

# Technological options for and Chinese government regulation of building energy efficiency

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**Abstract:** Improvement of building energy efficiency, as a part of sustainable development strategies, makes great contribution to global environment protection and energy security. Presented in this paper are (i) a comprehensive overview of the technological options for building energy efficiency, (ii) government regulation of building energy efficiency, especially in China, (iii) some suggestions suitable for China.

**Keywords:** building energy efficiency; technologies; regulation

## 1. Introduction

With growing concerns about global environment, world-wide energy security, and sustainable development, the demand for building energy efficiency is more urgent than it has ever been. In the industrialized countries, about 30 % to 40 % of gross national energy is consumed to maintain buildings. Even, in China, which is one of developing countries, building energy consumption is up to 13.6 % of total for the year 2000. Given the ever growing economy, population and standard of living, the current percentage will inevitably increase. Moreover, nonrenewable fossil fuels account for the bulk, about 80 %, of the world annual energy uses, so global demand for energy services has resulted in energy exhaustion and emissions of CO<sub>2</sub> to atmosphere. In order to balance energy, economy and environment in desirable way, many countries have been committed to reducing energy consumption, especially in building. However, it is not often wise decision to sacrifice health and productivity for energy savings, due to less comfortable and healthy working or living environment.

According to sustainable development strategies, goal of building energy efficiency is to achieve maximum energy efficiency of building without comprising of well-being and comfort of indoor environment, and to promote economy and society to maximum extent at minimum cost of resources and energy[1].

This paper will concentrate on techniques and implement of reducing use of building energy. In the end, it concisely offers some suggestions suitable for China.

## 2. Technological options for reducing use of building energy

As roughly estimated, thorough and effective building techniques could decrease building energy consumption by 66.7 % to 75 %. A wide variety of technological options could be used to achieve building energy efficiency. They fall into two main categories:

- 1) Reduce building energy consumption.
- 2) Use renewable energy source, such as solar, wind, biomass, and so on.

Each of these techniques will have a role to play in tackling building energy efficiency. The extent to which each technique is used will depend on many factors including climate, site, function of building, cost and social factors.

### 2.1 Reduce Building Energy Demand and Consumption

Reducing building energy demand and consumption, without compromising of good indoor environment quality, is cost-effective and will deliver useful reductions in energy use and environmental protection. Because building components and systems are interrelated to boost energy saving, it is critical to use whole-building design process by design teams. So, architects, engineers, building occupants and owners should go hand-in-hand from the beginning of process.

#### 2.1.1 Lowering Heating, Cooling and Lighting Load

Now HVAC and lighting are almost major energy consumers in buildings, building energy demand is directly related to thermal and lighting load. Therefore, the following techniques will focus on how to decrease heating, cooling and lighting load.

In energy-conscious building design, to make

optimum use of nature environment (e.g. breezes, sunlight, shade) could benefit not only good indoor environment quality, but also energy efficiency. If architects pay proper attention to passive means of heating, cooling, and lighting, the size of the mechanical equipment can be easily cut by 50 percent. The design of the passive heating, cooling, and lighting of building is just the component of integrated building design process. It can be accomplished in two tiers[2]: The first tier is the basic design of the building form and fabric to minimize heat loss in the winter, to minimize heat gain in the summer, and to use light efficiently. The second tier involves the use of natural energy through methods such as passive solar, nature ventilation, and daylighting system.

In the beginning of building design, architects should assess the local climate, such as typical meteorological-year data, to determine appropriate building designs. So, some countries divide their climate into different regions and make proper design strategies responding to climate. For instance, design techniques for each of 13 climate regions in U.S are given in Regional Guidelines For Energy-Conserving Home. Due to site and community, the microclimate can be significantly different from regional climate[3]. Then, architect can make proper use of site planning, such as vegetation, soil type, large bodies of water, form of land, and manmade objects, varied with climate, to make microclimate beneficial change. At last, architect should design building to actively use microclimate to control the indoor environment. At one side, building is beneficial to bring appropriate microclimate into interior. At other side, in harsh climate conditions, building can control winter heat loss and summer heat gain to maximum extent.

The flow of energy through the building envelope, which consists of roofs, walls, foundations, floor, window, door, and joint, represents a major component of the total thermal load of building. In buildings, envelope upgrades are often necessary and cost-effective to enhance interior comfort and energy efficiency[4]. By promoting the performance of envelope, energy consumption can decrease by 20-40%, but total investment only increases by 3-6%[5].

In whole-design approach, architect could choose cost-effective building techniques by information on energy-use and cost of options, which is provided by

engineers[6].

### 2.1.2 Improve Energy Efficiency of End-User

Energy efficiency improvement of end-user can contribute greatly to reduction in energy supply. HVAC accounts for a major share of energy consumption in building, which reach about 50 % to 70 % of the total [7]. Therefore, it is especially important to improve utilization energy efficiency of HVAC. Some ways of energy-efficiency improvement on HVAC system have been identified. These include:

1) Designing high energy-efficiency HVAC system proper for the type and function of building, such as cogeneration systems, district heating and cooling systems, thermal-storage systems, and so on.

2) Using energy management and control systems to monitor comfort levels, indoor air quality, energy use.

In addition, owners should be encouraged to use electrical appliances and office equipments, which are certified as high energy efficiency. Many countries carry out various certification programs on energy-saving products. For example, energy efficient products are certified as "Energy Star" in U.S. In Australia, energy efficiency of appliances with high consumption of energy can't exceed the limit values.

## 2.2 Chang to Renewable Energy

Renewable energy is vital to the deeper development of energy efficiency and environment protection. The key feature of renewable energy as a source of primary energy is inexhaustibility and wide availability. Many technologies of the renewable sources (eg., Solar, biomass, wind, geothermal) have been applied to building energy efficiency. Many of them could make significant contribution to electricity supply. Some example of them are introduced as follows[8]:

1) The methods of utilizing solar energy in building fall into three classes: solar thermal heat systems that produce hot water and steam for direct use including ice makers, building air conditioning, and ovens; photovoltaic system systems that produce electricity directly from sunlight and perform as part of the building envelope; solar thermal electric system that produce electricity by using the sun's heat to make steam.

2) Geothermal system that use the earth as a heat source/sink for augmenting the performance of electric heat pump systems and cooling/heating fresh air before supplying for indoor.

3) Wind systems that use wind to produce electricity. Also use night/natural ventilate to cool building.

4) Biomass systems that burn waste bio products (eg., corn stalks) to produce heat to generate electricity and use the heat directly.

### 3. Government regulation of building energy efficiency

In market economy system, government still should establish proper mechanism to manage, direct, and urge building energy efficiency. In general, government regulation of energy conservation and renewable energy approximately covers four aspects, consisting of technological policies, codes and standards, economic incentives, and information diffusion.

#### 3.1 Technological Policies

Because lack of technological policies in fact means to set barriers for market of building energy efficiency, many countries have made large quantities of related policies, such as *Energy Policy And Conversation Act* in U.S. Though China even took first step in 1980s, government has established and enforced serials of technological policies on building energy efficiency. For example, *Energy Conservation Law In People's Republic Of China*, the fundamental state code of energy saving, stipulates specific clause of building energy efficiency. That is "to adopt energy-saving constructional materials, appliances, and products, to improve thermal performance of envelope, and to reduce energy consumption of heating, cooling, and lighting according to related act and regulations, in the process of building design and construction". "Eleventh Five" Years Planning and 2010 Perspectives and Policy On Building Conservation Technologies have set clear goal of building energy efficiency in heating zones and hot summer and cold winter zone. And they introduced main tasks on building design, products, standards, and technological system. *Rules of Civil Buildings Energy Efficiency Management*, applying to residential buildings except existing buildings in central heating supply zones and new, retrofit, and extended hotels, makes the requirement for energy-conservation management during construction process.

#### 3.2 Codes and Standards

Setting codes and standards for building energy

saving is one of basic measures and important guarantees to enforce technological policies. Standards fall into two types: technical standards and products standards. In the following section, some codes and standards promulgated by Chinese authorities will be introduced as instances.

GB50176-93- *Thermal Design Code For Civil Building* sets requirement for thermal design in response to regional climates. According to considerable difference of climates in vast areas, China is divided into five thermal design zones, consisting of freezing zone, cold zone, hot summer and cold winter zone, hot summer and warm winter zone, and mild zone. And it provides requirement of clear thermal design matching each zone.

But it is insufficient to save energy by improving thermal performance as a sole measure. So JGJ134-2001-*Design Standard For Energy Efficiency Of Residential Buildings In Hot Summer And Cold Winter Zone*, JGJ26-95-*Energy Conservation Design Standard for New Heating Residential Buildings*, GB 50189-93-*Energy Conservation Design Standard on Building Envelope and Air Conditioning for Tourist Hotels*, provide minimum requirement for energy-efficiency technique measures and index of energy consumption related to building design, thermal performance, heating, ventilation, and air-condition. Moreover, energy efficiency standards for products are set, such as GB12.21.3-2000-*The Limited Values for Energy Efficiency and Evaluating Values of Energy Conservation for Room Air Conditioners*.

At the same time, energy policymakers in China has worked closely with the energy analysis program's China Energy Group, consisting of researchers, for nearly a decade, in order to promulgate and update building energy codes and standards.

#### 3.3 Economic Incentives

Because the first-cost of energy-efficient technologies and products is usually higher than the traditional ones, government should take good advantage of economic incentives to pull public demand for the improvement of building energy efficiency techniques and devices. In China, various economy leverages have been took by government, these include:

1) Allocate specific funds and subsidies, which are not commercially available, for programs of

development of update building energy efficiency technologies and products, such as large quantities funds for Chinese energy efficiency of end-user program granted by Chinese government in collaboration with UNDP and GEF.

2) Provide low-interests loan by political banks to encourage the popularization of building energy efficiency devices.

3) Free or reduce tax upon users of building energy efficient technologies and devices.

### 3.4 Information Diffusion

In order to increase consumers awareness and responsibility of building energy efficiency, Chinese government has took serials of actions to diffuse related information:

1) Demonstrate building energy efficiency projects in different climate regions, such as Tianqi Garden, a Chongqing demonstration project, in hot summer and cold winter zone.

2) Issue the "Energy Efficient Label" certifying energy-efficiently electric appliance, such as light, air-condition, washing-machine, and so on.

3) Analyze and report financial and environment benefits resulting from building energy-efficient technologies and appliances.

4) Spread knowledge of energy efficiency to energy-users by means of training and education.

## 4. Suggestion to building energy efficiency in China

Though China, the second energy consuming country, has made great achievement in building energy efficiency for two decades, it still has promising potential for energy efficient improvement. So some suggestion are made to attain higher target of building energy efficiency in future, they include:

1) Frame comprehensive building energy efficient technologies system according to weather, economy condition, energy source, function of building in

different areas in China and replace current single technologies with it.

2) Establish the rating system of building energy efficiency that match technologies systems.

3) Develop a set of low-energy building envelopes and appliances adapted to temporary economy condition.

4) Create the update building energy efficiency modes and utilize renewable energy.

5) Subdivide five thermal design zones into more proper zones, according to difference in climates, economy and social acceptability in each zone, and provide corresponding standards in fields of building design, building thermotechnical.

6) Set design standard of building energy efficiency for low-story residential building and public building.

7) Seek the further institutional and financial assistance from international.

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