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Energy consumption quota management of Wanda commercial buildings in China

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Abstract. There is limited research of commercial buildings' energy use data conducted based on practical analysis in China nowadays. Some energy consumption quota tools like Energy Star in U.S or VDI 3807 in Germany have limitation in China's building sector. This study introduces an innovative methodology of applying energy use quota model and empirical management to commercial buildings, which was in accordance of more than one hundred opened shopping centers of a real estate group in China. On the basis of statistical benchmarking, a new concept of "Modified coefficient", which considers weather, occupancy, business layout, operation schedule and HVAC efficiency, is originally introduced in this paper. Our study shows that the average energy use quota increases from north to south. The average energy use quota of sample buildings is 159 kWh/(m2.a) of severe cold climate zone, 179 kWh/(m2.a) of cold zone, 188 kWh/(m2.a) of hot summer and cold winter zone, and 200 kWh/(m2.a) of hot summer and warm winter zone. The energy use quota model has been validated in the property management for year 2016, providing a new method of commercial building energy management to the industry. As a key result, there is 180 million energy saving potential based on energy quota management in 2016, equals to 6.2% saving rate of actual energy use in 2015.

1. Introduction

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1.1 China's policy status of building energy consumption quotas

Energy use of China's building sector has dramatically increased within this decade. It accounts for 16% of global consumption, which increased at an average rate of 2.4% per year from 1997 to 2008. The major direction of building energy saving during 12th Five Year Plan (FYP, 2011-2015) concentrates on improving building envelope of new constructions, energy saving technologies/products, retrofitting of existing buildings and renewable energy use[1,2]. MOHURD announced that a preliminary energy saving target of 116 Mtce for China's building sector could be achieved by the end of 12th FYP [3]. Meanwhile, some researchers pointed out that blind development of energy saving technologies ignoring local conditions cannot really save energy use. Tsinghua University studies actual energy use data of 103 LEED certificated buildings [4]. The result shows the average EUI of LEED buildings is 217 kWh/ (m^2.a), which is not lower than others.

Therefore, researcher and policy makers realize that energy consumption quotas system of new- and existing- buildings is a truly effective method to control actual energy consumption of China's building compared to the previous method. Shenzhen takes the lead in addressing commercial building energy quota standard in the beginning of 12th FYP. Shenzhen Construction Bureau (SCB) issues three energy quota standards of existing office building, shopping center and hotel in 2012 [5].Those standards are revised and combined as "Standard for Energy Quota of Existing Commercial Building in Shenzhen" in 2015 (SCB, 2015). For instance, the energy quota is 100~110 kWh/ (m^2.a) of commercial office building and 300~320 kWh/ (m^2.a) of shopping center in Shenzhen.

On the basis, MOHURD promulgated "Standard for Energy Consumption of Buildings (draft for comment)" in Jun. 2014 [3]. The standard has 6 major innovations: 1)it covers both commercial and residential buildings; 2) it sets two targets of each type of building ,the restrict value and guide target; 3) it separates the new- and existing- buildings' target; 4) it separately issues heating use quotas (kgce/(m2.a)) and electricity use quotas(kWh/(m^2.a)); 5) four climate zones have different energy consumption quotas; 6) revising method of commercial building is provided considering operation hours, occupant intensity, HVAC system design difference, etc. Also take commercial office building in the hot summer and warm winter area (HSWW) for example, the restrict EUI is 110 kWh/(m^2.a) for existing ones, and the highest guide target is 75 kWh/(m^2.a); the restrict EUI is 90 kWh/(m^2.a) for newly constructed ones, and the guide target EUI is 65 kWh/(m^2.a). The major energy consumption quotas of other types of buildings are compared in Table 1.

Table 1. Comparison of energy consumption quotas between two standards

Type	SCB,2015 (Shenzhen only)	MOHURD, 2014 (HSWW area)			
		Existing		Newly constructed	
		Restrict	Guide	Restrict	Guide
Commercial office	110/105/100	110	75	90	65
Government office	90/85/80	80	55	55	40
Shopping center	320/310/300	300	245	100	80
Supermarket	310/300/290	290	240	105	80
5-Star hotel	220/210/200	220	160	120	100
4-Star hotel	190/180/170	190	140	110	90

1.2 Literature review of building energy consumption quota

Energy consumption quota is used to give a reasonable suggestion to the building operator to control the total energy use, usually only concerning about the electricity in the beginning. The energy data is determined based on several basic informations, consisting of building area, climate zone, occupancy, operating hours, mechanical system information, etc.

Two typical analysis methods are used to evaluate the building energy use, model simulation and statistical analysis [6].

Model simulation method uses mathematical method to analyze, compare or predict building electricity consumption, to evaluate the operation status of buildings mechanical system [7]. Carriere *et al.* studied the energy use characteristics of large commercial buildings [8]. Several building basic information are collected including building function, climate, ME system information, running time and so on [9]. The EPA's energy efficiency evaluation software, Energy Star in the U.S, presents the method to calculate the energy consumption quota of various types of buildings [10]. By entering the energy consumption, building area, the number of staff, etc, energy star tool compares the energy use quota with similar buildings in the database of the software and get the scores in centesimal grade system of this building. Those studies point out that temperature and humidity, occupant density and air-conditioning style are three most important impact factors of commercial building energy use.

Statistical analysis model used mathematical method, based on the statistical analysis software, to determine a reasonable energy consumption rage for buildings. Sharp used 6 significant factors from CBECS database in U.S., applied linear regression model of historical building energy use data, to predict commercial building Energy Use Intensity (EUI), and finally use median value as benchmarking index [11,12]. Zhang determined energy consumption, which is lower than 60% equal value as the energy use data [13]. German VDI 3807 evaluation system gives a calculation method of the energy consumption quota according to the building type, equipment power capacity, operation hours, etc. by investigation [10]. Those researchers illustrate that median or statistical distribution range is accurate than average, which can be considered as energy quota.

1.3 Limitation of present studies

There are two major limitations of present studies about energy use quota [14]. First, there was a very limited scope survey of energy use in large-scaled commercial buildings in China, instead of small-scaled investigations, case studies or scenario analysis. Thus, there is no energy use quotas model of large-scaled commercial building in China yet. Second, energy consumption quota tools like Energy Star in the U.S and VDI3807 in Germany are based on a box model, whose physical significance of regression equations are not clear to explain the impact factor of actual building energy consumption.

The method of this paper is original works of author members. This is the first and precious chance collecting hourly actual energy use data of hundreds of commercial buildings in China. Thus, on the basis of the qualified data, this study firstly introduces an innovative methodology of applying energy use quota model and empirical management to commercial building. A new concept of "Modified coefficient", considering weather, occupancy, business layout, operation schedule and HVAC efficiency, is introduced to adjust energy use quota. Furthermore, simulation is adopted to predict the optimal energy use of a typical commercial building, so as to evaluate potential of energy savings. The energy use quota model has been validated in the property management for year 2016, providing a new method of commercial building energy management to the industry.

2. Methodology

2.1 Definition and data source

There are 135 large-scaled commercial buildings, which are divided by three dimensions.

- According to the definition of five climate zones, dividing into severe cold, cold, hot summer and cold winter, hot summer and warm winter, and temperate.
- According to the city classification, dividing into first-tier, second-tier and third-tier.
- According to business maturity in each city, further dividing into type-I, type-II, type-III and type-IV.

All sample buildings were installed with Persagy energy metering system. Each building installs more than 150 three-phase smart meters on low voltage power distribution branches. Hourly energy use data of each meter is transferred to the server. Based on those meter data, same electricity metering model is applied, as shown in Figure 1. First class breakdown is defined by management partition, including public area, anchor stores, small tenants and error. Second class breakdown is defined by mechanical system, including HVAC system, lighting, utility equipment, information center and others. Third class breakdown is defined by device, such as chiller plant, air-handling terminals, elevator, drainage pumps, indoor lighting, landscape illume, etc.

The Electricity Use Intensity (EUI) is calculated by annual electricity consumption divided by business area. The business area equals to total building area minus parking area and machine room space. All building energy use data is collected by electricity metering system. Each sample building contains at least one-year electricity use data.

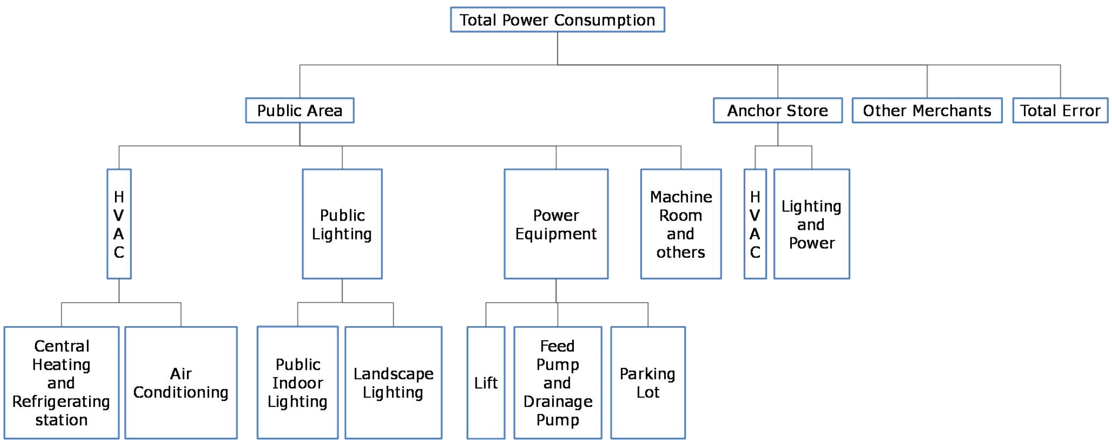

Figure 1. Electricity breakdown logical sketch map of sample buildings

2.2 Energy consumption quotas model based on historical data

135 sample buildings cover 21 provinces or cities in China, include five climate zones. The impact factors of building energy use can be separated into subjective and objective ones. The objective factor includes weather, architecture design, building envelope, mechanical system design, etc.; the subjective factor contains business hours and operation strategies. Hence, this

study conduct five "Modified coefficient", considering weather α_1, occupancy α_2, business layout α_3, operation schedule α_4 and HVAC system design efficiency α_5,so as to adjust energy use quota on the basis of historical energy data. EUI_{quota} is calculated according to the Equation (1) and Equation (2).

$$EUI_{quota} = EUI_0 \times max(\alpha_1, \alpha_2) \times \alpha_3 \times \alpha_4 \times \alpha_5 \tag{1}$$

$$EUI_0 = \frac{E_0}{A_0} \tag{2}$$

where

EUI_{quota}	annual electricity use quota per square meter, unit: kWh/(m^2.a)
EUI_0	annual actual electricity use per square meter, unit: kWh/(m^2.a)
E_0	annual actual electricity use, unit: kWh
A_0	Business area, equals to total building area minus parking area and machine room space
α_1	weather modifying coefficient
α_2	occupancy modifying coefficient
α_3	business layout modifying coefficient
α_4	operation schedule modifying coefficient
α_5	HVAC system design efficiency modifying coefficient

(1) Weather modifying coefficient: α_1

Ambient temperature, humidity and solar radiation are major climate impact factors of building cooling and heating load [15], especially to cooling load from ventilation [16]. Based on on-site investigation of commercial building in China, energy consumption of HVAC system takes 43% of public area energy use approximately. Hence, weather condition cannot be simplified in the energy quota model. The weather modifying model, firstly, calculating coefficient c_1. c_1 equals to the difference of outdoor and indoor enthalpy of sample building, divided by the average of this difference of all sample buildings which in same city type and climate zone, as shown in Equation 3. Secondly, this coefficient is only used to modify HVAC system energy use, as shown in Equation4. Thirdly, α_1 is calculated according to Equation (5).

$$c_1 = \frac{(i_{out} - i_{in})_{sample}}{(i_{0,out} - i_{0,in})} \tag{3}$$

$$E^*_{HVAC} = E_{HVAC} \times c_1 \tag{4}$$

$$\alpha_1 = \frac{\left(E^*_{HVAC} + E_{non\text{-}HVAC}\right)}{E_{Total}} \tag{5}$$

where

i_{out}	Outdoor enthalpy of sample building, unit: kJ/kg$_{dry\text{-}air}$. Data source is China Weather Reporting Website: http://www.cma.gov.cn/
i_{in}	Indoor enthalpy of sample building based on Wanda Plaza design standard, unit: kJ/kg$_{dry\text{-}air}$. In summer is DT=26℃, RH=60%, i_{in}=58.471 kJ/kg$_{dry\text{-}air}$. In winter is DT=22℃, RH=50%, i_{in}=43.122 kJ/kg$_{dry\text{-}air}$.
$E_{HVAC}{}^*$	adjusted HVAC energy consumption of sample building, unit: kWh
E_{HVAC}	actual HVAC energy use of sample building, unit: kWh
α_1	weather modifying coefficient
E_{Total}	total annual energy use of sample building, unit: kWh
$E_{non-HVAC}$	annual other energy use except HVAC of sample building, unit: kWh

(2) Occupancy modifying coefficient: α_2

Customers occupancy changes during business hours and varies from holidays and festivals in commercial building. By analyzing data from customer flow monitoring system, there is significant difference of occupancy index per square meter, due to the variation of city and district where sample building located. Customer occupancy is a key impact factor of building cooling and heating load which cannot be neglected as well. Based on daily customer occupancy data from monitoring system and chiller energy consumption data from electricity metering system, the nonlinear regression model is computed by Matlab, calculating regressed chiller energy consumption y^*, as shown in Equation (6). Secondly, c_2 equals to the y^* divided by actual chiller energy consumption by metering system, as shown in Equation 7. Thirdly, this coefficient is only used to modify HVAC system energy use, as shown in Equation7. Thirdly, α_2 is calculated according to Equation (8).

$$y^* = a \times e^{(bx_1)} \tag{6}$$

$$c_2 = \frac{y^*}{y_1} \tag{7}$$

$$E_{HVAC}{}^* = C_2 \times E_{HVAC} \tag{8}$$

$$\alpha_2 = \frac{E_{HVAC}{}^* + E_{Others}}{E_{HVAC}} \tag{9}$$

where

a、b	constant
x_1	daily cumulative passenger flow per unit area, unit: perple/m^2/day
y_1	daily actual electricity use of chiller per unit area, unit: Wh/m^2/day
y_1^*	adjusted daily actual electricity use of chiller per unit area, unit: Wh/m^2/day
α_2	occupancy modifying coefficient

(3) Business layout modifying coefficient: α_3

According to on-site investigation of large-scaled shopping mall opened during recent five years, catering tenants becomes more and more important, which takes 25%~40% of total tenants' area. Compared to retail shops, equipment heat and personal heat per square meter of catering area is higher and has obvious impact on building cooling load. Moreover, some catering tenants shut down make-up air fan, only turn on exhaust fan. It causes the cooling air of public area is extracted into catering area and exhausted, which increases building cooling load. Hence, α_3 modified HVAC system energy consumption according to the percentage of catering tenants' area.

Firstly, this study computes a simulation model of a typical sample building in DeST, simulates building cooling and heating load under different catering area scenarios. The regression of building load and catering area percentage is presented in Equation (10). The standard business layout scenario is catering tenants' area: other retail tenants' area: public area=40%: 20%: 40%. Based on simulation model, the building cooling load $y_{40\%} = 120W/m^2$.

Secondly, c_3 equals to the y divided by $y_{40\%}$, as shown in Equation 11. Thirdly, this coefficient c_3 is only used to modify HVAC system energy use, as shown in Equation (12). Usually, catering tenants' area percentage is lower than 40%, so if $y \le y_{40\%}$, then $c_3 \le 1, E^*_{HVAC} \le E_{HVAC}$; if $y > y_{40\%}$, then $c_3 > 1, E^*_{HVAC} > E_{HVAC}$. Finally, α_3 is calculated according to Equation (13).

$$y = 131.2x + 67.027 \tag{10}$$

$$c_3 = \frac{y_2}{y_{40\%}} \tag{11}$$

$$E_{HVAC}^* = \begin{cases} (1+c_3)\times E_{HVAC}, y_2 \le y_{40\%} \\ c_3 \times E_{HVAC}, y_2 > y_{40\%} \end{cases} \tag{12}$$

$$\alpha_3 = \frac{E_{HVAC}^* + E_{Others}}{E_{Total}} \tag{13}$$

Where

x_2	business layout of sample building
y_2	cooling load based on the simulation regression formula under the standard business layout of sample building, unit: W/m^2
$y_{40\%}$	cooling load based on the simulation regression formula under the standard business layout, unit: W/m^2
α_3	business layout modifying coefficient

(4) Operation schedule modifying coefficient: α_4

Operation schedule modifying coefficient is introduced to eliminate the differences of energy use caused by different business hours. Modified method is directly cited in session 5.3.4 of the national standard method "building energy consumption standard" (Draft for Comments, expected promulgation and implementation in 2016), as follows:

$$\alpha_4 = o.3 + o.7\frac{H}{H_0} \tag{14}$$

H	actual annual operation hours of sample building, unit: h/a
H_0	standard annual operation hours of building, commercial building of which is 4380 h/a
α_4	operation schedule modifying coefficient

(5) HVAC system design efficiency modifying coefficient: α_5

In order to eliminate the impact of system design differences, the model introduces HVAC system design efficiency modifying coefficient. The model has been simplified, only considering the design efficiency difference of chiller plant and HVAC terminals (AHU, PAU, FCU, etc.).

Firstly, calculating c_4 . c_4 equals to the $\overline{EER_0}$ divided by EER, as shown in Equation (15). If the chiller plant's EER of sample building is higher than the average EER of the same climate zone, $c_4 < 1, E^*_{chillerplant} < E_{chillerplant}$, which means the chiller plant of sample building should be more energy saving than previous energy use, as shown in Equation (16). If $c_4 \geq 1, E^*_{chillerplant} = E_{chillerplant}$, which means although the chiller plant's efficiency of sample building is lower than the average, the modifying energy use of chiller plant remains the same.

Secondly, calculating c_5 and modifying HVAC terminals energy consumption, as shown in Equation (17) and Equation (18).

Thirdly, α_5 is calculated according to Equation (19).

$$c_4 = \frac{\overline{EER_0}}{EER} \tag{15}$$

$$E_{Chiller\ Plant}^{\ *} = \begin{cases} c_4 \times E_{Chiller\ Plant} & EER > \overline{EER_0} \\ E_{Chiller\ Plant} & EER \le \overline{EER_0} \end{cases} \tag{16}$$

$$c_5 = \frac{\overline{ATF_0}}{ATF} \tag{17}$$

$$E_{Terminals}^{\ *} = \begin{cases} c_5 \times E_{Terminals} & ATF > \overline{ATF_0} \\ E_{Terminals} & ATF \le \overline{ATF_0} \end{cases} \tag{18}$$

$$\alpha_5 = \frac{E_{Chiller\ Plant}^{\ *} + E_{Terminals}^{\ *} + E_{Others}}{E_{Total}} \tag{19}$$

$E_{Chiller\ Plant}^{\ *}$	adjusted chiller plant energy consumption of sample building, unit: kWh
$E_{Terminals}^{\ *}$	adjusted HVAC terminal device energy consumption of sample building, unit: kWh
$\overline{EER_0}$	average chiller plant energy efficiency of the same climate zone compared to sample building
EER	chiller plant energy efficiency of system of sample building
$\overline{ATF_0}$	average air transfer factor of the same climate zone compared to sample building
ATF	air transfer factor of sample building
α_5	HVAC system design efficiency modifying coefficient

2.3 Quota validation by simulation

2.3.1 DeST model introduction.

In order to simulate the reasonable energy use of a sample building, comparing it with the energy quota and find out the possible energy saving potential, this study select a commercial building in the hot summer and cold winter area as an example, establishing a DeST model to simulate cold and heat load of the sample building.

DeST can be used to simulate and analyze both building energy consumption and HVAC system. It is developed by Tsinghua University with the aims to benefit for practical and research use of building simulation related applications in China [17]. It is commonly used in China nowadays, the calculation efficiency and accuracy have evident advantages [18].

The total building area is about 148 thousand square meters. The parking lot area is 119 thousand square meters. The total air conditioning area is 193 thousand square meters. The 3-dimention DeST model of this building is shown in Figure 2.

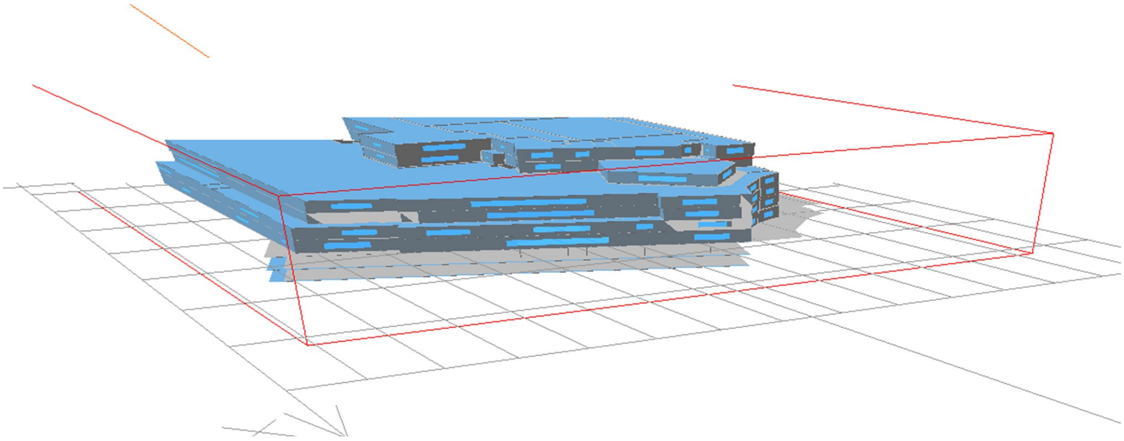

Figure 2. The simulation model of a commercial building in hot summer and cold winter area established by DeST

2.4 Simulation result of optimum energy quota

Based on the simulation result of hourly cold and heat load, and the on-site measurement of HVAC system efficiency, the optimized energy use of HVAC system is predicted, as shown in Table 2. Meanwhile, according to the on-site measurement and investigation, the optimum energy consumption of lighting, elevator, parking lots area, etc. is estimated, based on practical energy saving strategies.

The actual total energy use intensity of the sample building is 209 kWh/ (m^2.a), after optimizing, the optimum total energy consumption is 169 kWh/(m^2.a). The total energy saving rate is over 19%.

Table 2. Power consumption index comparison before and after optimization of the commercial building in hot summer and cold winter area

Type	Actual power consumption index	Optimize power consumption index	Area	Energy Saving	Partial energy saving rate
	(kWh/m^2.a)	(kWh/m^2.a)	(m^2)	(10^4kWh/a)	/
Indoor public lighting	25.6	15	26248	27.82	41.4%
Nightscape lighting	13	9.5	26248	9.19	26.9%
HVAC	46	38.5	67700	50.78	16.3%
Parking lot	11.2	7.6	47900	17.24	32.1%
Elevator	10	8.7	47900	6.23	13.0%
Tenants	72	61.2	45200	48.82	15.0%
Water supply and drainage pump	8	8	47900	0.00	0.0%
Machine room and others	23	20.5	47900	11.98	10.9%

Total (10^4kWh/a)	/	/	/	111.3	/
Total energy use intensity (EUI) (kWh/m^2.a)	208.8	169	/	/	19%

3. Results and discussion

3.1 Quotas for opened portfolio

Based on the historical energy data and modifying coefficient, energy use quota of sample buildings is calculated based on Equation 1. Energy use quota of 53 buildings with more than 1-year hourly energy data is shown in Figure 3. The average quota of each climate zone is increased from north to south.

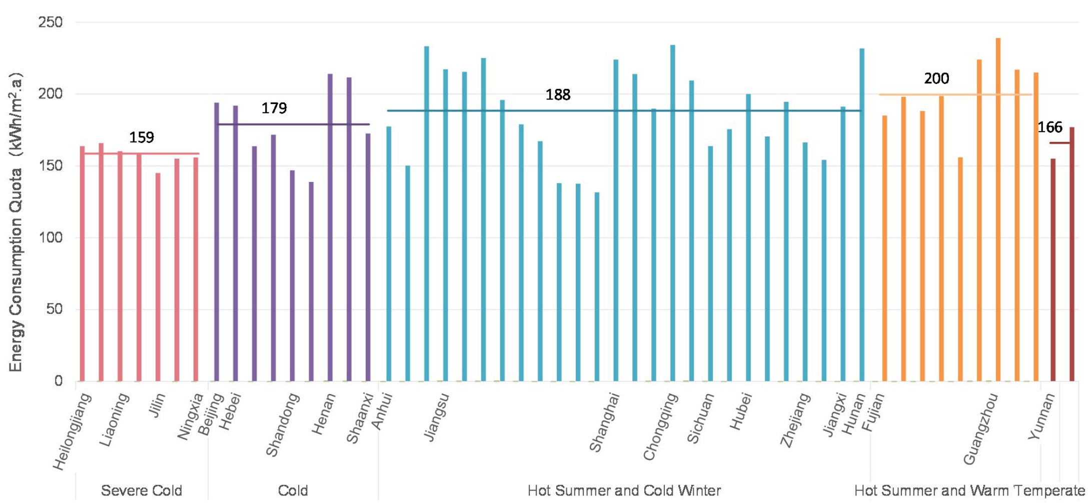

Figure 3. Energy consumption quota result of opened buildings (with hourly energy data more than one-year)

3.2 Quotas for newly-built portfolio

For buildings which opened in less than one year, since they are lack of whole year energy use data, the energy use quota is determined according to the quota of sample buildings in the same city district and climate zone, based on Figure 3. If there is no sample of the same matrix, the samples' average of the same province and climate zone is ensured as energy use quota approximately. The result of newly-built commercial buildings is shown in Figure 4. The average quota of each climate zone is increased from north to south.

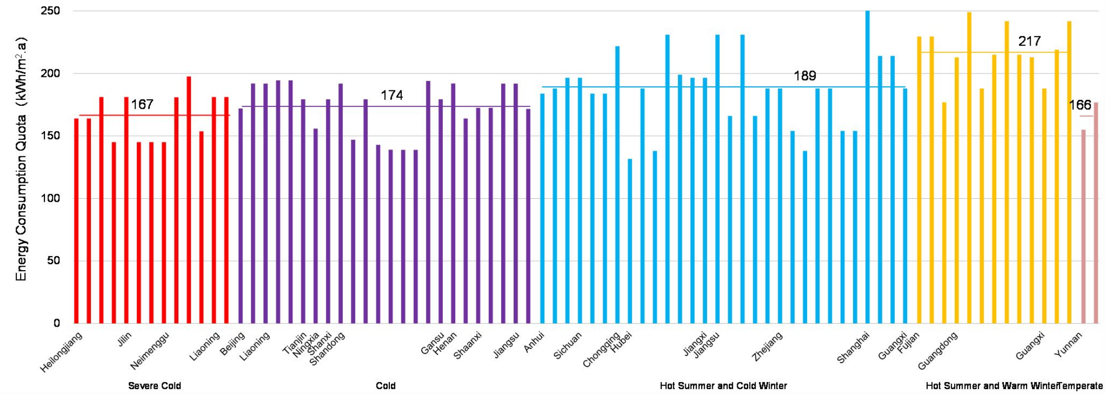

Figure 4. Energy consumption quota results of newly-built buildings (less than one-year)

3.3 Practical management in Wanda Plaza

3.3.1 Practical quotas management approach.

The energy use quota of buildings is used to guide their annual budget and provide practical suggestions of energy saving strategies. The deviation of energy metering data, energy bills and energy budget is compared to determine whether use energy quota calculated by session 3.1 or adjust quota due to special reasons.

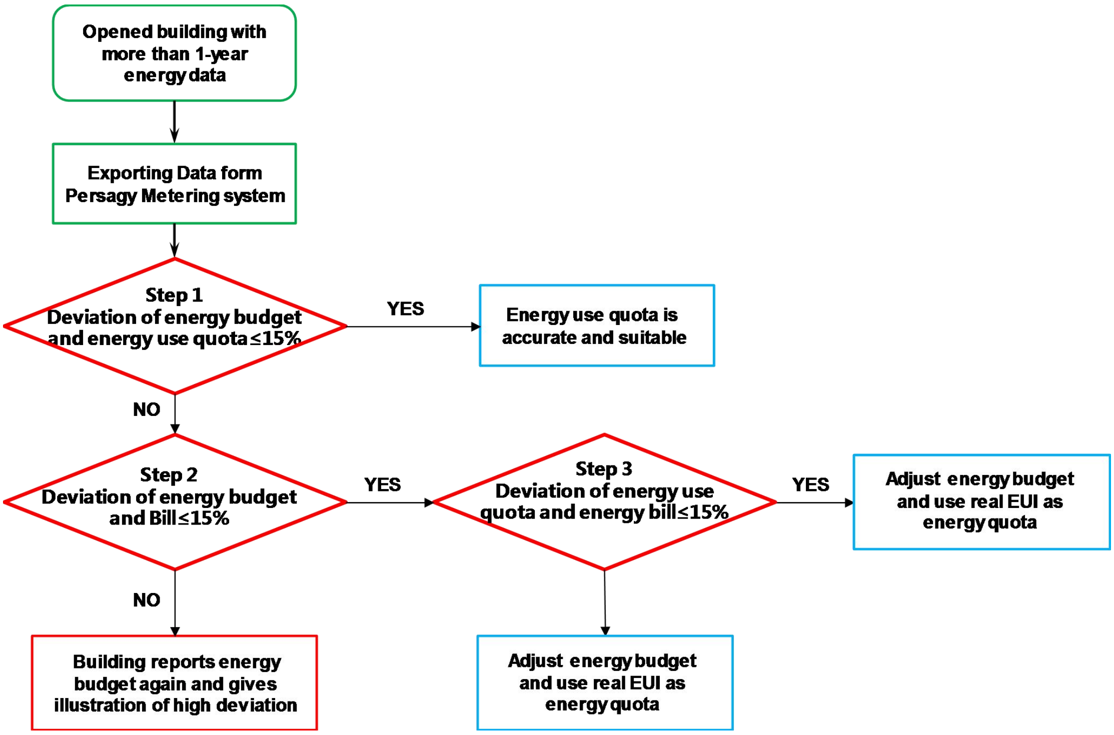

Figure 5. Logic diagram of energy quota determination for opened more than 1-year commercial building

Figure 5 illustrates logical process suitable for commercial buildings opened more than 1 year. If energy bills and energy budget can support that the energy quota is close to actual EUI and suitable for the building, the building manager should report further reason of their energy budget or change the budget to energy use quota instead. If energy bills and energy budget prove that energy quota is away from historical energy use, the energy use quota will be adjusted to the actual EUI.

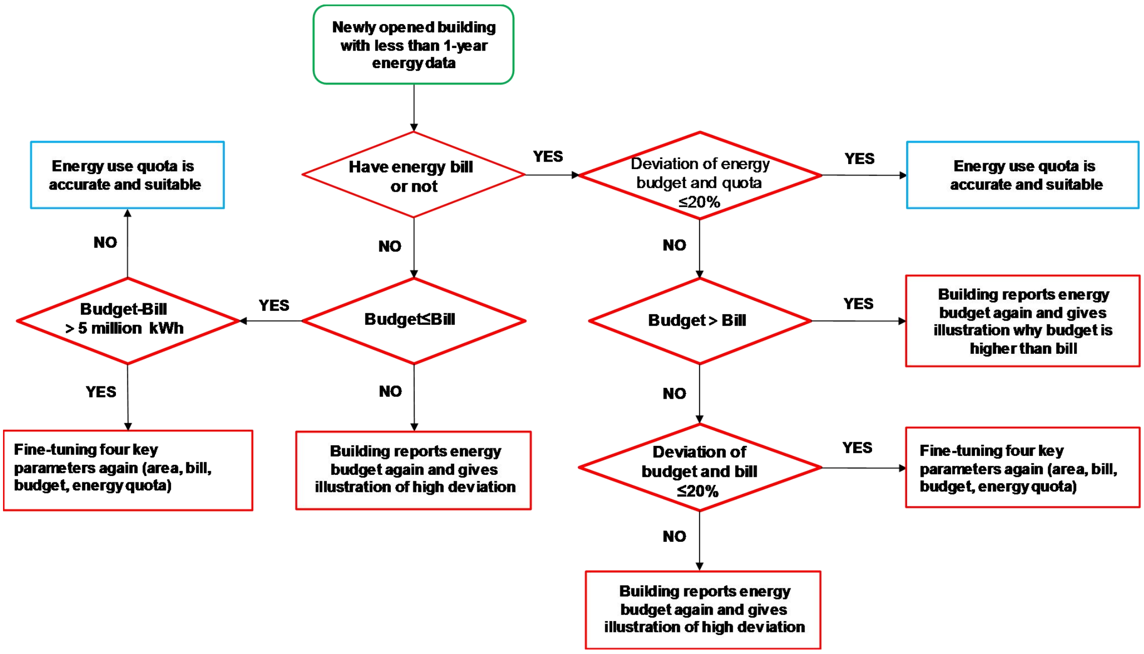

Figure 6. Logic diagram of energy quota determination for opened less than 1-year commercial building

Figure 6 reveals logical process suitable for commercial buildings opened within less than 1 year. If building has monthly energy bills and close to energy budget, then energy quota is suitable or need to be fine-tuned. If there is no energy bills or energy bill is away from budget and quota, then building needs to report further information for supportive or change the energy budget instead.

3.3.2. Empirical analysis of 2016 energy budget

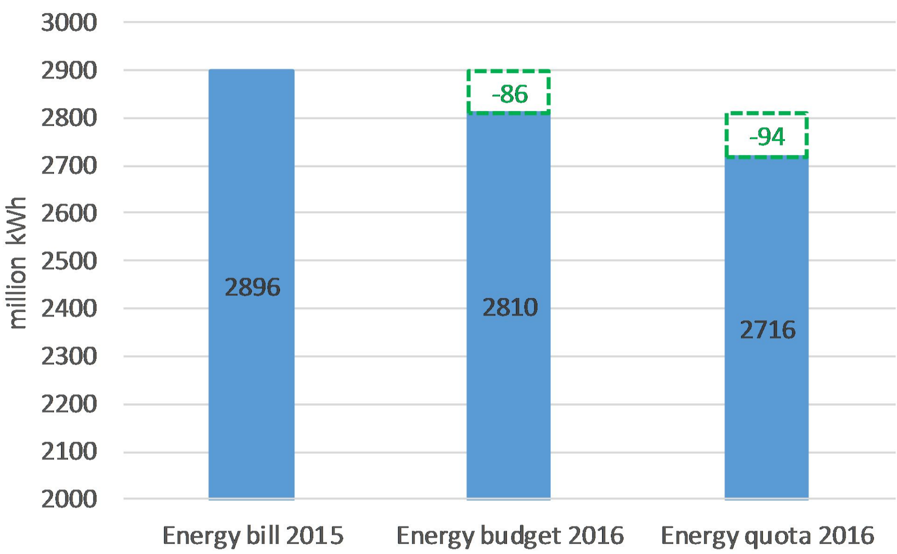

Figure 7. Comparison between energy bill 2015, energy budget 2016 and energy quota 2016

After applying practical quotas management approach, total energy budget of all sample commercial buildings in 2016 is 2810 million kWh, which is 3% energy saving compared to energy bill in 2015, as shown in Figure 7. If all building reaches energy quota 2716 million kWh in 2016, further 3.2% energy saving will be achieved. Hence, there is 180 million energy saving potential based on energy quota management in 2016, equals to 6.2% energy saving rate of actual energy use in 2015.

4. Conclusion

Energy consumption quota model, which considers a new concept of "Modified coefficient", considering weather, occupancy, business layout, operation schedule and HVAC efficiency, can be used for comparing and evaluating the performance of a large-scaled commercial building in China. The average energy use quota of shopping center is 159 kWh/(m^2.a) of severe cold climate zone, 179 kWh/(m^2.a) of cold zone, 188 kWh/(m^2.a) of hot summer and cold winter zone, and 200 kWh/(m^2.a) of hot summer and warm temperature zone. Phase- I of energy use quota management in this commercial building properties has successfully help building owners reducing 5%~12% annual budget approx.

However, because building energy use quota is analyzed based on historical data, if there is any wrong control logics or management problems caused energy waste, energy consumption quota will be inaccurate to some extent.

Besides, the phase-I study of energy use quota management doesn't consider the benchmarking with other properties EUI index in China, only compared within itself. The continued further study will collect a large number of commercial building samples with good energy metering data for benchmarking. In the upgraded Phase-II, historical energy data considering modified factor and benchmarking index compared with other properties will combined calculating energy use quota of each commercial building.

A. 1 Nomenclature Table

Symbol	Definition	Unit
EUI_{quota}	Annual electricity use quota per square meter	kWh/(m^2.a)
EUI_0	Annual actual electricity use per square meter	kWh/(m^2.a)
E_0	Annual actual electricity use	kWh
A_0	Business area, equals to total building area with subtraction of parking area and machine room space	m^2
α_1	weather modifying coefficient	-
α_2	occupancy modifying coefficient	-
α_3	business layout modifying coefficient	-
α_4	operation schedule modifying coefficient	-
α_5	HVAC system design efficiency modifying coefficient	-

i_{out}	outdoor enthalpy of sample building	$kJ/kg_{dry\text{-}air}$
i_{in}	indoor enthalpy of sample building	$kJ/kg_{dry\text{-}air}$
E_{HVAC}^{*}	adjusted HVAC energy consumption of sample building	kWh
E_{HVAC}	actual HVAC energy use of sample building	kWh
E_{Total}	total annual energy use of sample building	kWh
$E_{non-HVAC}$	annual other energy use except HVAC of sample building	kWh
x_1	daily cumulative passenger flow per unit area	$people/m^2/day$
y_1	daily actual electricity use of chiller per unit area	$Wh/m^2/day$
y_1^{*}	adjusted daily actual electricity use of chiller per unit area	$Wh/m^2/day$
x_2	business layout of sample building	-
y_2	cooling load based on the simulation regression formula under the standard business layout of sample building	W/m^2
$y_{40\%}$	cooling load based on the simulation regression formula under the standard business layout	W/m^2
H	actual annual operation hours of sample building	h/a
H_0	standard annual operation hours of buildings	h/a
$E_{Chiller\ Plant}^{*}$	adjusted chiller plant energy consumption of sample building	kWh
$E_{Terminals}^{*}$	adjusted HVAC terminal device energy consumption of sample building	kWh
$\overline{EER_0}$	Average Energy Efficiency Ratio: average chiller plant energy efficiency of the same climate zone compared to sample building	-
EER	Energy Efficiency Ratio: chiller plant energy efficiency of system of sample building	-
$\overline{ATF_0}$	average air transfer factor of the same climate zone compared to sample building	-
ATF	air transfer factor of sample building	-

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