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最佳实践：
中国南方地区首个被动式住宅

Best Practice:
The First Residential Passive House in Southern China

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摘要 / 德国彼特·鲁格建筑设计事务所专注于可持续的建筑和城市设计，在这一领域拥有20多年的丰富经验。2013年，事务所完成了位于中国南方地区的首个被动式住宅——“布鲁克”。该项目位于浙江长兴太湖附近，在与朗诗欧洲技术有限公司的建筑师和工程师团队以及来自德国被动式房屋研究所的沃尔夫冈·菲斯特博士和工程师的合作之下，通过应用能够改善建筑在运行过程中的性能的技术，设立了可持续发展的新标准，并成为了一个重要的里程碑式建筑。与中国传统住宅建筑相比，“布鲁克”能够节省95%以上的能耗，成为拥有温暖、潮湿气候特点的中国南方地区被动式住宅的先行者。将被动式房屋标准引入中国住宅建筑市场，是可持续设计中的一项成功实践，不仅能够为人类的未来减少能源消耗，并且将对环境条件起到积极的改善作用。

关键词 / 被动式房屋；中国南方；住宅建筑；开创性建设；可持续设计方法；生态开发

Abstract / With over 20 years of experience in the field, Peter Ruge Architekten (Germany) focuses on sustainable architectural and urban design. In 2013, the firm completed their first Residential Passive House, BRUCK, in Southern China. The project is located in Changxing, Zhejiang Province, near Taihu Lake. Together with the architects and engineers from Landsea Europe, and in cooperation with Doctor Wolfgang Feist and engineers from the German Passivhaus Institute (PHI), it establishes new standards of sustainability through techniques that seek to improve the building's operation over time and has achieved an important architectural milestone. With over 95 percent energy reduction over a conventional Chinese residential building, this is the first house of its kind to be realized in China's damp, warm, southern climate. The introduction of the Passive House standards to the Chinese housing market is an example of successful implementation of sustainable design that will considerably reduce energy consumption and improve environmental conditions in the future.

Key words / Passive House; Southern China; Residential Building; Pioneering Construction; Sustainable Design Methods; Ecological Development

被动式房屋设计在德国已有20余年的发展历史，请问被动式房屋在德国的普及情况如何？

彼特·鲁格（以下简称鲁格）：被动式房屋在德国的日益普及源于此类建筑在整个建筑生命周期内可以不断累积节省下来的能源花费。虽然在初始建设阶段，被动式房屋的投资成本会比普通住宅高出约15%，但根据模型显示，这类房屋能够在约6年的时间内通过节约运营成本而获得经济回报。随着能源和供暖价格的不断上涨，由节省运行成本而带来的经济效益将变得日益显著。

作为一个商业模型，尤其在物业出租仍然占据主导地位的房地产市场，被动式房屋业主向租户提供一个固定的建筑供暖费用，而其他情况下这部分费用会增长。这一固定花费有助于租户预测来年的租金。最后，德国较小的空气湿度和凉爽的气候条件非常适合被动式房屋的设计，因此也不会带来额外的花费。根据新的法规，截止到2020年，从公共运营设施开始，德国的所有建筑必须符合被动式房屋标准。

被动式房屋设计具体包括哪些特殊技术？被动式房屋的设计方法是否仅适用于新建建筑？

鲁格：在被动式房屋的设计中，第一个阶段应对当地气候条件进行分析以决定建筑朝向，通常包括计算墙体、屋顶和楼层所需的隔热材料用量，随后使用双层或三层玻璃和密封胶制作窗户。第二个阶段的设计内容包括：通风系统、建筑内外空气的热交换、整个建筑中供暖或制冷系统的有效分配，以及主要能源的使用程度。从审查的最高标准而言，建筑细部的质量和协调将对建筑的节能性产生重要影

The practice of Passive House design has emerged and developed over 20 years in Germany. Could you please generally introduce the current popularity of Passive Houses in Germany?

Peter RUGE (RUGE hereafter): The growing popularity of Passive House construction in Germany is due to the accumulative energy cost savings experienced throughout the building's lifecycle. For an additional investment of approximately 15 percent to the initial construction costs, Passive House models have demonstrated a financial return provided by operational cost savings over a period of approximately 6 years. As the price for energy and heating increase, the benefits provided by running cost savings become progressively substantial.

As a business model, especially in a real estate market still dominated by rental properties, Passive House landlords are able to provide a fixed building heating cost to tenants, where these costs would otherwise increase. This allows consumers to better predict their “second rent”. Lastly, weather conditions in Germany are ideal for Passive House design, due to the fact that buildings are subjected to less humidity and cooling can be provided at no extra costs. According to new legislation, by 2020 all German buildings, starting with publicly run facilities, must be built in compliance with Passive House standards.

What are the specific technologies and approaches of Passive Houses? Is passive design more widely employed in the construction of new residence, rather than improving the existing structures of built houses?

RUGE: When designing new passive buildings, the first stage of optimisation begins with an analysis of the local climate conditions to determine the structure's orientation, usually the calculations of insulation required for walls, roof and floor, followed by the use of double and triple glazing and sealants for windows. The next stage addresses ventilation, heat exchange of in-coming and out-going air, the efficient distribution of heating or cooling throughout the building and the extent to which primary energy will be used. At the highest level of scrutiny, the quality and coordination of structural detailing greatly influences the building's ability to operate efficiently. Building envelopes under the Passive House standard are required to be extremely airtight compared to conventional construction. This is achieved through air barriers, careful sealing of construction joints in the building envelope, and sealing of service penetrations. In the final stage, the building's production of energy requires modification, achieved through the implementation of mechanical systems that allow the building to operate more efficiency.

In essence, we like to think of it as dressing the structure in a big “pullover”, separating the interior and exterior conditions. Another important factor for a Passive House is to regulate the active consumption of energy, such as mechanically assisting natural ventilation or sensor operated lighting systems in order to regain the energy conducted inside the building envelope.

To create new buildings that integrate progressive technologies it is always more straightforward than improving the energy efficiency of existing structures. The conversion of existing buildings to meet Passive House standards is greatly determined by the integrity of the base structure and its proportional qualities. We have become highly experienced in methods for Passive House conversion and renovation. This long record is mainly due to the attributes of available building stock that lends itself to potential transformation. Vast quantities of the inner urban residential building styles in German cities, especially those from the 1950s, demonstrate simple forms and geometry, orientation, and window sizes. These combined attributes create conditions better suited to implementing the “pullover” as previously described and good candidates for conversion.

响。与传统建筑相比，被动式房屋的围护结构要求实现完全密封。这一点将通过空气阻隔层、对建筑围护结构中每个施工缝进行仔细密封，以及对与外部连通的墙体贯穿物进行密封来实现。最后一个阶段中将运用能够提高建筑运行效率的机械系统，对建筑能源生产的总体情况进行调整。

实质上，我们将这些围护结构视为建筑的大“套衫”，将内部环境和外部环境分隔开。被动式房屋的另一个关键因素在于能够对能源的主动消耗进行调节，比如通过机械辅助自然通风或通过传感器控制照明系统，以重获围护结构内部所传导的能源。

相比提高现有建筑的能源效率，采用先进技术建造新建筑更加直接有效。对现有建筑进行改造使其符合被动式房屋的标准，这在很大程度上取决于建筑基础结构的完整性及建筑质量。我们在被动式房屋的改造和翻新中积累了丰富的经验。这些项目主要是在具备改造潜力的建筑的基础上完成的。长期以来，特别是自20世纪50年代以来，德国城市中大量的住宅建筑风格所采取的的简单的几何形式、朝向和窗户尺寸，这些特征则更加有助于采用前文所提及的“套衫”结构，从而最终实现房屋的改造。

您如何看待中国目前的建筑节能现状?

鲁格：自2005年我在中国开展第一个项目起，中国在新建筑节能和城市规划方法方面都取得了巨大的进步。在部分早期项目中，我们很难说服客户对建筑的外墙保温技术进行投入，因为当时客户认为这是没有必要的。而在过去的10年中，我见证了中国在追求实现最佳设计实践的态度和节能策略方面的巨大改变。

在大多数情况下，被动式房屋的设计方法都能够实现预期效果，但要求中国的每一个住宅都符合被动式房屋的节能标准是不合理的。反之，我的建议是通过对项目的深思熟虑以及与客户共同协商来寻求建筑设计的最佳解决方案。这意味着需要转变客户观念，超越中国建筑固有的标准，使项目能够获得可行的经济和生态解决方案。

您曾指出，在中国的实践不能照搬德国的模式。请您结合在中国的实践项目，谈谈项目当地的环境和人文特点对项目的设计方案所带来的影响?

鲁格：在如今的新技术时代，建筑领域应该在传统技术和新知识体系的基础上寻求发展。对于每一个项目的可持续规划策略而言，清楚地了解当地的建筑技术、自然资源、气候条件和文化都是不可或缺的，而以上各个方面的优先顺序应根据项目的具体要求而定。只有建立起一套基于传统建筑技术的综合的、跨学科的、跨文化的设计方法，才能获得考虑全面的、适用于当地的方案。

这种对于所有因素所进行的独特的结合方式建立在对可持续性的六大要素的考虑之上，包括生态、经济、社区、技术、建造实践和场地条件。以上要素所建立的框架有助于识别当地的主动和被动参数。能够对建筑的可持续运行产生动态影响的“主动”参数，将有助于引导和支持最终的“被动”设计理念。

举例来说，我们在中国浙江完成的被动式住宅“布鲁克”的设计包括对当地的气候条件的考量，这对于技术概念的提出至关重要，该概念采用了最具创新性的节能系统和系统组件。在6~9月空气湿度持续较高的亚热带气候条件下，被动式住宅的室内舒适度将由制冷系统控制。“布鲁克”在当地气候带地区运行良好，能够在夏季减少制冷负荷。紧凑的设计减少了建筑表面积，同时绝缘建筑外壳的使用也显著地降低了墙体、屋顶和楼层的热传递。建筑的位置和朝向决定了建筑形式，并且影响了立面的遮阳元素的形式。

被动式房屋的建造成本通常高于普通住宅，您认为被动式房屋在中国的推广前景如何?

鲁格：根据长期以来我们在德国完成的被动式房屋设计经验，正如我前面提到的，被动式房屋的初始建造成本比传统建筑高约10%~15%。由于德国的被动式房屋周边具备完善的基础设施，因此成本增加的幅度较小。建设所需的材料设备的制造和运输十分便利，加之现场装配更容易实现，因此不会为

Can you comment on the current development and efforts on architectural energy efficiency in China?

RUGE: Since 2005, when I began work on our first project in China, large improvements have been made to ensure the architectural energy efficiency of new buildings and progressive methods of urban planning. During some of our early project experiences, it was difficult to convince clients to invest in ideas as simple as external thermal insulation, which at the time was considered unnecessary. Over the past 10 years I have witnessed vast improvements in attitudes toward best practice design and how energy saving strategies are achieved.

In many circumstances the methods involved in Passive House design fulfil desired outcomes, but not in all. Thus to suggest that every house in China should be designed to meet the level of energy efficiency set by these standards would be unreasonable. Rather, it is my architectural approach to find the best solutions for optimising a building design through careful consideration of a project’s brief and in consultation with my clients. This often means moving my clients’ ideas beyond conventional Chinese building standards and toward the best economic and ecological solutions feasible.

You have pointed out that the practice in China cannot indiscriminately copy the German mode. We wonder how you consider the local Chinese environment and

1. 南立面细节图。所有的私人房间和公共区域都采用三层玻璃窗，通过固定的遮阳元素为玻璃幕墙提供保护。© Peter Ruge Architekten
1. South elevation detailed drawing. Triple glazed window units have been used in all private rooms and common areas. Fixed sun shading elements are used to protect the glass facade. © Peter Ruge Architekten

项目成本带来很大负担。在德国，人工成本在建造成本中占有很高比例，材料组件所占比例则相对较低。由于中国的劳动力成本较低，所以定制的建筑组件成本所占比例较高，因此其被动式房屋的建造成本构成有所不同。目前，符合国际公认的被动式房屋标准的建筑项目越来越多，这将有助于降低和规范中国被动式房屋的建造成本。

“布鲁克”促进了被动式房屋概念在中国住宅市场的推广，并为未来的可持续发展设立了参照标准。这一公寓项目实现了双重目标：一方面能够为不同类型的员工提供住宿，另一方面也能为对可持续住宅的效益感兴趣的家庭提供暂住的机会。通过这种直接的体验，潜在客户能够获得他们对被动式房屋舒适度的切身体会，从而帮助推广节能建筑理念。

已竣工的被动式住宅“布鲁克”及其节能优势，对于中国的可持续发展起到了引导作用。中国作为世界上最大的住宅建设市场，正经历着快速的发展，每年会新增大量的住宅需求。我们预测未来将有更多的住宅能够达到被动式房屋的低能耗标准。在这一情况下，可持续建筑设计的成功实践对于重建最佳节能实践的行业标准具有重要影响，将减少总体能源消耗并改善中国未来的环境条件。LAF

culture in your design?

RUGE: As we move into a new age of technology, the field of architecture should seek development based on guidance from its traditions in combination with and a sound knowledge of new systems. A clear understanding of local construction techniques, natural resources, climate conditions and culture are integral to the sustainable planning strategy of each project, as is their prioritisation according to the briefs’ specific requirements. Only by establishing integrated, cross-disciplinary and inter-cultural approaches to design, informed by traditional building techniques, can a well-considered and locally appropriate scheme be achieved.

The unique combination of factors are established through consideration of the six pillars of sustainability, including ecology, economy, community, technology, building practice, and site conditions. These components create a framework that assists to identify location-based passive and active parameters. Active systems that dynamically influence the sustainable operation of the building is helpful to inform and support the final passive design concept.

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The consideration of local climatic conditions in the design of Passive House BRUCK in Zhejiang, China has been essential for the development of a technical concept that utilises the most innovative energy-efficient systems and system components. When designing passive houses in a sub-tropical climate, the interior comfort control is dominated by cooling, with high humidity from June to September. Passive House BRUCK performs quite well in this climate zone and basically offers the benefit of reducing the cooling load in the summer. It maintains a compact building mass to reduce surface area and employs a superiorly insulated building shell to significantly reduce heat transfer through the walls, roof and floor. The building’s position on the site and orientation has also directed the form and shaped the sun protection elements of facade.

The costs of Passive Houses are usually higher than common ones. What is your view on the future of the development of Passive House in China?

RUGE: From our long-term experience designing Passive Houses in Germany, we would consider the initial building costs of a Passive House to be approximately 10% ~ 15% higher than that of a conventional building. This minor increase in surplus is possible in Germany due to the established infrastructure surrounding Passive House builds locally. Access to the manufacture and distribution of necessary components or parts, and knowledge of their assembly onsite is more readily available and therefore less of a burden to project costs. As building costs in Germany are dominated by the high price of labour, the components required are comparatively lower in terms of overall building cost percentages. Passive House construction cost percentages in China would therefore slightly vary in response to the low cost of local labour, and increased cost of customised building components. An increase to the amount of locally produced building products that meet internationally approved Passive House standards would serve to minimise and standardise the building cost surplus required to build Passive Houses in China.

BRUCK is built to promote the concept of Passive House living specific to the Chinese residential market and set a benchmark for future sustainable development. These apartments have been realised for the dual purpose of hosting employees, and housing Chinese families interested in the benefits of sustainable living, with an opportunity to temporarily reside in the building. Through this direct experience, prospective clients gain their own understanding of the comforts of Passive House.

The completed Passive House BRUCK, and its benefits in terms of energy saving, is playing a leading role in the sustainable development of the Peoples’ Republic of China. As the world’s largest producer of housing, China is experiencing considerable growth, with a great demand for new residential units each year. We anticipate that more and more of these buildings are being constructed to meet Passive House and low energy standards. Under these conditions, the successful implementation of sustainable building methods have a significant influence upon re-establishing industry principles for best practice, reducing overall energy consumption and directly improving Chinese environmental conditions in the foreseeable future. LAF

2. 北立面透视图。在高度隔热立面上的封闭区域，通过彩色赤陶杆遮蔽物对建筑物的外壳提供保护，使其免受强烈日光的伤害。© Peter Ruge Architekten
2. North elevation perspective. The closed areas of the highly insulated facade act to protect the building shell from intense sunlight through a screen of coloured terracotta rods. © Peter Ruge Architekten