Energy Efficient Renovation of Existing Buildings
The Tangshan Pilot Project

Overview: Northern China
Buildings account for some 27 percent of China’s total energy consumption. In its efforts to satisfy the demands of an energy-hungry economy growing at roughly ten percent a year, with increased consumption and a rising demand for living comfort, the country is expanding all channels – fossil power and heat plants, atomic energy, renewable energies and energy saving in existing buildings.

According to official data China’s gross floor area was approximately 42 billion square metres in 2004, a figure that is growing by around 1–2 billion square metres each year. While there is no accurate breakdown on the distribution of housing for domestic and non-domestic use in each province, there is a general agreement about the need to improve energy standards for residential buildings in northern China.

The majority of these are constructed of precast concrete slabs or brick-laid walls and have a total gross floor area of 11–13 billion square metres. This is equivalent to 180–220 million 50m$^2$ apartments (with 60m$^2$ gross area), roughly five times the housing inventory of Germany. It is estimated that building renovation in northern China could result in CO$_2$ savings of up to 380 million tons per year, compared with 90 million tons of emissions for the whole of Germany.

Like the former Eastern Bloc states, China is plagued by poor building structures, inefficient housing techniques and ailing supply systems. Energy consumption is between 300 and 500 kWh coal per year per square metre of net living space, comparable with that of the unreconstructed East German precast concrete slabs buildings of the 1960s. High losses in long-distance heat conduction and low effectiveness in heat production exacerbate the problem.

The decades-long failure to conduct renovations has led to massive damage from humidity and condensate penetration, huge losses in ventilation heat because of leaky windows and frequent leakages in the heating system. The standard is single pipe heating with vertical distribution without heating valves. Upper-floor flats may reach 17–18 degrees C in the strong north Chinese winter, but the disadvantaged ground-floor flats are much colder – just 12–13 degrees C.

As prosperity increases, more and more families are buying additional electric heaters and air conditioners, which in certain regions has already led to temporary breakdowns in the power supply. Heating charges are currently calculated on the basis of living space. The political goal – yet to be implemented – is a consumption-based calculation that encourages energy saving.

The GTZ-MOC Project
It is exactly this complex problem that the Chinese-German joint project “Energy Efficiency in Existing Buildings” (EEEB) seeks to tackle. Jointly operated by the German firm GTZ and the Chinese Ministry of Construction (MOC) with an overall budget of about EUR 10 million, the project will run from 2005 to
2010. It covers political consulting for heat insulation ordinance, technical guidelines, and introduction of usage-bound clearance and financing models. The project also provides for technology transfer and knowledge distribution, a base study for the collection of inventory data, and systematic examination of possibilities for improvement, as well as introduction of modern energy-saving products and technologies. Other focuses are knowledge management (professional conferences, trainings, publications, guides etc.) and effectively implemented pilot projects. The German successes and experiences with the energetic renovation of former East German model buildings provide the background and model for this bilateral cooperation.

**Significance of the Pilot Project**

Almost the entire Chinese housing space – which was previously state owned – was sold off to residents around the year 2000. In contrast to Germany, where a large proportion of accommodation is rented, these buildings belong almost entirely to proprietary communities. Very often, they have established only the most rudimentary structures for common property management. The sale of apartments has liberated the public authorities from a lurking problem, which keeps closing in on the new owners: after 20–40 years of use, there is a huge need for corrective maintenance within the following few years to prevent the loss of numerous buildings.

Some rare attempts at energy-based renovation have been undertaken in northern China, though they were half-hearted and lacked an integral overall approach. The EEEB pilot project will show for the first time how to achieve multiple effects within a comprehensive concept for improvement: eliminating structural damage and reducing energy consumption. These measures will go hand in hand with a sustainable appreciation of living comfort, extension of building service life and reduction of future renovation costs.

**Choice of the Pilot Project Site**

In September 2004 a GTZ-MOC commission, accompanied by German and Chinese experts, visited the cities of Tangshan, Shenyang and Harbin to evaluate potential sites for the pilot renovation, selected by the communal Building Energy Efficiency (BEE) offices. It was agreed in December 2005 to conduct a planning workshop on Compound Hebei No.1 in Tangshan. Because this quarter is typical of numerous, almost identical settlements that have sprung up in the city since the 1976 earthquake, it would be possible to reproduce the results of the project exactly.

**Planning Concept and Baseline Study**

Current Chinese standards of renovation are roughly on a par with the German heat insulation regulations of 1977, producing suboptimal results by today’s standards. The German side proposed the realisation of three different standards to take account of this. One advantage of this approach is the potential for a broad range of planning and realisation experiences and results, which serve to maximise the pilot project’s “learning effect”.

**Lower-Standard Solution:** The design concept already existing in Tangshan may be defined as a “low-cost, low-performance” solution, where risk reduction should be optimised to guarantee greater safety and reliability.

**Middle-Standard Solution:** A middle alternative would be positioned between higher and lower standards and try to reflect what is possible.

**High-Standard Solution:** A high-standard solution would include improving heat insulation in the building shell, and using recyclable construction systems like drawn, rear-ventilated cladding or simple gable-roof superstructures, combined with further actions in the heating and ventilation systems. This solution should act as a medium-term standard, and offer the most important alternative for learning effects on the Chinese side.

Parallel to the discussions on the planning concept, GTZ developed a measurement concept for the baseline study, basing pre-renovation measurements on the heating period 2005/2006. Some key results are as follows.

During the heating period, an average temperature of 15–16 degrees Celsius was reached inside the buildings. The temperature in north-facing rooms on the lower floors reached only 12–13 degrees C. Although the
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heating period lasts from only mid-November until mid-March, (i.e., only when the outside temperature is 5 degrees C or below), the heat consumption of the net area of the buildings was 165 kWh/m². Condensation and mildew formation was observed in approximately 15 percent of the apartments, results that were confirmed through calculations and measurements. Old, badly fitting steel windows caused stunningly high leakage from the apartments. In addition, the temporarily inserted aluminium sliding windows were not insulated. A survey of residents revealed a strong desire for the buildings to be modernised, but as expected, less willingness to make a financial contribution to such work.

Post-Renovation Evaluation

Initial results showed that despite an average increase in temperature from 16 to 20 degrees C inside the apartments, energy consumption decreased by 43 percent, from 165 to approximately 95 kWh/m² (based on the net area). This indicates potential overall energy savings of up to 70 percent across the producer-distributor-consumer chain – a result achieved without a massive technical effort.

Consumption-Based Billing

There is one more important potential for energy saving: consumption-based billing, or VAR, (literally translated from German as “heating reform”). Since this concept was introduced in Germany, the country’s energy consumption has dropped by about ten percent. The comparatively high temperatures recorded in some apartments in the Tangshan pilot project indicate that there is a great potential for savings, since almost six percent of energy is saved for each degree that the temperature is reduced inside a building.

Results and Further Steps

In spite of some difficulties, the pilot project at Tangshan has been largely successful. It has achieved integral renovation of building exteriors and housing techniques, and functional improvements, all of which have contributed to improved quality of living for residents. It has shown that even without consumption-based billing, energy savings of over 40 percent are possible. The introduction of VAR would lead to further energy savings of around ten percent.

Parallel to renovation of buildings, improvements in long-distance heating nets and heat producers to modern standards could result in potential energy savings of up to 70 percent.

Encouraged by the success of the pilot project, the city government of Tangshan plans to renovate almost all of the city’s residential buildings – some 60 million square metres – in the next few years. A feasibility study should provide the basic data and the necessary planning tools. The project’s insights will also be transferred to other cities through conferences, training and additional pilot projects.

PROFILE

The Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH is an international cooperation enterprise for sustainable development with worldwide operations. It provides viable, forward-looking solutions for political, economic, ecological and social development in a globalised world. GTZ mainly works for the German Federal Ministry for Economic Cooperation and Development (BMZ). It also operates on behalf of other German ministries, partner-country governments and international clients, such as the European Commission, the United Nations and the World Bank, as well as on behalf of private enterprises. With 25 years of experience in technical cooperation in China, GTZ is continuously tailoring its portfolio to support China’s transition processes. Today, GTZ fosters China’s reform process as outlined in the 11th Five-Year-Plan, to build a harmonious, resources-saving society and strive for a balance between economic growth, social equality and environmental protection. As the German partner for sustainable development in China, GTZ presently works on 28 projects and in 13 public-private-partnership initiatives (PPPs).

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