# Innovative use of strategic energy design tools in building design in China

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**Abstract:** This paper expresses the importance of the use of strategic energy design tool in building design in China. The features of this kind of tool have been illustrated. The reliability, user friendliness, and usability are the most important characteristic of the early design software. This paper introduces an integrated energy design tool – LT Europe, which is widely used in the UK architectural practice and European. The climate data for Beijing has been produced from Meteonorm and integrated into LT Europe. A case study has been performed and the comparisons have been made by applying the Chinese old and new building energy regulations. It has been demonstrated that LT Europe software can be used for Chinese building energy design at the early stage by creating the local proper climate data.

**Keywords:** energy design tool, strategic design, LT, energy consumption, $CO_2$ emission

## 1. Introduction

It is worldwide concerned that energy consumption in buildings has a great impact on environment. Therefore the architects and building designers have an important role in low energy building design. The interest in low energy building design continues to make demands for design tools. So the computer software engineers together with building scientists made a great effort in developing software. The detailed energy simulation models can produce accurate results for the energy consumption analysis and mechanical design. For example, Doe2, Energy Plus, Tas, Ies etc are the worldwide commonly used energy simulation software, but in the process they require very steep learning curve and large amounts of data and time to produce useful results. Furthermore, the detailed simulation models require a description of the building and its system often unavailable at early design stage. It is increasingly recognised, however, that it is at the early, strategic stage of the design, that the ultimate performance of the building is largely determined. For example, decisions about plan depth, orientation, fenestration, all will have influence on the potential for the use of daylight, natural ventilation, heating and cooling demand. This in turn has knock-on effects on plant and equipment, ultimately having major impact on performance.

## 2. The desired feature of the strategic design tool

*2.1 As a strategic design tool the required features by users usually include reliability, user friendliness and usability.*

It is the most important that the software produce the accurate results. This will depend on the accuracy of the mathematic model implied within the software. Secondly the user friendliness is very important, particularly at the early stage. The GUI interface is one of the key factors which affect the user friendliness. It includes:

1) The time it takes to describe the building;
2) The accuracy which this description is input to the program;
3) The ability to operate quality assurance procedures; and
4) The ease with which design changes can be analyzed

The input interface of most building energy design tools currently used is either graphic or menu driven which simplifies its use. Output may be digital (i.e columns of figures with little formatting), tabular or graphical. The usability of strategic energy design software can therefore be evaluated in relation to its characteristics when:

- learning to use
- preparing input data
- running the program
- interpreting the results

## 3. LT Europe

The LT Method (LT standing for Lighting and Thermal) addresses the impact of environmental parameters on building energy consumption.

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Historically it was developed as a manual method using pre-computed energy curves showing the annual primary energy consumption per square metre against glazing area, for various parameter values such as climate, orientation, and system efficiency (1). The curves were generated using a quasi-steady state thermal model and an hourly daylight/artificial light model, but no free-floating temperatures were available. The latest software based version , called LT Europe integrated dynamic thermal model running in real time, providing the prediction of overheating, the effect of natural ventilation and the effect of night purging, as well as annual energy use. Pan European climate data are embedded.

LT Europe is an integrated strategic energy design tool with the features mentioned above. The sketch design can be drawn, using familiar drawing tools, and most of the spatial parameters to be input (e.g. plan, section, glazing ratio, height of obstructions) from the interface. It is possible to import existing graphic backgrounds (e.g. a site plan showing adjacent buildings or an existing building plan) and then trace over this to create the spatial data. (See Fig.1.) The input data of the building system and fabric are limited at the least requirement. The parameters for the system are boiler efficiency, cooling efficient of performance, ventilation rate, ventilation strategy, internal gain, lighting datum, occupancy pattern etc. The parameters for the fabric include U value of envelop (wall, roof, floor and glazing), which can be edited as shown in Fig.2.

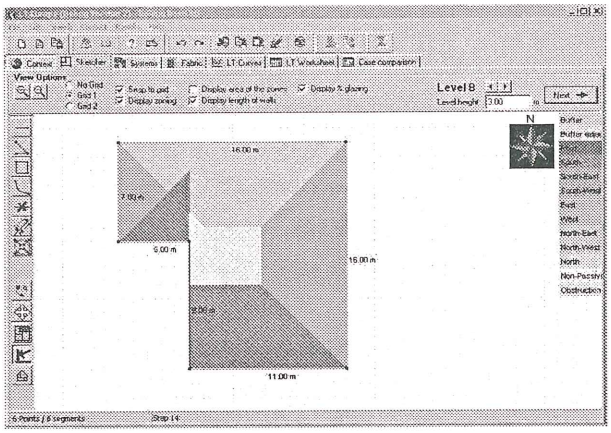


Fig. 1 The Sketcher allows the plan of the building and surrounding obstructions to be input using familiar drawing tools

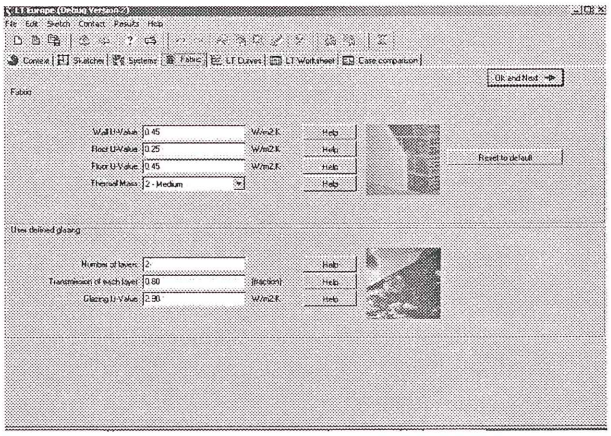


Fig. 2: The Fabric input screen presents default values which can be edited.

## 4. Innovative use in China

China's buildings sector currently accounts for 23% of China's total energy use and is projected to increase to one-third by 2010. The level of energy efficiency in the Chinese residential building stock remains low. Energy efficient building design can promote wider sustainable development aims and objectives because it produces environmental, social and macro-economic benefits in addition to a significant impact on household's ability to obtain adequate levels of affordable thermal comfort. Therefore it is important to develop energy efficient building design and technologies that can be applied in China. It is particularly important for the architects and building designers to use at the beginning of the building design. LT method has been successfully used in architectural practice at the building design early stage in the UK and European. Recent collaborating between the Faculty of Urban Construction and Environmental Engineering, Chongqing University and the Martin Centre at the Department of Architecture, Cambridge University discussed the possibilities of the extending LT method to the different climate and building context of China. Several case studies have been carried out. For example, a case study for a new building design in Beijing has been performed. The hourly climate data of solar radiation (diffuse and direct), air temperature, wind speed and relative humidity have been produced from Meteonorm and integrated to the LT Europe software.

### *4.1 Building information input*

The building form has been directly drawn from the interface. The building is a "L" shape office building with eight stories. The base case designed 25% glazing ration in each facade with single glazing. The geometric building form is easily drawn from the interface. The next floor is duplicated from the previous floor (see Fig.1). The Building System and

Building Fabric information were input with old regulation value: the U value of the wall is 1.7 $W \cdot m^{-2} \cdot K^{-1}$, the U value of the floor and roof are 1.28 $W/m^2K$, the U value of the glazing is 6.4 $W/m^2K$. The infiltration rate is 1 air change per hour. Internal heat gain is 15 $W/m^2$. The internal designed lighting level is 300 lux. The building is medium weight.

*4.2 LT curve*

This is the first of the output screens showing the results of a parametric run of the solver. A set of curves relating to energy use (heating, cooling, ventilating, lighting) as a function of glazing ratio is shown for two premier zones (so that comparisons can be made). Overheating is also shown for three ventilation regimes including night ventilation. Note that ventilation energy represents the fan power for air-conditioning and is not thermal energy. With the LT curve shown in Fig.3, the design can find the optimum glazing ratio in each façade.

*4.3 LT sheet*

LT sheet is the tabulate result of each zone and the whole building. It gives the results of annual energy consumption and the total $CO_2$ emission (see Fig.4).

*4.4 Comparison*

The input parameters can be changed for each case and results can be compared by multiple running. The second case changes the U value of the wall, roof and floor to the new energy regulation (JGJ 26-95) required values. They are 0.8 $W/m^2K$ for roof and floor, 1.16 $W \cdot m^{-2} \cdot K^{-1}$ for wall and 4 $W \cdot m^{-2} \cdot K^{-1}$ for glazing. Some other changes such as applying ventilation strategy for the overheating comparisons, reducing infiltration rate etc, has been made and performed. From the results we can see that the heating energy was significantly reduced by implying the new building regulation, so causes the total annual energy reduction (see Fig.5). Furthermore when reducing the infiltration, the heating energy was reduced further.

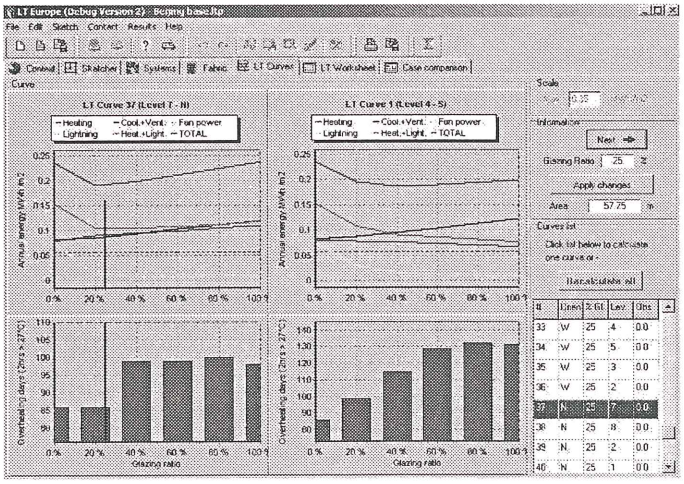



Fig. 3: LT Curves showing annual energy use per square metre for heating, cooling, ventilating and lighting, and overheating days, as a function of glazing ratio. Left curve shows the south premier zone and the right curve shows the north premier zone.

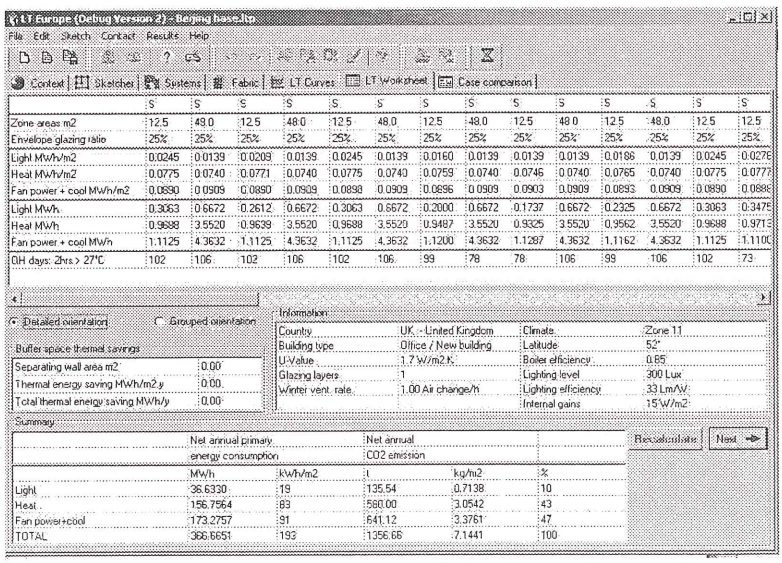



Fig.4: LT sheet showing annual energy use per square metre for heating, cooling, ventilating and lighting in table

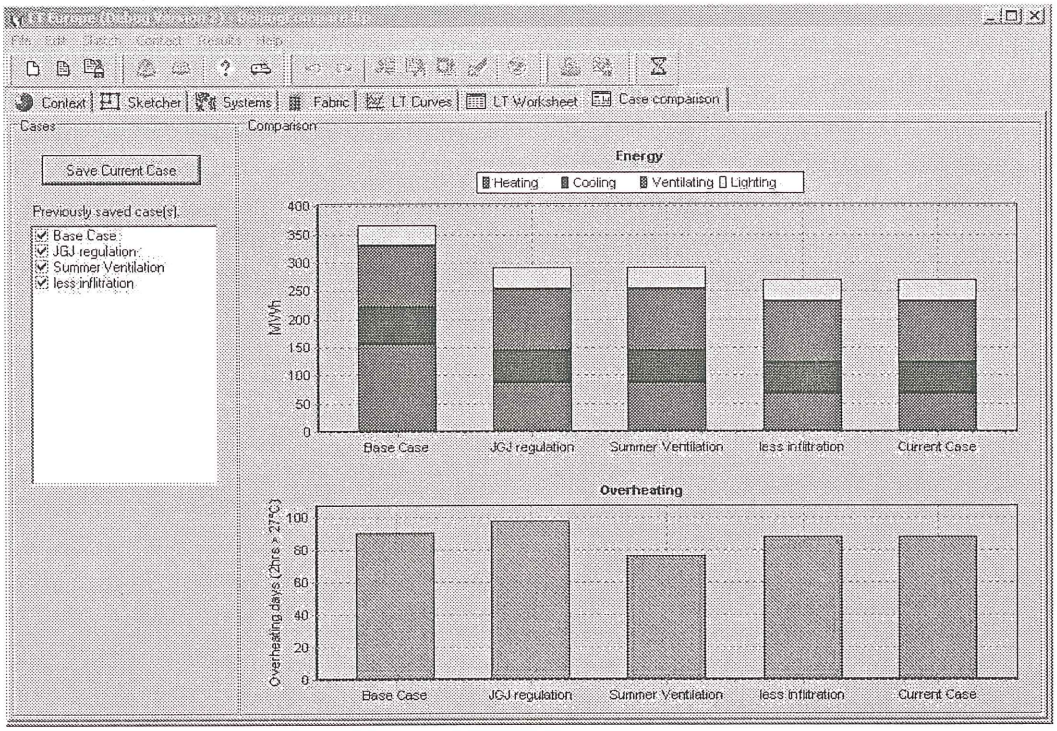



Fig.5:The reduction of total annual energy when implying the new building regulation

## 5. Conclusion

It is important to innovate the strategic energy design tools using in the early design stage in China. The features required for this kind of tool should be reliable, use friendly and easily. The LT Europe is an ideal tool to meet these purposes. It requires less information which is available at the design early stage. The building geometric input via GUI interface makes it user friendly. The both tabulate and graphic results displays give the designer clear indication. The software allows the user to perform the different cases and make a comparison so to choose the optimum design option. This is particularly important at the early design stage. However we must bear in mind that this software is suitable for the strategic design rather than a detail energy simulation. The future studies can be extended to create a set of climate data of China and create the climate map of China. Some default values should be decided based on the Chinese building energy design regulations.

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## References

1 Baker N, Steemers K. LT 2.1 in Energy and Environment in Architecture, E&FN Spon, Taylor FrancisGroup, London 1999.

2 Baker N, Yao R, LT Europe – an integrated energy design tool, Design with the Environment PLEA 2002 Conference, Proceedings, pp669-673, Toulouse France.

3 Yao.R, Li B, Kang Y, Passive design for residential buildings and thermal comfort in south China, , Design with the Environment PLEA 2002 Conference, Proceedings, pp113-119, Toulouse France.

4 Li B, The report of the project "Improving indoor environment for residential building in Chongqing", Chongqing Jianzhu University Press, 1997

5 Chinese Standard,(1996) Energy Conservation Design Standard for New Heating Residential Buildings, JGJ 26-95, Chinese Construction Industry Publisher, Beijing