Integration for daylight and electric lighting plays an important role for NZEB

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Integrated solutions for daylight and electric lighting in NZEB office building

In CABR NZEB office building, the integrated solutions for daylight and electric lighting have improved the luminous environment and achieved nearly 75% energy-saving rate.

The project

China Academy of Building Research Near Zero Energy Office Building is located in No.30, BeiSanHuanDong Road, Chaoyang district of Beijing. The building was officially put into use in 2014, and the certification target is 3-star level green building and LEED-NC platinum (Fig.1).

According to the principles “passive priority, active optimization, economical and practical”, this office building integrates advanced building technology, evaluating with actual data, as a demonstration for the development of ultra-low-energy buildings in China. This project is located at east longitude 116°20’, north latitude 39°56’, nearby BeiSanHuan road in Beijing (Fig.2). The north and northeast side of the office building is the high-rise office building of CABR, and the south side is the office building of institute of building fire research (Fig.3).

The first and second floors of the office building are significantly sheltered, and the third and fourth floors have good views and daylighting.

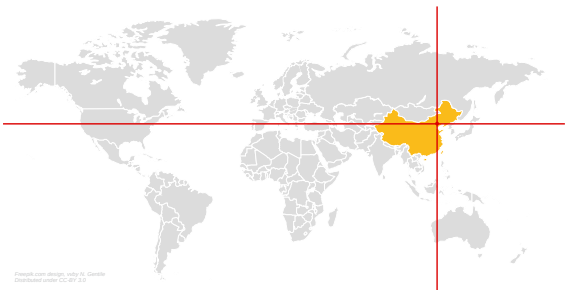
This 4-storey office building, with a total area of 3692 square meters, is mainly used for office and conference, hosting a staff of about 160 people.

Figure 1. China Academy of Building Research (CABR) in Beijing.

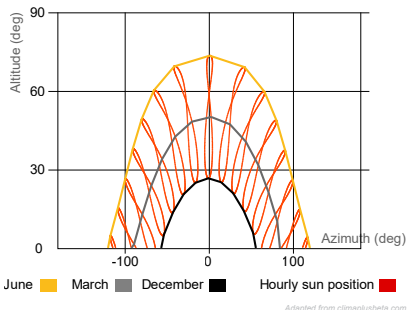
Daylighting and lighting solutions

Different daylight and electric lighting solutions are tested in the rooms of this building.

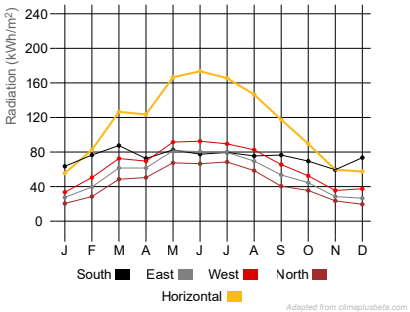
Horizontal blinds are used for sidelit windows. Compared with the traditional roller shade, the embedded horizontal blind has a better adjustment performance, which can make indoor illuminance more uniform and make full use



Location: Beijing, China
40.60,103.46



Sun path for
Beijing, China



Global horizontal and vertical radiation for
Beijing, China

IEA SHC Task 61 Subtask D
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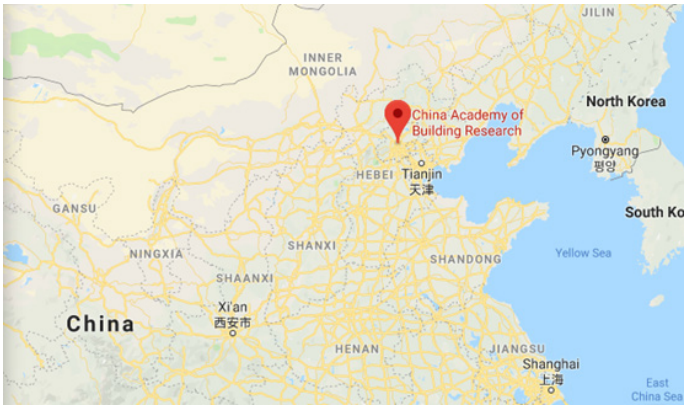

Figure 2. Location of CABR NZEB in the eastern part of China. Map data ©2019 Google

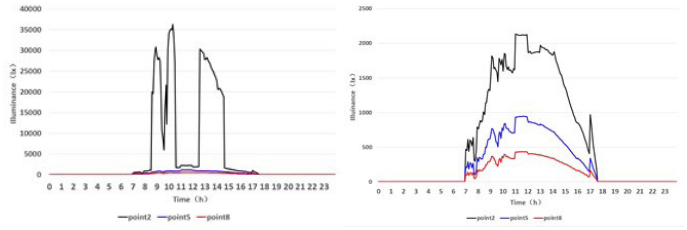

Figure 4. Measured illuminance (lux). Indoor illuminance distribution without blinds (left) and indoor illuminance distribution with embedded blinds (right)

Figure 5. The CABR conference rooms. On the ceiling, the tubolar daylighting system can be seen.

Figure 3. Sorroundings of the CABR nZEB building.

of daylight while avoiding glare, as shown in figure 4.

The conference room on the fourth floor of CABR demonstration building adopts an adjustable light pipe lighting system to ensure daylight and avoid excessive heat entering the room (Fig.5).

A total of 655 sets of high-efficiency energy-saving luminaires and 167 sensors of illuminance, infrared, mobile and so on are used in this project. The luminaires used in this demonstration building are all from Philips. Office general lighting adopts fluorescent grille with T5 fluorescent lamps and LEDs (for comparative analysis). In addition, corridors and public spaces adopt LED downlights. Detailed information are shown in Table 1.

Room 407 on the fourth floor adopts POE power supply technology with 8 sets of luminaires, which can realize centralized control and single luminaire control mode with mobile phone APP.

We carried out the optimization lighting design on the basis of choosing high-efficient luminaires, and under the premise of meeting the lighting requirements, the lighting installation power is reduced to achieve lighting energy saving. The illuminance distribution of typical rooms is provided in Figure 5.

Table 1. List of the luminaires installed in this case study.

	Luminaire type	Luminaire specification	Installation	Application area
1	Embedded fluorescent grating lamp	TBS737 2XEco TL5-25W HFE ETO	Embedded	Office
2	Embedded fluorescent grating lamp (light sensor)	TBS737 2XEco TL5-25W HFR 1-10V ETO	Embedded	Office by the window
3	Embedded LED luminaire	PowerBalance RC600B LED41S/840 W30L120 PSD	Embedded	Office, conference
4	Embedded LED luminaire(light sensor)	PowerBalance RC600B LED41S/840 W30L120 PSD + ACL	Embedded	Office by the window
5	Embedded LED luminaire	SmartPanel RC160V LED34S/ 840 PSD W30L120	Embedded	Reception room
6	Embedded LED luminaire	GreenPerform Troffer RC100C LED35S/840 PSD W30L120	Embedded	monitor room
7	Embedded LED downlight	LuxSpace BBS489 1000lm 4000K PSD-DALI	Embedded	conference
8	Embedded LED downlight	GreenSpace DN181B 1000lm 4000K	Embedded	Corridor, toilet
9	Embedded LED downlight	GreenSpace DN182B 1500lm 4000K	Embedded	Main entrance hall
10	LED ceiling light	Hengjie LED ceiling lamp	Surface mounted	staircase
11	LED batten luminaire	GreenPerform Batten BN208C LED40/ NW L1200 FR	Surface mounted	air-conditioning control room, storeroom

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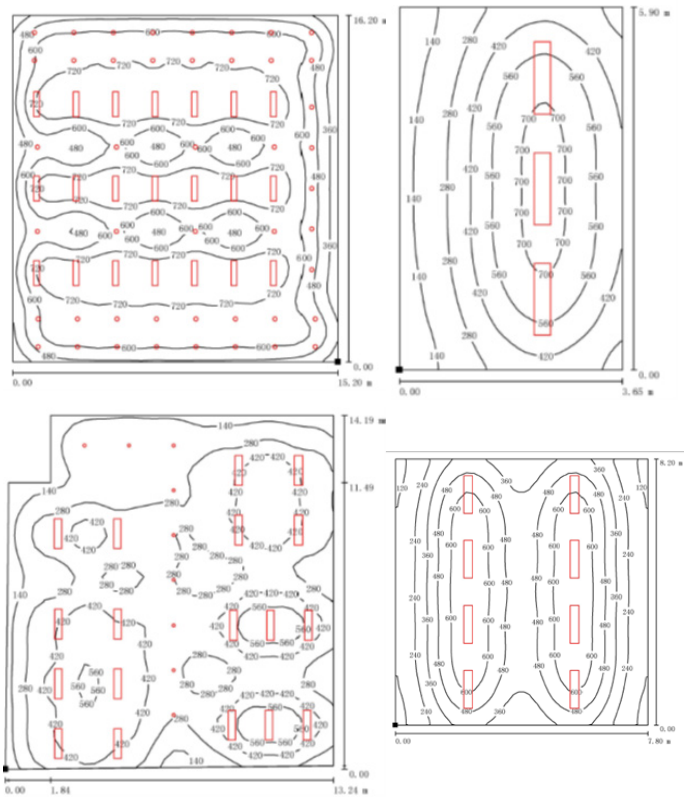

Figure 6. Distribution of artificial lighting illuminance (lux) for the following rooms: conference room at the fourth floor (top-left), reception at the second floor (top-right), open-plan office at the second floor (bottom-left), a private office (bottom-right).

Table 2. Measured average daylight factor (ADF), illuminance, and uniformity ratio (U_0) for the tubolar daylighting system without electric lighting. The outdoor illuminance was 500 lux during the test.

Mode	ADF (%)	Illuminance (lux)	U_0 (%)
Side window with Tubular Daylighting System	0.73	365	0.4
Tubular Daylighting System	0.61	305	0.3

The lighting control system adopts the intelligent lighting control system provided by Philips and Lutron, which includes absence sensing, dimming and other control methods. Luminaires near windows can adjust the light output according to the daylight and areas such as conference room, office and corridor are equipped with absence sensing so as to automatically turn off lights when people out. A variety of lighting modes are set up in conference room to reduce lighting energy consumption.

Monitoring

Energy

According to the actual test data, the annual lighting energy consumption is 6.15 kwh/m^{2}y.

Photometry

The daylight factor of conference on the fourth floor was

Table 3. Test results for the rooms in CABR.

Room	Room type	Light source	Parameters	Lighting standard value	Measured value
401	Conference room (major)	LED	E_h (lux)	300	603
			U_0 (%)	0.6	0.74
			CCT (K)	4000	4048
			CRI	$R_a \geq 80$	83.2
				$R_9 > 0$	22
			LPD (W/m^2)	9	5.7
213	Open plan office	T5 lamps	E_h (lux)	300	448
			U_0 (%)	0.6	0.74
			CCT (K)	3300-5300	4212
			CRI	$R_a \geq 80$	80.6
			LPD (W/m^2)	9	7.9
412	Private office	T5 lamps	E_h (lux)	500	631
			U_0 (%)	0.6	0.84
			CCT (K)	3300-5300	4212
			CRI	$R_a \geq 80$	80.6
			LPD (W/m^2)	15	10.6
311	Private office	LED	E_h (lux)	500	768
			U_0 (%)	0.6	0.67
			CCT (K)	4000	4048
			CRI	$R_a \geq 80$	83.2
				$R_9 > 0$	22
			LPD (W/m^2)	15	5.3
319	Open plan office	LED	E_h (lux)	300	832
			U_0 (%)	0.6	0.8
			CCT (K)	4000	4048
			CRI	$R_a \geq 80$	83.2
				$R_9 > 0$	22
			LPD (W/m^2)	9	5.5
	Video conference room	LED	E_h (lux)	750	1108
			U_0 (%)	0.6	0.6
			CCT (K)	4000	4048
			CRI	$R_a \geq 80$	83.2
				$R_9 > 0$	22
			LPD (W/m^2)	-	5.2
	Entrance hall	LED	E_h (lux)	200	404
			U_0 (%)	0.60	0.67
			CCT (K)	-	3990
			CRI	$R_a \geq 80$	84.6
				$R_9 > 0$	23
			LPD (W/m^2)	-	3.9
	Corridor	LED	E_h (lux)	100	162
			U_0 (%)	0.60	0.94
			CCT (K)	-	3990
			CRI	$R_a \geq 80$	84.6
				$R_9 > 0$	23
			LPD (W/m^2)	-	3.9

test, as shown in Table 2. The actual test results of the light environment of typical rooms in this demonstration building are shown in Table 3. The actual lighting effect is shown in Figures 7, 8, and 9.

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Figure 7. Lighting environment for a private office equipped with LED panels. Electric lighting set to 100% output (left) and 50% dimming (right).

Figure 8. Lighting environment of the open-plan office (LED)

Circadian potential

All the offices are daylit spaces, providing plenty natural light to the staffs. To our experience, daylight can provide a sufficient circadian stimulus.

User perspective

Survey questionnaires on the luminous environment for the staffs were proposed. According to the survey results, more than 85% people expressed satisfaction or great satisfaction in general. More than 90% are satisfied with the automatedcurtains. The staff showed appreciation for the daylight, which makes them more active and happier.

Lessons learned

Daylight plays an important role in offices, and it's also the key factor for energy-saving. Based on good daylighting design and control, the energy-saving rate could reach 75%, compared to the Chinese lighting design standards.

In this project, fluorescent lights are also used in some areas, in order to do a comparative study. LED lighting is more efficient than other sources, combined with intelligent control, and integrated with daylight, the lighting energy consumption of the project could be less than 5 kWh/m^{2}y if all LED lights are used, based on the simulation results.

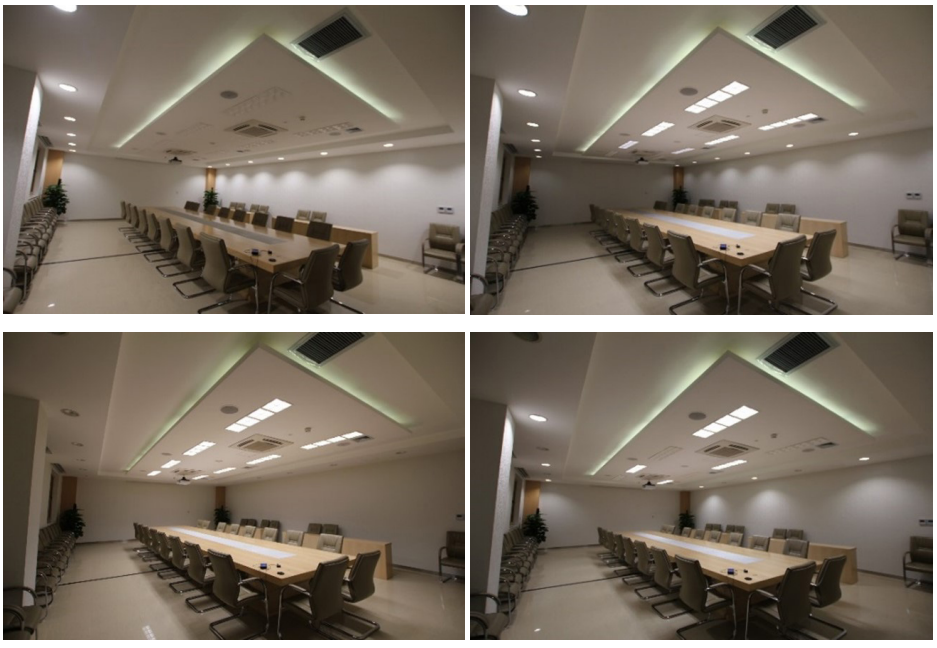

Figure 9. Lighting environment for different scene settings (or "modes") in the video conference room equipped with LED.

Further information

http://www.chinaibee.com/

Acknowledgements

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Support on site: www.chinaibee.com