# Impacts of shading effect from nearby buildings on heating and cooling energy consumption in hot summer and cold winter zone of China

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## 1. Objective

In the roadmap for reduction of $CO_2$ emission, the main menus are introduction of equipment with high energy efficiency and building materials with high thermal insulation. However, reductions of emission through urban or building block design are not discussed well now. Actions from micro scale viewpoint will be also important. Shading effects from nearby buildings in building block scale affects to residential space cooling, space heating and illumination.

In cities of the central China, like Shanghai, with large annual climatic variability, numerical simulations on indoor electricity use in eQUEST are performed. As a parameter on shape of building blocks, W/H is adopted and the optimal design of residential building blocks in viewpoint of energy consumption is studied.

## 2. Residential energy consumption in China

China is classified into five climatic zones. In the hot summer and cold winter zone, 30 to 55% of domestic electricity is used for air conditioning[1]. We expect, therefore, there might be conflicts of countermeasures between summer and winter, namely actions for reduction between space cooling and space heating.

## 3. Numerical simulation in eQUEST

Physical basis: Thermal conduction theory

Parameters: a) Building structure; b) Meteorological data in studied cities in typical year; c) Habits of residents on electricity consumption

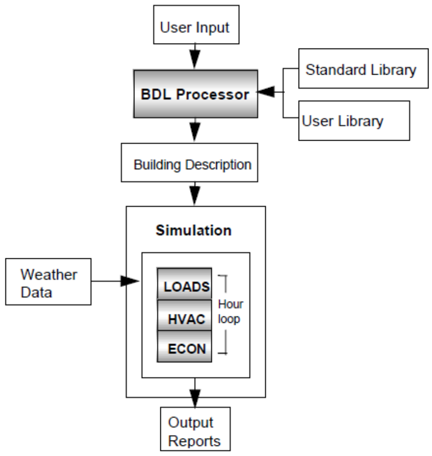


Fig 1 Flowchart of numerical simulation in eQUEST

Table 1 Dimensions of target residential building[2]

| | |
|---|---|
| Residential building type | Non-single household, six-story |
| Shape (Height is for 1 story) | Length: 66 m, Depth: 12 m, Height: 3 m |
| Outer skin structures | National Standards JGJ 134-2001 |
| Temperature, Illumination | Heating 18℃, Cooling 26℃, Illumination 500 lx |

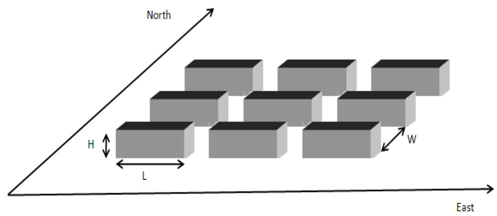


Fig 2 Model residential estate

We compute indoor air conditionings load affected by outdoor meteorological conditions and illumination load by shading effect from nearby buildings through whole year numerical simulation.

## 4. Building orientation, street width and shading effect on energy consumption

For indoor energy consumption, building orientation and street width are important. In case of facing south, impact of shading in winter noon is large. On the other hand, in case of facing east or west, impact of solar gain in summer morning and evening is large. Therefore, we need to choose prioritized actions in consideration to the orientation. Each purpose of energy use shows different performance to the parameter of W/H. The larger W/H gives the larger space cooling load. On the contrary, it gives the smaller space heating load and illumination load.

As the result, we can find 1.5 as the optimal value of W/H and to cut down the growing of cooling load in narrow canopy

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zone, opening windows and in-taking outdoor cooler air is recommended. Prioritized countermeasures considering shape of building blocks are necessary.

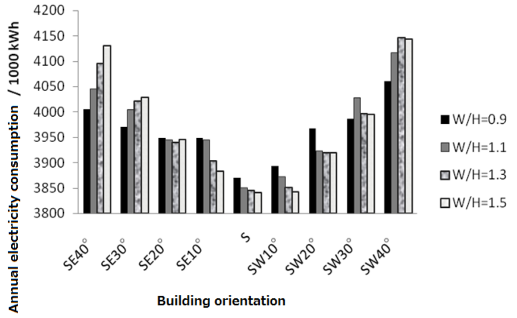


Fig 3 Building orientation and street width vs annual electricity use

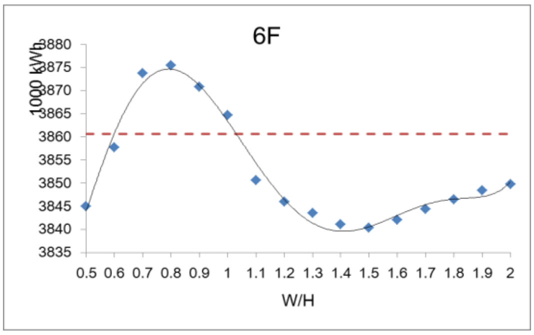


Fig 4 Shading effect from nearby buildings on energy consumption

## 5. Numerical simulation on space cooling and heating load of five middle latitude cities in China

In the hot summer and cold winter zone of China, shading effect from nearby buildings reached to 10 to 20% in case of space cooling energy decrease and 0 to 20% in case of space heating energy increase. In Shanghai and Wuhan, these two effects are canceled each other. However, in Changsha, Chengdu and Chongqing, the increasing effect for space heating is not obvious. This reason might be a small solar radiation in winter.

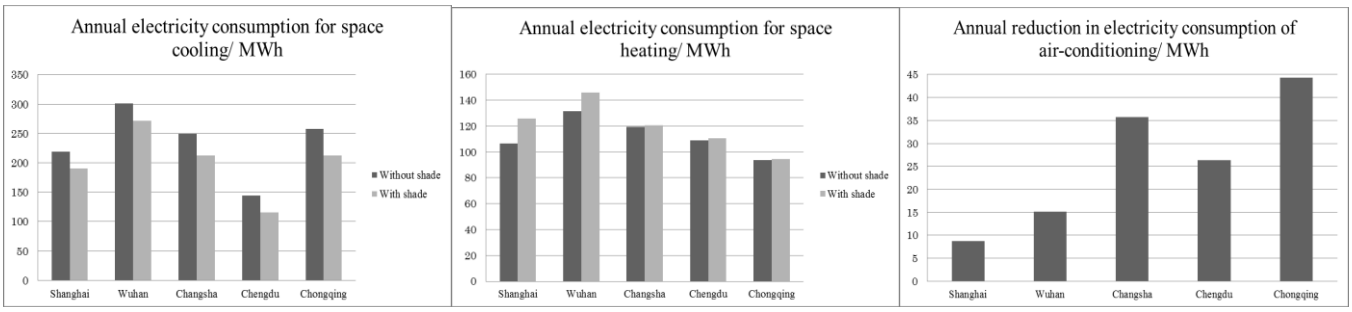


Fig 5 Numerical simulation on space cooling and heating load of five middle latitude cities in China (Shading effect from nearby buildings)

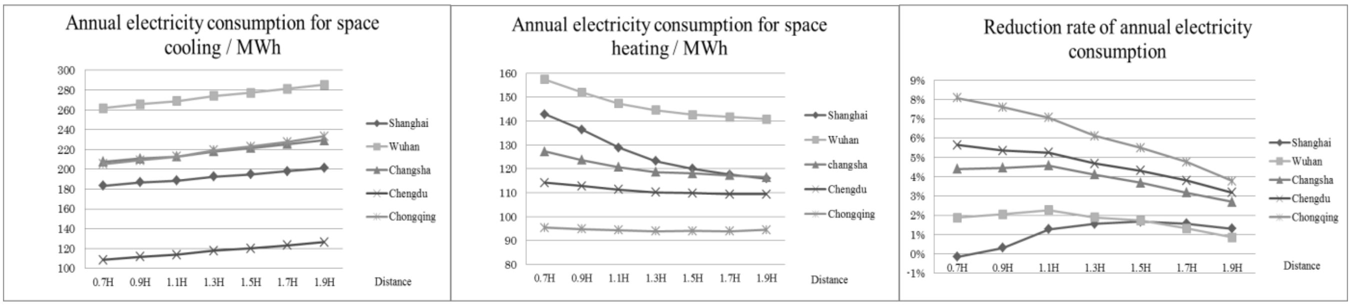


Fig 6　Changes in electricity demand due to the increased distance between the north and south buildings

## 6. Conclusions

Space cooling (wider W, higher load) and space heating, illumination (narrower W, higher load) show different performances for variability of W/H. It gives the optimal value of W/H (1.5 around) for the minimum total electricity consumption. Effect of W/H varies on building orientation. Prioritized countermeasures considering the shape of building blocks are necessary. In inland three cities, design which enhances shading effect from nearby buildings is strongly recommended. In Shanghai and Wuhan, we can find the optimal W/H. In addition, combination of wide street width and shading effect from tall deciduous trees beside south wall is valid.

## References

1) Jiang Y., Lin B.R., and Zhu Y.: *Energy Efficiency in Residential Building*. Beijing: China Architecture and Building Press, 2006

2) Ministry of Construction of PRC, *Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Zone* JGJ 134-2001. Beijing: China Architecture and Building Press, 2001 [*in Chinese*]