30wh/m2.

While an external sunshade was a critical component in creating a well-protected exterior façade, it also had the potential to obstruct

%-90%。由于湿度高，昼夜温差变化极少发生，使得该地区整个夏季温度居高不变。全年湿度恒定。冬季温度有所下降，平均维持在20°C中间范围内。5月至7月，沙尘暴频繁覆盖整个城市。

沙瓦哈岛紧邻现有的城市中心，通过一系列相互连接桥梁，沙瓦哈岛被开发成为大陆的延伸。位于这个新开发区中心的是沙瓦哈广场。沙瓦哈广场在岛上的地理条件富有象征性，其地块呈弧线，形成一个小海湾，成为整个开发区的核心。沙瓦哈广场包括功能所需的270,000平方米甲级写字楼和22，500平方米中央证券交易所。总体规划决定了办公功能被划分成四栋塔楼， 并形成中央证券交易所大厦的正式背景（见图4）。每栋办公塔楼的朝向也在总体规划中被预先限定，它是以围绕证券交易所的形式布局为前提，而不是按日照分析得出的最佳方向所定位。

由于塔楼的朝向定位不可改变，其外墙设计则更成为关键，既要作为功能多样化帷幕以保护建筑体，同时又不失现代化商务写字楼的特征。没有捷径可取，沙瓦哈广场的外墙立面需要为办公室内提供自然采光，保护建筑低挡季节性沙尘暴，减少通过外墙的传热，降低用于室内空调制冷所需的能源消耗，保证建筑使用期限内所需的长久性质量。为了实现这些目标，采用独特的外墙遮阳系统解决方案，可直接对日照方向作出回应，而不依靠建筑本身的朝向。无论日光如何照射，室内空间整年保持遮阳（见图5）。该系统被分为三种类型：南外墙立面，东/西外墙立面，和中央体量。

为朝南的外墙设计了一系列外部玻璃遮阳板，被动地为建筑遮挡日光直接照射。玻璃遮阳板在竖向的最佳间隔为一米，以遮挡全年日光照射，同时为室内用户保留无论在站和坐状态下对外的视野。每个遮阳板从玻璃外墙面向外延伸750毫米，并且由两层8毫米的超白玻璃及其之间的夹胶层结合而成。嵌入在夹胶层内为一层PET聚酯薄膜带双色圆点图案布满在薄膜上。利用内有饰点的玻璃遮阳板，达到外墙面的可见光透过率减少了55%，使低辐射镀膜玻璃的直接太阳能负荷从506wh/m2大幅降低至30wh/m^2 。

虽然外部遮阳是创造一个保护良好的外墙立面的关键，但如果不仔细考虑，它也有可能阻碍室内用户的视线和光照需求。两个主要设计因素克服了这样复杂的问题。首先，选用超白玻璃作为遮阳板材料为室外遮阳板创造一个非常通透的表面。虽然从直觉上看似矛盾，但通过消除玻璃的颜色，遮阳板材本身就不会影响由室内向外望的视线。其次，双色圆点图案允许遮阳面一侧白和另一侧黑。白色饰点面向天空，反射日光至室外并减小热岛效应。

Figure 4. Rendered perspective of Sowwah Square (Source: Goettsch Partners)
图4. 沙瓦哈广场渲染效果图（资料来源：Goettsch Partners）

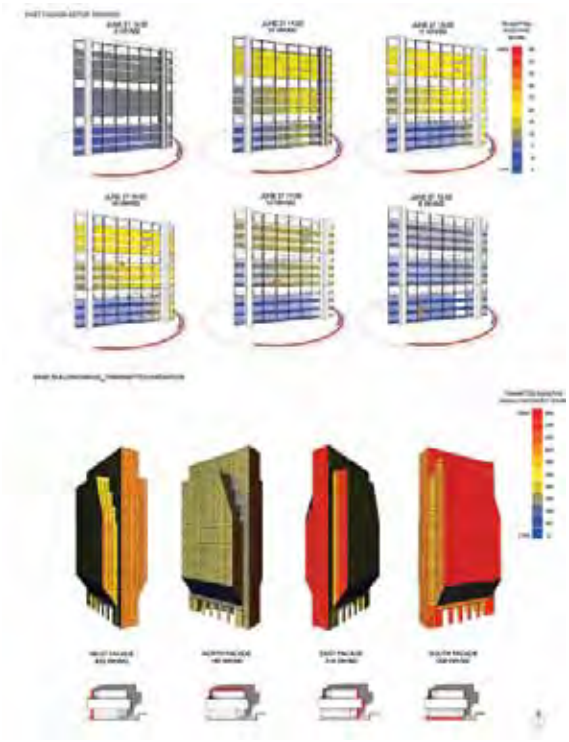

Figure 5. Solar shading analysis of each façade orientation. Upper diagrams show reduction values due to operable shading system (Source: Goettsch Partners)
图5. 不同朝向遮阳分析图，图表上部为使用可控遮阳系统后降低的数值（资料来源：Goettsch Partners）

internal views and light from occupants if not carefully considered. Two main design features overcame this complication. First, the use of low-iron glass for the substrate of the sunshade created an extremely transparent surface for the external shades. While intuitively this may seem contradictory, by eliminating color from the glass the views from the interior looking out remain unaffected by the substrate itself. Secondly, the two-color dot pattern allowed a white-on-one-side and black-on-the-other-side shade to be created. The white dots were oriented toward the sky, reflecting the sunlight to the exterior and reducing the heat island effect. On the underside of the shade, the black dots were used in order to eliminate reflection and create a visually neutral surface which is designed to disappear when viewed from the interior, enabling an unencumbered view to the surrounding context.

For the east and west façades, the same fundamental shading system is used as on the south façades. However, to combat the intense solar radiation from the low morning and afternoon sun angles, it was necessary to motorize the shades and allow them to actively rotate based on the sun's path across the sky (see Figure 6). By adopting the same shading system for both façade types, the buildings maintain a consistent architectural expression on all sides, despite their unique orientations. Yet by motorizing the east and west façades the same system is able to meet the shading requirements of each orientation. To combat windblown sand, specially sealed motors were used to minimize the potential for infiltration and locked motors. Internal analysis indicated that the solar load reaching the façade was reduced from 420wh/m2 to 15wh/m2.

Unlike the typical walls of the south, east, and west façades, the central mass of each tower represents the solidifying geometry of the central core, providing a grounded counterpoint to the soaring volumes of flanking office space. To articulate this underlying concept, the façade system used to enclose this portion of the tower required a unique solution which would read differently than the aesthetic consistency of

在遮阳板底面，黑色饰点可以帮助消除反光并建立一个视觉上的中性表面，其设计目的是从室内往外看时，黑色饰点消失以保证对周围环境清晰的视野。

东西两面外墙采用与南外立面基本相同的遮阳系统。然而，为对抗由早晨和下午较低的太阳高度角所产生的强烈太阳辐射，有必要采用机动遮阳，使其根据空中日光路径有效地主动旋转其角度（见图6）。在两种外墙立面上采用相同类型的遮阳系统，尽管其独特的朝向定位，建筑体上各立面的建筑设计表现得以保持统一。然而通过机动方式处理东西两面外墙上的相同系统能够满足对每个方向的遮阳要求。为了阻挡风沙，使用特殊密封的发动机，以尽量减少潜在的渗透和发动机锁定。内部分析表明，外墙上的太阳能负荷量从420wh/m²大幅度降低至15wh/m²。

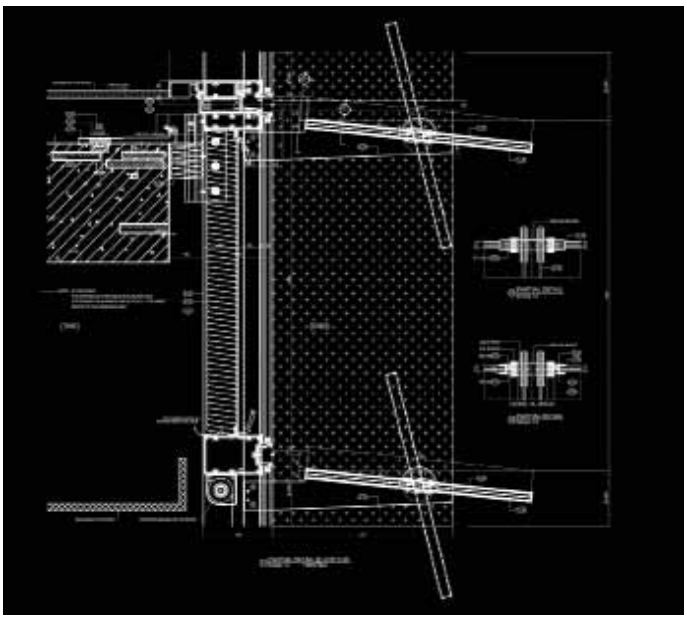

Figure 6. Technical detail of operable shading system (Source: Goettsch Partners)
图6. 可控遮阳系统的技术详图（资料来源：Goettsch Partners）

与典型的南，东，西外墙立面不同，每座塔楼的中央体量代表核心筒的稳固几何形态，与左右两侧高耸体积的办公空间形成对比。为了阐明内涵概念，这部分塔楼幕墙系统需要一个独特的处理手法，与东西两侧主立面一致的外观不同。采用双层幕墙不仅能够创造出一个独特的建筑外观，同时能够为塔楼屏蔽日光和风沙。室内遮阳设太阳能跟踪装置可避免日光直射，而双层幕墙的内腔为室内与室外温差不一创造了温差缓冲区。为了防止空腔内热积聚，双层玻璃内腔还额外用作典型办公楼层的回风井。预处理排风缓解沿外墙极度辐射热温差，提供一个更舒适的工作环境，甚至沿外墙周边。

通过这些设计努力，沙瓦哈广场成功地实现了视野扩展，自然采光，舒适工作环境，和建筑节能等一系列目标。沙瓦哈广场预计可减少28%的能耗，超过ASHRAE90.1中所定的基准（见图7）。

芝加哥， 美国

芝加哥位于美国中北部区，在密歇根湖的南端。类似于大连，芝加哥湿润大陆性气候，四季分明，温度变化从冬季最低-5℃至夏季最高24℃。由于邻近的内陆湖所产生的小气候影响，与邻近内陆地区相比，气温较冬温夏凉。与大连不同，尽管它的绰号为“风城”，由于城市沿湖岸线的湖泊所影响，芝加哥的风模式既不规律也不够强劲，不足以在市区范围内产生能量。

东伦道夫道300号是为健康护理服务公司（HCSC）和其下蓝十字

the east and west main façades. A double-skin façade was developed which was able to create an architecturally distinct expression while maintaining its ability to shield and protect the tower from sun and sand. Solar tracking interior shades provide protection from direct solar exposure while the double skin cavity creates a thermal buffer between the interior and exterior temperature differences. To help combat heat build-up within the cavity itself, the double-skin cavity additionally served as the return air shaft for the typical office floors. The pre-conditioned exhaust air buffers the extreme radiant temperature differential along the exterior wall and provides a more comfortable work environment, even along the perimeter wall.

Through these design efforts, Sowwah Square was able to achieve its goal of expansive views, natural light, a comfortable work environment, and an energy efficient building. Sowwah Square is estimated to realize a 28% reduction in energy consumption over an ASHRAE 90.1 baseline (see Figure 7).

Figure 7. Construction photo of Sowwah Square with operable shades in closed position (Source: Goettsch Partners)
图7. 沙瓦哈广场可控遮阳板处于关闭状态的施工照（资料来源：Goettsch Partners）

Chicago, United States of America

Chicago sits at the southern tip of Lake Michigan in the north central zone of the United States. Similar to Dalian, Chicago's climate is humid continental with all four seasons distinctly represented; ranging in temperature from -5°C in the winter to 24°C in the summer. A microclimate effect is created by the neighboring lake, producing temperatures warmer in the winter and cooler in the summer than neighboring inland locations. Unlike Dalian, Chicago's wind patterns are generally not consistent and strong enough for power generation within the city proper, despite its moniker as "the windy city," due to the lake's effect along the shoreline of the city.

300 East Randolph is a build-to-suit office tower designed as the headquarters for Health Care Service Corporation (HCSC) and its Blue Cross Blue Shield of Illinois division. Prior to the development of 300 East Randolph, HCSC had moved operations four times in 25 years. Their desire was to create a long-term real estate plan which

蓝盾伊利诺分部的总部以特别设计的办公大楼。东伦道夫道300号开发之前，HCSC曾在25年之内换址四次。他们所愿望的是建立一个长期的房地产计划，既可满足他们迫切的需要，又具有灵活性，以适应其长期发展需要。该公司还希望通过简化管理和培养员工之间更大的社会意识来稳固其经营业务。

HCSC在芝加哥市中心的格兰特公园北端，以前土地是为伊利诺州中央铁路局所拥有的。HCSC是想找到一个经济合理的设计解决方案来满足他们的当前的目标，又同时为他们的未来需要提供灵活性。解决方案显然是进行分阶段性地开发，但照惯例它意味着分开的设施和额外的土地成本。

为了达到客户的期望，设计小组为高层建筑设想出一个创新的分阶段解决方案。取代建在格兰特公园地块的第一阶段和日后建在

Figure 8. Phasing diagram of 300 East Randolph (Source: Goettsch Partners)
图8. 300 East Randolph阶段图解（资料来源：Goettsch Partners）

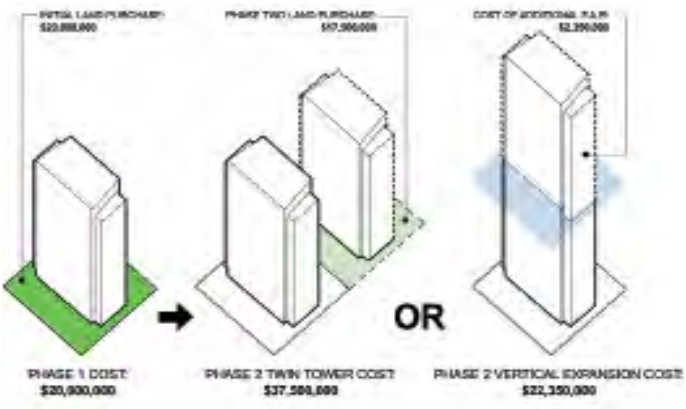

Figure 9. Cost analysis diagram of purchasing additional land versus air rights (Source: Goettsch Partners)
图9. 支付额外土地和制空权的成本分析图（资料来源：Goettsch Partners）

met their immediate needs with flexibility to accommodate growth. The company also wanted to consolidate their operations in order to streamline management and foster a greater sense of community among employees.

HCSC purchased land at the north end of Grant Park in downtown Chicago in an area previously owned by the Illinois Central Railroad. The challenge for HCSC was to find a design solution which allowed them to meet their immediate goals while accommodating flexibility for their future, all within an economical approach. The obvious solution of a phased development made sense financially and accommodated growth, however it would have traditionally meant separate facilities and additional land cost.

In order to achieve the client's desires, the design team proposed an innovative phasing solution for a high-rise building. Instead of building the first phase on the Grant Park parcel and later constructing a second phase on an adjacent site, the firm designed an initial building that could nearly double in height at a later date (see Figure 8). This vertical expansion approach was unprecedented for a building of this size but one that made sense for the client. An analysis showed that vertically expanding the building – even with the cost of additional F.A.R. and a 20% increase in structural premiums – would save approximately US$15 million over the cost of purchasing and securing a neighboring parcel of land (see Figure 9). More importantly, the proposal to expand vertically gave the client unparalleled efficiency and flexibility, allowing them to realize their goals of consolidation and growth under one roof. The project ultimately consisted of 218,000 square meters over 57 floors. Phase 1 was completed in 1997 and included 133,000 square meters over 33 floors. Phase 2 added an additional 85,000 square meters and 24 floors in 2010.

While the vertically phased tower ultimately solved HCSC's specific needs for their operation, it also provided a sustainably driven approach for the project and the city of Chicago. By expanding vertically instead of creating a second office tower on adjacent land, 300 East Randolph increased the density of its site by over 60% and allowed adjacent land to remain open to development for other functions (see Figure 10).

In addition to forming a link between the city's business district and the mixed-use development to the east, 300 East Randolph became a physical link to the city and beyond through the interconnected lower levels of the tower. Below street level, 300 East Randolph serves as a connection to Chicago's expansive underground pedestrian corridors; including the local pedway to the Millennium Metra Station, which

相邻地块上的第二阶段的方案，本公司最初所设计的建筑，可在日后增加近一倍的高度（见图8）。这种垂直扩展方法在这一尺度的建筑中未有先例的，但对客户其意义显而易见。分析表明，垂直扩展建筑－即使包括额外的容积率和增加20%结构所用成本–与购买和确保周边地块的土地成本相比还是可节省约为1.5千万美元（见图9）。更重要的是，垂直扩展给予客户无可比拟的效率和灵活性，让他们认识到在同一个屋檐下就可稳固和发展自己的目标。该项目最终由57层楼组成，共计218,000平方米。第一阶段已于1997年完成，包括33层楼，133，000平方米。第二阶段又额外补充了24层，85,000平方米。

垂直分阶段塔楼不但最终解决了HCSC其独特的运作需求，同样地也为项目和芝加哥市提供了一个可持续发展的模式。通过垂直扩展而不是在毗邻的土地上建造第二办公大楼，东伦道夫道300号的地块密度增加60%以上，并允许相邻地块可有其它功能的开发（见图10）。

Figure 10. Photo of Phase 2 under construction (left), and after completion (right) (Source: Goettsch Partners)
图10. 第二阶段施工中的照片（左图）与完成时照片（右图）（资料来源：Goettsch Partners）

除了在城市商业区和以东的综合开发区之间形成一个衔接，东伦道夫道300号还通过塔楼底层与城市和其之外的相互连结成为一个实体联系。 在街道层之下，它作为芝加哥的四通八达的地下行人通道连接点；而且包括连接千禧地铁站的地下通道，地铁服务通至芝加哥南部郊区和北印地安那州。此外，地下通道还直接连接到相邻千禧公园拥有超过2000个车位的地下公共停车库。实际上，尽管超过218,000平方米，东伦道夫道300号本身仅有137个车位。

东伦道夫道300号，因此成为地块及城市中的一个尺度更大并全面的可持续发展方式的一部分。通过增加项目地块的密度与及空出相邻供都市住宅发展用的地块，东伦道夫道300号有效的减少芝加哥的碳排放量和交通支出。实际上，在芝加哥，城市居民的碳排放量是美国全国平均水平的约2/3，驾驶距离也比平均水平少30%（北海能源，2009年）。通过对城市发展诸如东伦道夫道300号的分析和考虑，这些数字是可以改进并找到一个可行的可持续发展解决方案的。

provides train service to Chicago's south suburbs and northern Indiana. Additionally the pedway connects directly to the underground parking garage below adjacent Millennium Park, providing access to over 2,000 public parking spaces. Despite comprising over 218,000sm, 300 East Randolph contains only 137 parking spaces on site.

300 East Randolph, therefore, became part of a larger, holistic approach to the sustainability of a site and its city . By increasing the density of the project site and freeing adjacent sites for urban residential development, 300 East Randolph inherently helped reduce Chicago's carbon emissions and transportation expenditures. In fact, in Chicago, urban residents produce roughly 2/3 the carbon emissions of the national US average and drive 30% less vehicle miles than the regional average (CNT Energy, 2009). Through careful consideration of urban developments such as 300 East Randolph, these numbers can be improved and a solution to a sustainable future can be found.

Conclusion

While the effects of climate change may be universal and critical across the world, this is not to say that the solutions for climate change are the same and universal. What may be an appropriate solution in one region may not be so in another. Just as all urban centers are not created equal, neither should the solutions proposed for each urban center remain the same. As the authors of tomorrow's urban fabric, it is our responsibility to carefully consider and understand the appropriateness of each design solution, both with a global and a local eye towards sustainability. We must look for the opportunities to integrate our buildings into the local climate, the local culture, and the local economy of a project so that it becomes a catalyst for further sustainable growth. Through this critical assessment of sustainability and urbanization, we believe we will find a solution to climate change and will create a better tomorrow.

结论

虽然气候变化影响可能是全球普遍存在和世界各地所关注的问题，但这并不是说，解决气候变化的方案是一样并通用的。在一个地区可能是合适的解决方案，可能并不适用于其他地方。正如所有的都市中心都不是相同地建成，为每个都市中心所提出的解决方案也不应保持不变。作为未来城市肌理的创造者，我们有责任去认真考虑和了解每个设计方案的适宜性。要同时从全球和区域角度看可持续性。我们必须探寻各种机会来结合建筑的地域性，包括当地气候，文化和经济，使我们的建筑成为进一步可持续发展的催化剂。通过对可持续发展和都市化的临界评析，我们相信我们会找到一个解决气候变化问题的方案，创建一个更美好的明天。

References（参考书目）:

The World Bank (2009). **World Development Report 2009: Reshaping World Geography.** Washington: The World Bank

The Brookings Institution (2012). **Global MetroMonitor 2011: Volatility, Growth, and Recovery.** Washington: Brookings Institution

World Resources Institute (2012). **Population and Human Well-being: Urban Growth.** Washington: World Resources Institute

Dodman, D. (2009). **Urban Density and Climate Change.** Analytical Review of the Interaction between Urban Growth Trends and Environmental Changes, paper 1.

Magellan Development Group, LLC. http://www.magellandevelopment.com/lakeshore-east/

CNT Energy (2009). **ChicagoRegional Energy Snapshot: Profile and Strategy Analysis.** Chicago: CNT Energy.