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Sustainability with a View
可持续性展望

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在WSP工作的25年里，苏珊在很多大型以及具有挑战性的工程项目里都出任主工程师。她专注于给客户提供高品质、有价值和创新的思路，以可持续发展为重中之重。

Abstract

All truly great outcomes are the result of collaboration. In a building's life cycle, collaboration between designers, owners, builders and users can result in improved long-term performance. Tall building energy-use is heavily weighted on the tenants that occupy them in addition to the "base" building's performance. This paper will explore the roles of developers and tenants and how partnerships between them will significantly reduce resource consumption over the building's life.

The 326-meter-tall, 61-story, Transbay Tower in San Francisco, California will be the primary case study with analysis, research and life cycle cost models developed during design. The Transbay Tower is being developed in partnership by Boston Properties and Hines and will be the centerpiece of the Transbay development in San Francisco and is located adjacent to the multi-model Transbay Transit Center described as the "Grand Central Station of the West". The tower is pursuing LEED Platinum Certification by the USGBC.

Keywords: Transbay Tower, Sustainability, Transit Center, UFAD, Urbanism, Co-Generation

摘要

所有真正伟大的成果都是通力合作的结果。在一个建筑物的生命周期中，通过设计方、业主、建设方和最终用户之间的配合将会极大地提高建筑物在未来长期稳定的性能。高层建筑除了本体的能耗外，租户在使用期间的能耗占据了总能耗中很大一部分。本文将探索发展商和租户间的相互作用、以及他们之间互惠的合作关系将如何在建筑的生命周期中显著减少资源的耗费。

本文以这座位于加州旧金山的326米、61层高的跨海湾大厦作为主要的研究对象，重点阐述了设计过程中所做的分析、研究以及全生命周期费用模拟。这座大厦的联合发展商是Boston Properties 和 Hines，是规划中的旧金山交通枢纽中心的重点项目。本项目紧邻被称为"美国西部最宏伟的中央车站"的多形态跨海湾交通中心。这座大厦将寻求美国绿色建筑协会的LEED白金证书认证。

关键词: 跨海湾大厦，可持续性，交通枢纽中心，地板下送风系统，城市化，热电联产

The Transbay Tower, now officially named The Salesforce Tower, was conceived as the centerpiece of a bold urban development plan to create a transit-oriented neighborhood in downtown San Francisco. The 61-story building is this paper's primary case study, with emphasis on the analysis, research and life-cycle cost models developed during design. Developed in partnership between Boston Properties and Hines, the 1,070-foot-tall tower will be the tallest building in San Francisco upon its completion in 2017. It is seeking LEED Platinum certification.

Many separate facets of sustainability have been considered and intertwined from the beginning of the Tower's design in order to create a truly unique sustainable workplace. While many buildings achieve laudable and commendable sustainability results through design alone, the Transbay Tower team ventured steps further to integrate high-performance, cutting-edge design with neighborhood planning and transit

跨海湾大楼，现在正式的官方名称为Salesforce大楼，是作为旧金山城市规划中的市中心交通枢纽配套项目启动的。本文以这座61层的大厦作为的主要研究对象，重点阐述了设计过程中所做的分析、研究以及全生命周期费用模拟。这座326米 (1070英尺) 高的大厦的联合发展商是Boston Properties 和 Hines，在2017年建成后将会是旧金山最高的建筑。这座大厦将寻求LEED白金证书认证。

在大厦设计初期，为了创造一个真正不同于往常的可持续的办公场所，我们就考虑到了可持续性设计的错综复杂的各个方面。当很多建筑物仅通过设计就取得了令人赞许的可持续性成果时，跨海湾大厦项目的团队把目光投向实施综合了周边地区整体规划、以交通中心地位为导向的高性能、最先进的设计，将建筑、结构和机电设计紧密结合，用户和业主密切配合，进行了大厦的优化设计。

orientation; integrated architectural, structural and MEP design; and tenant and owner coordination to optimize building performance.

A New Transit Hub

The key to the new Transit District is a much-needed multi-modal transit hub, The Transbay Transit Center, which sits adjacent to the Tower. The Transbay Transit Center will allow people to conveniently commute into the heart of San Francisco via multiple bus and rail lines and future high-speed rail from Los Angeles. Designed as an amenity-filled "Grand Central Terminal of the West," the Center will unify 11 disjointed transit systems in a modern, daylit, open and inviting space. The Transbay Transit Center is at the heart of the revitalization of the neighborhood and the viability of the Transbay Tower, as well as other planned development in the area (see Figure 1).

In addition to those transit systems which will feed directly into the Transit Center, the Bay Area Rapid Transit (BART) light rail lines, which bring commuters into the city from five surrounding counties, have stations located within one block of the Transbay Tower. The transit-friendly location, combined with cyclist-friendly amenities in the building itself, allow the tower to promote convenient low-carbon transportation for the new influx of office workers. Additionally, nearly 4,400 new residential units located in new buildings surround the tower's site as part of the comprehensive San Francisco Transit District Plan, with the Transbay Transit Center and Tower at its core for the creation of a dense, walkable environment.

While there are advantages in terms of sustainability, these types of new, high-density, mixed-use urban developments are not inviting or livable in the long term if they fail to blend nature into their development plans. In this case, the synergy of the built environment with the outside surroundings is achieved via the tower's grand plaza, home to 24 native Sequoia trees and a 5.4-acre park that sits atop the transit center's roof and is accessible from the fifth level of the tower. The park provides urban refuge for the public and is fully self-sufficient in terms of both water and energy. Further, it acts as a hub for people to meet and connect with one another and provides a sanctuary for people and a habitat for local botanical and wildlife species (see Figure 2).

Water and Energy Efficient Systems

While most tall buildings are constrained in land, skin area and roof space, that does not mean the design and engineering cannot offset the dense load of occupants stacked in height. The Transbay Tower sets an exemplary model in using density to its advantage in terms of water use and energy efficiency.

During design, projected water use in the tower was studied closely. Engineering strategies employed include model potable water use reduction incorporated into the tower design. Rainwater is captured from the roof, the façade and adjacent plaza; grey water is captured from lavatory sinks, showers and HVAC condensate drains and treated for reuse for landscaping and flushing toilets. The toilets are dual-flush, urinals are pint-flush and all sinks are low-flow. The combined strategies reduced the annual water use of the building by nearly 45 percent or 4,000,000 gallons of water. What's more, with water-related energy use in California consuming approximately 20 percent of the state's electricity, and 30 percent of the state's non-power plant natural gas, saving water allows the building another avenue to save energy. (Managing an Uncertain Future 2008)

Figure 1. Transbay Transit Center and Tower Arial View. (Source: Pelli Clarke Pelli)
图1. 跨海湾交通中心和大厦空中鸟瞰图 (来源: Pelli Clarke Pelli)

新的交通枢纽

新的交通中心区是一个随着城市发展而迫切需要的多功能多生态交通枢纽。跨海湾交通中心可以方便地接纳通过各种交通手段来到旧金山心脏的人们，包括公共汽车、有轨电车以及未来的高速列车等。作为"美国西部最宏大的交通枢纽中心"，本交通中心将11个交通系统连接在一个现代化的、四季如昼、开放、宾客如归的空间内。跨海湾交通中心位于富有活力的市中心，使得本市区的规划获得了新生，跨海湾大厦更为本地区充注了新的活力。(参见图1)

除了那些直接连接到本交通中心的交通系统外，连接旧金山周边5个县的湾区轻轨捷运系统 (BART) 都将在距离跨海湾大厦一条街的地方停靠。交通便捷的位置，结合建筑内对骑自行车的人的设施，将为大楼提供条件向大批全新办公人员的涌入推广便利、低碳的交通环境。另外，在旧金山交通中心区整体规划中，本大厦四周将新增加将近4400个住宅单元，再加上交通中心以及大厦本身，这里将形成一个人口密集的步行街的整体环境。

在拥有众多的可持续性的优点的同时，如果不将大自然的因素考虑进发展规划中，那么这些全新的、高密度的、多功能城市发展

Figure 2. Transbay Transit Center Park. (Source: Pelli Clarke Pelli)
图2. 跨海湾交通中心公园 (来源: Pelli Clarke Pelli)

The approach to creating a high-performing, energy-efficient tall tower must focus on the design of the architectural and structural systems before turning to the MEP systems, as optimizing the design reduces the reliance on the MEP systems. To that end, the Tower's envelope minimizes solar heat gain through the use of high-performing glass, deep horizontal sunshades and vertical mullions that also create a unique tapestry and add depth to the glassy façade. The 14-foot, 9-inch, typical floor-to-floor heights and minimum 10-foot ceilings allow more daylighting to penetrate deeper into the office floors.

In addition to high performing architectural and structural systems, the MEP design is able to leverage the San Francisco climate, which is mild with the majority of daytime temperatures between 50° F and 70° F. As a result, outside air can typically be used for ventilation and free cooling, providing a low-energy, high-quality, flexible solution to meet the requirements for increased office environment standards (see Figure 3).

Unique Underfloor Air Distribution System

An underfloor air distribution (UFAD) system is the silver bullet in terms of energy efficiency for the Transbay Tower. UFAD systems have several sustainable advantages over traditional overhead systems, including improved thermal comfort stemming from individual occupant control, improved ventilation effectiveness and indoor air quality, quieter air distribution, increased flexibility to accommodate tenant churn, significantly fewer hot and cold calls, and reduced energy use (see Figure 4).

The UFAD system increases the number of available hours of free cooling by delivering outside air at a lower temperature at the floor level and mixing it quickly with the warmer occupied space air. Architectural coordination of large outside air ducts can be challenging particularly in tall towers where shaft space is at a premium. In this case, the architects cleverly integrated the outside air and relief louvers into the façade between horizontal louvers at each floor. The bands of the louvers are disguised and the texture creates an interesting façade. The horizontal outside air ducts are coordinated with the floor structure and the core shear walls, and extended into the two air handling rooms on each floor.

The air-handling units are custom "Tri-Path" units, proprietary to Hines, and have the advantage of providing a 100 percent air economizer and simultaneous heat recovery. The units are designed and arranged to serve both the perimeter and interior zones from a single air handling unit without the installation of mechanical equipment above the tenant ceiling or below the raised access floor (see Figure 5).

Each tri-path unit is constructed with three separate air tunnels, or "paths," with the top and middle air paths working together to serve the tower's perimeter zones. The bottom down-flow air path serves the UFAD interior zones by combining cooling air transferred from the middle air path with return air to achieve the desired underfloor supply air temperature. The heat from lights, bodies, and computers, etc. in the return air is used for heat recovery to warm the perimeter, where heat is lost through the glass façades. The UFAD system saves approximately 75% in fan energy compared to an ASHRAE 90.1 baseline VAV system. The floor-by-floor system, as opposed to a central system, allows tenants to easily measure their own fan energy use, lower their energy consumption, and save money.

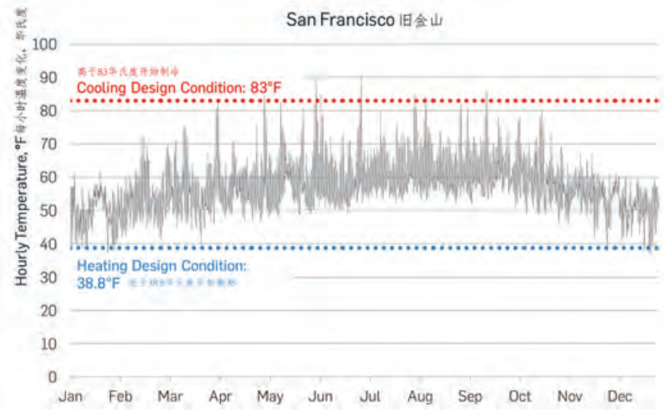

Figure 3. San Francisco Climate Graph. (Source: WSP)
图3. 旧金山气候图 (来源: WSP)

Figure 4. Transbay Tower Section. (Source: Pelli Clarke Pelli and Steelblue)
图4. 跨海湾大厦断面图 (来源: Pelli Clarke Pelli和Steelblue)

规划不可能长期发展下去。本例中，建筑环境与外界环境的和谐共处是通过大厦下方的大广场实现的，广场上有24棵当地的红杉树，一个5.4英亩 (18060平米或27亩) 的公园坐落于跨海湾交通中心的楼顶，跨海湾大厦可以通过5楼的通道连接到公园。公园给公众提供了一个远离城市喧嚣的宁静场所，公园的水和能源完全自给自足。再者，公园还扮演一个让人们会面、拉近人们距离的作用，并给人们提供一个放松的场所，同时也给当地的植物和野生动物物种提供了栖息地。 (参见图2)

高效节水节能的系统

大多数的建筑物都受土地、外表面积、以及楼顶空间的限制，但并不意味着工程设计不能降低高层建筑垂直空间内的大密度负荷。跨海湾大厦在高层建筑的节水节能方面树立了一个典范。

在设计过程中，我们用模型对大厦用水进行了仔细研究，并将模型中减少饮用水的措施结合到大厦的工程设计中。从屋顶、外墙和相邻的广场回收雨水;从洗手间洗水盆、淋浴和空调冷凝水排水管回收灰水，经处理后再用于绿化和冲洗厕所。厕所是两档冲水、小便池是低水量冲洗、所有的洗手池都是低流量龙头。各种节水措施综合起来，每年可以节约年度用水量中约45%、或4000000加仑 (14908立方) 的水。更重要的是，在加州，与水相关的能源消耗大约占全州20%的发电量，和全州30%的非发电天然气。节水带来另一种途径的节能。 ("管理一个不确定的未来"2008)

Indoor Air Quality and Overall Improved Office Environment

Additional benefits of UFAD systems are improved thermal comfort, ventilation efficiency and indoor air quality. By allowing individual workers to have some control over their local thermal environment, individual comfort preferences can be accommodated at their workspace by adjusting the openings in the swirl diffuser. A higher degree of ventilation efficiency is provided by greatly increased quantities of outside air and some improvement in indoor air quality can be achieved by delivering the fresh supply air near the occupant at floor or desktop, allowing a floor-to-ceiling air flow pattern to more efficiently remove contaminants from the occupied zone of the space. Overall, the UFAD system creates a healthier and more comfortable environment for the building tenants.

Tri-Generation and Future Energy and Carbon Concerns

Provisions for future-proofing the building for the tenants and owners were considerations of the WSP design and a future cogeneration or tri-generation system was planned for the Transbay Tower with the following objectives:

1. Provide cost-effective approach to deliver energy for tenants.
2. Utilize a directed-biogas-driven cogeneration system that provides renewable energy to the project in excess of LEED and Cal Green requirements.
3. Reduce the overall greenhouse gas emissions of the project.
4. Improve the reliability of the electric and chilled water (or heat) supply to the building.
5. Deliver chilled water to tenants from cogeneration heat with an absorption chiller. This could potentially reduce the size and operational costs of the chiller plant.
6. Increase the redundancy of energy sources and services to the project.
7. Increase the overall long-term value of the Transbay Tower Building.

A 1,000 kW biogas/natural gas-driven cogeneration system including four (4) 250 kW reciprocating gas engines has been planned for the third floor directly above the central plant and adjacent to the life safety generator. The 1,000 kW plant will produce electricity and cooling to support the tenant 24-hour loads such as server and IT

要创建一个高性能，高能效的高层建筑必须着眼于建筑和结构系统的设计，然后再转向机电系统，因为优化设计将会减少对机电系统的依赖。为此，大厦的围护通过使用高性能的玻璃，深度水平遮阳和垂直竖框，最大限度地减少太阳热量的吸收，也创造出独特的挂靠的玻璃幕墙并增加了玻璃外墙的深度。典型的楼板到楼板的高度14英尺9英寸 (4.5米)，和最小的10英尺 (3.3米) 高的天花板高度可增加天然透光到办公室内的深处。

除了高性能的建筑和结构体系，机电系统的设计还可以充分利用旧金山温和的气候，旧金山白天气温多数在50°F (10°C) 和70°F (21°C)之间。如此一来，外面的新风通常可以用于通风和免费制冷，为空调系统提供了一种低能耗，高品质，灵活的解决方案，可以满足不断增加的办公区里的室内环境标准的要求。(参见图3)

独特的地板下送风系统

谈到跨海湾大楼的节能效果则要提到地板下送风系统(UFAD)。相对于常规的顶部送风系统，地板下送风系统有几个可持续优点，包括提供了个别温度及湿度的可控性去改善舒适性，提高了通风效率以及室内空气品质，安静的空气输送，增加了租户改造的灵活性，明显减少了租户们对于过热和过冷的埋怨，并显著降低了能耗等 (参见图4)。

利用新风温度较低的条件并且与区域较暖的循环空气快速混合，地板下送风系统增加了免费制冷的小时数。但是对于大型的新风风管与建筑的配合将会是一个挑战，特别对于高层建筑竖井空间更是如此。在这种情况下，建筑师聪明地将新风和排风百叶设计在每层的幕墙上。百叶的板和纹路经过精心修饰，创造出一个精致的幕墙。水平的新风风管与楼层结构和核心筒剪力墙完美结合，连接到每层的2个风机房。

暖通风机机组是定制的Hines专有的"三通道"机组，能在进行100%空气节能优化器并同时提供热回收。风机机组的设计和布置以单一风机同时服务内部区域和外部区域，而不用在租户的天花或抬高地板下安装暖通设备。(参见图5)

每个三通道机组都是由三个单独的风管构成，上方和中间的风管一起服务外围区域。底部的下沉气流服务地板下送风系统的内部区域，通过将来自中间通道的过渡的冷空气与回风进行混合以达到所需要的地板下送风温度。回风中来自照明、人体、和计算机等的热量经过热回收对外围区域进行加热，因为外围区域有玻璃幕墙温度会降低。与美国标准ASHRAE 90.1的基准变风量系统相比，地板下送风系统节约了大约75%的风机能量。分层的系统相对于中央系统，方便租户对自己的风机耗能进行计量，降低其能耗并节省金钱。

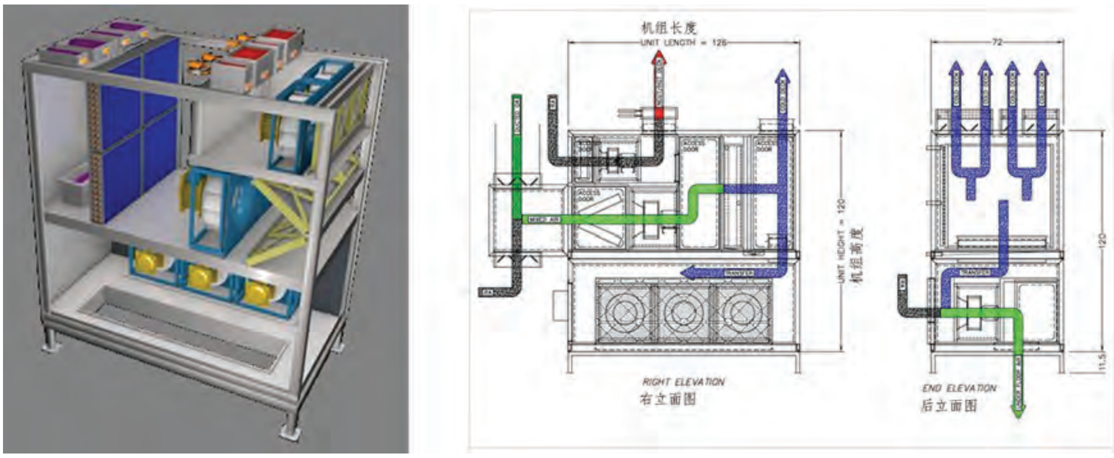

Figure 5. Transbay Tower UFAD Tri-Path Unit. (Source: Hines and WayPoint Systems, Inc.)
图5. 跨海湾大厦地板下送风系统三通道机组 (来源: Hines 和 WayPoint系统公司)

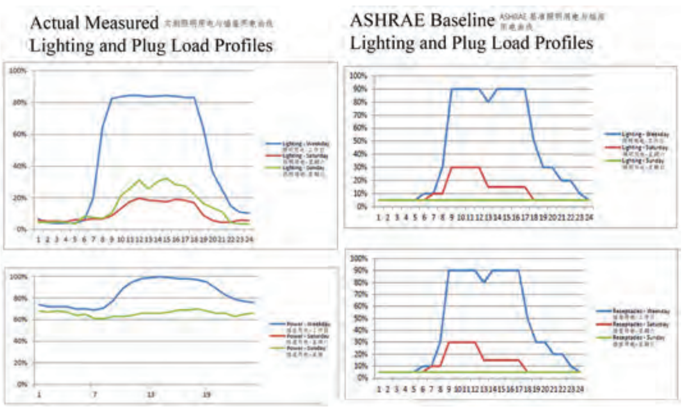

Figure 6. Tenant Energy Profile Comparison. (Source: WSP)
图6. 租户能耗比较 (来源: WSP)

rooms. The annual electrical production is estimated at 38% of the total building energy. The approach to the cogeneration plant sizing was to reduce the continuous "base load" of the building and data was collected to predict the future building load profiles by collecting the utility data from similar local projects.

Energy modeling typically assumes that building loads drop-off to close to zero at night; however, as the diagrams show, this is not truly the case. Office buildings actually require a significant amount of air conditioning and power for tenant servers that operate around the clock. Data gathered by engineers at WSP shows that the base load of office tenants is much higher than previously thought. WSP sized the future co-gen units to support this 24/7 load (see Figures 6).

By using directed biogas – which is harnessed from agriculture – in lieu of natural gas, the carbon emissions of the building will be significantly off-set. In San Francisco, biogas is pumped into utility gas lines in neighboring Sonoma County and replaces a portion of the natural gas used for the cogen operation. Biogas is a renewable resource that has a measurable positive impact on the carbon footprint of tall buildings.

The Roles of the Tenant and Landlord in Sustainable Design

Tall buildings can lead the way in sustainability at high heights. But sustainability in tall buildings is not possible without the collaboration between landlord and tenants, as a large part of the building performance depends on the tenant and what they do in their space. The tenant-controlled energy use in the Transbay Tower is 60 percent of the overall use.

How does a building owner continue the sustainable direction when interfacing with tenants when the building comes online and in subsequent tenant renovations?

Research from *Working Together for Sustainability: The Rocky Mountain Institute (RMI) - Building Owners And Managers Association (BOMA) Guide For Landlords And Tenants* found that one of the main barriers is the "split incentive" issue, which results from the structure of many commercial leases. Net leases and modified gross leases, the most common, typically make the building owner responsible for bearing the cost of all capital upgrades. Energy costs, being a routine operating expense, are paid by the tenants. In other words, the owner makes the capital investment to improve the building and the tenant is the sole beneficiary of the reward of reduced operating expenses. The result is that commercial real estate owners have little direct financial incentive to upgrade their buildings to save energy.

室内空气品质以及总体提高了的办公环境

地板下送风系统还提高了热舒适性、通风效率以及室内空气品质。地板下送风系统允许办公室的工作人员对其周围局部的热舒适性进行调节，通过对工作场所的蜗旋式出风口进行调节达到自己舒适的程度。通过提供大量的新风来提高通风效率，并通过给工作人员的地板或办公桌输送新风来提高室内空气品质，形成一个地板到天花的气流模式，高效地从人员区域去除污染物。总之，地板下送风系统给建筑内的租户建立了一个更为健康和更为舒适的工作环境。

热电冷三联产以及对未来节能和碳排放的考虑

WSP设计团队为跨海湾大厦业主和租户考虑了在将来设置一台热电联产或热电冷三联产系统，其特点如下:

1. 为租户提供费效比高的能源使用策略。
2. 使用生物气体直接驱动的热电冷联产系统为本项目提供可再生能源，超过LEED 和 Cal Green (加州绿色建筑) 的要求。
3. 减少本项目总的绿室效应气体排放。
4. 提高大厦供电和冷冻水 (或热水) 供应的可靠性。
5. 通过三联产系统中的吸热式冷冻机给租户提供冷冻水。潜在地降低了中央工厂的容量以及运行费用。
6. 增加本项目能源供应的多样性和冗余。
7. 增加了跨海湾大厦长期总的价值。

在大厦三楼中央机组上方紧靠救生发电机的位置预留了一个1,000 kW生物气体/天然气驱动的热电 (冷) 联产系统包括4个250kW往复式燃气机。此1,000 kW机组将发电并制冷以支持租户24小时的负荷如服务器和计算机房负荷等。热电联产机组的年度发电量为全部大厦用电量的38%。热电联产机组的安装可以降低大厦的"基本负荷"。为了预测本建筑将来的负荷曲线，我们收集了当地同类型项目建筑物的负荷曲线数据并进行了分析。

一般来说能耗模拟中都假设建筑的负荷在夜间降到零，但是如图所示，实际情况却不是这样。办公楼实际上需要一定数量的空调负荷以及供电用于租户的服务器运行。从我们WSP的工程师收集到的数据显示办公楼租户的基本负荷明显高于之前认为的数值。WSP选择预设一个热电 (冷) 联产机组来支持大厦的24/7满负荷运行 (参见图6) 。

使用农作物直接生成的生物气体代替天然气，本大厦的碳排放将显著降低。在旧金山，生物气体通过相临的Sonoma县的市政气体管道输送到场址，可以替代热电联产中一部分的天然气。生物气体是一个可再生能源，对于超高建筑的碳排放起到可计量的积极的影响。

租户和业主在可持续设计中的作用

高层建筑可以在可持续性方面达到一个新的高度。但是高层建筑的可持续性如果没有业主和租户之间的合作是不可能的。建筑内租户的类型，以及租户将在建筑内进行什么样的活动对于建筑的性能有很大的影响。在跨海湾大厦内租户直接的能耗占大厦总能耗的60%。

当建筑物投入使用，并且租户进行改造时，大厦的业主将如何与租户互动，继续朝着可持续的方向发展?

To further complicate the issue, unless the tenant space is separately metered or sub metered, all of the tenants pay a pro rata share of the building's energy costs. Therefore, tenants have little incentive to modify their behavior or implement any energy-reduction strategies because they must share the reward of their improved behavior while also sharing the costs of other tenants' wasteful behavior.

In the fall of 2011, RMI and BOMA International partnered to explore ways to overcome the split incentive barrier. They assembled a select group of leasing and commercial real estate stakeholders, as well as individuals and organizations that have already explored these issues and developed potential solutions. The cited guide is a result of the workshop. It provides a framework for instituting cooperative and productive relationships between landlords and tenants and seeks to address some of the non-technological barriers to energy efficiency, such as split incentives, tenant behavior, and transparency.

The guide outlines five actionable steps that building owners and tenants can take to partner in the shared goal of energy efficiency: make energy use and costs more transparent; engage building occupants in saving energy; incorporate energy efficiency in tenant fit-outs; plan ahead for deep energy retrofits; and structure agreements to benefit both parties. (Working Together for Sustainability 2012)

These steps require a higher degree of collaboration on the parts of owners and tenants and the historic win/lose mentality associated with real estate will need to give way to a drive towards a longer term view that factors the environment into the investment equation.

Transparency in energy consumption by tenants and their energy needs can save energy over the terms of the lease. Often tenants ask for outsized electrical and HVAC capacity that landlords feel obliged to provide for fear of losing a prospective tenant. Tenants typically request 6-10 watts per square foot to be available for their use, but studies show that tenant loads rarely exceed three watts per square foot and typically average below one watt per square foot. This leads to oversizing of both the electrical and HVAC systems and results in wasted infrastructure and energy costs over the life of the building. Most of the life cycle costs associated with oversizing of systems are passed on to the tenants.

Historically, the market is set on extremely high power densities and this will only change when the tenants gain a clear understanding of their actual loads through metering and are willing to be transparent with their requirements. The idea here is to right-size the building and have the tenants and landlord take advantage of the long-term energy savings and reduced equipment maintenance and replacement costs. Tenants and landlords both benefit from detailed and accurate metering of discrete loads. From this information they can connect behaviors with energy consumption and make beneficial decisions.

Landlords can also help to make the tenant fit-out more energy- and water-efficient by having tenant design guidelines that outline steps to achieve greater efficiency or by having examples of highly sustainable tenant fit-outs available to see and test drive. They may be able to leverage greater buying power and potentially pass discounts by buying attic stock of low energy (LED) lighting or lighting controls. Landlords provide leadership and inspiration to their tenants by educating them and demonstrating how to save energy and money.

The Transbay Tower owners are now developing tenant design guidelines that will maximize the energy savings of the whole building. In California, strict energy codes require low energy design. However

来自*"携手共建可持续发展: 洛基山研究院 (RMI) -建筑业主和管理人员协会(BOMA)的*"业主和租户指导"一文的研究显示，其中一个主要障碍来自于由很多商业租赁的结构带来的"分摊费用"的问题。最普通的是净租赁合同和修改后的总租赁合同，通常由建筑物业主承担物业更新的费用。而能耗的费用，作为一个常规的运行费用，通常由租户承担。换种说法，如果业主进行物业投资提高建筑物性能，而租户是降低运行费用之后的唯一受惠者。带来的结果就是商业建筑的业主出于经济上的原因不愿为了节能而对建筑进行更新。

我们再进一步，除非对租户的空间进行单独计量或者进行次级计量，否则所有租户将会按照比例份额支付建筑物的能源费用。所以，租户也没有什么动力来改正他们浪费能源的行为或者实施任何能降低能耗的策略，因为他们在分享由于改正浪费能源的行为而带来奖励的同时，却也需要分担其他租户的浪费行为的成本。

在2011年秋天，RMI 和 BOMA国际进行合作，探索如何克服"分摊费用"的堡垒的方法。他们组织了一组租赁和商业建筑物业主，以及一些已经进行过这方面探讨并取得一定成果的团体和个人进行研讨。以上所引用的"业主和租户指南"就是他们研讨会的成果。"业主和租户指南"成为业主与租客之间的合作和生产关系的框架，解决了一些影响能源效率的非技术性壁垒，如费用的分摊，租客浪费能源的行为，以及租客能源利用的透明度。

"业主和租户指南"一共概括了建筑物业主和租户可以共同执行来提高能效的5个可操作的步骤: 让能耗和费用更加透明; 让建筑内的办公人员参加节能的活动; 在租户精装修的过程中考虑节能措施; 提前规划进行节能改造; 制定租赁结构使双方都能受益。(携手共建可持续发展2012)

这些步骤要求业主和租客采取高度的合作，由于历史原因造成的得/失心应该让位于未来长期的对环境的影响。

租户在能源消耗上及其能源需求上的透明度，有助于节省其在租赁期内的能耗。通常租户索要超过实际需要的电气容量和暖通空调容量，而业主因害怕失去一个租户觉得有责任为其提供这些超过实际需求的容量。租户通常要求每平方英尺6-10瓦 (70-110瓦/平米) 可以供其使用，但研究表明，租户的负载很少超过每平方英尺3瓦 (33瓦/平米)，通常平均低于每平方英尺1瓦 (11瓦/平米)。这将导致了电气和暖通空调系统的规模较大，并导致在建筑物的生命周期内的基础设施和能源利用上的过度浪费。而大多数与系统选型过大相关的生命周期费用都转嫁到租户身上。

从历史上看，市场将供电功率密度设置得很高，而这种情况只有在租户通过计量手段完全了解到他们的实际负荷，并且愿意对他们的要求透明化后才能得到改变。正确的做法是正确选则系统的容量，并使得业主和租户通过节能而长期受益，并减少设备维护和更换的费用。通过对不连续负荷详尽和准确的计量，租户和业主双方都能受益。基于此信息，他们还可以培养自己的节能意识和行为，并作出有利的决定。

通过建立租户装修设计准则，概括性说明节能的方法步骤，业主还可以帮助租户在装修过程中更加节能和节水; 或者通过提供高度可持续性节能节水的租户装修示范，供其他租户参考。租户可以在现阶段花大价钱购买低能耗的LED照明设备以及照明控制设备，但是长期来看会达到节能和节省费用的效果。业主通过教育租户，并演示如何节省约能源和金钱，对租户进行指导和启发。

跨海湾大厦的业主现在正在发展租户装修设计指南，将会使整个大厦最大程度地节约能量。在加州，严格的节能规范要求低耗能的设计。但是装修设计指南将争取更大的节能效果，同时为各种类型租户提供装修设计的灵活性。

the design guidelines will strive for even greater energy savings while providing the design flexibility for a wide variety of tenants.

The owners agreed upon a modified gross lease where the tenants' energy use will be measured and billed, providing incentives for the tower tenants to minimize their energy use. The backbone of the tenant metering system is provided by the landlord and the individual meters for the lease areas are provided by the tenant so both share in the cost of the system. Tenants can monitor their loads and track energy use. They will be able to use this information to manage their energy footprint.

The tower's occupants will play a significant role in the overall environmental impact of the building. The tenant loads make up more than 60 percent of the overall building energy profile and therefore can have a significant positive or negative influence on building performance.

Conclusion

The Transbay Tower serves as a strong example of the successful collaboration between owners and occupants, the built environment and the outdoors, the necessity for an urban habitat to offer intelligent and interconnected multi-modal transit systems, and sustainability in tall buildings. As a transit-oriented and resource-efficient development, it succeeds on all levels.

Sustainability for Transbay Tower is achieved through many avenues, from the UFAD system, the planned future use of biogas for the onsite co-generation units, water efficiencies and reuse and the inclusion of tenant metering and monitoring systems. These strategies will provide long-term performance and energy savings.

Further, upon its completion it will serve as a model for collaboration and partnership. The synergy between developers and tenants is paramount to this building's success. It is what ensures the tower remains a truly sustainable structure, and this translates positively on the future of the city. True sustainability is not just the implementation of low consumption or regenerative systems but how people interface with the building.

As populations increase worldwide, urban centers will continue to build vertically. The Transbay Tower will not only drastically change the skyline of San Francisco but also lead the way in energy efficiency for office buildings, and in so doing serve as a model for future cities' development and effectual conservation of resources in tall structures (see Figure 7).

一旦租户同意对其能源使用情况进行计量和计费，业主则应该同意修改总租赁合同，对租户提供奖励，尽量减少租户能源的使用。租户计量系统的主干系统由业主提供，而租赁区域的各自的仪表由租户提供，这样双方都分担了计量系统的成本。租户可以监控他们的负荷并跟踪能源的使用情况。他们将能够利用这些信息来管理他们的能源消耗。

大厦的租户在对大厦的总体环境影响中充当主要的角色。租户负荷占据了总的大厦能耗的60%，因此会对建筑物性能产生显著的正面或者负面的影响。

结论

跨海湾大厦在业主和租户间的成功合作、建筑环境与外界环境之间的和谐共处、提供高度智能化和相互联系的多功能多模态交通中心、以及高层建筑的可持续性等方面都是一个成功的典范。作为一个依托于公共交通中心及高效利用资源的项目，本大厦在所有层次上都取得了成功。

通过采取许多手段，从地板下送风系统，规划现场的热电冷联产机组在未来使用生物气体，节水以及水的循环利用，到给租户提供计量和监测系统等，跨海湾大厦在个方面都取得了可持续性。这些策略将会带来大厦长期的高性能和节能效果。

此外在建成后，跨海湾大厦将成为一个合作和伙伴关系的典范。在发展商和租户之间的协同合作对本大厦的成功至关重要，确保了本大厦在未来长期保持可持续发展的构架，并在未来城市发展中转化为一个积极的因素。真正的可持续性不仅可实现可再生系统的低耗费，更能体现人类如何与建筑物互动。

随着世界范围内人口的增加，城市中心将持续向空中发展。跨海湾大厦不仅彻底改变了旧金山的天际线，更在办公楼的节能设计方面起了带头羊的作用，并且为未来城市发展中高层建筑如何有效利用各种资源树立了一个典范 (参见图7) 。

Figure 7. Transbay Tower Crown. (Source: Pelli Clarke Pelli)
图7. 跨海湾大厦冠顶 (来源: Pelli Clarke Pelli)

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