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Sustainability Certification as a Tool for Design Optimization

将可持续性认证用作设计优化工具

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Abstract

The paper examines the performance of high-rise buildings according to two green building / sustainability rating tools. It reviews the potential these tools have for improving the performance of high-rise buildings, both with regard to the design and the usage phases, with a particular focus on the minimization of building materials (and thus also of the carbon footprint and the investment). The paper starts with a presentation of Plot 15, the first LEED Platinum certified high-rise in Russia. It then analyses the performance of the building according to LEED 2009 and subsequently compares this with the performance the building would have when analyzed with LEED v4. Finally the paper takes a look at another international rating tool, viz. DGNB, and examines the performance Plot 15 would have when studied with this particular system.

Keywords: Sustainability, Certification, Green Building, LEED, DGNB, Russia

摘要

本文根据两个绿色建筑/可持续发展评估体系分析了高层建筑的性能。它从设计和使用阶段评述了这些体系对提高高层建筑性能的作用，尤其侧重于建筑材料的精简 (减少碳足迹和投资)。本文从介绍Plot 15——俄罗斯第一座获得LEED白金级认证的高层建筑开始，然后根据LEED 2009分析了建筑的性能，随后将其与该建筑根据LEED v4认证分析的性能进行了比较。最后，本文还论及另一个国际评估体系，即DGNB，并分析了经过该系统评估的Plot 15应有的性能。

关键词: 可持续发展, 认证, 绿色建筑, LEED, DGNB, 俄罗斯

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Introduction

The paper examines the performance of high-rises as a building type according to two green building / sustainability rating tools. It reviews the potential these tools have for improving the performance of high-rise buildings, both with regard to the design and the usage phases, with a particular focus on the minimization of building materials (and thus also of the carbon footprint and the investment). The paper starts with a presentation of Plot 15, the first LEED Platinum certified high-rise in Russia.

The paper then focuses on two of the world's leading certification systems, viz. US-based LEED and Germany-based DGNB. While for the time being, LEED certainly is the more widely known and used rating tool, DGNB appears to offer several advantages inherent in its comprehensive approach towards sustainability in the built environment. But what difference does this make for the building performance – and how can it help the designers? The article offers an in-depth comparison between the two systems and their respective strengths and weaknesses.

引言

本文根据两个绿色建筑/可持续发展评估体系分析了作为建筑类型之一的高层建筑的性能。它从设计和使用阶段评述了这些体系对提高高层建筑性能的作用，尤其侧重于建筑材料的精简 (减少碳足迹和投资)。本文从介绍Plot 15——俄罗斯第一座获得LEED白金级认证的高层建筑开始。

本文随后着重介绍了两个世界领先的认证体系，即美国的LEED和德国的DGNB。虽然目前，LEED无疑是更广为人知并被广泛使用的一项评估体系，DGNB却在建成环境的可持续性综合解决方案方面具有其内在的优势。但是，它们对建筑性能有什么影响呢? 它们如何对设计师起到帮助呢? 本文深入比较了这两个体系并指出了各自的优势和劣势。

高层建筑的可持续性 - Plot 15项目

莫斯科的Plot 15项目由两座细长高耸的大厦组成，高度均达283米。由于楼层平面图呈凸透镜状，两座建筑呈对称排列，将一个218米高的空中花园围在中间。两座大厦的底部由裙房相连 (见图1)。

与莫斯科的其他高层项目相同，该建筑群也是混凝土结构。整个项目按照俄罗斯的

Sustainability in High-Rises – The Case of Plot 15

The Plot 15 project in Moscow consists of two slender high-rise towers, both reaching a height of 283 m. Based on lens-shaped floor plans, the buildings are arranged symmetrically to each other, enclosing a 218 m-high sky garden. In the lower section both towers are linked by a base building (see Figure 1).

As most other high-rise projects in Moscow, the building complex is built as a concrete structure. The entire project was designed according to the relevant Russian SNIP codes. The regular slabs are flat reinforced concrete slabs with a thickness of 300 mm. To avoid punching of slab at column location and to minimize the deformation for façade supports, edge beams are designed around the perimeter. In several levels, the two tower parts are linked by a wide-spanning slab.

The horizontal stiffness of the building is provided by several concrete cores. As the basement was already erected when the redesign started, the given cores were smoothly integrated into the re-design. Also, the main columns of the already built below-grade structure continue to be key players in the new load bearing system. To increase the overall lateral stiffness and thus to reduce the required core walls, the two towers are coupled with x-bracings.

The LEED Certification of Plot 15

LEED is an internationally recognized sustainable building certification system overseen by the US Green Building Council. It provides third party verification that a building has been designed according to its methodology which prioritizes energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources.

A building's overall rating is based on the number of credits it successfully meets, and is awarded based on the evidence provided by the design team when applying for certification. Within each credit category there are a combination of prerequisite credits which must be met and a variety of credits that the design team can choose to pursue. This means design teams can choose different combinations of credits to achieve the same rating.

Plot 15 has now successfully been granted a Pre-Certification rating of Platinum (according to LEED 2009). It is an energy and water efficient building that will offer occupants high comfort levels. Full design of the building was undertaken by the Werner Sobek Group.

From the outset of the project both the client and design team were fully committed to achieving the first Platinum rated office building in Russia. The building received an overall score of 86 points to achieve this. All credits applied for were granted, except one, viz. PLF 3: Occupant and Usage Data.

The LEED system was beneficial in providing a roadmap for increasing the building's ecological qualities. It was often beneficial to promote the benefits of particular measures in terms of credits earned and financial returns to ensure certain measures were adopted by the designers and the investors alike.

Quite a number of water efficiency measures such as significant water reduction consumption, green roofs, and stormwater management were specifically included because of LEED. The building subsequently uses 59% less water than a comparable baseline building. The volume of stormwater that is discharged to the municipal storage system has

Figure 1. Plot 15 in Moscow, Russia –rendering. (Source: Werner Sobek, Stuttgart)
图1. 位于俄罗斯莫斯科的Plot 15项目—— 效果图（来源: Werner Sobek, Stuttgart）

有关SNIP规范设计。常规板坯是厚度为300毫米的钢筋混凝土无梁板。为了避免在柱子附近范围的楼板开洞，并尽量减少外墙支架的变形，建筑采用了沿着周边设计的边梁。两座大厦在多个楼层由大跨度楼板相连接。

建筑的水平刚度由多个混凝土芯提供。由于新设计开始时底部已经架起，预定的混凝土芯得以顺利融入新设计。此外，已建成的地下结构的主体仍将成为最新承载系统的关键部分。为了增强整体横向刚度并减少所需的承重墙，两座大厦均配有X型斜撑结构。

Plot 15的LEED认证

LEED是美国绿色建筑委员会监管下的一项国际公认的可持续建筑认证体系。它为建筑提供第三方验证，确认该建筑根据其方法设计，注重节约能源，提高了用水效率，减少了二氧化碳排放，改善了室内环境质量和资源管理。

建筑的总体评估基于它成功获得的分数，其评级则基于申请认证时设计团队提交的证明。每个指标类别都由部分必须满足的先决分数和部分设计团队可选择完成的分数组成。这也意味着设计团队可以选择不同的分数组合来获得相应的评级。

Plot 15目前已成功获得铂金级预认证 (基于LEED 2009) 。这个节能节水的建筑将为住户提供高舒适度的居住环境。建筑的全部设计工作由沃纳索贝克集团负责。

项目伊始，客户和设计团队即完全致力于获得俄罗斯第一座获得白金级认证的办公楼。该建筑获得了86分的总分实现了这一目标。该建筑获得了申请的所有分数除了一项PLF 3: 住户和使用数据， 。

LEED体系为提高建筑的生态品质提供了路线指南，该体系强调了分数获得和财务回报方面的特别措施的比重，这有利于确保设计师和投资者采取相应措施。

为了获得LEED认证，该建筑采取了不少节水措施，如显著减少水消耗、绿色屋顶和雨水管理等。最终，该建筑比基准建筑减少了59%的用水量。利用雨水收集系统和密集的绿色屋顶，排放到城市污水管网系统的雨水量也减少了85%。此外，所有收集的雨水均经过TSS处理效率达80%以上的系统处理，从而确保排出的水是优质水 (见图2) 。

been reduced by 85% through rainwater harvesting and intensive green roofs. Furthermore, all rainwater that is captured is treated by a system with a TSS treatment efficiency of more than 80% - thereby ensuring discharged water is of a high quality (see Figure 2).

As Plot 15 is a commercial office building the client was keen to ensure that tenants were responsible for their own cooling and that this was consistent with the cooling systems provided for landlord areas (for reasons of cost and ease of maintenance). The first designs proposed Variable Refrigerant Flow VRF systems for both tenants and landlords. Though this provided the flexibility the client desired, it came at an energy penalty. By simulating and showing the impact on LEED rating of the two options, the client was able to see the benefits of a centralised cooling system for landlord areas. This centralised cooling in combination with a high performance façade was crucial to scoring highly on the Energy credits. Using the software Integrated Environment Solutions (IES), ASHRAE 90.1 Simulations showed that energy efficiency measures reduced energy costs by 30%.

Dynamic energy modelling in IES shows that the building consumes 32% less energy than a comparable building according to the ASHRAE 90.1 Standard – the resulting savings are 24,520 MWh (-32%) and 71,770 RUB (-30%) respectively per year.". Plot 15 is estimated to consume 52,710 MWh, while the baseline building was estimated to consume 77,230 MWh. These savings were achieved from space heating and cooling, fans, and internal lighting controls and efficiencies as well as a high performance fabric.(see Figure 3).

The challenge of the project was to deliver real energy savings and improved sustainability strategies with a very tight budget, for a client who was very commercially astute. All technologies proposed and improvements made were commercially viable with very little extra-over costs for this.

Many renewable technologies were investigated in the early stages, however the analysis showed that, given the spatial restrictions of the building and budgets, the technologies would do very little to reduce the overall environmental footprint of the building - for example, only a very small PV plant could have been installed on the building roof and this would have contributed a token amount of energy to the building's overall demand. Instead, sustainability and energy reduction was incorporated within the design process of all disciplines.

What Difference Would LEED V4 Make?

LEED is adjusted at intervals to current building standards. This allows for one's own ideas to be positively assessed using the "Innovation in Design" criteria in the system, thus enhancing and improving the system. In 2013, a new system version LEED v4 was released, which deals more specifically with current concerns and uses currently applicable norms and guidelines as its assessment benchmark. This section presents some of the criteria of the updated v4 system which can be influenced by resource-efficient high-rises.

Area Efficiency

As was the case in LEED 2009, when an already developed site is built up again or existing buildings repurposed, it will be positively assessed in v4. This should counteract the increased incidence of soil sealing. Particular emphasis is placed on land in densely built-up areas. The correspondingly high property prices in these locations are "compensated for" with a high score in the LEED system. The best assessment score is achieved when the building covers a small area of land and the open spaces are accessible to pedestrians and occupants of the building.

由于Plot 15是一座商业办公楼，业主希望租户拥有独立的冷却系统而又希望该系统与该业主区域的冷却系统保持一致(出于成本和易于维护的原因)。第一个设计方案提出了为租户和业主安装可变制冷剂流量多联机系统。该方案满足了客户的灵活性要求，但在节能方面却不如人意。通过模拟这两种方案并说明其对LEED评级的影响，客户意识到了在业主区域安装中央冷却系统的优势。这个中央冷却系统，加上该建筑的高性能外墙，对能源一项的高得分起到了重要作用。利用集成环境解决方案 (IES) 软件，ASHRAE 90.1模拟标准表明该节能措施降低了30%的能源成本。

IES的动态能量模拟表明，根据ASHRAE 90.1标准，该建筑比同类建筑减少了32%的能耗，每年节约的能源总量和能源成本分别为24,520兆瓦时 (-32%) 和71,770卢布 (-30%) 。Plot 15预计将消耗52,710兆瓦时能源，而基准建筑预计将消耗77,230兆瓦时能源。这些能源节约通过空间加热和冷却、风扇和内部照明控制和效率以及高性能织物来实现 (见图3) 。

该项目的挑战是在紧张的预算条件下为具有相当商业敏锐性的客户实现真正的节能和改善可持续发展战略。所有技术方案和改进方案均是经济可行的并且几乎没有额外增加的成本。

项目还在早期阶段对许多可再生能源技术进行了调查，但是其分析结果表明，由于受到建筑空间和预算的限制，这些技术对减少建筑整体环境足迹的作用非常小。例如，该建筑的屋顶只能安装小型光伏设备，而这也只能象征性的解决建筑的能源需求。反之，可持续发展和节能减排已融入所有科目的设计过程。

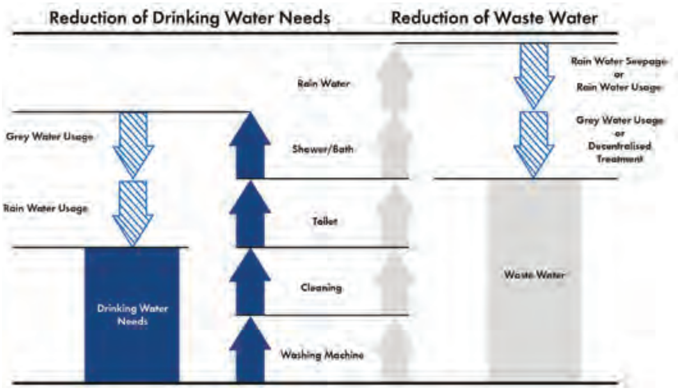

Figure 2. Reduction of water consumption in Plot 15. (Source: Werner Sobek, Stuttgart)
图2. Plot 15减少的用水量 (来源: Werner Sobek, Stuttgart)

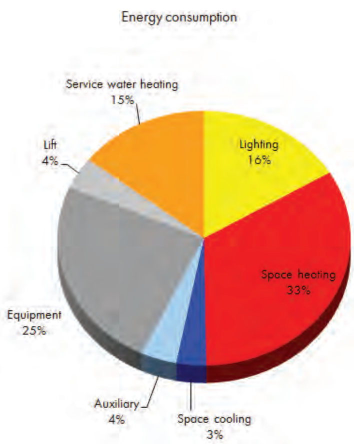

Figure 3. Distribution of energy consumption in Plot 15. (Source: Werner Sobek, Stuttgart)
图3. Plot 15的能耗分布 (来源: Werner Sobek, Stuttgart)

Energy Efficiency and Water Management

As did its predecessor, LEED v4 also places special focus on the economical use of energy and water. This is evident from the new "Integrative Process" requirement, which calls for assessments at an early design stage of the building's energy and water consumption that will be dealt with in later design stages. The category for the assessment of water consumption has been extended to issues such as the obligation to measure consumption and the consideration of water consumption for cooling in buildings. A reduction in drinking water consumption in the building is rewarded in LEED v4 with more points than before. In addition to an adjustment to current standards, other matters are also considered when assessing the energy requirements: Consumption measurement is now mandatory in this regard. The consideration of demand response programmes is new, and is becoming increasingly important, particularly in countries with peak electricity demand for cooling purposes.

Indoor Environmental Quality

In LEED v4 the number of points for the assessment of daylight availability in the building has been increased. Verification can be performed by various methods; the assessment is done in two stages. For maximum points, however, a regular exposure to light of 90% of the regularly used areas must be provided by daylight.

Materials and Life-Cycle Assessment

In LEED v4, new emphasis is placed on the life cycle of a building (set as 60 years) and related resources in several credits within the materials & resources category. In addition to the known criteria for individual materials which assess the use of regional availability and recycled components, environmental product declarations (EPD), and materials with comparatively low environmental impacts are now taken into consideration. In addition to the use of existing buildings, newly constructed buildings and components can now be considered in a cradle-to-grave life cycle assessment. The environmental impact of the materials of the new building is compared to a reference building of the same size, use, etc over 60 years. What is critical here is that the construction of the reference building be based on typical constructions for the corresponding building type and a minimum energy quality of the building must be shown; the configuration of components, however, is largly left to the user. The resulting comparative value is therefore only partly representative. Since energy consumption of the building is not included in the assessment of this credit, an improvement of the thermal properties of the building envelope or thermal mass of the structure will automatically give a less favorable result as the use of materials usually increases with these measures. This credit should therefore actually be taken in conjunction with the requirement for assessing the energy efficiency - the most important criterion in the LEED system; but at the moment, each requirement is examined independently of the others. In this version, the life cycle assessment is still a tool to optimize the design without using its potential for a holistic approach.

Resource Efficiency

The ideal LEED project in terms of area efficiency was and is a high-rise building, which is built on a redevelopment plot in a dense, mature neighborhood with good access to public transport. Because the gross floor area of the building contributes to assessing the density of the surrounding neighborhood, high-rise projects win from the start, due to the sheer number of Storys. The positive assessment of the Plot 15 project using LEED 2009 would therefore not change if LEED v4 were used, but may well be slightly improved because of the inclusion of the funding of compensatory measures.

LEED v4可能会带来什么不同结果?

LEED每隔一段时间都会对现行建筑标准进行调整，使每个人的想法都能通过该体系的"设计创新"标准得到积极评估，从而提高和完善该体系。2013年，LEED发布了新的系统版本LEED v4，对人们最关注的问题提出了更具体的论述，并且将目前适用的规范和准则作为其评估标准。本节介绍了升级后的v4体系中受资源节约型高层建筑影响的一些标准。

面积效率

同LEED 2009一样，已开发的场所再次建设或现有建筑改变用途时也需经过v4的积极评估，从而消解由此引起的土壤板结现象的增加。升级后的体系高度重视建筑密集地区的土地。这些地区高昂的楼价得到了LEED系统高比分的补偿。当建筑仅占很小的土地面积并且公共空间向行人和住户开放时，该建筑将获得高分。

能源效率和水管理

同上一版本一样，LEED v4还特别注重能源和水的有效使用，这一点从全新的"一体化进程"规定中可见一斑。该规定要求在早期设计阶段对建筑的能源和水消耗量进行评估并在之后的设计阶段进行处理。耗水量评估科目已经延伸到一系列其他问题，如能耗计算的义务和建筑冷却的耗水量计算等。在LEED v4体系中，建筑饮用水消耗量的降低比之前占据了更多的比分。除了对现行标准进行调整，该体系在评估能源需求时还会将其他因素考虑在内: 能耗计算目前已成为强制性要求。需求响应计划的要求是最新推出的，并且正变得越来越重要，特别是对因冷却而产生高峰电力需求的国家而言。

室内环境质量

在LEED v4体系中，室内日光可用性的评估比分有所增加。日光可用性验证可能采取多种形式进行; 评估将分两个阶段进行。为了获得最大分值，常用区域90%的光线必须由日光提供。

材料和生命周期评估

在LEED v4体系中，最新重点放在了建筑的生命周期上 (设定为60年) 和相关材料的生命周期上，这一点体现在材料和资源科目的部分分值上。除了特定材料的已知标准——评估区域可用性和回收组件的使用，环保产品声明 (EPD) 和对环境影响相对较小的材料也被纳入考量范围。除了现有建筑的使用，新建建筑和组件目前也被纳入了终生生命周期评估的考量范围。新建筑的材料对环境的影响与使用年限超过60年的相同面积、相同用途的参考建筑进行了比较。这里的关键之处在于必须证明参考建筑的结构基于相应建筑类型的标准结构和建筑的最小能源质量; 但是，组件的配置在绝大程度上由用户决定。因此，其所得到的比较值仅具有部分代表性。由于建筑的能耗不包括在本分值的评估范围内，围护结构的热性能或建筑结构的热质量的改善会为分值带来不太有利的结果，因为材料的应用通常随着这些措施而增加。因此，本分值应与评估能源效率的要求——LEED系统最重要的标准相结合; 但在此刻，每个要求都独立进行检查。在这个版本中，生命周期评估仍然是优化设计而无需使用其全盘着眼的潜能。

资源效率

不论是过去还是现在，在面积效率方面最理想的LEED项目仍是高层建筑，因为它建在重建地块密集成熟的居民区并享有便利的公共交通设施。由于建筑的总楼面面积有助于评估周边居民区的密度，高层项目从一开始就因楼层的数量之多赢得了先机。因此，根据LEED 2009对Plot 15项目展开的积极评估将如LEED v4评估一样不会产生任何变化，但可能因补偿措施资金的介入而得到轻微改善。

根据LEED v4展开评估之时，其优势来自于将资源节约型高层建筑与传统设计相比较的生命周期分析。然而，估算传统设计作为比较值看起来会如何，以及优化带来的质量差异会有什么不同，这一点比较困难。为了实现标准的正确应用，规定参考值是一个可

When performing the assessment using LEED v4, advantages would certainly be gained from a life-cycle analysis comparing resource-efficient high-rise buildings with conventional designs. Estimating how a conventional design would have looked as a comparison value and exactly what mass differences arise from the optimization would, however, be difficult. For proper application of the criterion, defined reference values would be desirable. With Plot 15, the design would still be compared to conventional Moscow construction methods. Since the criterion for assessing energy efficiency when compared to the LCA can contribute to a much higher certification score, however, one may well continue to focus on optimizing energy consumption during operation, without contrasting this with embodied energy in the construction when using LEED in the future.

To put it in a nutshell: The assessment of Plot 15 according to LEED v4 would probably not lead to a significantly different result than the assessment performed in LEED 2009.

DGNB – An Alternative Sustainability Certification for Plot 15?

Introduction

The DGNB certification system is a transparent assessment tool for the sustainability of buildings. There are different assessment approaches depending on the type of use. The principles of the system described below are always the same, but the benchmarks vary depending on the purpose of the building (e.g. different lighting requirements for an office and a museum).

DGNB assessment is carried out in comparison with regulations currently in force and measures other indicators in comparison with average German and European building standards. Exact compliance with regulations or standards corresponds to a score of 50% (Bronze Certificate), while a Gold certificate requires a score of 80%. In each criterion, the level of compliance may vary between 0% and 100% (full compliance with the threshold value).

Sustainability according to DGNB is assessed based on five main groups of criteria and various sub-groups. Equal weighting of the main quality groups – ecological quality, economic quality, sociocultural and functional quality, and technical quality – ensures that all aspects of sustainability are considered. Location quality is also assessed, but does not form part of the overall assessment (see Figure 4).

The assessment does not focus on individual measures, but on the entire building over its entire lifespan (50 years). DGNB does not rate, for example, the specific type of cooling system selected for the building, but rather assesses thermal comfort (sociocultural and functional quality) and tests either by simulation or measurement whether thermal comfort requirements have been met. Cost and energy consumption of the cooling system are considered in another quality group and are included in the life-cycle costs or analysis. Thus, different quality characteristics are never combined in a single criterion. This gives the design team maximum freedom with respect to optimization strategies.

In the following paragraphs, selected topics have been listed which are of particular relevance with respect to resource-efficient high-rise buildings.

Priorities of the DGNB System in the Assessment of High-Rise Buildings

In order to maximize the sustainability of a building, an integrated design process is vital. This is the only way partially conflicting interests

取的的做法。Plot 15的设计仍将与传统的莫斯科施工方法进行比较。虽然评估能源效率的标准在与LCA相比时能够获得更高的认证分数，但是人们很可能会继续专注于在操作过程中优化能耗，而不是在将来使用LEED时将之与施工中的内涵能源相比较。

总而言之: 根据LEED v4展开的Plot 15评估可能不会与LEED 2009评估的结果产生明显差异。

DGNB – Plot 15的可持续认证替代方案?

简介

DGNB认证体系是一个透明的建筑可持续性评估体系。根据使用类型的不同还有各种评估方法。如下所述，该体系的原则都是一样的，但其基准取决于建筑用途 (例如: 办公室和博物馆的照明要求有所不同) 。

DGNB评估通过与现行法规相比来展开并通过与德国和欧洲普通的建筑标准相比来衡量其他一些指标。与法规或标准的精确合规性对应50%的比分 (铜牌证书)，而金牌证书需要获得80%的比分。合规程度可能在0%和100%之间变化 (完全合规可得基础分值) 。

根据DGNB的规定，可持续性评估基于五个主要标准类别和多个细分类别。主要质量类别——生态质量、经济质量、社会文化和功能质量以及技术质量——的相同比重确保考虑到可持续性的各个方面。位置质量也会经过评估，但不构成整体评估的一部分 (见图4) 。

该评估并不侧重于单个措施，而是专注于建筑的整个生命周期 (50年) 。例如，DGNB不对建筑选用的特定冷却系统进行评估，而是评估其热舒适性 (社会文化和功能质量) 并通过仿真或测量来测试其是否满足热舒适性的要求。冷却系统的成本和能耗被归为另一质量类别并被列入生命周期成本或分析。因此，不同的质量特性不用单一标准来衡量。这为设计团队的优化战略带来了最大程度的自由。

以下内容列举了与资源节约型高层建筑最相关的一些主题。

DGNB评估高层建筑时的优先事项

为了最大限度地提高建筑的可持续性，集成设计过程至关重要。这是将相互冲突的因素——如能源效率和舒适性或固定预算金额的可选投资方案采取被动措施 (如保温、装玻璃等) 或主动措施 (如高效冷却、低温系统等) 等权衡因素转换成令人满意的最佳优

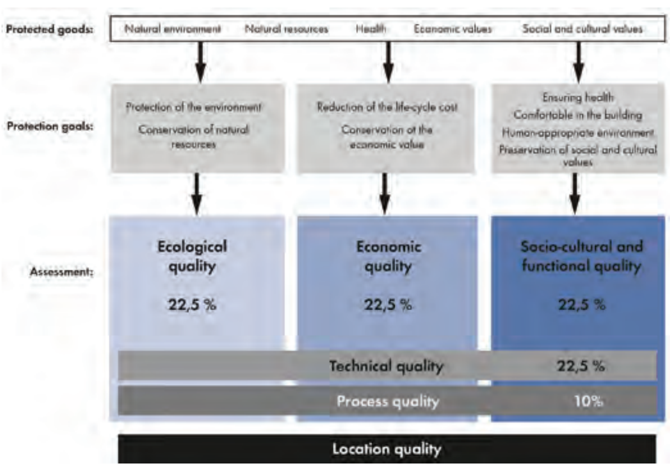

Figure 4. Basic structure of the DGNB rating tool. (Source: Werner Sobek, Stuttgart)
图4. DGNB评估体系的基本结构 (来源: Werner Sobek, Stuttgart)

such as energy efficiency and comfort, or trade-offs such as alternative investment of a fixed budgeted sum in either passive measures (such as insulation, glazing, etc.) or active measures (such as efficient cooling, low temperature systems, etc.) can be considered satisfactorily to best advantage. Since it is generally recognized that this type of integrated design process is an essential component of a sustainable building, the DGNB assesses process quality separately, and accords it a possible 10% of the overall assessment.

Also, no individual measure is assessed on its own merits, but different aspects are combined to give an overall value. In terms of high-rise buildings such as Plot 15, this means, for example, that the rainfall run-off which occurs as a result of its geometry or measures such as rainwater harvesting and green roofs recede into the background, and the assessment will be largely determined by water-saving fixtures and the possible use of grey water.

The requirements to be met in LEED v4 to achieve a positive assessment of area efficiency will also lead to a positive assessment in the DGNB system. In addition, the DGNB offers a positive assessment to achieving the highest possible floor space to gross floor area ratio. This goal, shared with investors in terms of resource efficiency, is more difficult to achieve for high-rises due to the relatively high surface coverage for the support structure and vertical access for goods and people. Special consideration in the design process is therefore essential – a coordinated energy design in this regard can be as critical as a high-quality structural design, which not only saves construction area, but also avoids restricted usable spaces and niches.

Both effects on the environment and the cost of a building are considered over the lifespan of the building. Buildings are responsible for emissions and resource consumption not only in operation, but in all stages of their life-cycle – including raw material extraction, production and use, maintenance and decommissioning. The resulting emissions cause a variety of environmental problems to which the DGNB gives consideration: global warming potential, ozone depletion potential, ozone formation potential, acidification potential and eutrophication potential as well as renewable and non-renewable primary energy consumption. In each case, the sum of the environmental effects during the construction ("grey energy" or embodied energy) and occupation phases is assessed, so that, for example, an energy payback in respect of insulation can be calculated.

While in terms of primary energy, the influence of building use today usually still prevails, future efficiency targets will place increasingly more importance on the structure of a building. A different picture is already emerging with other parameters. The comparison shows that a LCA-optimized design (and that means a particularly optimized structural design for high-rise buildings such as Plot 15) can contribute to environmental protection and to a better DGNB assessment (see Figure 5).

For the purposes of DGNB, a sustainable building must also, among other things, be reasonable in terms of cost. As with the LCA and water consumption, individual aspects are not considered on their own, but in the light of the building's performance over its lifespan. All costs are calculated over a period of 50 years. The life cycle costs make up between 11% and 13.5% of the building assessment, depending on the type of use. On the one hand, this weighting within the system reflects its importance for investors; on the other, it prevents one from being able to simply "buy" a Gold certificate by including

势的唯一途径。由于人们普遍认识到，这种类型的集成设计过程是可持续型建筑的重要组成部分，因此DGNB对过程质量进行单独评估并为其提供整体评估10%的分值。

此外，DGNB不会从本身的价值对个别措施进行评估，但会结合不同的方面给出总体价值。对于Plot 15等高层建筑而言，这意味着，因建筑的几何形状或雨水收集和屋顶绿化等措施引起的降雨排水已不再主要的考量对象，而评估将在很大程度上取决于节水装置和灰水的可能用途。

在LEED v4体系中为获得积极的面积效率评估而满足的要求也将在DGNB体系中获得积极评估。此外，DGNB还为较高的楼面面积/总楼面面积比提供了积极的评估。根据投资者在资源效率方面的共识，这一目标对高层建筑而言很难实现，因为高层建筑为了实现稳定的支撑结构和货物和人员的垂直进入具有较高的表面覆盖率。因此，设计过程中的特别措施必不可少——这方面的协调能源设计与高品质结构设计同等重要，它不仅节省了建筑面积，而且还避免了可用空间和位置限制。

这些措施对环境和建筑成本的作用将持续至建筑的整个生命周期。建筑不仅在运营过程中还要在其生命周期的各个阶段对排放和资源消耗负责——包括原材料开采、生产和使用、维护和关停。由此产生的排放物会造成各种环境问题，而这也正是DGNB的考量内容: 全球变暖潜势、臭氧消耗潜势、臭氧生成潜势、酸化潜势和富营养化潜势以及可再生和不可再生一次能耗。在每种情况下，DGNB都会对施工阶段和入住阶段的环境影响总和 ("灰色能源"或内涵能源) 进行评估，从而计算出保温所需的能耗等。

在一次能源方面，建筑如今的影响力通常仍然存在，未来的效率目标将越来越侧重建筑结构。随着其他参数的出现，这一现象已经有所不同。比较表明，LCA优化设计 (经过特别优化的高层建筑结构设计，如Plot 15) 能够为环保做出贡献并获得更好的DGNB评估结果 (见图5) 。

为了获得DGNB认证，一座可持续型建筑还还必须保持成本合理。LCA和水消耗评估体系并未考虑个别方面，而是对建筑整个生命周期的性能进行评估。所有成本均按50年的使用年限计算。根据使用类型的不同，生命周期成本将占据建筑评估11%-13.5%。一方面，该体系的这一比重反映了其对投资者的重要性; 另一方面，它能够防止某些人通过计入任意选择的措施组合来简单地"买入"金牌证书。因此，如果没有经过合理的优化，获得良好的生命周期成本评估，一座建筑是不可能获得DGNB金牌证书的。

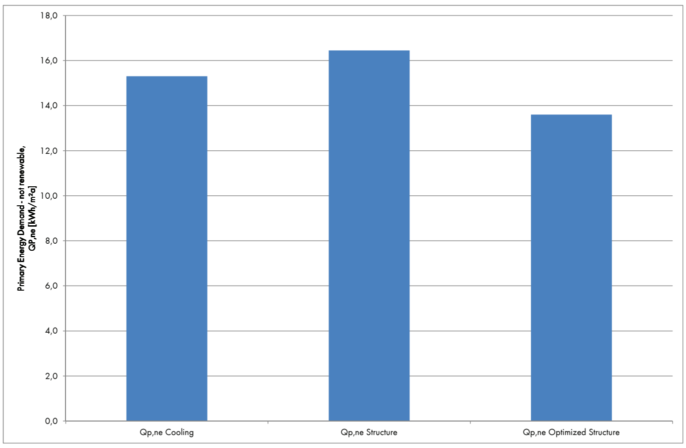

Figure 5. Comparison of average energy consumption for cooling and structure per year. (Source: Werner Sobek, Stuttgart)
图5. 冷却和结构的每年平均能耗比较 (来源: Werner Sobek, Stuttgart)

any combination of arbitrarily chosen measures. Without sensible optimization and as a result, a good rating for life cycle costs, the DGNB Gold certificate is practically impossible to obtain.

Consequences of the DGNB System in the Assessment of High-Rise Buildings

The examples given above indicate that a high-rise building has both advantages and disadvantages as a result of the type of certification process selected. Because tower blocks are typically located in city centres, mostly positive assessments come from the criteria focusing on infrastructure. However, in DGNB this does not carry quite as much weight as in LEED. The DGNB system thus immediately reveals possible planning weaknesses.

To counteract this effect, close collaboration between the architect, technical building equipment designers and structural engineers is essential to achieve an LCA-optimized, resource-efficient building. The reward and the learning curve associated with this process is found in process quality, which is why integrating DGNB certification into the design process can have a positive influence on complex buildings such as high-rises.

Conclusion

This paper has shown how the design process of high-rise buildings can be significantly improved through the use of certification systems such as LEED and DGNB. Especially in countries where sustainable building strategies are not yet very strongly rooted in planning culture or in statutory regulations, targeting sustainability assessment at an early stage can achieve important benefits. This statement applies to both assessment systems considered, i.e. LEED and DGNB. Nevertheless, there are important differences between the two systems in the weighting of individual factors and in creating an overall view.

In LEED, the change from the 2009 version to v4 only partially resulted in adjustments to current regulations. In general, high-rises assessed using the LEED system have an advantage over other types of buildings due to their efficient use of space. Because the DGNB system makes a holistic assessment with equal weighting of different qualities, building high-rises does not automatically lead to a better (or worse) rating. Rather, a finely graduated observation is made possible, which gives designers a variety of design options to work with.

For simplicity, we can say that LEED is particularly suitable for a simple assessment of ecological qualities, while DGNB is a complex tool for defining, planning and assessing all sustainability qualities in detail for both designers and builders. Both systems can and should be seen not only as systems for the assessment of completed buildings, but also, and more importantly, as design optimization tools. Without rating systems there is no reliable way to predict the energy and environmental efficiencies of a building. The rating systems provide a scientific and quantitative measure about the optimal performance of the buildings.

DGNB体系对高层建筑评估的影响

上文给出的例子表明，根据所选认证过程类型的不同，高层建筑各有优点和缺点。由于高层建筑通常位于市中心，大部分积极的评估来自于侧重基础设施的标准。但是，在DGNB体系中，这一点并未占据如LEED一样大的比重。因此，DGNB系统能够立即体现规划弱点。

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结语

本文阐述了如何通过LEED和DGNB等认证体系来显著改善高层建筑的设计过程。特别是可持续型建筑战略尚未体现在规划文化或法律条例中的国家，在早期阶段设定可持续性评估的目标能够获得多个重要的好处。本论述适用于LEED和DGNB等评估体系。不过，两个体系在个别因素的比重和整体评估方面有显著区别。

在LEED体系中，2009版到v4版的变化仅部分导致现行法规的调整。一般情况下，通过LEED体系评估的高层建筑优于其他类型的建筑，因为它能够有效地利用空间。DGNB体系通过相同比重的不同要素进行整体评估，建设高层建筑并不会自动获得更好 (或更差) 的评估。相反，精细分级的评估反倒成为可能，从而为设计人员提供多种设计方案选择。

为了简单起见，我们可以说，LEED特别适用于生态质量的简单评估，而DGNB则是适用于设计师和建造者定义、规划和详细评估所有可持续性要素的一个复杂体系。这两种体系都能并且应被视为已完工建筑的评估体系，而且更重要的是，设计优化工具。除了评估体系，其他方法都不能可靠地预测建筑的能源和环境效益。评估体系为建筑的最佳性能提供了科学化的定量测量措施。