Sustainability and Durability for the Buildings and Cities in China

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SUMMARY:

Increasing urbanisation and climate changes is one of the greatest challenges in the 21st Century. Many regions already face different negative impacts on cities such as growing local pollution, solid and liquid waste, traffic congestion and noise pollution. A growing consumption of fossil fuels in cities leads to increasing CO2-emissions accelerating climate change. Wherever in the world or in China, cities trying to reduce their carbon footprint. In that context, the concept of so called "low carbon cities" is promoted. Currently, nearly 100 cities in China are considering the low carbon concepts. To build a low carbon city or a low carbon building is not an easy task as there are various barriers to be considered, such as financial, traditional and institutional barriers. Buildings are belonged to the most traditional and slow-changing innovative areas in industry. Further solutions are different for hot and warm climates than for cold climates.
But the objective for the next years must be a significant reduction of energy consumption, together with an increasing awareness for the continuing rise of energy costs, increasing population and the needs to save energy in order to reduce emissions. Following this way of the durability of the buildings in China have to be increased, actually the lifetime of a building in China correlates to 37 year, in Europe the lifetime of a building correlates to 136 Years! So all the efforts have to focus not only on new buildings, as well focus on the buildings from the 1980s, specially, the residential buildings are included.

Introduction

There is the big problem of the 21st Century in China. More than 350.000.000 people in china will move in the cities till 2025. The urbanisation rate in china reached 50% in the year 2011. So up to now, 2.000.000.000sqm each year are built and expanded to the cities. As much as 50% of all new buildings in the world are built in China. This Development leads China in the 21st Century, but there is another aspect; 40% of all concrete and steel are used in china, for the production a huge amount of CO2-Emission will be discharged. 30-40% of waste is produced in the building industry and the finished building consumed 30% of all energy and produces the same amount of CO2-Emissions.

The urgent need for buildings resulting from economic development has led to impressive and remarkable forms of architecture, many of which have been designed and planned by architects with their regional perspectives. However, it is often the case that neither prevailing climate conditions nor the availability of particular building materials have been properly accounted for.

This often stands in sharp contrast to the traditional development of structural design and construction methods, which are adapted to end use, locally available construction materials and building traditions. Important aspects of housing and living traditions may be completely ignored. People often aspire to western models in terms of quality of life and lifestyle. This also applies to their living space and the architectural environment.

Problematically, the possibilities for the realisation of buildings and apartments differ. Though buildings may conform externally to western models, they lack essential elements which account for the quality and serviceability of a building or apartment. Often flats and offices are sold in a basic configuration, frequently without taking into account functionally important details such as

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- adequate moisture proofing,
- sufficient drainage of roofs and façades,
- thermal insulation adapted to the climate conditions,
- measures to limit overheating in summer,
- an airtight building envelope,
- adequate sound insulation, especially for structure-borne sound,
- Acoustic damping in rooms.

An example may help to illustrate this: according to western tradition, it is expected that a house, apartment or office will be equipped with central heating and can be cooled if necessary. In China, however, the installation of technical systems for heating and cooling is the responsibility of the tenant/buyer. Thus individual, decentral air-conditioning units are generally used, and both heating and cooling are powered by electricity only, leading to extremely high peaks in power consumption.

The eyesores resulting from construction had done too hastily and under pressure also reveal substantial flaws in the quality of planning and execution. Energy-saving thermal insulation is often not taken into account or cannot be taken into consideration because of a lack of calculation models, which can be applied pragmatically.

Energy-saving thermal insulation ultimately helps to reduce energy demand for heating and cooling to an economically acceptable level and guarantees a high indoor comfort and a heathy environment.

With regard to operational costs, two objectives need to be addressed:

- energy demand for heating and cooling must be minimised
- it is vital to avoid extreme demand peaks (costs of providing capacity for peak usage)

The energy demand for heating and the connection capacity requirement are mainly influenced by:

- heat loss by transmission through the building's envelope
- ventilation heat loss due to air exchange (airing of rooms)
- heat losses due to air leakage through gaps in the building's envelope

The energy and connection power required for cooling of a building are influenced by:

- internal loads
- heat gain by transmission
- solar heat gain
- latent heat due to condensation in the air-conditioning unit

One must bear in mind that inappropriate use can substantially increase demand and power required. The objective for the next years must be a significant reduction of energy consumption per capita, together with an increasing awareness for the continuing rise of energy costs, increasing population and the need to save energy in order to reduce emissions. As well users behaviour need to be improved, therefore the price per kWh for electricity need to be increased, because the costs are too cheap according to the world market.

What are the essentials?

The United Nations Framework Convention on Climate Change of 1992, and the Kyoto Protocol to the United Nations Framework Convention on Climate Change of 1998 were the first step for the reduction of greenhouse gases in CO_2-equivalents[1] as the starting point of the climate change. In the following years the nations followed the agreements and implement the requirements in national rights. A further reduction of the emissions of greenhouse gases in CO_2-equivalents by 2020 compared to 1990 is fixed as a result of the follow-up agreement to the Kyoto Climate Protocol of the UN conference of Paris in 2015.

[1] The year of reference for CO2, CH4, N2O, is 1990; for CFC, HCFC and CF6, it is either 1990 or 1995.

On 22 April 2016, 174 countries, in a Key role China and the U.S., signed the agreement in New York and began adopting it within their own legal systems (through ratification, acceptance, approval, or accession). According to the organizing committee at the outset of the talks, the expected key result was an agreement to set a goal of limiting global warming to *< 2 degrees Celsius (°C)* compared to pre-industrial levels. The agreement calls for zero net anthropogenic greenhouse gas emissions to be reached during the second half of the 21st century. In the adopted version of the Paris Agreement, the parties will also "pursue efforts to" limit the temperature increase to 1.5 °C. The 1.5 °C goal will require zero emissions sometime between 2030 and 2050, according to the scientists.

So the next will be the strong politically implemented by the on the total energy efficiency of buildings. Based on experience, it is shown that the highly complex approach of the evaluation methodology involves extensive calculation work and, in the meantime, requires very specific knowledge in the fields of building physics and mechanical services.

In the process, the relation with the building and the optimisation of the building's envelope are often forgotten.

Which improvements are needed?

The first step, to avoid not only an extreme increase of energy demand for heating and cooling, but also extreme peak loads, which can lead to a supply shortfall. Correct consideration of the requirements while planning the building's envelope, especially the façade is essential.

Therefore, a new planning and control instrument including a certification system will be developed, which will enable both the architects and the authorising authorities to apprise and assess the energetic behaviour of buildings using average technical expertise and at reasonable cost. Nevertheless, this is definitely not possible by using the actual existing Building Energy Efficiency computer programs.

For this, it is vital that the basic physical structure of buildings be considered exclusively in respect to regional climatic conditions. Calculations must be based solely on the results of thermal balance equations. The assessment must be made unaffected by political and lobby influences, which often play a role: e.g. primary energy sourcing.

This includes economic considerations definitely, in which the investment costs for additional insulation are set against operating and maintenance costs.

An established method of verifying, ensuring and if necessary improving the quality and durability of buildings including building services is the use of quality control systems, which should be included:

Step 1. Exclusively the building's envelope
Step 2. Exclusively the HVAC equipment
Step 3. Assessment of the quality of planning
Step 4. Assessment of the quality of execution

For the assessment and optimisation of the building's envelope, a possible assessment system is proposed below, which comparatively easily, yet relatively accurately reflects the energetic quality of the building with respect to heating and cooling.

With these experiences, it is possible to simulate the whole CO2-Emissions from building and whole cities. The possible CO_2 savings potential of the new Low Carbon Cities currently being planned shows that an economic and ecological building process in China will be realisable once the requirements of the energetic quality of the buildings are reasonable increasing as well as the requirements for efficient energy distribution and energy production systems.

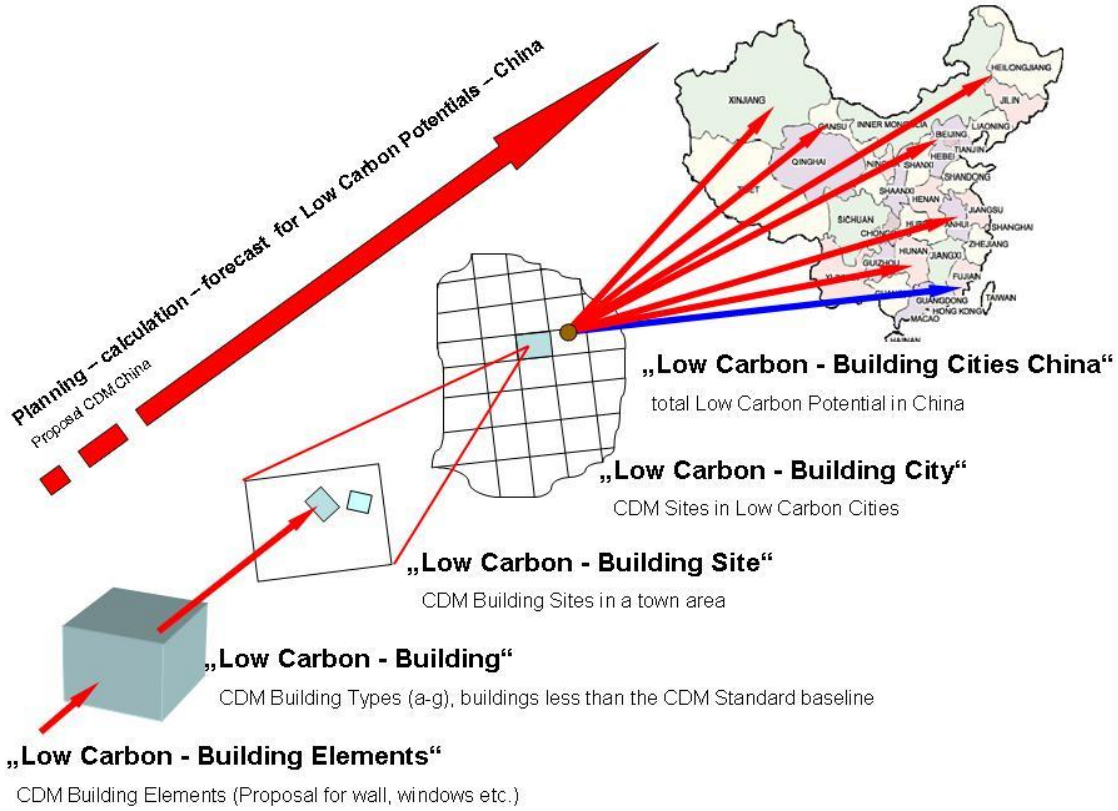

Figure. *Bottom-up-Calculation for the expected CO_2-Emissions in China*

This offers China the possibility to receive a forecast of the Low Carbon potentials for their NEW LOW CARBON CITIES. With these tools China can influence and lead the market under the aim of LOW CARBON reduction during the next years to full fill the domestic emission reduction goals. The project will provide the guideline during the planning and realisation phase of Low Carbon Cities. Only with this approaches it will be possible to find solutions for the practical implementation for different climate situations (heating, cooling, heating and cooling) and for suitable requirements.

This building process may lead the way to accomplish the global restriction of CO_2 emissions in the construction sector. But, these actions have to be done in a short term.

Which work needs to be done in a short term - which work needs to be continued?

1. *A planning and controlling instrument implemented in the Chinese certification system need be improved.*

   The planning tool – LowEnergyCertificate- LEC[2], an output from the sciences and research between Germany and China is ready to use, and can be implemented in the Chinese Green Building Standard Certification System!
   This tool will enable both, the architects and the authorities to apprise and assess the energetic behaviour of buildings using average technical expertise and at reasonable cost. For this, it is vital that that the basic physical structure of buildings be considered exclusively in respect to regional climatic conditions. Calculation is based solely on the results of thermal balance equations.

[2] More information of the sciences and research project see at www. http://lowenergycertificate.com

LEC provides architects and engineers to describe the energy demand for heating (only), heating and cooling and cooling (only) for different kind of buildings (residential, office and commercial buildings; new and existing buildings). Therefore, they have the possibility to optimize the building envelope during the planning stage for the regional climatic conditions in China.

Additionally, a worldwide comparability of the building energy standard is now possible by using LEC.

2. *The part of the science and research project "Low Carbon Economy in Cities of China 中国城市的低碳经济 - BEE (Building Energy Efficiency) Simulations, Possibilities to estimate the national potential of CO2-Emissions 建筑节能模拟 - 对国内碳排放估算的可能性,[3] "financed by the German and Chinese Government need be continued.*

   In consequence of the development of the city planning in china during the next years and the increasing building industry, the Chinese government needs a set of guideline and reliable prediction methods for the regional LOW Carbon potentials and their application. This project offers China the possibility to receive a forecast of the Low Carbon potentials for their NEW LOW CARBON CITIES. With these tools China can influence and lead the market under the aim of LOW CARBON reduction during the next years to full fill the emission reduction goals. The project will provide the guideline during the planning and realisation phase of Low Carbon Cities. With this knowledge, the building ground to the developers could be sold by different aspects:

   a. *The developer pays a high price for the land and has to follow the official requirements in the case of energy saving.*

   b. *The developer pays a low price for the land and follows a highly requirements in energy saving. His benefit is a high durability and sustainability of the buildings*

3. *New restoration concepts for the residential buildings of the 1980ies in China.*

   This science and research project was supported by the Hefei University and the HAWK Hildesheim Germany. The project deals with the topic "Development of restoration and modernization concepts of buildings from the 1980s in different climatic zones of China".

   Many people living in such buildings are the middle class who would like to stay in their compounds in downtown. Since most of them don't want to move in the suburb, they would like to keep their neighborhoods and stay in their apartments in which they and their families have been living for Generations. A survey shows the efforts, needs and the wishes of the residents that how much money they would to invest in the restoration and the surrounding to keep their homes.

   To find this new concept, first different climate regions of buildings were selected. The regions of Shanghai, Guangzhou and Shenyang have different climatic conditions. Therefore heating and cooling of the building are needed in different regions. Following the different climate zones, different walls, soils and roof structures shall be created to optimize the energetic behavior. The software tool LowEnergyCertificate takes a closer look at the heating and cooling period, while different energy standards from 2-5 stars could be generated. Those variants reflect different qualities with respect to building envelope and HVAC Systems. The aim of the calculations by the software Therakles were to promote the comfort of the people and estimate the energy demand for heating, cooling and dehumidification.

   In a second step different concepts for the building envelope and the HVAC Systems has been selected and to calculate the restoration costs.

   Third, new work plans for the restoration process for China need be created to show how and where the residents can accommodate during the restoration phase in the compound.

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[3] Carbon Market in the new building sector in China; supported by the German Government BMU… more see http://www.building-physics.net/webfm_send/843

The first research shows clearly, that new concepts of restoration could be established for the cities, to save the identity of the people and the cities in her social environment in China.

4. *Restoration of building and monuments*

   During the last years, the science and research between the Tongji University and the HAWK University has been developed. In several projects, such as the historical areas in Shanghai, the Monuments in Macao, the Temples in the Shanxi Province and in Ningbo the international Standards of WTA[4] had been tested for the renovation and restoration of the monuments in China. The projects showed, that in cooperation with Germany a new view of the restoration process of the cultural heritage in China need to be found to save the important (building-) history of China during the next hundred years.

[4] WTA International Association for Science and Technology of Building Maintenance and Monument Preservation; see http://www.WTA-international.org