INTEGRALNI I ODRŽIVI PRISTUP PROJEKTOVANJU U ZGRADARSTVU – IDEJNO REŠENJE OBJEKTA JAVNE UPRAVE U PEKINGU

INTEGRATED SUSTAINABLE BUILDING DESIGN – CONCEPTUAL SOLUTION OF A MUNICIPAL GOVERNMENT BUILDING IN BEIJING

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Jedno od ključnih pitanja XXI veka jeste očuvanje kvaliteta životne sredine. Iako su veliki uspesi postignuti u polju čistih izvora energije, kontrola i maksimalno smanjenje potrošnje energije je od velikog značaja. Ova studija se bavi pitanjima u okviru projekta za objekat javne uprave visoke efikasnosti koji je lociran u Pekingu, Kina. Rad proučava sve aspekte integralnog projektovanja modernih zgrada, sa ciljem niske potrošnje energije i kvaliteta unutrašnje sredine. Kroz proces integrisanog dizajna promenjene su adekvatne mere vezane objekat ove vrste i njegovu lokaciju, dok se implementacije vršila na osnovu njihovih prednosti i nedostataka. Rezultati dobijeni kombinovanjem ovih mera ukazuju na njihov značaj, i u saglasnosti su sa LEED standardom koji se koristi za projektovanja zgrada. Studija ukazuje na značaj primene integralnog pristupa projektovanju zgrada kako bi se umanjio njihov negativan uticaj na životnu sredinu.

Ključne reči: *životna sredina; održivi razvoj*

One of the most important issues of the 21st century is the preservation of the environment and its quality. While great efforts have been made regarding clean energy sources, it is crucial for us to monitor and minimize our energy consumption. This paper tackles these issues in a framework of a high efficiency municipal building located in Beijing, China. Research explores all the aspects of intelligent building design, with the goal of low energy consumption and better indoor environmental quality. Through the process of integrated building design many techniques have been tested and applied, relative to their benefits and drawbacks. The results produced by the combination of these techniques indicate their significance and are in compliance with the LEED standard used for building design. The paper shows the importance of adapting integrated building design for lowering their negative impact on the environment.

Key words: *environment; sustainable developmen*

1 Introduction

1.1 Project goals

The goal of the project was to create sustainable and highly efficient municipal building with a low environmental impact through integrated building design. This includes a tendency for low energy consumption approaching "Net Zero Energy" and reduction of CO_2 emission, while also taking into account the high level of comfort required in a modern building. LEED Rating System served as guidance for achieving desired sustainability. Several other projects [3], [13] were thoroughly analyzed in search for innovative solutions. The building is to be used as a municipal center in Beijing.

1.2 Techniques for accomplishing goals

- High performance Envelope design
- HVAC system
- Luminance level controlled lighting
- Use of Photovoltaic panels
- Use of PCM (Phase change materials) in envelope

1.3 Standards used for compliance

- ASHRAE Standard 189.1 2014
- ASHRAE Standard 90.1-2013 (I-P)
- ASHRAE Standard 62.1-2013
- ASHRAE Standard 55
- ASHRAE Handbook HVAC Applications 2011
- LEED v4

2 Architectural report

Beijing, the capital of People's Republic of China, one of the largest cities in the world, a place where tradition meets modern day culture. This complex and beautiful environment was the setting for our project.

2.1 Site and Accessibility

In the northern part of the city lies the *Huayuan Road District*. Mainly residential, but also containing a large number of commercial buildings along the main streets and avenues, on one of which we have chosen a site for our building (Figure 1). The site is located on the Jian'an Road, one of the largest ring roads that surround Beijing. It is a high frequency location and a suitable location for a municipal government building.

Just north of the site lies the Olympics village constructed during the Olympics 2008. This means the site is accessible and easy to navigate to. Accessibility is defined by the number of subway stations and bus lines surrounding the site. Also the main roads contain cycling lanes**,** which contribute to the accessibility.

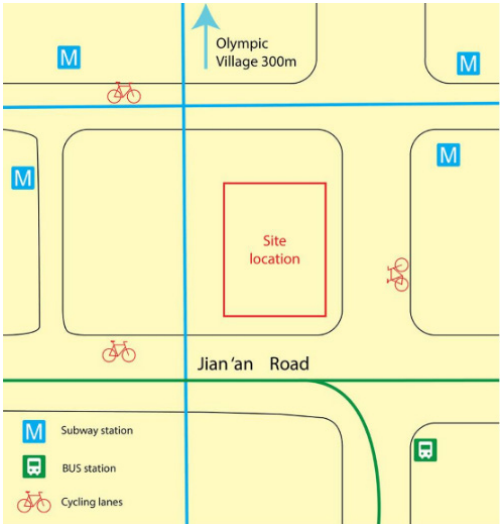

Figure 1 – Site Location

2.2 Concept

The idea was to design an inviting structure, housing an important city attribute, a Municipal Government Building.

2.3 The Building design

The building design was guided by the location itself, while keeping in mind the usage of space that it provides. Its main long axis runs North-South, and the short axis from the East to the West following the orientation of the Beijing street grid. This was used to define the areas of the facade, to be or not to be transparent, taking into account the benefits of the suns energy and the beauty of daylight.

Figure 2 - The building design

The whole southern, and part of the eastern facade are tilted towards the ground, forming a 71 degree angle with the horizontal plane (Figure 2). This was done to minimize the entrance of sun's rays during the summer months, but also allowing the rays to enter the building during the winter months, thus not overheating the space in the summer, and heating it up during the winter. Another example of application of tilted facade is to be found at Federal Center South, the building which is certified LEED platinum and is in top 1% of the most energy-efficient office buildings in entire USA [12].

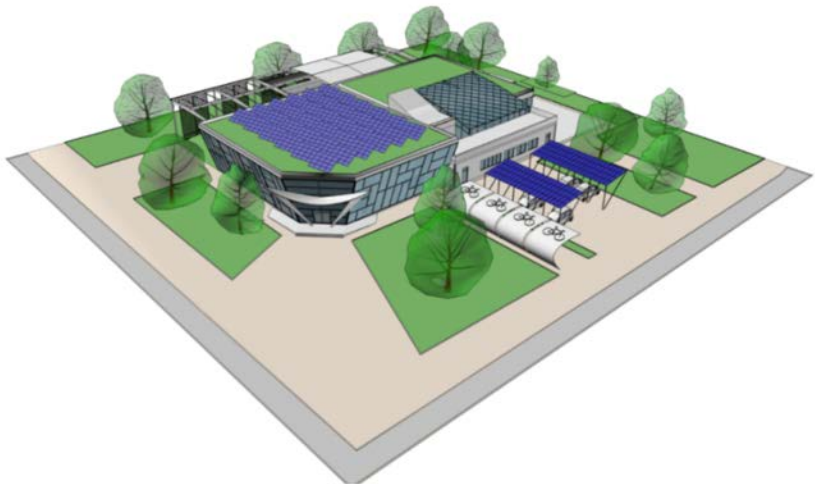

Figure 3 - Building exterior

As described, one of the goals was to create an inviting structure, thus the large number of entrances. The idea was to place a main entrance used by everybody who wanted to enter the space, this entrance is located on the south eastern side facing the street corner. The street corner is the busiest place on a street, a high profile space (Figure 3). There is one more entrance to the building, intended to be used by the people working in it.

The architectural aspect of the building was simple. Providing the municipal government building with all of the required rooms and spaces, but also adding some features, like the skylight atrium for the office space and large glass facades for the common grounds, which contribute to the work environment comfort (Figure 4).

The climate of Beijing is clearly of the continental monsoon type and is classified as Mixed-Humid (4A) with relatively dry and cold winters and humid, warm summers. For obtaining psychrometric chart of Beijing's climate we used *Climate Consultant 6.0* software only for working hours (6a.m.-6p.m.). Necessary HVAC and architectural design strategies for providing maximal comfort are listed on the chart.

Figure 4 - Building interior

3 Beijing's climate and geothermal potential

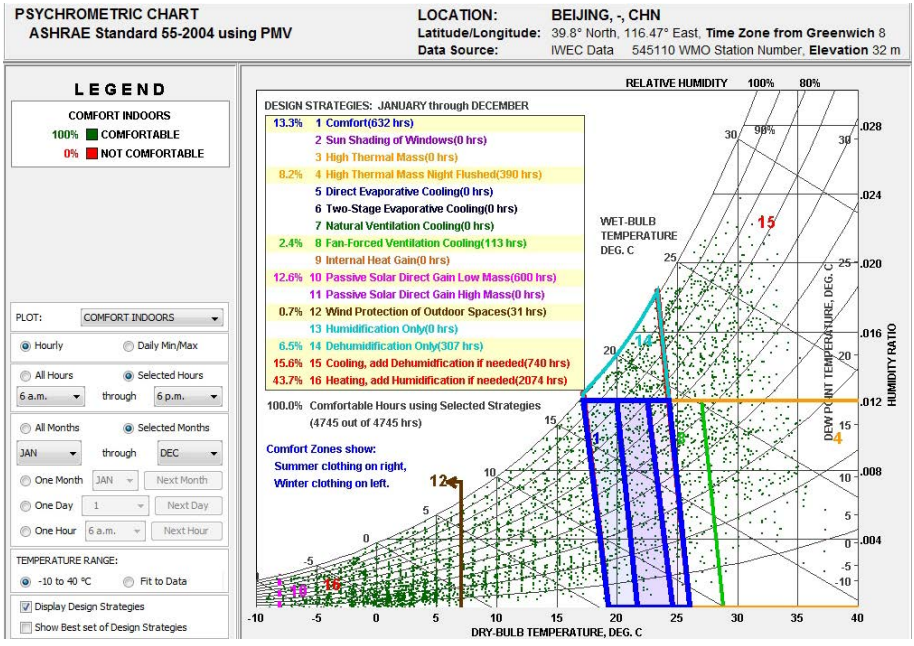

Figure 5 - Psychometric Chart for Beijing

3.1 *Geothermal energy potential of Beijing*

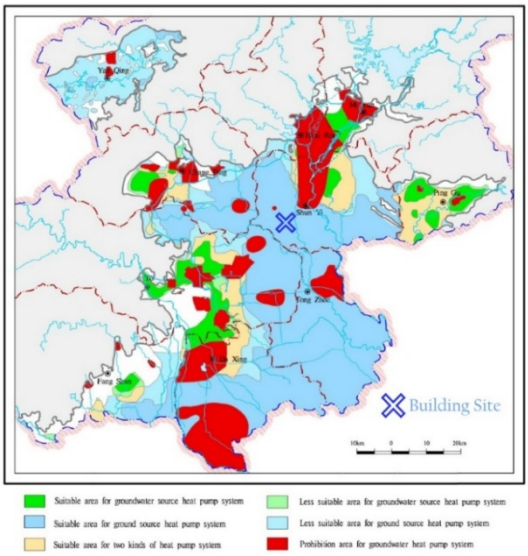

Figure 6 - Beijing Geothermal potential map [1]

There is a rapid growth in usage of geothermal energy for HVAC purposes. The application area of ground source heat pump projects has an annual growth rate of over 150% in recent years. Particularly in Beijing, total heating power of more than 1000MWt was installed by year 2009 and kept growing. [1], [2]. According to several Reuters articles from 2012, most of the Olympic sport facilities with installed Ground Source Hat Pumps are out of use [4] (e.g. Beijing Olympic Forest Park, circa 140kW, Football court "Bird's Nest", Olympic tennis courts and Olympic Badminton and Gymnastics Hall).

4 Mechanical Systems Design

4.1 *Building Envelope and Thermal Loads*

Envelope was designed to exceed standard requirements thus increasing building's overall performance. U-value criteria was used for envelope elements selection and no trade-offs were made regarding U-values of envelope constructions.

Additional attention was paid to selection of recyclable materials. The thermal batt insulation for steel frame cavity is produced from up to 90% recycled plastic PE bottles and is 100% recyclable, resistant to mold, zero ozone depleting potential and zero global warming potential. Metal framed walls are also recyclable, easier for assembly and cheaper for transport.

Table 1 - Comparison between ASHRAE 90.1-2013 baseline and final proposed envelope

Construction	Type	*U-Value* [W/m^{2}°C]	
		ASHRAE 90.1-2013 requirement	Proposed case
Exterior wall	Steel Framed	0,327	0,195
Exterior Window (fixed)	Triple glazed with argon with low E coating, steel framed window	2,15	0,785
Skylight	Triple pane low E	2,84	0,3
Roof	IEAD roof	0,164	0,108
Floor (Mass)	Heavy concrete, foam board insulation	0,291	0,2

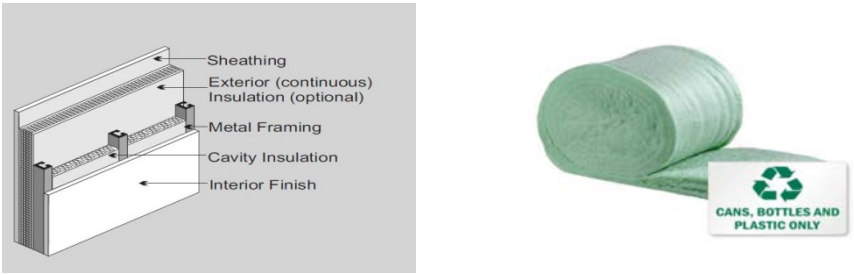

Figure 7 - Steel framed walls and recycled PE insulation

Raised floor have air barriers which increase the R-value of these constructions. Vegetated surfaces and PV panels are roof-installed features which increase its R-value. The skylight and its triple pane glazing have two low-E coatings and U-value of 0.3 W/m^{2}°C, so it minimally affects overall roof insulation performance.

4.1.1 Thermal Loads

Thermal loads (heating/cooling loads) were determined according to the ASHRAE Handbook [5] and ASHRAE Standard 90.1 2013 [6] in order to conduct adequate system selection for maintaining thermal comfort. Software used for building energy simulation is *Sketchup* plugin *OpenStudio* with *EnergyPlus* engine. Ideal air load simulation was done using weather file for Beijing for two cases:

1. ASHRAE 90.1 2013 baseline envelope with Window-Wall Ratio of 40% without skylight
2. Proposed improved envelope with skylight and described fenestration

The loads comparison is given in Table 2.

Table 2 – Ideal Air Loads comparison for baseline envelope and proposed case envelope

Envelope	Proposed Envelope		ASHRAE 90.1 2013 Baseline Envelope	
Month	Cooling Load (KWh)	Heating Load (kWh)	Cooling Load (KWh)	Heating Load (kWh)
Jan	1,0	14,6	0,0	42,6
Feb	2,3	7,0	0,0	25,5
Mar	4,8	2,2	0,0	11,4
Apr	8,5	0,6	1,1	2,9
May	13,9	0,1	5,2	0,4
June	21,4	0,0	12,7	0,0
July	25,4	0,0	19,1	0,0
Aug	23,3	0,0	16,4	0,0
Sept	15,6	0,1	6,5	0,3
Oct	7,8	0,8	0,8	4,0
Nov	2,4	4,8	0,0	18,7
Dec	1,1	10,4	0,0	33,9
Annual	127,5	40,8	61,8	139,8
Total	168,3		201,6	

Improved envelope makes savings of 17%. Window-Wall Ratios of southern, western and eastern side of the façade are 100%, 70% and 60% respectively, increasing the amount of sunlight for illumination of working space. Northern façade was designed without fenestration to reduce conduction heat losses during winter, but the skylight was added on the northern open office, illuminating all the spaces in the northern part of the building and contributing to the heat loss reduction through solar radiation heat gains during winter. The overall Window-Wall Ratio is slightly over 65%.

4.2 Thermal Environmental Conditions for Human Occupancy

4.2.1 Indoor air quality

Summing up the air pollution situation, natural ventilation is disabled by installing fixed windows in the whole building. A two stage air filter system is responsible for dealing with various contamination levels. When contamination level is

lower, the inlet airstream passes through the standard filter set consisting of a set of medium filters with MERV 13 categorization by ASHRAE 52.2 [7]. This filter set causes lower pressure drop, while combined with UV lights and ionic cleaning provides properly purified air. When contamination ratio reaches critical levels, the airstream is bypassed to the advanced air purifier which consists of MERV 16 certified F-class filter which is fairly widespread in Beijing.

4.2.2 Under Floor Air Distribution

The Under Floor Air Distribution is sophisticated and elegant solution and meet the demands set by standards ASHRAE 189 [8], ASHRAE 55 [9] and ASHRAE 62.1 [10]. The Under Floor Air Distribution provides isothermal environment in the occupied zone, which is also confirmed by the E_Z = 1.0 (air distribution effectiveness). Therefore, warmer air and products of exhaled air take place in upper-ceiling area. This process of stratification has beneficial effects on thermal comfort of the occupants [11]. Furthermore, there is no need for high air inlet speeds and uncomfortably low inlet temperatures, because of the diffusers' displacement density. Air is ducted to the space through swirl diffusers in the inner part of the rooms and through in floor active chilled beams (Figure 8). Supply air covers designed sensible and latent loads while chilled beams cover additional solar heat gains.

Figure 8 - Under Floor Air Distribution

4.2.3 CFD analysis report

A CFD analysis in Design Builder software showed that the temperatures for desired thermal comfort in the occupied zone can be maintained with Dedicated Outdoor Air System supplying the minimum necessary outdoor air to all spaces except atrium, where a 6% increase of the minimal flow rate maintains the conditions within the specified limits. In this way, both sensible and latent loads are covered without additional systems.

The atrium with skyline and a common small office were taken as representative examples of spaces to preview the air stream lines and temperature zones formed by the Under Floor Air Distribution system. Cooling supply air temperature is 19˚C and air flow equals to space air flow divided by number of diffusers installed in room. Active chilled beams were excluded from the analysis.

Flow pattern, shown on the CFD analysis reports is achieved with passive swirl diffusers (Figure 9*)* that have a manual adjustment of the supply jet directions.

Manual adjustment means that the occupants can change the angle of the inlet air stream to avoid draft in their exact location in the conditioned space.

Figure 9 - Swirl diffuser

The CFD analysis was performed on the 0-degree position (straight up), so the final flow pattern may change depending on personal adjustments of the diffusers. This layout of the air inlet and outlet diffusors, adapted to the size of the space is used in most of the offices, conference rooms, etc. to ensure the right comfort conditions in the occupied zone.

The corridor surrounding the atrium space on the first floor shares the same air space with the atrium, therefore it's necessary to maintain a higher pressure in the corridor, to prevent the warmer and used air from the upper layers of the atrium to get into the corridor.

4.2.4 Small Offices

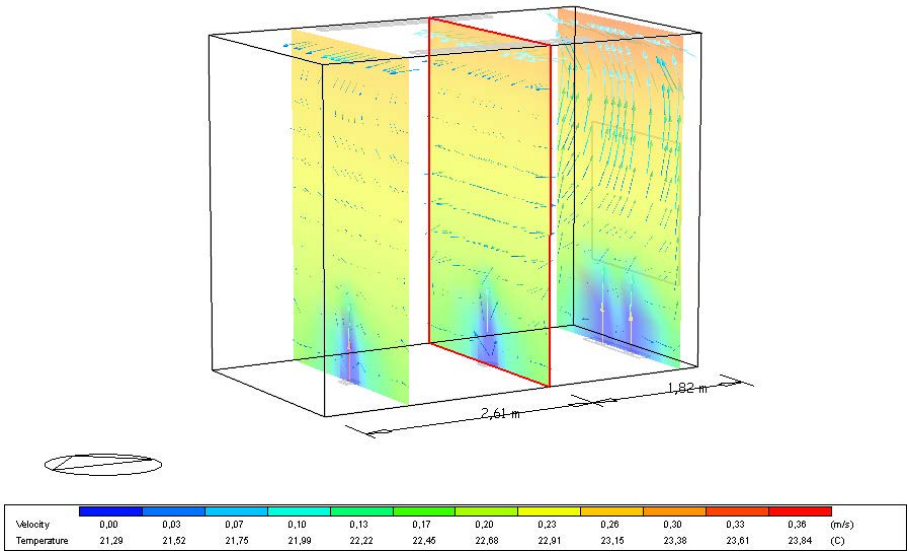

Figure 10 - Small Office CFD

Figure 10 shows temperatures and air velocity vectors in common small office. Air mixing achieved with this type of air distribution is obviously satisfying. In addition, it's proved that we could maintain the comfort needs with a 50% lower flow rate, using the Under Floor Air Distribution system and two lengthwise placed air extractors.

4.2.5 Atrium

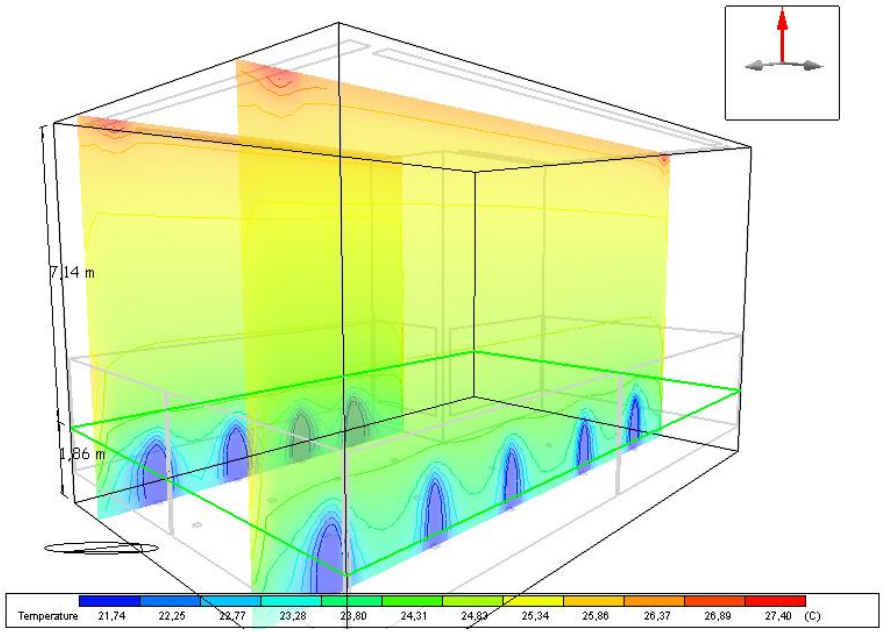

Figure 11 - Atrium CFD

The atrium (Figure 11) is a considerably large space because of its height of 9 meters. The air outlet diffusors are installed in 1st floor ceiling because of the atrium's interior layout. Detailed analysis in the atrium showed that the calculated flow rate of $v = 0{,}648\, m^3/sec$ was not sufficient to maintain the required thermal conditions in the room, but an increase in total airflow of 6% was necssary to meet required conditions.

4.2.6 HVAC System

The HVAC system is in charge of reaching and maintaining designed thermal conditions in the building during the occupied hours (21/23˚C and 55% RH). Dedicated Outdoor Air System with heat recovery equipment is used to constantly provide 100% freshly treated outdoor air to the occupants whilst recovering sensible heat from the return air with heat recovery wheel (Figure 12). The ventilation calculations have shown that the peak air flow rate through the AHU is 14.5 m^3/sec. In floor water cooled active chilled beams (IACB) integrated in raised floor cover additional solar heat gains. Water is cooled by the ground source heat pump.

4.2.7 Ground Source Heat Pump system

The Ground Source Heat Pump system (GSHP) consists of 4 identical heat pumps and each of them has heating/cooling capacity of 40kW. The example of

similar project [13] was studied and adopted in terms of connecting GSHPs, so they are connected in series and start up sequentially depending of the load.

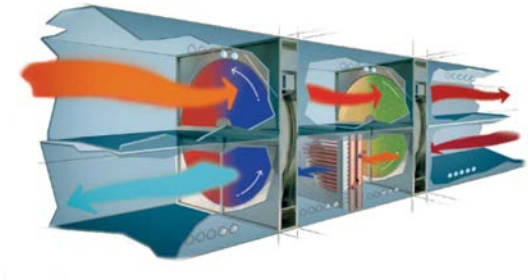

Figure 12 - DOAS Heat Recovery

Figure 13 – Vertically drilled holes

An example from Case Study [1] was taken as reference for borehole disposition and depth assessment:

We see an example for #2 game hall in the Olympic tennis courts located in Beijing Olympic Forest Park. GHP was used for summer cooling and winter space heating. 35 holes were drilled to 100 m depth with diameter Ø150mm. They are in a 7m×7m layout. Double U pipes of PE material were installed in the holes for heat exchange. The GHP unit has 138.2 kW heating capacity (input power 37.5 kW) and 139.6 kW cooling capacity (input power 32 kW).

Table 3 – Installed Heat Pumps

System	Heat exchanger type	Power	COP
Heat pump	Vertically drilled bore-holes	4x40 kW/piece	4.8

The number of 42 vertically bored holes (Figure13) was determined proportionally to the example, whereas the diameter of Ø150mm and depth of 100m remained the same as in *Beijing Olympic Forest Park*, and the layout was increased to 10m×10m, placed on the northern side of the site. The Ground Source Heat Pump system and HVAC system are situated in the basement. All the pumps are steered by a CPU cascade control system, so only one heat pumps works on low demand and all of them work on peak demand.

Arguments in favor of selecting Ground Source Heat Pump system:

- ✓ Building Site is suitable for both ground- and groundwater source heat pumps systems,

- ✓ Several Ground Source Heat Pump with total nominal power of approximately 150 kW would cover both heating and cooling peak loads, and serve as spare service water heater,
- ✓ Conditions in most thermal zones are similar, this means all zones can by treated by the same HVAC system
- ✓ If combined with PV panels, the CO_2 emission would be reduced to a considerable extent, giving possibility for Greenhouse Gases reduction incomes in following years of system utilization.

4.3 Lighting

4.3.1 Interior lighting

Lighting types were selected with tendency to fit into interior while meeting illumination level for specific spaces and minimizing electricity consumption.

According to Building Area Method-Table 9.5.1. ASHRAE 90.1-2013, Lighting Power Density (LPD) for office space type is 0.82 W/ft^2 (10.8 W/m^2), which amounts up to 27620 W when multiplied with total building area of 2566 m^2. When compared to the standard's baseline, selected lighting system decreases electricity demand by 53%. Table 4 shows selected illumination level, lights and installed power.

Table 4 - Lighting levels and selected lighting

Space type	[lux]	Lighting type	Luminous Flux [Lumen]	Power [W]	Area [m^2]	Number of lights	Installed power [W]
Open / Enclosed office	500	600x600mm dimmable LED panel	3300	48	950	143	6864
Conference room / Classroom / Break Room	300				573	52	2496
Exhibition Hall	400				283	34	1632
Entrance / Lobbies / Corridors	200	300x300mm dimmable LED panel	700	10	634	181	1810
Restrooms / Mechanical Room	200				128	36	360
Total installed power [W]							13162

4.3.2 Lighting control

Different types of sensors and controllers are to be installed in areas with different occupancies in order to use minimal energy needed for meeting required illumination level (Figure 14).

Figure 14 - Lighting control equipment

However, all the interior lights should have scheduled shutoff during non-working hours with override for eventual overtime hours of work.

4.3.3 Lighting level control

Lights in large spaces on the perimeter and atrium have automatic responsive controls for sidelighting and toplighting respectively, due to its exposure to sunlight of various intensity. The lights in Primary and Secondary Daylighted Areas will be continuously controlled with dimmers.

Occupancy control

Spaces of relatively smaller area and rather discrete occupancy profiles such as enclosed offices, restrooms, classrooms, meeting rooms and emergency vehicle garage will have ceiling mounted occupant sensing devices that shut off lights after the space is unoccupied longer than 10 minutes.

4.4 Photovoltaic System

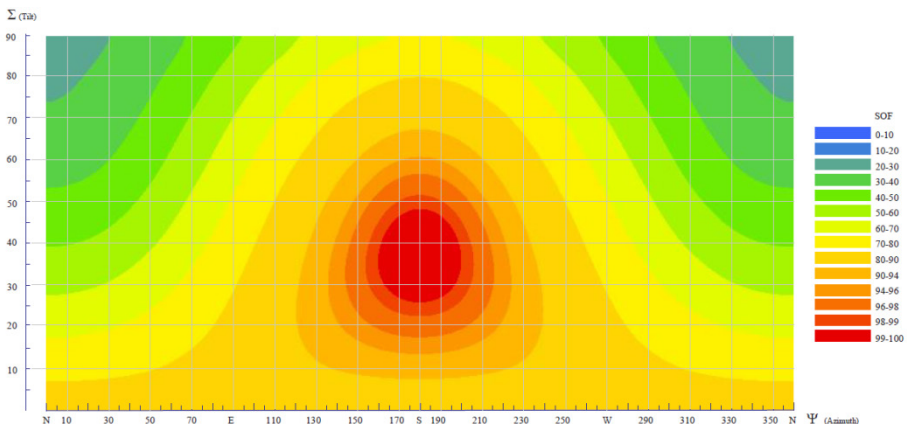

Figure 15 – Sky cover and solar elevation

Beijing sky is rather cloudy during summer months than it is during winter months (Figure 15). This means that the electricity production by PV roof mounted panels is equalized throughout the year, making better balance in electricity power demand from network. The solar elevation never exceeds 75˚ in Beijing, so the tilt angle of PV panels should be sloped to increase the irradiated surface.

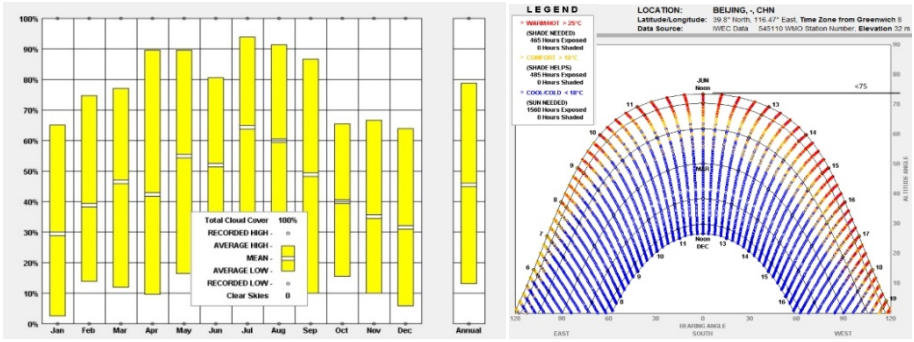

Figure 16 - Optimal PV panels orientation

Calculation conducted in *Skelion Sketchup* extension showed that the optimal orientation of PV panels is as previewed in Figure 16. The panels are fixed, lined up in rows and orientated according to the optimal azimuth. The distance between two rows is set to avoid shading on 21st December at 12h.

Table 5 – Electricity production by PV panels

Location: Beijing / CHN		PV panels orientation:	
Latitude:	39,9765	Azimuth:172˚ Tilt:37˚	
Longitude:	116,3952	Nominal Power: 230W	
Month	*Em* [kWh/month]	Month	*Em* [kWh/month]
Jan	3898	Jul	4121
Feb	3839	Aug	4110
Mar	4800	Sep	4576
Apr	4830	Oct	4200
May	4951	Nov	3444
Jun	4569	Dec	3608
Total energy [kWh/year]		50946	

The building has unobstructed view of the sky with no neighbor building throwing shadow on it. That increases its potential for electricity production remarkably. Total number of 153 PV panels (230W each) with total nominal power of 35.2kW is installed on the rooftop. Shading losses are estimated to be up to 0.35%. Estimated annual electricity production is nearly 51MWh per year which represents over 23% of annual electricity consumption.

4.5 PCM material in floor

Southern, western and eastern side of the building have large fenestrated surfaces. Despite triple glazing windows with low-e coatings the biggest deal of cooling loads origins from solar transmitted energy through windows/curtain walls. PCM panels (60x60cm) are installed in floor surfaces which receive most of the direct sunlight (perimeter spaces and atrium) to reduce the impact of the solar transmitted energy and to minimize the cooling peak loads during summer days. They are able to absorb excessive amounts of heat, and activate at temperature range of 22-24˚C with approximate heat absorption capacity of 155 kJ/panel.

Temperatures of floor are previewed in Figure 17. Floor surfaces with temperatures higher than mean room air temperature represent additional heat source in rooms and transfer additional heat to the room air, also affecting the air in underfloor plenum.

EnergyPlus simulation (without PCM floors) shows window transmitted beam solar radiation rates and temperatures of certain floor surfaces exposed to direct sunlight.

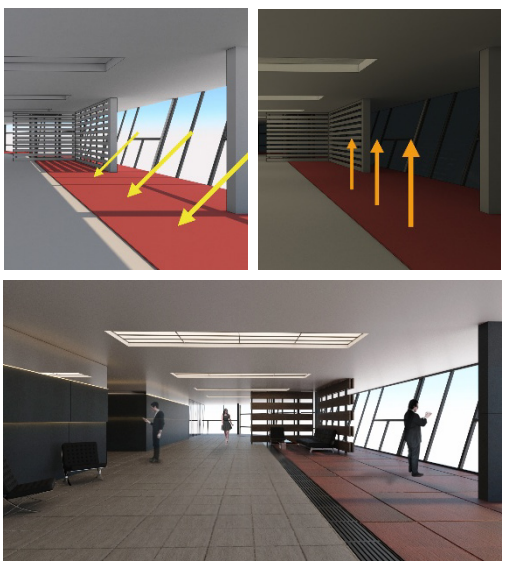

Figure 17 – floor temperatures at 12h on 21st July

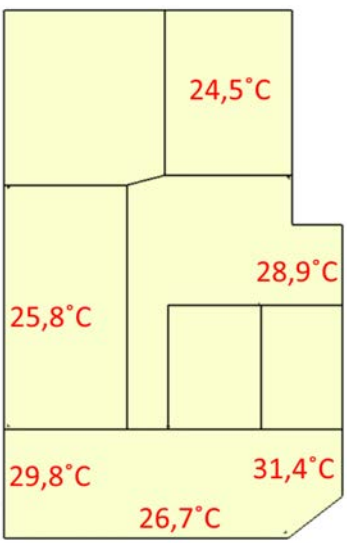

Figure 18 – PCM floor panels

Table shows solar beam radiation energy transmitted through windows (for 21st July) and total heat capacity of PCM floor panels if they were arrayed alongside the curtain walls in 3 or 4 rows stretching to 1,8m or 2,4m inside the space area. Depending on the area covered by PCM panels, heat capacity of the floors range from 15% to 49% of the direct solar radiation energy transmitted through fenestration.

During the day the heat is absorbed and released during night hours, as depicted on Figure 18. This feature could offset cooling peaks during summer, but also help maintaining setback temperature during winter nights. Besides above mentioned, constant floor temperature contributes to the uniform temperature interior surfaces and reduces interior heat exchange through radiation, thereby increasing human comfort.

Table 6 – Heat capacity of PCM floor panels compared with heat gains from direct solar radiation

				Capacity (kJ)		% absorbed	
	Peak hours window transmitted beam solar radiation energy (kJ)	Length (m)	Number of tiles	3 rows	4 rows	3 rows	4 rows
East Ground Floor	94967	18,00	30	13950	18600	14,7	19,6
East 1st Floor	93850	18,00	30	13950	18600	14,9	19,8
Exhibition Hall	97420	47,00	78	36270	48360	37,2	49,6
West Ground Floor	91204	22,50	37	17205	22940	18,9	25,2
West 1st Floor	92100	22,50	37	17205	22940	18,7	24,9
South Ground Floor	98540	47,00	78	36270	48360	36,8	49,1

4.6 Conclusion

Integrated design contributed to the creation of a modern, energy efficient and LEED certified administrative building with annual (electrical) energy consumption per area of 83,5 kWh/m^2, with 17% decrease of thermal loads achieved with high performance building envelope, and 23% electricity needs covered by PV panels. Installed lighting power is initially reduced by 53% through lights selection based on illumination level. Minimizing electricity consumption of installed lighting is achieved with continuously controlled light dimmers.

Acceptable thermal comfort and air quality are achieved with adequate air filters and underfloor air distribution as verified by CFD analysis. Table 7 and Figure 19 present energy consumption and peak power demand respectively for each month.

Table 7 - Energy consumption

Energy consumption [kWh]	Month	Heating Loads	Cooling Loads	Interior Lighting	Misceleanious Equipment	Fans	Pumps	Humidification	Cooling Peak Load/Area W/m^2	Heating Peak Load/Area W/m^2	Total Annual Load/Area kWh/m^2
	Jan	14643	0	1688	5032	611	1600	378	55,2	57,9	83,5
	Feb	9954	0	1329	4565	436	1600	341			
	Mar	2676	415	1257	5129	440	1600	376			
	Apr	431	3406	1051	4765	355	1600	365			
	May	0	9759	1119	5129	296	1600	347			
	Jun	0	12780	964	4941	295	1600	305			
	Jul	0	14264	1056	4953	307	1600	316			
	Aug	0	13972	1197	5129	303	1600	294			
	Sep	30	7543	1182	4863	364	1600	295			
	Oct	814	337	1436	5032	463	1600	362			
	Nov	5614	0	1624	4941	429	1600	364			
	Dec	14435	0	1690	4953	495	1600	377			
	Annually	48597	62476	15592	59432	4794	19200	4120			

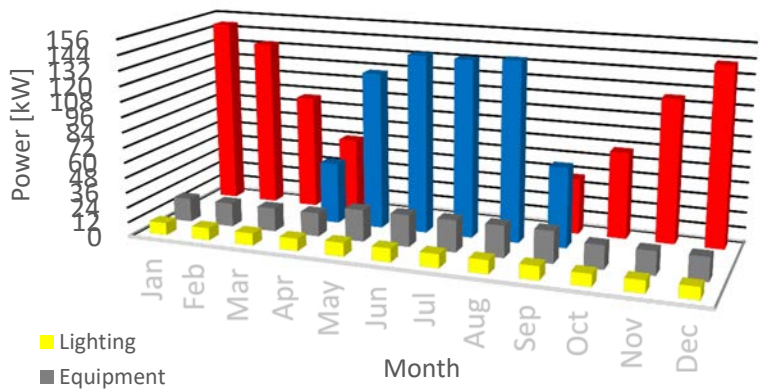

Figure 19 – Graph of monthly power peak demand

5 Appendix: LEED Certification

In order to certify that the design of this building reached the health, durability, affordability and environmental aim, LEED 2009 Green Building Rating System [14] has been chosen for the evaluation. The final score of this project in LEED rating is 81, which can be qualified as “Platinum” level (80-110 points).

Table 8 – Leed certification

LEED v4 for BD+C: New Construction and Major Renovation

Project Name

Date

Y	?	N					Achieved points:
Y			Credi 1	Integrative Process		1	1
			Location and Transportation		Possible Points:	16	15
			Credit 1	LEED for Neighborhood Development Location		16	
Y			Credit 2	Sensitive Land Protection		1	1
Y			Credit 3	High Priority Site		2	1
Y			Credit 4	Surrounding Density and Diverse Uses		5	5
Y			Credit 5	Access to Quality Transit		5	5
		N	Credit 6	Bicycle Facilities		1	1
Y			Credit 7	Reduced Parking Footprint		1	1
		N	Credit 8	Green Vehicles		1	1
			Charging stations are planned (with existing PV panels above parking lots)				
			Sustainable Sites		Possible Points:	10	9
Y			Prereq 1	Construction Activity Pollution Prevention		Required	
Y			Credit 1	Site Assessment		1	1
Y			Credit 2	Site Development--Protect or Restore Habitat		2	2
Y			Credit 3	Open Space		1	1
Y			Credit 4	Rainwater Management		3	2
Y			Credit 5	Heat Island Reduction		2	2
Y			Credit 6	Light Pollution Reduction		1	1
			Water Efficiency		Possible Points:	11	8

Y		Prereq 1	Outdoor Water Use Reduction	Required	
Y		Prereq 2	Indoor Water Use Reduction	Required	
Y		Prereq 3	Building-Level Water Metering	Required	
Y		Credit 1	Outdoor Water Use Reduction	2	1
Y		Credit 2	Indoor Water Use Reduction	6	6
	N	Credit 3	Cooling Tower Water Use	2	0
Y		Credit 4	Water Metering	1	1

		Energy and Atmosphere	Possible Points:	33	28
Y		Prereq 1	Fundamental Commissioning and Verification	Required	
Y		Prereq 2	Minimum Energy Performance	Required	
Y		Prereq 3	Building-Level Energy Metering	Required	
Y		Prereq 4	Fundamental Refrigerant Management	Required	
Y		Credit 1	Enhanced Commissioning	6	6
Y		Credit 2	Optimize Energy Performance	18	13
Y		Credit 3	Advanced Energy Metering	1	1
Y		Credit 4	Demand Response	2	2
			The building is going to participat in demand-response programs in the future!		
Y		Credit 5	Renewable Energy Production	3	3
Y		Credit 6	Enhanced Refrigerant Management	1	1
Y		Credit 7	Green Power and Carbon Offsets	2	2

		Materials and Resources	Possible Points:	13	9
Y	Y	Prereq 1	Storage and Collection of Recyclables	Required	
Y	Y	Prereq 2	Construction and Demolition Waste Management Planning	Required	
	N	Credit 1	Building Life-Cycle Impact Reduction	5	3
	N	Credit 2	Building Product Disclosure and Optimization - Environmental Product Declarations	2	1
Y		Credit 3	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2	2
	N	Credit 4	Building Product Disclosure and Optimization - Material Ingredients	2	1
	N	Credit 5	Construction and Demolition Waste Management	2	2
			75% of the construction waste will be recycled. Wood waste to BIO-fuel.		

		Indoor Environmental Quality	Possible Points:	16	15

Y	Prereq 1	Minimum Indoor Air Quality Performance	Required	
Y	Prereq 2	Environmental Tobacco Smoke Control	Required	
Y	Credit 1	Enhanced Indoor Air Quality Strategies	2	2
Y	Credit 2	Low-Emitting Materials	3	2
Y	Credit 3	Construction Indoor Air Quality Management Plan	1	1
Y	Credit 4	Indoor Air Quality Assessment	2	2
Y	Credit 5	Thermal Comfort	1	1
Y	Credit 6	Interior Lighting	2	2
Y	Credit 7	Daylight	3	3
Y	Credit 8	Quality Views	1	1
Y	Credit 9	Acoustic Performance	1	1

	Innovation		Possible Points:	6	3
N	Credit 1	Innovation Utilization of the waste heat from the Server room		5	3
N	Credit 2	LEED Accredited Professional		1	0

	Regional Priority		Possible Points:	4	0
N	Credit 1	Regional Priority: Specific Credit		1	0
N	Credit 2	Regional Priority: Specific Credit		1	0
N	Credit 3	Regional Priority: Specific Credit		1	0
N	Credit 4	Regional Priority: Specific Credit		1	0

Total	Possible Points:	110	97

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points

PLATINUM RATING

6 References

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[4] http://www.citylab.com/work/2012/07/beijings-olympic-ruins/2499/ ; May 2016
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[13] **Maja Živanić, Vladimir Munćan, Igor Mujan, Aleksandar Anđelković**, Integrated sustainable building design of the two story office, research and development facility, New York City, USA
[14] LEED 2009 for New Construction and Major Renovations Rating System, USGBC, 2009.