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Effective & Sustainable Tall Buildings: A Blueprint for the Future

高效和可持续性的高层建筑：未来蓝图

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Steve Watts is a Director of Davis Langdon, an AECOM company, based in London. A cost consultant, he leads the firm's global Tall Buildings Group, with a corporate CV of over 500 tall buildings. Steve has worked on many towers, including The Leadenhall Building in the City of London and the Shard at London Bridge - together with numerous international commissions. He has been the UK Country Leader for the CTBUH for a number of years, while chairing the Finance & Economics working group. He is also a Trustee.

Steve Watts现任Davis Langdon董事，这是AECOM旗下一家公司，其总部设在伦敦。 身为成本顾问，其领导公司的全球高层建筑团队，曾参与超过500多座高层建筑工程。Steve联合其他众多国际建筑协会，共同参与过多个高楼项目，包括伦敦市内的The Leadenhall Building和伦敦桥的The Shard。他还曾担任世界高层都市建筑学会（CTBUH）英国领袖多年，同时担任财政及经济学工作组主席。现也担任受托人。

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Judit Kimpian, Director of Sustainable Architecture & Research at Aedas R&D, has been driving the practice's transition to a design approach centered around the whole-life value of buildings. With a background in design and virtual information modeling, she is leading cross-industry collaborations such as the RIBA|CIBSE platform CarbonBuzz to close the performance gap between design expectations and actual outcomes. Judit has built a team of specialists who bring together expertise from design, fabrication, engineering, life-cycle modeling and post-occupancy evaluation. She coordinates the practice's implementation of Soft Landings.

Judit Kimpian，凯达环球（Aedas）研发部下属可持续性建筑与研究分部主管，一直致力于推动将建筑实践转变为一种以建筑终身价值为核心的设计方式的理念转换。通过自身在建筑设计和视觉信息建模的专业背景，其领导了一系列跨行业合作项目，如CarbonBuzz系统(英国皇家建筑师协会RIBA/皇家注册设备工程师协会CIBSE平台) ，用来缩小设计预期和实际结果之间的绩效差距。Judit组建了一个拥有设计、制造、工程、生命周期建模和使用后评估等各方面专长的专家团队，协调行业实践的“Soft Landing软着陆系统”的实施。

Abstract

The 'Future Office' Study responded to the challenge of creating a tall office buildings in central London for half the current benchmark – without compromising design credentials and while ensuring true sustainability. The principle of exploring the environmental, social and economic sustainability (planet/people/profit) of a tall building underpins a new methodology for quantifying options in terms of capital and whole life costs, spatial efficiency, embodied and operational carbon and fit-for-purpose criteria such as comfort and adaptability. The exercise challenged industry preferences and raised fundamental questions such as: can buildings which have been through such evaluation make a city more competitive? Is investment directed in the right places? Is sustainability better achieved through architecture rather than technological fixes?

Keywords: Tall, Sustainable, Future, City, Skyscraper

摘要

本文以“未来办公楼”为主题，探究了在伦敦中心地带建造一座高层建筑所面临的挑战。该研究探讨了兼备环境、社会与经济（“地球/人/利润”三重标准）的设计所需遵循的原则，为引入一套崭新的方法奠定了基础，该方法通过诸如资本与使用期成本、空间效率、表现和操作性碳排放与适用性标准，如舒适和适宜性等多种角度，对设计方案进行了量化。 这一研究实践挑战以往的行业偏好，并提出： 通过该评估的建筑能够使城市更有竞争力吗？投资是否适得其所？通过建筑是否比通过技术手段更加能够获得可持续性？

关键词：高层、可持续、未来、城市、摩天大楼

Background

A 'Blueprint for the Future?' is a rather grand question for a title, one that implies a comprehensive and revolutionary answer. This is perhaps too much to ask, but it is hoped that the principles underpinning the study outlined in this paper provide a useful agenda to help prompt and assess a developing, or even new, tall building typology.

This work was hatched five years ago when cost consultants from Davis Langdon's Tall Buildings Group met the Sustainability and Advanced Modeling Team at Aedas and started a journey of honest and insightful collaboration.

That first meeting realized a common pursuit of a proper understanding of the evolving concept of sustainability, together with a methodology that frames this wide and complex subject. The lack of available data was bemoaned as was the vast range of statutory and advisory edicts, largely uncoordinated and in some cases conflicting.

On the back of a paper for the 2008 CTBUH World Congress in Dubai on The Economics of Sustainable Tall Buildings, Davis Langdon, Aedas, Hilson Moran Partnership (services) and Arup (structures) began work on creating a Tall Buildings Parametric Model (see Figure

标题

作为文章标题，“会否成为未来的蓝图？”是个相当宏大的问题。它暗示了一个全面而革命性的答案。要回答它或许太难，但是我们希望，本文所论述的研究所基于的若干原则，能够为促成和评估一个发展中的、甚至是崭新的高层建筑的类型学提供有用的方向和指引。

这项工作于五年前开始策划，当时来自Davis Langdon 的高层建筑组的成本顾问们和凯达环球（Aedas）的可持续性及高级建模团队正式会晤，并开展了诚恳而高瞻远瞩的合作。

第一次面议，使双方在如何恰当理解可持续性这个演进中的概念方面，以及为这一广泛而复杂的学科构建一个方法论的问题上，达成了统一的目标。当时的研究，面临了数据上的匮乏，以及大量的法定和咨询法令互相不统一甚至彼此冲突的规定性与建议性条文的重重阻碍。

紧接着，2008年在迪拜举行的世界高层都市建筑学会（CTBUH）第八届全球会议上关于可持续高层建筑经济学的论文之后，Davis Langdon，凯达环球（Aedas），以及希尔森莫兰合伙事业有限公司（Hilson Moran Partnership）（服务）和奥雅纳工程顾问公司（Arup）（结构）开始合作，着手创建一个高层建筑模型（参见图1），该模型通过一个互动的平台来显示

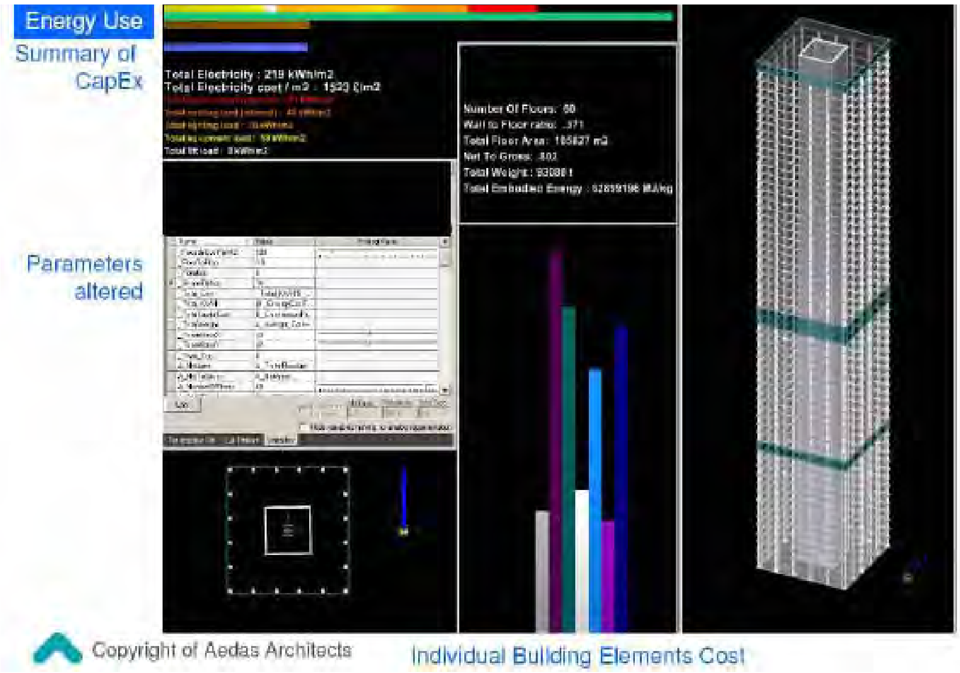


Figure 1. Parametric Model (Source: Aedas Architects)
图1.参量模型（出自：Aedas Architects）

1) to demonstrate, on an interactive platform, the long-term economic and sustainable impacts of different high-rise forms. This parametric model showed the effect of parameters such as height, floor plate size, orientation, shape, etc on not only construction costs, but also life-cycle costs and carbon emissions.

The future is of course characterized by uncertainty, and the doubt associated with data on the long-term aspects of running a building has historically presented a barrier. The parametric model attempts to prevent these crucial parts of an asset's life cycle from being ignored. These elements invariably have a much greater impact than capital cost on the performance of a building – particularly large and complex undertakings like towers – and are substantially influenced at concept stage, so they should be included in any commercial assessment of the project at the outset.

Bringing a different value perspective to the feasibility stage was an essential premise of the model; there are perhaps three fundamental concepts from this early work that have been a consistent theme to this day:

- Value Perspectives – the ability to measure value from different standpoints.
- Collaborative Assessment – the power of a team working together and the ultimate aim of strengthening the tie between those who produce buildings and those who use them.
- Long-Term Improvements – it is an approach that relies on and therefore encourages the collection of data relating to how buildings are used

Two years later in Spring 2010, with further development of the parametric model in the interim, a meeting with Sir Stuart Lipton of Chelsfield Partners, a renowned property developer in the UK, played catalyst for the next stage of this work.

The purpose of the meeting was to offer Sir Stuart a review of the London Office Market, but the discussion took a number of important and relevant turns before arrival at the crux. One of these avenues is how Georgian architects, such as those that designed many impressive

不同高层建筑形式的长期经济和可持续性影响。这一参量模型，显示了诸如高度、楼面面积、朝向、形状等参量对于建筑成本，以及生命周期以及碳排放的影响。

当然，未来充满了不确定性，在长期建筑运营问题上，对数据可信性的疑问，历来便是一个阻碍。参量模型试图防止资产生命周期的一些关键部分被人们所忽视。和资产成本相比，这些因素无一例外地对建筑性能的影响更大 – 尤其是像高层塔楼这样的大而复杂的建筑而言 – 并在概念定义阶段有着实质性的影响，因此，它们无疑从一开始，便被包含在任何项目的商业评定工作中。

在可行性分析阶段，将一种不同的价值视角置于显要地位，是本模型的一个基本前提；的确，一直以来，这项工作从早期开始便可能产生了三个基本性概念，并作为一个一贯的主题延续至今：

- 价值视角 – 从不同角度衡量价值的能力。
- 合作性评估 – 团队合作的力量以及加强建筑建造者和使用者之间的联系的最终目的。
- 长期改进 – 该思路注重和鼓励在建筑如何使用问题上的相关数据的收集。

两年后的2010年春天（参量模型在此期间也有了进一步的发展），我们与在英国享有盛誉的房地产开发商切尔斯菲尔德公司（Chelsfield Partners）的斯图尔特·利普顿爵士（Sir Stuart Lipton）进行了一次会晤。这次会面后来推动了这项工作的进一步发展。

该会面的意图是为了让斯图亚特（Stuart）爵士深入了解伦敦的办公楼市场，然而会谈几经（事后看来，是重要而关系重大的）周折后，方才触及问题的核心。其中一个议题，便是关于乔治国王时代的建筑师的讨论，他们之中那些设计了伦敦的大街和广场周边那许多鳞次栉比的壮观房宇的建筑师，是如何依照建筑书本的范例行事，最终却化陈规为神奇——这一讨论，或许攻破了“标准化一定意味着低质量”的现代神话。

这一议题在回顾Davis Langdon在伦敦市中心办公室基准调查（参见图2）时，再次被提及. 该建筑基准显示了建筑的外围与核心成本的各个重要方面——不过该成本的水平和其它世界城市相比逊色很多。其中一个原因是伦敦的高层建筑在外形上注重建筑

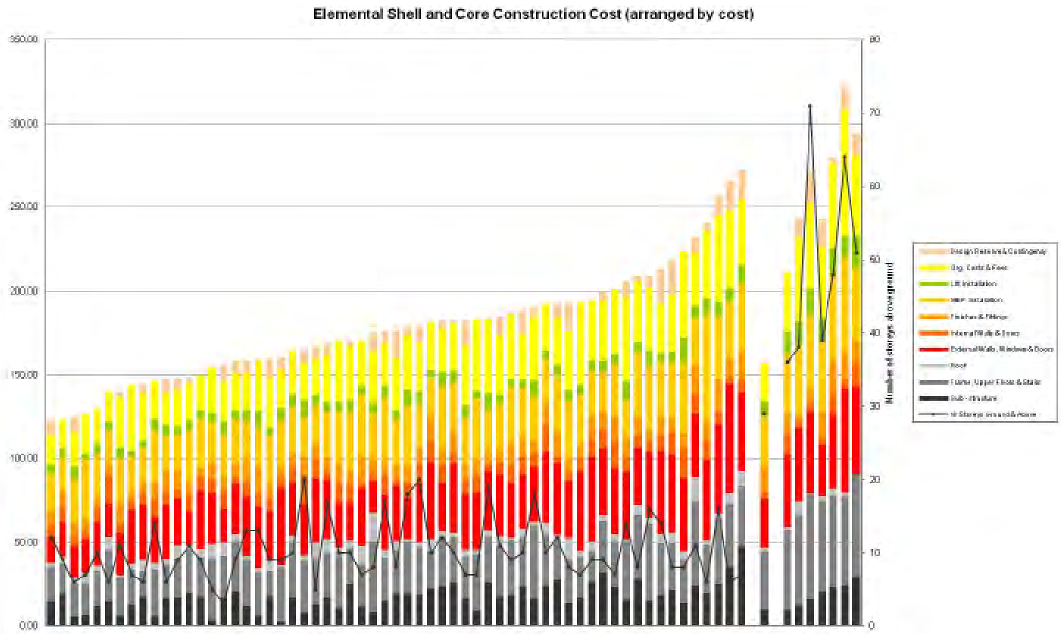


Figure 2. CLO office benchmarking 2010 (source: Davis Langdon)
图2. CLO 办公楼基准成本 2010 （出自： Davis Langdon）

houses that line the streets and squares of London, would have used architectural pattern books to impressive effect – perhaps dispelling the modern myth that standardization has to mean low quality.

This theme was referred to during a review of Davis Langdon's Central London Office Benchmarking (see Figure 2), showing a significant range of Shell & Core construction costs – but also a level of costs that does not compare well with other global cities. One of the reasons is the penalty paid by London's tall buildings for its array of shapely architectural and engineering structures, in the form of high wall:floor ratios (see Figure 3) (the amount of facades for every square meter of floor area). London's towers average over 0.50 (i.e. 50 m^2 of facades for every 100 m^2 of floor area) compared to not much more than 0.30 for the Asia-Pacific icons. So, before one even thinks about the specification of the external walls, there is a 50% to 60% premium for their expanse, which can affect the bottom line by 10% or more.

This reinforces the point that shape is at least as important as height when it comes to tall buildings economics. But it is not the only reason for the variance in high-rise cost across the globe, and it was against this background that Sir Stuart set the key challenge: to create a forty-story office tower in Central London for £125/ft^2, which represents half the mean cost of the landmark towers that were in various stages of development in the United Kingdom's capital.

It was clear from the outset that reaching that cost target required a back-to-basics approach to form and specification as well as innovation in materials, methodology and process and learning relevant lessons from other parts of the world.

And so the 'Future Office' Study began, which is now being posed as the question: is this a blueprint for the future?

To start, WSP Cantor Seinuk was asked to come up with the ideal structural solution for such a building, one without complexity, using standard sections and arranged on an optimum grid. Each discipline was set the same fundamental challenge, and five months later the team, through a series of iterations, influenced by open discussion and debate, had an answer. Assuming a forty-story shell and core office tower in Central London, sixty year lifespan and a British Council for Offices guide specification, the cost-optimized scheme was presented: a notional 54 x 54 m square tower (see Figure 4) with a central concrete

与工程学结构的匀称对称所带来的负面后果，即建筑面积比（参见图3）（即每100平米楼面面积所对应的外墙面积）。伦敦塔的平均比率超过0.5（如每100平米楼面面积对应50平米的外墙面积），而与之相比，亚太地区的代表性高楼仅为0.30。因此，姑且不论外墙的规格，仅其面积之大，就带来了50%到60%的额外费用，这可能将最低成本提高了10%或更多。

这一事实，进一步印证了“在高层建筑经济学中，建筑的外形至少和高度一样重要”的说法。然而，这并不是造成全球高层建筑成本差异的唯一原因，并且正是在这一背景下，斯图亚特爵士指出了最关键性的难题：以125英镑每平方英尺的造价，在伦敦中心区建造一座四十层的办公楼，这个价格是英国首都在其不同的发展阶段所建地标性建筑的平均成本的一半，标志着一种新型可持续性办公楼（不论如何定义）的诞生。

事情一开始便很明了，要想接近上述目标成本，除了必须回归到形式和规格的基本思路之外，还需要考虑到材料以及方法和程序上的革新，并从世界各地学习相关经验。

自此，“未来办公楼”研究项目便正式起步，并成为了今天所讨论的议题：它，是否会成为未来的蓝图？

Figure 3. Asia vs London Wall: floor (Source: Davis Langdon)
图3.亚洲vs. 伦敦：外墙-底台面积比率（出自：Davis Langdon ）

core; double-deck vertical transportation strategy; four-pipe fan coil system with centralized plant; steel frame with perimeter columns at 6 m centers and 15 m core-glass spans; double-glazed curtain walling based on a chassis system that allows alternative orientation of panels and the ability to incorporate solid elements to satisfy user comfort and building regulation requirements.

This large, regular floorplate, together with a floor-to-floor height of 3.8 m, produced a wall:floor ratio of 0.28 and an overall net:gross floor area efficiency of 75% (80% above ground) –a very good result of a commercial building of this height. These efficiencies also helped us to achieve a shell and core cost of around £140/ft^2 – much lower than initial expectations.

But this only addressed the capital cost aspect of the challenge. To create a truly sustainable building, it needs to be at once environmentally, socially and economically sympathetic – the "three Ps" of people, planet and profit. The work had to also confront the whole-life costs of the building, its carbon credentials and its fitness for purpose, which required evaluating this baseline option against alternatives (see Figure 5). These included a precast façade instead of the curtain wall system, short-span steel and short-span and long-span concrete in terms of structure. System alternatives considered were centralized versus decentralized and fan coil versus chilled beam. The team also quantified the benefits of going down a mixed mode route.

A methodology was developed to quantify key design options across the three Ps, based on the Olympics' embodied carbon foot-printing template (London 2012), energy costs over 60 years and user criteria such as comfort and adaptability. This resulted in the Sustainability Evaluation Matrix (see Figure 6), color-coded to allow an interpretation of qualitative considerations against financial and environmental impacts.

These appraisals show how different value perspectives provide a different answer, demonstrated by some of the following examples.

Profit

The 'profit' aspect of the scheme relates to the financial drivers of a tower, including net internal area, capital cost and life cycle costs (maintenance, energy, replacement, repairs etc).

From a net internal area perspective, the best performing combination was found to be a curtain wall, steel frame and decentralized air handling system. This follows logically since concrete occupies more space than steel, whether as a column or a façade panel. Centralized servicing (the industry standard in the UK) requires greater core area to move air through the building and an entire mid-rise floor for plant: moving to a decentralized air handling strategy may incur additional equipment and other costs, but frees up valuable space.

In strictly capital cost terms, short span concrete was found to be the most effective, because the floor-to-floor height can be lowered when integrated with the ventilation system. Assuming a fixed number of floors in the comparison, less actual building is ultimately built, approximately 6 meters. In addition to the capital cost savings, embodied energy savings of 240 kg Co2e/m^2 were achieved. The shorter building also saves money over the whole life of the building because there is less façade to clean, maintain and replace.

For whole-life costs, the running costs can vary by over £200/m^2/year depending on the mechanical system. Overall, a centralized plant together with chilled beams yielded the lowest energy consumption and maintenance costs. This assumes the building is continuously

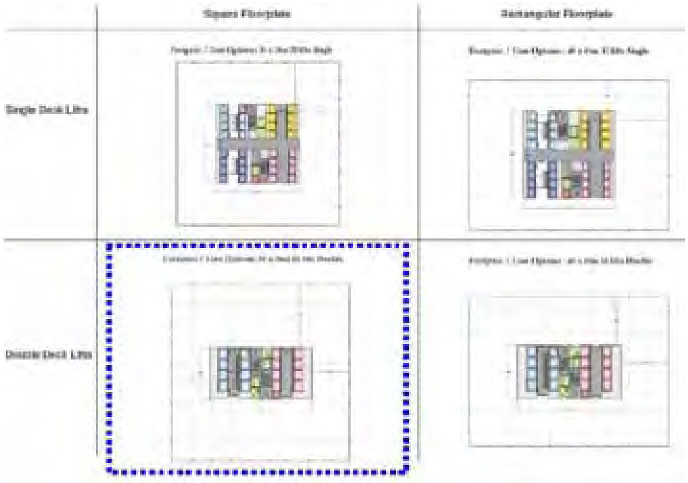


Figure 4. Optimised floor plates showing selected floorplate (Source: Future office study)
图4. 优化的楼底台面积，显示所选楼面（出自：Future office study ）

作为开端， WSP Cantor Seinuk公司被要求为该建筑提供一个最理想的结构性方案，要求是该方案不能复杂，使用标准截面，按照最优网格布置。每一项要求都是一种根本性的挑战. 五个月以后，该团队通过一系列反复的琢磨，公开研讨和辩论，最终得出了结论（实际上只是一个开端）： 假定伦敦中心区一座四十层“壳-芯”办公楼，使用寿命六十年，规格采用英国办公楼委员会指导规定，其最佳成本优化方案如下：54米乘以54米的正方形高楼（参见图4）；混凝土中央核芯；双层垂直运输方案；集中式四管式风机盘管系统；周边柱网中心间距为6米，核心筒-玻璃跨度为15米，钢架结构；双层玻璃幕墙，其底架系统可调节面板朝向，能够整合各实体单元，从而满足用户舒适度且符合建筑规章的规定。

大而规整的楼面，加之3.8米的楼面间距，从而得到0.28的墙体：地板比率，净/总楼面面积计算的空间效率为75%，（地上为80%）——这一系列关键指标，对这种高度的商用建筑而言也是令人满意的设计方法。这些比率参数，也帮助我们实现了约140英镑/平方英尺的外围与核心成本——远低于最初的预期。

不过这才仅仅解决了该挑战的资金成本问题。要建造一座真正可持续建筑，需要同时实现环境、社会和经济多方面的和谐统一-这也是为什么“未来办公楼”研究涵盖了人，地球，利润三重标准的原因。本项工作还必须应对建筑的使用期成本、碳排放资质及其功能适用性等问题。这意味着要对这种基础方案和其它选择性方案（参见图5）进行对比评估。其中包括选用预制外立面而不是玻璃幕墙系统，结构方面采用短跨度钢架和短及长跨度混凝土结构。所涉及的系统性选择性方案包括中央式VS分离式系统，以及风机盘管VS冷冻梁等。同时，团队还对采取混合性方案的益处进行了量化

本研究依据奥运会隐含碳足迹模板（伦敦2012）、60年间的能源成本、以及舒适性和适用性等用户指标等，开发了涵盖 “三P（people, planet and profit ）”标准的量化关键设计方案的一整套研究方法。最终结果见可持续性评估矩阵（参见图6），图中以不同色彩分类和标记，以便根据经济和环境影响进行定性考量和分析。

这些评估内容，显示了不同的价值视角将如何带来不同的解答，正如以下一些例子中所示。

利润

与高层建筑财务驱动因素相关的方案的利润因素，包括净室内面积、资本成本、生命周期成本（维护、能源、替换、修理等费用）。

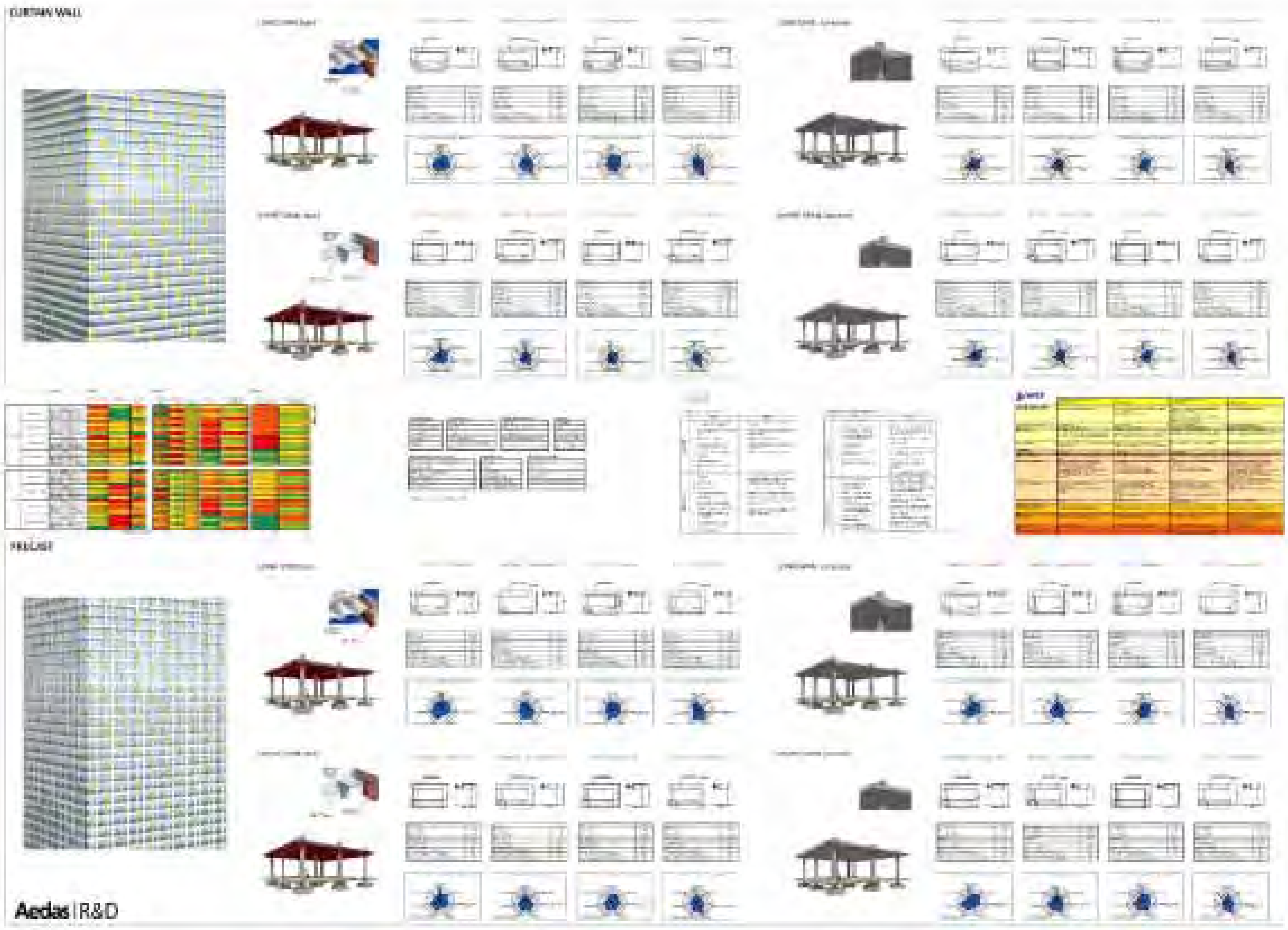
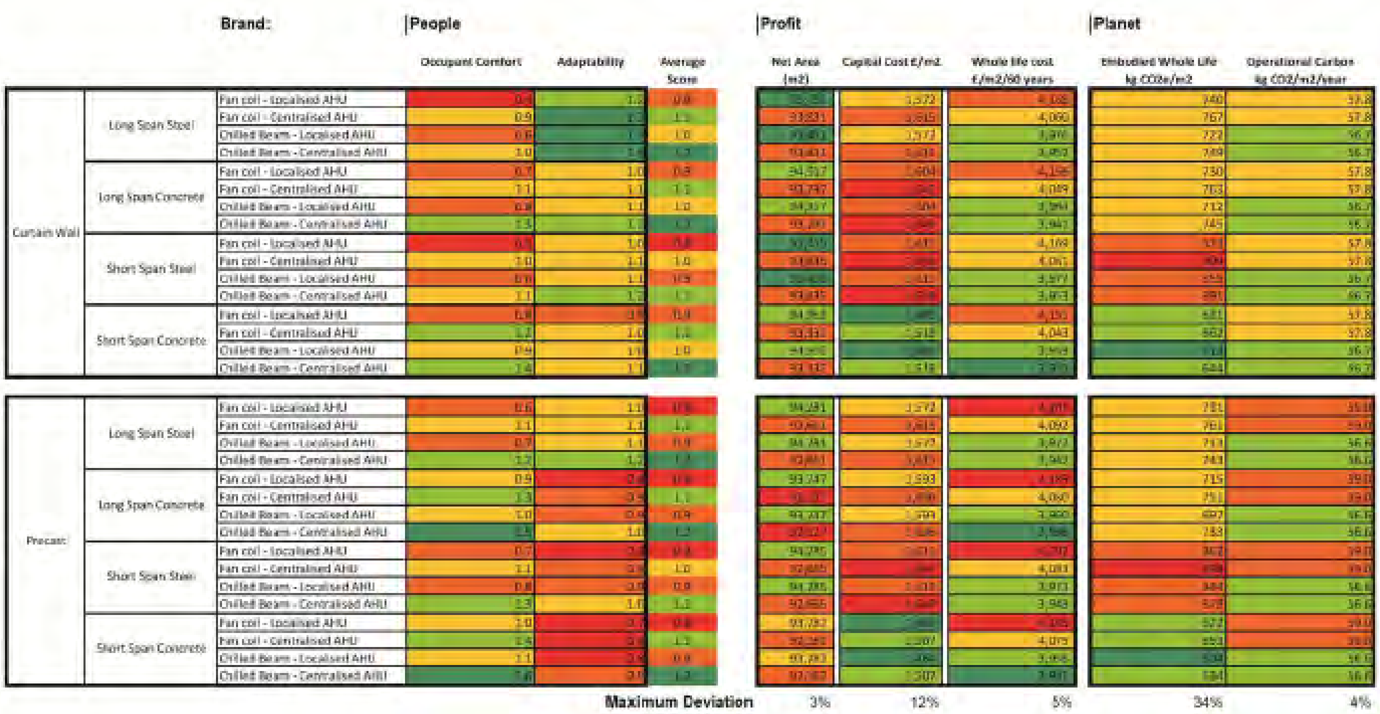


Figure 5. Options assessed across all parameters (Source: Future office study)
图5. 评估全部参数的可选方案（出自：Future office study）



Brand:			People			Profit			Planet	
			Occupant Comfort	Adaptability	Average Score	Net Area (m2)	Capital Cost £/m2	Whole life cost £/m2/60 years	Embodied Whole Life kg CO2e/m2	Operational Carbon kg CO2/m2/year
Curtain Wall	Long Span Steel	Fan coil - Localised AHU	0.4	1.2	0.8	[illegible]	1,572	4,102	740	57.8
		Fan coil - Centralised AHU	0.9	1.2	1.1	93,831	1,615	4,080	767	57.8
		Chilled Beam - Localised AHU	0.6	1.3	1.0	93,401	1,572	3,976	722	56.7
		Chilled Beam - Centralised AHU	1.0	1.4	1.2	93,401	1,604	3,952	749	56.7
	Long Span Concrete	Fan coil - Localised AHU	0.7	1.0	0.9	94,517	1,604	4,196	730	57.8
		Fan coil - Centralised AHU	1.1	1.1	1.1	93,797	[illegible]	4,089	763	57.8
		Chilled Beam - Localised AHU	0.8	1.1	1.0	94,357	[illegible]	3,994	712	56.7
		Chilled Beam - Centralised AHU	1.3	1.1	1.2	93,200	[illegible]	3,947	745	56.7
	Short Span Steel	Fan coil - Localised AHU	0.5	1.0	0.8	[illegible]	1,637	4,169	573	57.8
		Fan coil - Centralised AHU	1.0	1.1	1.0	93,805	[illegible]	4,061	400	57.8
		Chilled Beam - Localised AHU	0.6	1.1	0.9	[illegible]	[illegible]	3,577	555	56.7
		Chilled Beam - Centralised AHU	1.1	1.2	1.2	93,835	[illegible]	3,893	591	56.7
	Short Span Concrete	Fan coil - Localised AHU	0.8	0.9	0.9	94,363	[illegible]	4,150	631	57.8
		Fan coil - Centralised AHU	1.2	1.0	1.1	93,332	1,518	4,043	662	57.8
		Chilled Beam - Localised AHU	0.9	1.0	1.0	[illegible]	[illegible]	3,959	[illegible]	56.7
		Chilled Beam - Centralised AHU	1.4	1.1	1.2	93,332	1,518	[illegible]	644	56.7
Precast	Long Span Steel	Fan coil - Localised AHU	0.6	1.1	0.8	94,291	1,572	[illegible]	791	59.0
		Fan coil - Centralised AHU	1.1	1.1	1.1	93,863	1,615	4,092	761	59.0
		Chilled Beam - Localised AHU	0.7	1.1	0.9	94,744	1,577	3,972	713	56.6
		Chilled Beam - Centralised AHU	1.2	1.2	1.2	93,861	1,615	3,940	743	56.6
	Long Span Concrete	Fan coil - Localised AHU	0.9	0.4	0.6	93,747	1,593	4,189	715	59.0
		Fan coil - Centralised AHU	1.3	0.9	1.1	[illegible]	1,690	4,060	751	59.0
		Chilled Beam - Localised AHU	1.0	0.8	0.9	93,207	1,599	3,990	697	56.6
		Chilled Beam - Centralised AHU	1.5	1.0	1.2	92,827	1,646	3,586	733	56.6
	Short Span Steel	Fan coil - Localised AHU	0.7	[illegible]	0.8	94,295	[illegible]	[illegible]	362	59.0
		Fan coil - Centralised AHU	1.1	0.9	1.0	92,685	[illegible]	4,083	498	59.0
		Chilled Beam - Localised AHU	0.8	0.9	0.8	94,205	[illegible]	3,903	344	56.6
		Chilled Beam - Centralised AHU	1.3	1.0	1.2	92,466	[illegible]	3,948	529	56.6
	Short Span Concrete	Fan coil - Localised AHU	1.0	[illegible]	0.8	93,782	[illegible]	[illegible]	522	59.0
		Fan coil - Centralised AHU	1.4	[illegible]	1.1	[illegible]	1,507	4,075	653	59.0
		Chilled Beam - Localised AHU	1.1	[illegible]	0.9	93,783	[illegible]	3,956	534	56.6
		Chilled Beam - Centralised AHU	1.6	[illegible]	1.2	[illegible]	1,507	[illegible]	584	56.6
					Maximum Deviation	3%	12%	5%	34%	4%

Figure 6. Sustainability Evaluation Matrix (Source: Future office study)
图6. 可持续性评估矩阵(出自：Future office study)

occupied during standard working days. As this system serves multiple floors, extended office hours and occasional vacancies mean parts of the building are being serviced when empty.

Even within the 'profit' category, each financial parameter tends to point to a different structural, mechanical and façade strategy for the tower.

Planet

'Planet' covers the embodied and operational carbon over the design life of the building, excluding deconstruction. As with capital costs, building less structure uses fewer resources, meaning a short span concrete structure has the least embodied carbon – provided the client doesn't object to internal columns. Benefits can also be gained by exposing the concrete soffit and potentially using the thermal mass of the floor as part of the mechanical system, thereby lowering temperature control.

For the façade, a precast system may have lower embodied energy but the heavy thermal mass of concrete can trap internal heat gains in the space causing an increase in cooling loads and operational carbon. On the other hand, the recyclability of curtain wall systems can also be compromised by the application of high-performing glass coatings. The greatest difference is between short span steel and centralized fan coil versus the short span concrete and decentralized chilled beam combination. This is largely due to less structure built for the second option. While differences between operational carbon are small between the mainstream systems, adding mixed mode ventilation can save up to 12% on operational carbon emissions.

People

A subjective scoring system was employed to assess 'people' aspects relating to occupant comfort, noise, air quality and spatial quality and adaptability. The latter takes into account the increasing demand for reconfigurable office sub-divisions, connections between floors and alternative systems to support a more collaborative work environment.

Although a concrete façade system performed better for reducing noise pollution from the external environment, it is considerably more difficult to cut holes in this systemt for connecting localized air handling systems to the outside. Concrete structure was also the most successful acoustically; however, if one wants to create an internal stair or atrium once the building is complete, steel is a better choice.

Localized fan coil systems are perceived as more difficult to maintain and are more risky in terms of air quality whereas centralised chilled beam systems offer just as much comfort but are less complex.

Summary

The study challenged some industry default preferences such as long span steel structures – although there are other factors at work in such decisions, like time, that were not part of our calculation. The analyses also highlighted a significant range of outcomes within each of the categories. In the profit section, for example, there was a 3% difference between the highest and lowest net areas, a 12% best-worst spread in capital costs and 3% in whole life costs which themselves tend to be about three times greater than capital costs. From the perspective of 'planet', the best solution was 34% more efficient in embodied carbon. And while operational carbon might exceed embodied carbon by a

就净室内面积而言，最佳的性能组合，由幕墙、钢框架与分离式空气调节系统组成。这一点合乎常理，因为无论是柱子还是外墙板，混凝土都比钢铁占用更多的空间。集中式铺设公共设施（英国工业标准）要求更大的核心区域实现空气在建筑物之间的流动，并且要占用一整个中部楼层来安放设备：分散式空气调节方案可能带来额外的设备和其它成本，但是可以释放出宝贵的空间。

在严格的资本成本条件下，短跨距混凝土效益最高，因为在它与通风系统一体化的情形下，可以降低楼层间的高度。也就是说，同样的楼层数量，需要修建的高度可降低（约6米）。 这样，除了节约资金成本外，能耗可以减少250公斤二氧化碳当量/平方米。同时，高度较低的建筑物因其需要清洁、维护和替换的外墙面较少，其使用期限所产生的成本会更少。

对于使用期限成本而言，因机械系统的不同，其日常管理费用的差异可能超过200英镑/平方米/年。总体上，集中式设备与冷梁相结合，所产生的能量消耗和维护成本将降至最低。该结论的假定前提是，建筑物处于持续使用状态，并且只在标准工作日运营；同时由于该系统服务于多个楼层，因而加班以及偶尔的空置则意味着系统也在为建筑中空置的区域提供服务。

因此，即使在“利润”的范畴内，每一个经济参数都表明了一种不同的高层建筑结构、机械和面墙策略。

地球

“地球（环保因素）”包括建筑物设计寿命期内的隐含碳和营运碳的排放（不包括建筑物的拆除）。 就资金成本来说，低层建筑结构消耗更少的资源，这意味着短跨混凝土结构隐含碳的排放量最小 – 前提是客户接受内立柱结构。通过暴露混凝土底部，以及对作为机械系统组成部分的楼面热容量的潜在利用，以降低温度控制，亦可达到相同效果。

就外墙而言，预制系统可以降低隐含能耗，但热容量大的混凝土会积蓄来自建筑空间的内热，并导致制冷负荷和营运碳排放的增加。在另一方面，幕墙的再循环能力亦可因高性能玻璃涂料的应用而被降低。最大的差别存在于短跨钢、中央式风机盘管组合与短跨混凝土、分离式冷梁组合之间。这在很大程度上是因为使用第二种方案所需要建造的结构更少。同时，主流系统之间运营碳排放量的差异并不大，使用混合模式通风设备可以节省高达12%的碳排放量。

人

在对与居住舒适度、噪音、空气质量、空间质量（比如，顶棚高度的增加）及适应性等进行有关的“人”的因素进行评估时，采用了主观评分系统。后者考虑到人们对可重构细分办公区，以及通过楼面与可替代系统的结合来支撑一个更加协同的工作环境的日益增长的需求。

虽然混凝土外墙系统在降低外界噪音污染方面发挥了更好的作用，但是为了将局部性空气调节系统与外界相连，在立面开孔方面却相当困难。同样的，混凝土结构在隔音效果上表现最佳；但是，在建筑物已经建成的情形下，如果要设置内楼梯或门厅，钢结构将是一个更好的选择。

人们一般认为，局部性风机盘管系统更难以维护，并且在空气质量方面具有更高的风险；而中央式冷梁系统则能提供与之相当的舒适度，并且在结构上更为简洁。

Figure 7. The Public Realm and Urban Context (Source: Jason Hawkes et al.)
图7. 公共领域与城市环境（出自：Jason Hawkes et al.）

factor of around six, as buildings become more operationally efficient the carbon impact of construction will become more significant.

The overriding finding was that, no matter what the question, the profit, people and planet answers tended to be contrary.

Beyond that initial realization, discussion and debate brought possible broader implications, raising such questions as:

- Is investment directed towards the right outcomes?
- Should sustainability be sought through architecture rather than expensive technology?
- How will buildings that have been through this type of appraisal look?
- Could such an approach make the city more competitive?
- How can this evaluation process help to set the right brief?
- How can sustainability and effectiveness be linked to value?

While the study concentrated on the evaluation of a building, the importance of the wider public realm, and the implications for the competitiveness and attractiveness of a city as a whole should not be underestimated (see Figure 7).

London is not the only city evaluating the broader impact of investment in energy, carbon and cost. Earlier this year news arrived from the 'Big Apple' that in some quarters questions are being asked about its sky-high costs. For example, a slightly dubious but nonetheless powerful comparison was made that the retrofit of the Empire State Building cost more than a third of the money spent on building the world's tallest skyscraper, Burj Khalifa in Dubai (Lentz, 2011). 'Apples versus Oranges' maybe, but these are the sort of pertinent questions that helped to kick-start the study in London, and resurfaced during its dissemination.

Hope Cohen of the Center for Urban innovation is quoted as saying of New York: "When will we reach the threshold that people will choose to not build here and build somewhere else instead?" (Lentz 2011). This goes directly to the matter of a city's competitiveness, both nationally and internationally, and is just as topical in New York as in London, Shanghai and elsewhere.

A recent collaborative effort with Aedas' Shanghai office showed that while the baseline typology for tall office buildings is similar there are important differences between cost, whole-life cost and attitude-to-resource consumption and occupier comfort between the Far East, the UK and North America.

小结

本研究对某些建筑业普遍默认的参考基准（至少在伦敦如此），诸如长跨钢结构等提出了质疑——尽管一些在实际工作存在的决定性因素（如时间）并不在我们的计算评估范围之内。本文的分析同时也凸显了各类别下的一系列重要分析成果. 比如，就利润而言，在最大净面积和最小净面积之间，存在3%的差距；而最佳资本成本与最劣资本成本间的差异为12%，建筑物使用期成本的浮动范围则为3%（使用期成本本身约为资本成本的4倍）。从“地球（环保因素）”的角度，隐含碳排放最优解决方案的效率比最劣解决方案高34%。而营运碳排放量是隐含碳排放量的7倍；建筑物营运的效率越高，建造对碳排放的影响越为显著. 或许这些本身足以证明，对这些参考基准进行重新考量是十分必要的。

从各个角度来观察，本文的最终结论给出的答案都会是截然不同的。换句话说，不论问题是什么，从利润、人和地球（环保因素）角度得出的回答，都可能是彼此对立的。

在上述初步认识的基础之上进行进一步的争论和探讨，为我们带来了更深入的启示，并引发了如下问题：

- 投入能带来正确的产出吗？
- 能否通过建筑结构本身而非高昂的技术，实现建筑的可持续性吗？
- 依本评估方法设计的建筑物会显现什么样的外观？
- 本文所提出的方案能让城市更具竞争力吗？
- 本评估程序应如何帮助实现正确的建筑标准？
- 可持续性与效率如何与价值实现关联？

本研究在以对建筑物评价为中心的同时，我们不应该低估更为广泛的公共领域的重要性以及城市作为一个整体所具有的可比性和吸引力的重要性（参见图7）。

伦敦并非是惟一一个对能耗、碳排放和成本方面的投资所产生的更为广泛的影响进行评估的城市。今年的早些时候，纽约传来消息，有些区遭到了有关其“超高成本”问题的质询。比如，一个无把握但却令人震撼的成本对比显示，帝国大厦的建筑成本比世界最高建筑“迪拜塔”超出1/3。虽然两者可能没有太大可比性，但它所引发的问题是十分中肯的，有助于推广伦敦的这项研究，并使其重新受到舆论的关注。

城市改革中心的霍普·科恩曾经这样描述纽约：“什么时候我们才会真正地迎来那一天，人们不再选择在此造房而改投他处？”（Lentz ，2011年） 该评论直截了当地切中了一座城市在国内和国际间的竞争力问题，这也是和纽约、伦敦、上海以及其它大都市息息相关、广受关注的话题。

近期，一项凯达环球建筑设计咨询有限公司上海办事处合作参与的研究显示，虽然高层办公楼的基本类型大同小异，但在成本、使用期成本、资源消耗的态度和使用舒适度上，远东、英国和北美之间存在重要的差异。该研究团队正期待对这些内容在议上作进一步说明。

最近，作为英国最大并且最杰出房地产公司之一的英国房地产投资信托公司（British Land）的董事会主席评论说，伦敦市需要变得更有竞争力，并且需要新的建筑样式，以使伦敦有朝一日变得更加具有创新和适应能力。让生活在这座城市的承租人主动要求“相互连通”，并且希望根据经营业务的变化，能在垂直和水平维度上灵活多变地重新配置其占有的空间。

对未来办公楼的研究，并不会给人们提供一个最终答案；在很大程度上它不过提供了一个评估框架，这一框架能够根据具体的需求作出评估和考量。比如，尤其是在假定伦敦商业地产的基本评估显示其平均寿命在25-35岁之间的情形之下，是谁认为60年是建筑物的适当年龄？

Recently, the chairman of one of the UK's largest and most prominent property companies, British Land, commented that the City of London needs to be more competitive – but also that a new form of building is required to enable it to get to that position: a much more adaptable model. His tenants are demanding 'inter-connectedness' and want to be able to reconfigure their space, vertically as well as horizontally, as their business changes (Grigg, C. 2012).

The Future Office Study internationally did not produce an answer. Rather, it provides a framework for assessments which can be valued and weighted according to specific needs. For example, who is to say that a 60 year lifespan is appropriate – especially given that a rudimentary assessment of commercial buildings in London could show an average lifespan of 25-35 years.

Increasingly there is a sense of awareness by occupiers of the potential of an office building to improve their business performance. A shift in focus is underway from traditional means of assessing a building to something more holistic. More studies are also emerging demonstrating a link between high energy consumption and reduced comfort. Buildings that are well operated tend to have more satisfied occupiers as a recent British Land paper indicates (Grigg, C 2012). As more tenants and landlords begin to target lower energy use for both productivity and corporate social responsibility reasons, investors are keen to focus on measures that demonstrate direct performance improvements – in general, less 'bolt-on techno-bling' and better consideration of occupier needs. There is also a growing consideration of the global marketplace in which our cities compete, a battleground that features costs, sustainability and effectiveness as measure of success.

In this cross-continental 'battle', cities use tall building icons to enhance their skyline and promote their emergence on the world stage. There will be a place for icons, in both developing and established environments their value – while difficult to quantify – extends beyond the confines of the project. Equally, it may be argued that the definition of 'iconic' requires widening, to encompass innovation in functionality, sustainability, usability and some other wealthy and valuable criteria. Buildings are increasingly perceived as an ecosystem of space, fabric, services, equipment and occupiers where the interaction between these and its context creates a building's true character.

The Future Office Study is not an exercise in creating an optimum future form for a commercial tower, rather a transparent tool that enables all interested parties to understand the full range of impacts of early design decisions. In that sense, maybe it does represent a blueprint for the future, one in which successful tall buildings are sustainable, efficient and effective products (designed for the right life-span) addressing value beyond the short-term, and optimized through genuine and honest collaboration.

越多潜在的办公楼使用者更加敏锐地认识到，办公楼必须有助于其经营业绩的增长。 人们关注点也在渐渐转移 – 目前尚较和缓 –从传统的建筑物评价方式（代理人信息、标准技术规范，以及与功率相关的通常所谓“马力”标准）开始向更为全面的评价方式转移。同时，越来越多的研究，揭示了高能耗与低舒适度之间存在的关联性。正如近来英国房地产投资信托公司的一篇论文（Grigg，C 2012年）所指出的那样，运营良好的建筑物的使用者满意度更高。并且随着更多的承租人和业主出于提高生产率和公司社会责任的原因，开始追求能耗的降低，投资者们也开始热切地专注于能够直接带来性能改良的措施——总的来说，少一点“结构紧固，技术精湛”方面的追求，多一点对使用者自身需要的考量。同时，对全球市场的关注度亦在持续增长，这一市场正如战场，各大城市在其内相互竞争，成本、可持续性和效率等因素成为衡量胜利的标准。

在这场横跨各洲的“战斗”中，各大都市通过高层标志性建筑来提升其城市高度，拔高其在世界舞台之上的形象。然而，应该存在另一种标志性建筑，它们在发展和建立人居环境方面的价值 – 虽然难以量化–超出了建筑项目本身的实用价值。同样地，“标志性”一词应具备更广泛的定义，并包括功能上的创新、可持续性、可用性和其他富有意义的价值标准。越来越多的人们认识到，建筑是一个由空间、构造、服务、设备与使用者所组成的生态系统，在这一系统中各因素相互作用，它们共同决定了建筑物的真正品质。

未来办公楼的研究，并非是要给商业办公楼创设一个最佳的未来样式，而是要提供一个透明的工具，以使所有利益相关方能够对初期设计决策所带来的全部利害真正有所认识。在此意义上，它确实可能代表一种未来的蓝图。在这一蓝图中，成功的高层建筑都将超越短期的价值，真正成为可持续的，高效节能的，功能卓越的建筑（按其使用寿命进行设计），并通过务实而真诚的合作实现最优化的标准。

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