采访日期 Interviewed Date
2014-05-13

中图分类号 / TU986.2
文献标识码 / C

中国特色的建筑节能之路

The Road to Energy-smart Buildings with Chinese Characteristics

采访 Interviewed by / 李霞 Xia LI，涂先明 Xianming TU
整理 Edited by / 李霞 Xia LI
翻译 Translated by / 陶然 Ran TAO

江亿 Yi JIANG
中国工程院院士；清华大学建筑学院教授、博士生导师
Anacademician of the Chinese Academy of Engineering; Professor and Doctoral Supervisor of School of Architecture, Tsinghua University

摘要 / 近年来持续高速的城市化进程和大量的基础设施建设导致我国的能源消耗量不断增加。本文中，作者首先介绍了我国能源消耗的总体情况以及建筑节能方面存在的误区；随后提出了建筑节能的具体措施；最后指出只有营造与自然和谐的室内环境，才能实现具有中国特色的、可持续性的建筑节能发展道路。

关键词 / 建筑节能；能效观念；使用方式；节能途径

Abstract / Speedy urbanization and massive infrastructure construction in recent years has lead to increasing energy consumption in China. In this text, the interviewee introduces the general state of energy consumption in China and misunderstandings about energy-smart buildings. Then specific proposals for energy conservation in architecture have been proposed. At last, the interviewee concludes that only the interior environments in harmony with nature can support sustainable development of energy-smart buildings with Chinese characteristics.

Key words / Building Energy Conservation; Energy Efficiency Concept; Operation Methods; Energy-saving Approaches

请您介绍一下我国目前能源消耗的总体情况，以及在节能推进方面存在哪些困难？

江亿（以下简称江）： 2013年，中国的能源消耗总量位居世界第一，占世界总量的22%。但由于我国人口数量庞大，人均能源消耗水平低于发达国家，不到美国的1/3。总量高、人均低，这是我国目前能源消耗的特点。

“节能”的字面含义是减少能源的消耗，但是我们面临的实质问题是如何减缓能源消耗总量的不断增加。2005年时我们曾预测，到2020年我国的能源消耗上限为40亿吨标煤，可在2012年就已达到36亿吨标煤，因此在能耗总量的控制上存在巨大压力。

面对这样的能源消耗趋势，我们必须调整当前的经济发展模式。从能源消费结构来看，我国的工业（主要为制造业）用能约占全国总能耗的65%，消费领域（建筑运行和交通运行）的能源消耗约占35%，这与美国的情况正好相反。现在经常讲“与国际接轨”，但在建筑节能方面却是不可行的。中国目前的建筑能耗并不高，但处于上升阶段，因此不可效仿美国等发达国家的建筑发展模式，而应走一条符合中国国情与人民生活方式的中国特色的节能发展道路。目前我国建筑运行能耗一直维持在社会总能耗的20%~25%，为实现我国经济建设的健康发展，未来建筑能耗不能超过社会总能耗的25%这一上限，即10亿吨标准煤以内。

中国高速的城镇化进程和大量的基础设施建设是导致我国近年来能耗持续上升的主要原因。中国的制造业能耗主要来自于钢材、有色金属、水泥的生产，而仅钢材一项就占到了全国总能耗的20%。导致这一现象的主要原因在于城镇化带来了巨大的建设量，刺激了旺盛的市场需求。综合考虑我国人口增长率、城市化率与土地资源情况，我国人均建筑面积目标应控制在40m^{2}左右，以人口峰值15亿计算，建筑建设总量应控制在600亿平方米较为合理。但是截至2013年，建筑建设总量就已达到500亿平方米，并且新建建筑面积仍在逐年增长，仅2012一年的新增建筑面积就达36亿平方米。因此，逐渐减缓建设速度，实现软着陆是控制我国能源消耗的关键。

也许有人会认为，控制发展速度和建设量会导致对劳动力需求的减少，但是，劳动力永远是最宝贵的资源。如果我们朝着提高产品和服务质量的方向发展，将大量的劳动力集中到提高文化、教育、

Could you please introduce the current state of energy consumption in China and difficulties it faces in advancing energy conservation?

YI Jiang (JIANG hereafter): China is now the biggest energy consumer in the world, accounting 22% of global consumption in 2013. However, our energy consumption per capita is lower than that of many developed countries. Per capita, it is less than one third that of the United States. The energy consumption pattern in China can be summarized by a high total use contrasted with low per capita consumption.

Energy-conservation is to reduce energy consumption, but the essential problem we face is how to slow down the increasing total energy consumption. In 2005 we forecasted that the upper limit of our energy consumption would be 4 billion TCE by 2020, but by 2012 we had already reached an annual consumption of 3.6 billion TCE. We face a huge issue of controlling the total energy amount consumed.

Facing this trend, we must adjust of the current economic development mode. From the perspective of energy consumption structure, manufacturing accounts for about 65% of national energy consumption and consuming sector (including construction operation and transportation operation) takes the rest 35%. In most developed countries, including the United States, this is the opposite. As much as China may want to adopt international standards, this is not possible in the architecture industry. The architectural energy consumption in China is not high, but in the rising stage. In this case, it is not feasible to follow the European or US model, instead we should develop an energy-smart system specific to Chinese needs. The current building operations make up 20% ~ 25% of total energy consumption. In order to achieve the healthy economic development, we must keep this number under 25% in the future, meaning. within 1 billion TCE.

Rapid urbanization and accompanying massive infrastructure development are the main causes of increased continuous energy consumption. Energy consumption in the manufacturing industry mostly comes from production of steel, nonferrous metals and cement. Steel production alone accounts for 20% of total national energy consumption. Massive construction from urbanization stimulates the strong market demand. Considering population growth, urbanization rates, and land resources, new construction should be limited to an area of 40 m^2 per capita. Based on a peak population of 1.5 billion, total building construction should be contained to 60 billion square meters. However, by 2013, this index had already reached 50 billion with the new building areas increasing every year which attained to 3.6 billion square meters in 2012. Therefore, construction should be slowed and limited to meet these emission goals.

Control over the development progress and construction amount will lead to decreasing demand over work forces that, however, work forces are forever the most valuable resources. Effective GDP growth can be realized if we aim at improving product and service quality, centralize large amount of work forces to improve culture, education, medical and insurance industry, and therefore, improve the additional value of the products.

Do you think there are misunderstandings about architectural energy conservation?

JIANG: Currently, the greatest misunderstanding is that adoption of advanced energy-smart technology can guarantee efficient energy consumption. That is not the whole story. Take the air-conditioner for example. Residential buildings using central air-conditioning consume 20 kWh/m^2 in Beijing, 5~8 kWh/m^2 by individual households and 2.3 kWh/m^2 by split-type conditioners. Such differences are not caused by air-conditioning system and appliance efficiency, but by different using modes. Although

医疗、保险等行业的水平上来，提升产品的附加值，就能够实现GDP的有效增长。

您认为目前对于建筑节能方面的认知存在哪些误区?

江：目前大众对于建筑节能存在的最大误区就在于认为采用先进的节能技术就一定能够实现节能。事实并非完全如此，以空调为例：在北京，使用中央空调的住宅单位面积日耗电量约20度，户式中央空调为5~8度，分体式空调为2.3度。这种差异不是由于空调系统和装置本身的效率造成，而是由不同的使用模式所导致的。尽管通过技术手段提高能源利用效率固然是重要的节能途径，但我们不能认为堆砌一大堆新技术就能实现建筑节能，其核心在于朝着节能方向去引导大众的行为方式和使用模式。通过技术创新，研究发展一套适合于中国的建筑使用模式，而不是简单地照搬国外的节能技术。

减少我国建筑整体能源消耗的具体途径包括哪些?

江：首先要严格控制我国城市建筑面积总量。各地政府应根据未来人口规模来制定并严格执行建筑量控制规划。其次要实现用能总量的控制，对各类建筑设定用能上限，以及对非住宅建筑实行用能定额管理。预测出在合理的运行管理下，被评建筑在不同气候和建筑利用率等条件下的煤、天然气、热力、电力等能源的消耗数量，作为这类建筑的用能指标，从而实行大型公共建筑能耗配额政策。第三，采用新的技术改善北方地区延续了数十年的集中供暖模式。仅京津冀地区每年供暖燃煤消耗就达1亿多吨，这对环境和能源带来了巨大的压力。这样的需求已经很难与目前中国的能源、环境状况匹配。我们应积极寻求其他的能源类型，例如可以通过逐步改造，采用清洁、输送方便的天然气作为热源。

零碳建筑的造价通常高于普通建筑，零碳建筑的高造价如何通过后期使用过程中的能源节省得到补偿?

江：所谓“零碳建筑”，更准确地说，应该称之为“零能耗”建筑，也就是在建筑的运行过程中没有任何能源消耗。我个人并不主张盲目推广零碳建筑，因为此类建筑往往只是综合科技的展示品。节能绝不是简单地安装一些所谓的节能设备就可以实现，而是必须真正把实际能源消耗量减下来。如果那些高科技设备在没有到达使用年限的时候就已经损坏或热效率下降，零碳建筑反而可能从“零能耗”变成“能耗大户”。如果我们能够将修建“零碳建筑”的这部分高出的造价用于，将对整个社会和经济的发展做出巨大贡献。

因此，我国的城市建筑应依靠合理的建筑设计、用能系统设计、正确的运行管理方法，以及倡导使用者的节能理念与生活方式来实现真正意义上的节能。

您认为应该如何对既有建筑，特别是玻璃幕墙建筑等高能耗建筑做出节能方面的改善?

江：我认为，目前中国城市的建筑用能普遍不高，过高能耗的建筑仅占大约5%。因此，对既有建筑的节能改善工作应视具体情况而定。对于中国20世纪80年代建造的居民楼来说，普遍存在窗户漏风、保温效果差的问题，只需要对其进行适当的改造，如换上气密性更强的外窗，就能够起到很好的保温节能效果。对于大型公共建筑，特别是高能耗的玻璃幕墙建筑来说，我认为应该从以下三个方面来解决高能耗问题：1）对既有大型公共建筑实行用能定额管理；2）积极推行各种有效的节能改造措施，降低既有大型公共建筑能耗，如在玻璃外墙设隔板和檐角等；3）建立和完善各地大型公共建筑用能的数据统计工作及节能监管机构和机制。

其次，我想要强调的是，建筑室内环境的营造一直存在两种不同的思路，一种是追求与自然和谐，主张从“天人合一”的自然论出发来营造适宜的室内环境。譬如圆明园中围绕福海建有不同朝向的建筑，在不同时节可以居住在相应的建筑中。另一种方式是凭借人类不断发展的科技水平，主张通过一些途径将自然环境与室内环境隔断，尽可能地避免自然环境对室内环境造成影响，从而使室内环境适宜居住。这种从“人定胜天”的机械论出发，完全依靠机械手段营造出“人工环境”的方式体现了人类试图驾驭自然之心。但正是这种方式导致建

it is important to improve energy efficiency through technological advances, we cannot use a hodgepodge of new technology to get us there. Rather, we must shift public conduct and consumption towards an idea of energy conservation. We should study and develop architectural usage patterns that respond to our national condition through technological innovation instead of imitating foreign models.

What approaches can reduce overall architectural energy consumption?

JIANG: First, the total amount of urban built area should be strictly controlled. Local governments should define the total amount of urban building based on future population projections. Construction control planning should then be enacted and executed. Secondly, we should reinforce control over total energy consumption, set the upper limit per building types, and conduct quota-management for the energy consumption of non-residential buildings. By forecasting the energy consumption amount, including coal, natural gas, thermal power and electricity under different climate and building utilization conditions, we can establish appropriate rates for different building types. Such predictions should serve as a type of architectural energy consumption index that can facilitate energy quotas for large public buildings. Finally, we should adopt new technology to improve centralized heating systems that have been used for decades in northern China. Over 100 million TCE is used annually just to heat the Beijing-Tianjin-Hebei region. This region is under huge pressure to improve its energy consumption, as its current patterns are highly incompatible with the energy and environmental conditions in China. We should actively seek other types of energy. It is possible to introduce gradual reform and use clean and transport-efficient natural gas as a heating resource.

The cost of zero-energy buildings is higher than ordinary buildings. How this high cost be compensated through energy conservation during the running process?

JIANG: So-called “zero-energy” buildings should be called “zero-energy consumption” buildings, meaning that no energy consumption takes place. Personally, I am not an advocate of such buildings. “Zero-energy” buildings are usually only a demonstration of new technology. Energy conservation should not just be about installing some energy smart equipment; it should be about actually reducing consumption. A building can just as easily shift from zero-energy to energy-devourer if the high-tech equipments are damaged or fail before the expiring date. If the high cost can be used to acts reducing the energy consumption of existing buildings, it would make great contribution to socio-economic development.

Therefore, the building energy conservation should be realized through reasonable architectural design, energy system design, operation and management method, and greater energy-conserving ideology and lifestyle.

How do you think we can improve energy-conservation of existed buildings, especially high-energy consuming buildings such as those with glass-walls?

JIANG: The current urban building energy consumption in China is generally not high. High energy consumption buildings only accounts for about 5%. Therefore, energy-saving reconstruction to the existing buildings should depend on the specific conditions. Residential buildings constructed in the 1980s often have poor air and thermal insulation. Simple replacements, such as installing airtight windows, can greatly improve thermal insulation. For large public buildings, especially those with high energy-consuming features like glass walls, I think three approaches should be considered. First, quota-

筑能耗不断升高，因此我们应回归到与自然和谐的道路上来。

在节能上，发挥人的主观能动性非常重要，不同的使用行为和操作方式，都会导致建筑能耗的不同。举例来说，空调本来只是调节室内温度的一种辅助手段，但是现在很多的大型公建完全依靠中央空调系统维持室内热湿环境，这是非常不可取的：既使人无法发挥主观能动性，也造成了能源的浪费——一座无法开窗的建筑就不能被称之为好的建筑。我们必须高度重视人在建筑中的行为和真正需求。应该优先采用自然手段来调节室内环境，结合机械手段来进行辅助调节，以满足局部空间的具体需要。因此，只有将室内外环境设计相结合，营造与自然环境和谐的室内环境，人们才会减少对机械的“依赖性”，才能推动建筑节能的发展。LAF

management should be implemented for existing large public buildings. Sencond, we should actively promote energy efficiency measures and replacements that can reduce usage in existing buildings. For example, set insulation boards outside glass walls and at the corner of eaves. Finally, we should establish agencies and standards for measuring energy consumption in large public buildings.

Moreover, I would like to emphasize that there are two pursuits for creating interior environments. One is to create indoor spaces that are in harmony with nature. For example, the buildings around Fuhai Lake at Yuanming Yuan face different directions in order to create different interior environments throughout the year. The second pursuit of architecture is to separate interior from exterior in order to protect ourselves from environmental conditions through technologies. The artificial environment was created mechanically based on the ideology that human will prevails. As we have improved that using building technology to separate ourselves from nature has been one of the causes of increased energy consumption, we should return to the road of being in harmony with the nature.

It is very important for designers to initiate energy conservation measures. Different user behaviors and operations will lead to different building energy consumption. For example, the air conditioner was originally used to regulate interior temperature, but now the indoor thermal and humidity environment is totally depend on centralized air conditioning systems. This approach is inadvisable: it not only makes people cannot take the initiate, but also leads to unecessary energy consumption. We cannot say a building good if it does not have operable windows. We should place a great value on human behavior and demands. Natural measures should be used before mechanical treatments that only partially meet local demand. Indoor and outdoor design should be better integrated in order to lessen our dependence on mechanics, and to increase our environment harmony with nature. LAF