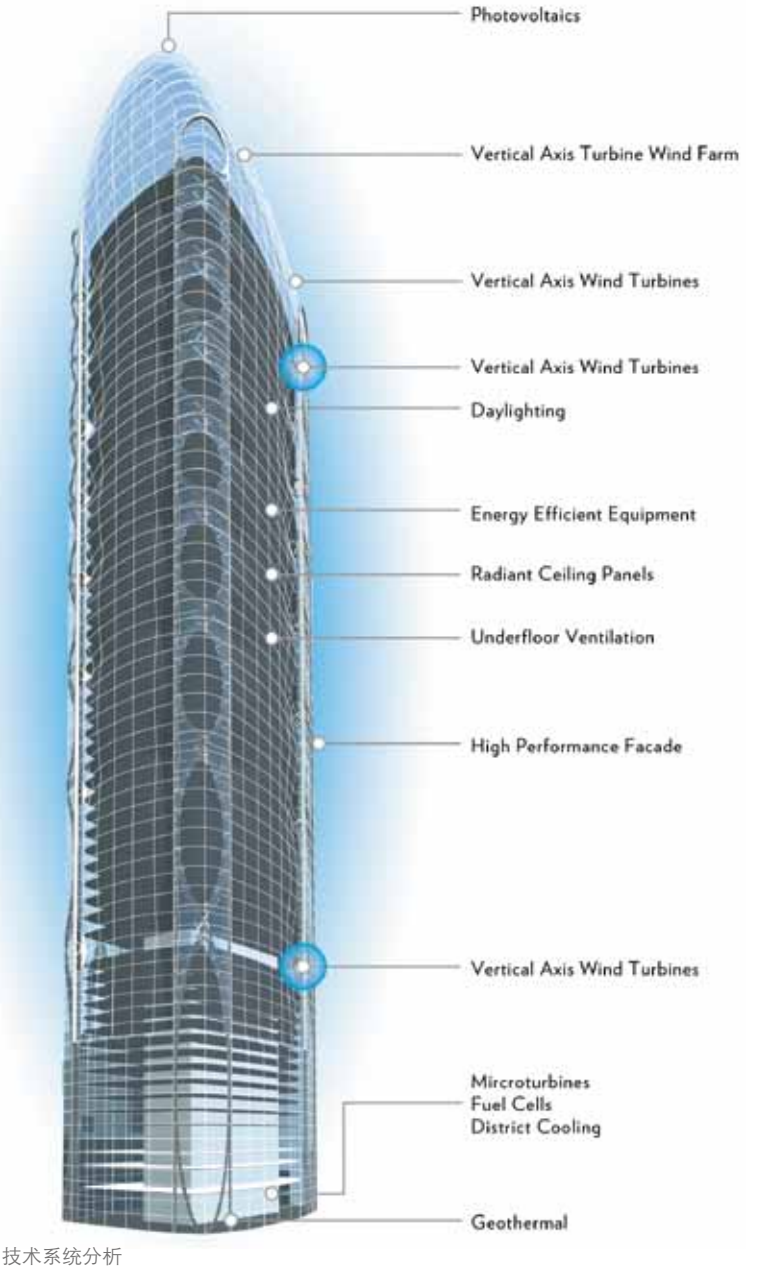
洁净技术塔，芝加哥，美国伊利诺伊州

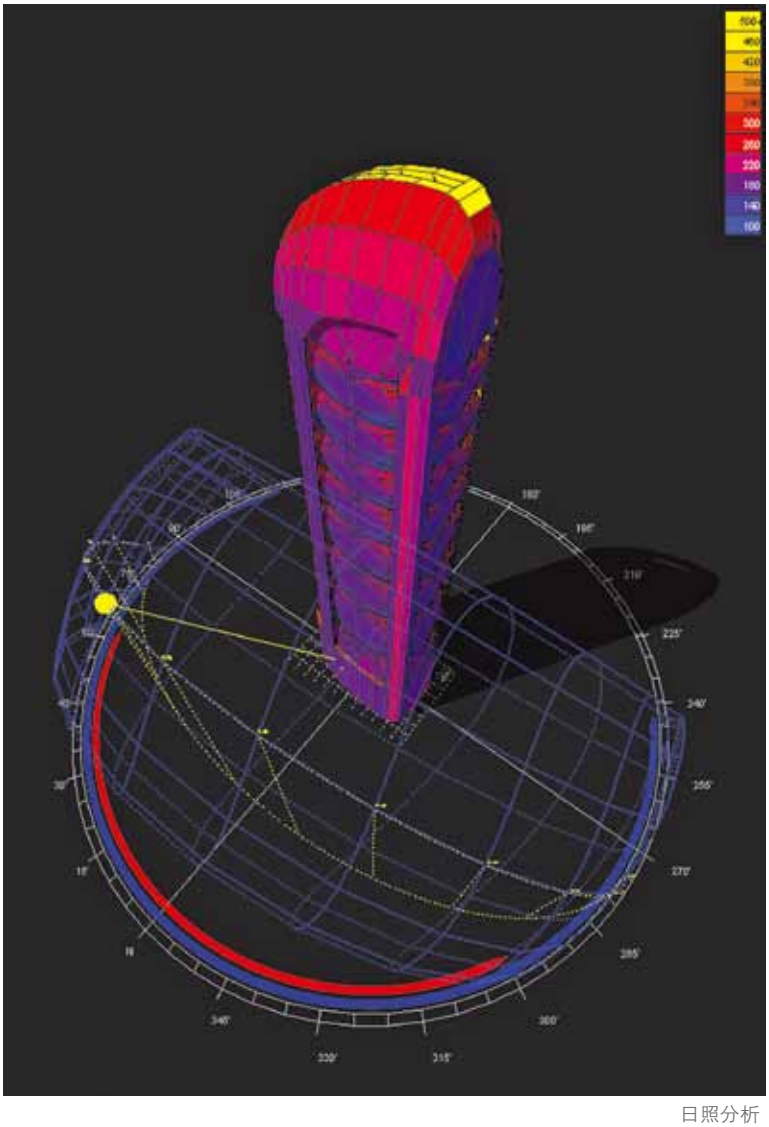
Clean Technology Tower, Chicago, Illinois

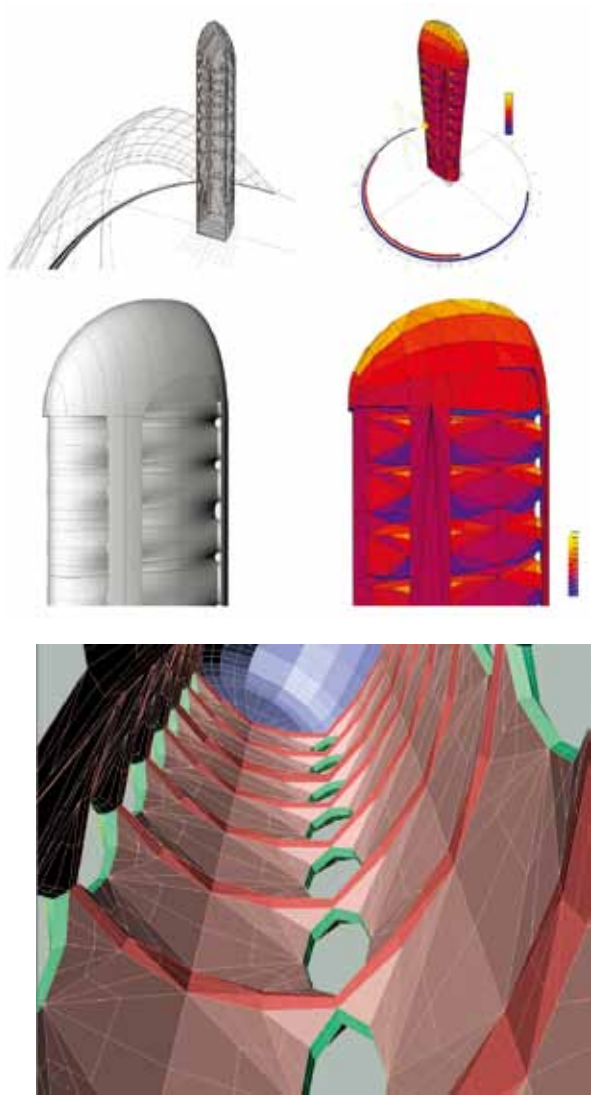
建筑设计 Adrian Smith + Gordon Gill 建筑设计事务所
资料提供 Adrian Smith + Gordon Gill 建筑设计事务所
编校 朱晓琳

建筑外观



技术系统分析





日照分析

洁净技术塔是Adrian Smith + Gordon Gill建筑设计事务所在2006年公司创建初期所设计的项目之一，这是一个高效能、零能耗的综合使用开发项目。既是对其所在芝加哥的建设场地的回应，又可以作为一种表达可持续发展的建筑设计模式而进行广泛推广。该项目也试图表达Adrian Smith + Gordon Gill对可持续发展、高效能设计的理解，以及其对建筑可帮助解决世界上将要发生的能源和碳危机的信心。

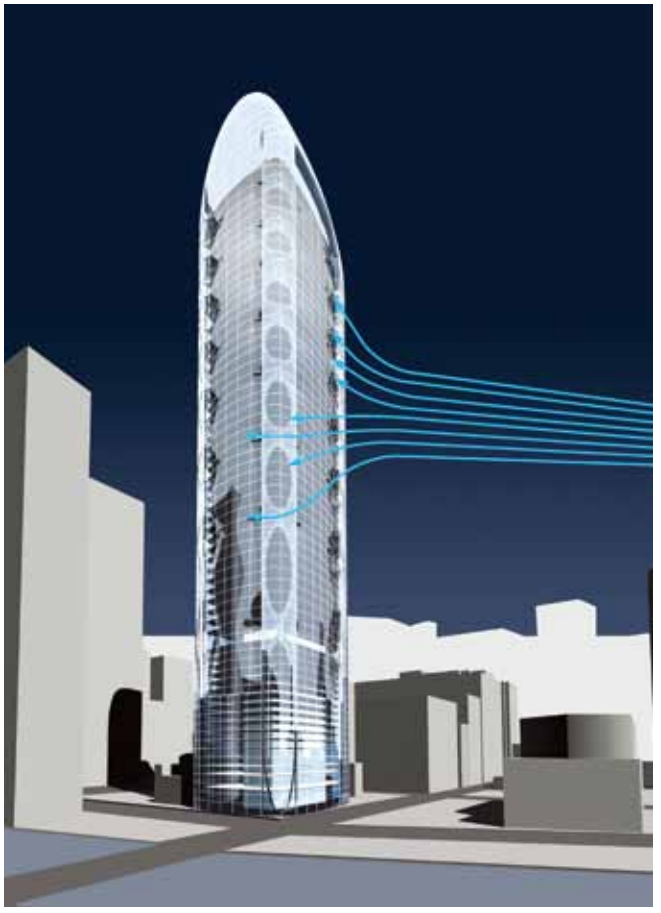
塔楼使用先进的可持续发展的系统和策略来促进它与所在环境的共生关系。塔的选址和体型出自对自然力的利用，此举是用传统的方法来获取能源以提高效率。

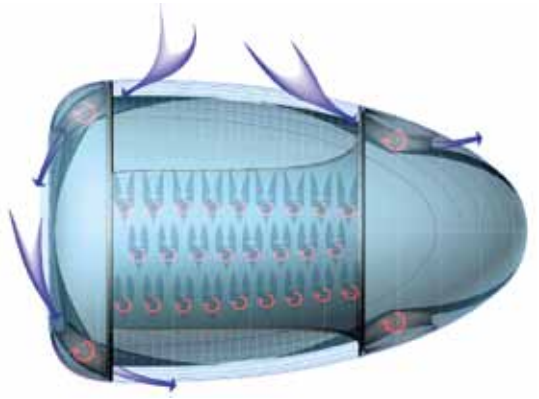
这些设计模式在考虑针对芝加哥地域气候条件的同时，其主导原则和采用的技术也将是具有普遍性的。与之相类似的结构可以在全世界范围内进行建造，同时又可以成为对所在建设场地的回应。

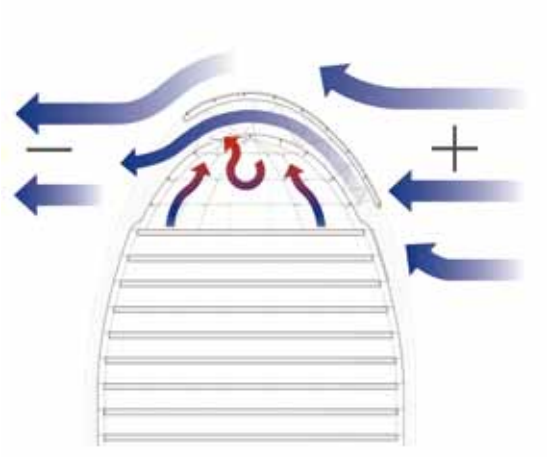
Upon the founding of Adrian Smith + Gordon Gill Architecture in late 2006, one of the firm's first projects was Clean Technology Tower, a high-performance, net-zero-energy mixed-use development designed both for a specific site in Chicago and as a prototype to demonstrate sustainable architecture principles that can be widely applied. The project was also intended epitomize AS+GG's commitment to sustainable, high-performance design and its belief in the role of architecture to help address the world's ongoing energy and carbon challenges. The tower uses advanced sustainability systems and strategies to foster a symbiotic relationship with its environment. Sited and formed to harness natural forces, the tower refines conventional methods of capturing those forces to increase efficiency.

While the prototype design is specific to Chicago, its guiding principles and applied technologies are universal. Similar structures could be built around the world, and each would be formed in response to its particular site.

Originally envisioned for a site in Chicago's West Loop near Willis Tower (formerly known as Sears Tower), Clean Technology Tower features about 167,225 square meters (1.8 million square feet) of office space, 27,870 square meters (300,000 square feet) of hotel space, a spa and street level retail. Office space is located on high floors to maximize views and take advantage of natural daylight. Dedicated elevators provide access for both office and hotel tenants to all of the tower's amenities.







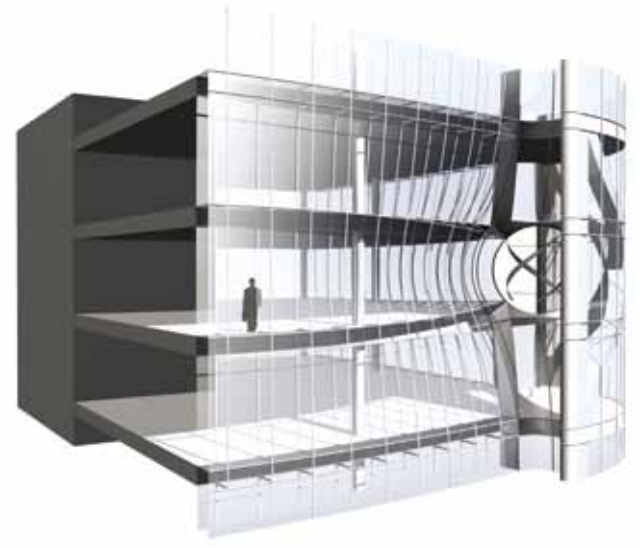
风环境分析

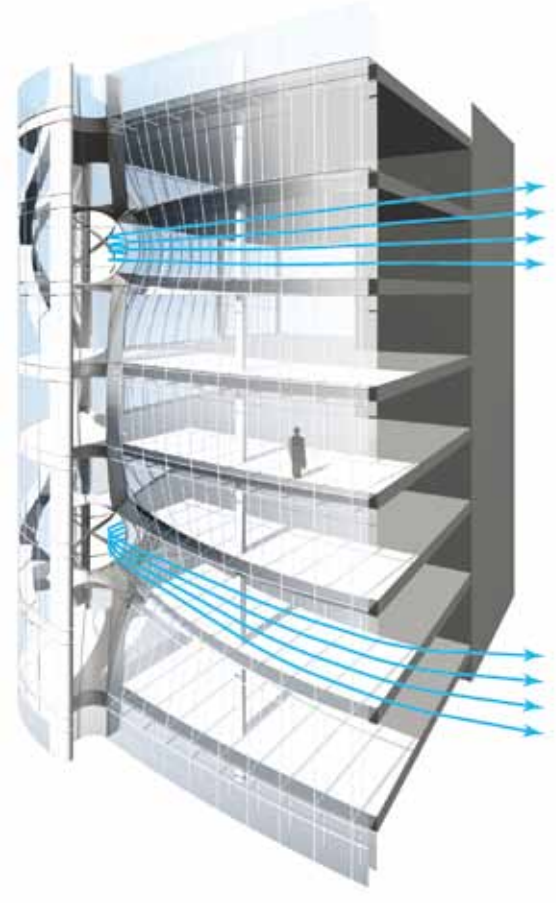
起初设想的建设场地是在芝加哥的西环，靠近威利斯大厦（西尔斯大厦），洁净技术塔约包括167 225m^{2}的办公面积，27 870m^{2}的酒店空间，一个SPA和街道层的零售商店。办公空间位于较高的楼层，享有良好的自然采光和景观的优势。办公和酒店的租户通过专用电梯可以方便地使用塔楼内的娱乐休闲设施。

不像大多数芝加哥的摩天楼将机电设备系统设置在屋顶上，洁净技术塔则拥有一个戏剧性的穹顶，提供了可以尽情瞭望天空和城市的景观平台，可以看到位于它北面一个街区的威

Unlike most skyscrapers in downtown Chicago, which typically store mechanical systems on their roofs, Clean Technology Tower features a dramatic dome at its top that offers unrestricted skyward views (including spectacular views of Willis Tower one block to the north), creating a grand amenity space for conferences, banquets and other gatherings.

The aerodynamically rounded, double-skinned dome is formed to allow air to move around, over and through it, reducing structural pressure, providing natural ventilation and generating power via integrated vertical-axis wind turbines. Wind striking against a square or rectangular shape at the top of a building creates vortex action which increases structural pressure against the building and causes it to oscillate. On Clean Technology Tower, the curved shape of the dome allows the wind to flow over it, reducing the amount of wind





利斯大厦的雄伟景色，又为会议、宴会和其他集会活动创造了一个高雅的环境设施。

具有双层表皮的穹顶符合空气动力学原理，容许空气环绕其上下左右自由地流动，减小了对结构的压力，有利于自然通风，同时可以通过与建筑整合为一体的垂直轴的风力发电机发电。如果建筑物的顶部呈方形或长方形会增加风的漩涡作用，加大对建筑物的结构压力进而造成塔的摆动。而洁净塔的弧型穹顶容许风的通过，减少了风压并使风压变得恒定和连续，使塔体更加稳定。

pressure and making that pressure more constant and continuous. That in turn reduces stress against the building, making it more stable.

The softly molded exterior wall system features notches housing vertical-axis wind turbines that funnel and harvest the prevailing southwest winds at accelerated speeds. The tower's massing is distinguished by an ascending pattern of apertures in the exterior wall that house the wind turbines, taking full advantage of faster wind speeds at higher altitudes. Placement of the turbines at the tower's corners is intentional; wind speeds and pressure increase as air passes into the turbine housing. The building's orientation on the site, facing the prevailing winds from the southwest, facilitates wind power collection, funneling the air into the turbines at faster speeds, maximizing energy generation.

The dome is also designed to facilitate natural ventilation at highaltitudes. Wind moving through the double-skinned dome creates a negative pressure that

柔软的模塑外墙系统带有凹槽，垂直轴的风力发电机暗藏其中。凹槽起到烟道的作用，并且有利于获取和加速主导的西南风。塔楼外墙上的穿孔凹槽图案成为其造型上的显著特征，并且最大化了在较高的地带利用更大风速的优势条件。在塔的转角处安置了风力发电机，当空气经过发电机外壳凹槽时其风速和压力均会增加。建筑物面对主导的西南风，有利于收集风力，将空气以较高的速度引入发电机实现最优化的发电。

穹顶的设计也是为了加强高位处的自然通风。风通过双层外皮的穹顶产生副压从而实现自然通风，减少通风设备所消耗的能量。穹顶为建筑物的使用者提供了令人惊奇的多层娱乐空间，并形成了壮观的城市天际线。

由于穹顶的圆角和外墙可以减弱建筑物的风漩涡作用和减少结构压力，从而降低了结构用材，这也意味着减少了施工过程中的碳排放量。除了风力发电机外，洁净技术塔还考虑了一系列的节能系统和策略，包括光伏发电和地热能源，其总的结果就是要创造一个零能耗项目。

在穹顶和外墙上设置光伏发电组件是设计团队经过对建设场地环境深入分析后的决定，洁净技术塔自身的枕状形体利于取得更多的太阳能量及降低下方的温度。

从过往的一些项目如中国广州的珠江塔（由Gordon Gill和 Adrian Smith在SOM时设计）所得的经验，Adrian Smith + Gordon Gill的设计团队预计与弧形枕状形体下面向内倾的自成形体一样，小面或枕形可以给洁净技术塔更多利用光伏板发电的机会。因此，在每一枕形的上方，窗间玻璃墙板将向外弯曲，使薄膜光伏板暴露在更多的阳光下，同时为其下方的可见玻璃遮阳和减小眩光。

数码模型同样也显示出最大获取阳光的位置位于塔顶，因而设计团队将注意力集中在穹顶的遮阳和光伏建筑一体化的层面。玻璃上采用的薄膜光伏板呈渐变分布，穹顶的最顶部兼有发电和遮阳的光伏板覆盖。而在以下的楼层中，由于景观变得更为重要，覆盖的光伏板将逐渐减少。

洁净技术塔也是芝加哥的第一个双层玻璃幕墙项目，在夏季玻璃之间的空隙可以获得温暖的空气并排到室外；在冬季，空隙中收集的被太阳照射的热空气将成为环绕在建筑物周围的“保温毯”。

外墙模数化的板和窗框是另一个值得注意的特点，经过精心设计的柔和的风力发电机外壳凹槽沿着建筑体的通高分布。此外，为了便于施工还设计了另一个外墙方案——外墙可用直线的窗框和均匀形状的楼板。

produces natural ventilation, reducing energy consumption by exhaust fans. The tower's domed top also provides a stunning, multi-story amenity space for building users, affording them with spectacular views of the city skyline.

The rounded corners of the dome and exterior wall were found to reduce wind vortex action and structural pressure on the building. That makes for less structural material required for construction, along with a significant reduction of the embodied carbon associated with construction. Besides the wind turbines, Clean Technology Tower integrates a variety of systems and strategies, including photovoltaics and geothermal energy generation; the overall result is to create a net-zero-energy project.

The placement of integrated photovoltaics on the building's dome and exterior wall was informed by extensive environment analysis of the building site. That analysis, conducted by the design team, showed that Clean Technology Tower's form could be shaped to respond to higher levels of solar exposure at the top of the pillow shapes and lower temperatures beneath due to self-shading.

Drawing on their experience on previous projects such as Pearl River Tower (designed by Gordon Gill and Adrian Smith while at Skidmore, Owings & Merrill) in Guangzhou, China, the AS+GG design team anticipated that a faceted or pillowed shape could give Clean Technology Tower better opportunities for energy generation via photovoltaics as well as self-shading on the inward-angled undersides of the curved pillow shapes. At the top of each pillow, the spandrel glass could be curved outward, providing better exposure for thin-film photovoltaics that would also shade and reduce glare on the vision glass beneath.

Digital modeling also revealed that the greatest solar exposure is at the top of the tower, which focused the team's attention on opportunities for shading and BIPV-generated energy in the dome. That in turn informed the design of graduated zones of thin-film photovoltaics applied to the glazing.

The very top of the Clean Technology Tower dome is covered with photovoltaics, which provide energy generation and shading. PV coverage reduces as access to views becomes more important at floor level.

Clean Technology Tower also features one of Chicago's first double climate walls, which capture warm air in an interstitial space between the glass walls and exhausts it outside the building in summer months. In the winter, the solar-heated air collects inside the interstitial space and forms an insulating "blanket" around the building.

The wall design is notable also for its molded slabs and mullions, which are softly sculpted around the turbine housing along the length of the tower's body. For greater ease of construction, an alternate scheme for the building skin provides for an exterior wall with straight mullions and evenly shaped floor slabs.

双层幕墙系统