



让我们共同打造气候中和的未来
Building a climate-neutral future together

Sino-Swiss Cooperation on Zero Emissions Building

Zero Emissions Building Demonstration Project Report

Chinese Honeybee Museum

Liuba County, Hanzhong City, Shaanxi Province

ENGLISH VERSION



MARCH 2024



中华人民共和国
住房和城乡建设部



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Building a climate-neutral future together

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The Sino-Swiss Zero Emissions Building Project is an international collaboration funded by the Swiss Agency for Development Cooperation in partnership with the Chinese Ministry of Housing and Urban-Rural Development. The project aims to reduce greenhouse gas emissions and enable carbon neutral development of the building sector in China by sharing Swiss know-how on sustainable and zero emission building.

Implementation partners:

Intep Integrated Planning
Skat Consulting
China Academy of Building Research

WeChat:



Web:

zeb-china.org

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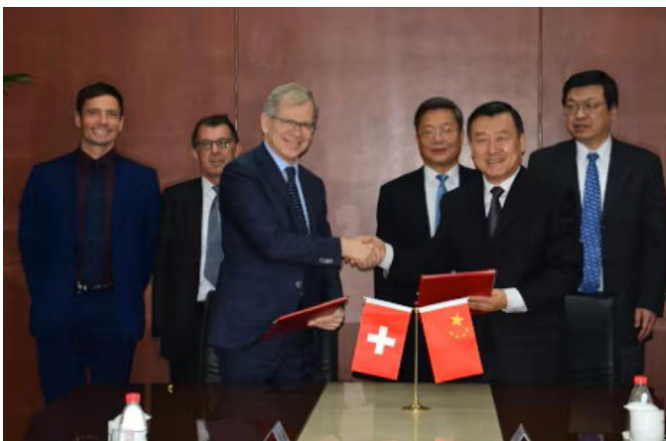
1. PROJECT BACKGROUND

1.1. About the Sino-Swiss ZEB Project

To jointly address global climate change and to strengthen cooperation between China and Switzerland in the field of emissions reduction in the construction industry, the Ministry of Housing and Urban-Rural Development of the People's Republic of China and the Swiss Federal Ministry of Foreign Affairs signed a Memorandum of Understanding (MoU) on 24 November 2020. The Memorandum focuses on fostering international cooperation in the field of building energy efficiency. Within the framework of this MoU, the Swiss Agency for Development and Cooperation (SDC) initiated and funded the Sino-Swiss Zero Emission Building (ZEB) Project. The project aims to support China in formulating the technical standard for zero carbon buildings and long-term roadmaps for reducing carbon emissions in the construction industry. Switzerland contributes by sharing know-how, showcasing demonstration projects of zero emission buildings in four different climate zones, and carrying out various forms of capacity building activities to promote the carbon-neutral development of China's construction industry.

Project Purposes:

- Upgrading existing building energy efficiency standards to zero carbon technical standards
- Implementing demonstration projects (DP) in four typical climate zones to test the new ZEB standards and finding potential for optimization
- ZEB capacity building and knowledge dissemination



Ambassador Bernardino Regazzoni and Vice Minister Ni Hong, sign the project agreement. Image: Swiss Embassy in Beijing

1.2. Selection of demo projects

Demo project goals

- To reach the requirements of China's national technical standards for zero carbon buildings.
- To serve as case studies to guide and educate further projects in achieving the ZEB standard.
- Evaluation committee and selection process
- CABR collected applications for potential demonstration projects by an official call.
- Prior to the evaluation of applications, a project presentation with Q&A was held, in which Chinese and Swiss experts participated.
- A separate evaluation based on selection criteria was carried out by Chinese and Swiss experts.
- With Sino-Swiss joint feedback and recommendations, Mohurd announced the selected demo projects.

Selection criteria

- ELIGIBILITY CRITERIA: Political commitment, funding commitment, possibility of intervention, potential for affordability and replicability, visibility and accessibility, diversity
- RATING CRITERIA (Evaluation weight): CO2 emissions reduction potential and other environmental benefits (40%), number of beneficiaries (20%), light-house potential (20%), incentives by local government (20%)
- PILOT- PROJECT SUITABILITY (1st batch): Quick-starter, compatibility with draft ZEB-Standards, pilot characteristics, availability of data

Selecting time

March 2023

Why selected – ZEB potential

- The project has potential for designing and technical improvement, as well as emission reduction
 - Very nice project with special spirit in very rural environment. This is a good example to show ZEB as contributing to biodiversity. Easy to communicate. The project shows potential to meet ZEB goals.
 - The project planning team is open and has strong willing to learn from Swiss experience

- The environment and project context has similarities like comparable building physics as well as natural environment in Switzerland – this enables the easy adoption of Swiss experiences.
- The roof and façade can be easily equipped with integrated energy-saving solutions like PVs, shading-systems etc.
- The timetable of using/operation can be scheduled flexibly, regarding energy-using optimizing
- possible inputs for improvement from the side of Swiss experts
 - Suggestion to integrated energy-saving solution on roof and façade, especially by HSLU team led by prof. Adrian Altenburger
 - Optimizing the operational management and usage concept with special support by intep inhouse sustainable Facility Management team
 - Suggestion on the material selection and circular construction for saving embodied energy, with special support by HSLU team led by Prof. Gianrico Settembrini
 - Support on energy and emission calculations, especially with consulting and monitoring by Swiss ZEB standards- and calculation expert, Martin Ménard and local ZEB expert Li Yin
 - Optimizing the selection and combination of building technology and energy solutions

1.3. Working process

Sino-Swiss team

The Sino-Swiss expert team is composed of Swiss and Chinese specialists. The Chinese DP team first proposed design prototypes and zero-carbon design strategies. After reviewing the design features of the project, the Sino-Swiss expert team gave tailored feedback to the design team on the design prototype and strategical concept, which the design team will integrate as they adapt the project. The Swiss team also arranged webinars to exchange on specific zerocarbon topics based on the questions from the DP team. The ideas contributed by the Swiss experts are based on their international experience from Switzerland, Europe, and other similar climate zones around the world.

The goal of Sino-Swiss cooperation

The goal of Sino-Swiss cooperation is to jointly monitor and improve the quality of the demonstration project and support the project to meet the ZEB-standards. The cooperation is mutually beneficial – the Swiss team brings experience and expertise to China, while the Chinese colleagues can share their experiences for the Swiss to learn from. Jointly the Swiss and Chinese teams discover what the best solutions are to develop a successful zero emission building.

Working process

Webinars, online workshops, RTIPs, Charrettes, WeChat discussions and site visits were held to turn ideas into constructive proposals. The transparent exchange is very helpful for determining the project's feasibility.



Figure 1: Rendering of the project in early planning phase. Source: Project Presentation 17.03.2023 ©XAUAT



2. PROJECT INITIAL STATE

2.1. Project organization

In March 2023, the project “Public Building of Bee Research and Tourism base for Rural Revitalization of Huoshaodian, Liuba County, Hanzhong City, Shaanxi Province” was selected as one of the 2nd batch Demonstration Projects of Sino-Swiss ZEB Project. This project is a ministerial-level international cooperation project initiated by the Chinese Ministry of Housing and Urban-Rural Development and the Swiss Agency for Development and Cooperation. The project commenced in May 2023 and, after around 1 year of joint efforts by Sino-Swiss teams, is expected officially completed with its construction in May 2024.

Investor

Liuba Yunmu Rural Tourism Development Co., LTD

Lead planning team

Architectural design and Research Institute, XAUAT

Sino-Swiss ZEB international joint consulting team

Xi'an University of Architecture and Technology, CABR

Inter-Skat, Low-tech, UAD, HSLU, EMPA, etc.

2.2. Project overview

Location

Liuba County, Hanzhong City, Shaanxi Province
(Climate zone cold area)

Building use

comprehensive building integrating popular science research, interactive experience, bee culture display and bee product sales

Structural system

Steel structure

Area

- Planned land area: 4674 m²
- Total construction area: 1530 m²
- Building energy reference area: 1391 m²

Investment costs

22 million RMB

Energy concept

see schema in Annex A.2

- Air source Variable refrigerant flow(VRF) multi-connector units for space heating and cooling with primary energy efficient
- Mechanical ventilation with heat recovery (optional with natural ventilation)
- Lighting system: select efficient lighting fixtures

Other sustainability concepts

- Increase the natural ventilation effect of the building through reasonable design of the opening fan of the glass curtain wall, control of the building depth and other measures.
- Passive, structural outer shading could, especially with the hexagonal design, help reduce solar gains in summer and thus cooling energy, at the same time meet the sunshine requirements in winter
- Design as Sponge Park
- Maximize the use of renewable energy within the site, 112.9kWp installed capacity of PV system consisting of three parts:
 - Roof photovoltaic using BIPV system (Monocrystalline silicon modules) with total installed capacity of 58.32kWp
 - Photovoltaic shed for Parking lot using BAPV system(Monocrystalline silicon modules) with a total installed capacity of 40.45kWp
 - Vertical sun visor photovoltaic using thin film photovoltaic glass CdTe) with a total installed capacity of 14.13kWp



Figure 2: Project located in a very rural environment, Source: XAUAT

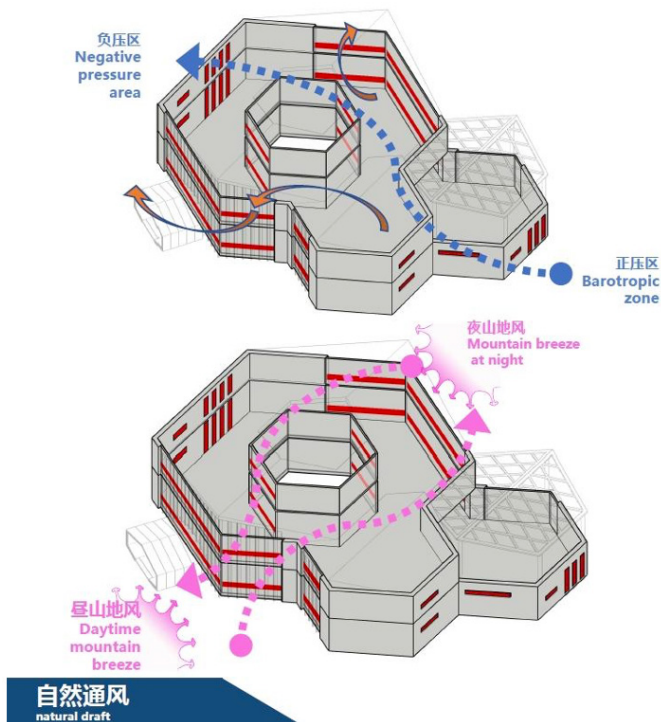


Figure 3: Natural ventilation as passive measure to reduce energy consumption, Source: Project Presentation 17.03.2023 ©XAUAT

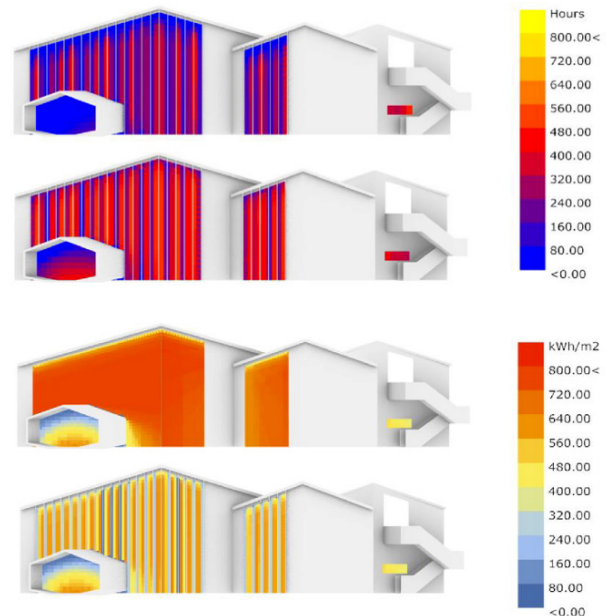


Figure 4: sunshine analysis and radiation analysis of the curtains wall, Source: Project Presentation 17.03.2023 ©XAUAT



Figure 5: Methods to achieve sponge park, Source: Project Presentation 17.03.2023 ©XAUAT



3. SINO-SWISS COOPERATION

3.1. About the DP design team

The Xi'an Demonstration Project Architectural Design Team is led by Professors Zhixing Luo and Kun Zhou from the College of Architecture of Xi'an University of Architecture and Technology, along with Yuechao Liu (Northwest China Architecture Design and Research Institute Co., Ltd.), who serves as an external tutor. Together, these three professors lead graduate students to form an "industry-academia-research and utilization" team, which combines the concepts of architectural design and zero-carbon technology through the design of the whole process. The concept of combining architectural design with zero-carbon technology runs through the whole design process. The design team completed this zero-carbon public building in the hinterland of the Qinling Mountains, based on the design ideas of 'locality, small scale, and variability'. The design of 'locality' serves to establish and reinforce the cultural identity and value identity of the villagers, thereby potentially enhancing their sense of belonging. The 'small-scale' design strategy prioritizes lightweight and high-strength structures, the utilization of low-carbon materials, and the creation of simple yet elegant spaces, to reduce carbon emissions. The 'variability' approach establishes a zero-carbon target at the design stage and avoids design methods that may result in significant carbon emissions. The 'variability' approach establishes a zero-carbon target at the design stage, thereby enabling the accurate control of carbon emissions at this phase of the project. This is achieved by avoiding design solutions that may result in significant carbon emissions.

The landscape design of the project was completed by the team of Associate Prof. Weifeng Guan from the College of Art, Xi'an University of Architecture and Technology. The structural and electromechanical design was done by several engineers from the General Design Institute of Xi'an University of Architecture and Technology.

3.2. First evaluation of Swiss team

General evaluation by Swiss team

- The project is characterized by a holistic approach with a life-span of 50 years. It is a mature

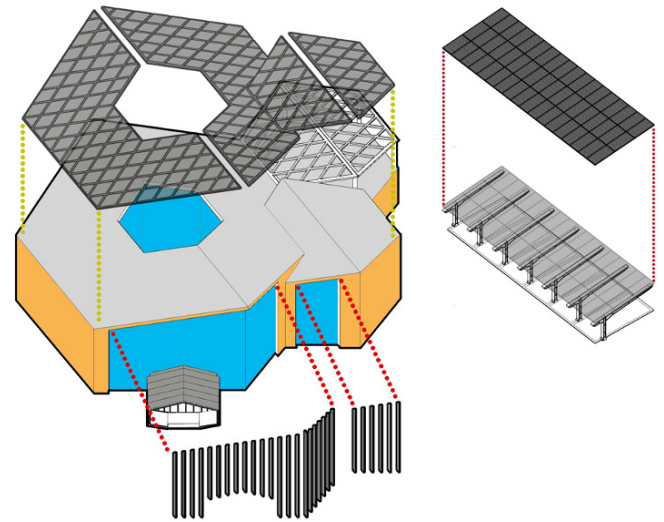


Figure 6: Offset by rational use of renewable energy, Source: Project Presentation 17.03.2023 ©XAUAT

project by an integral planning team with participation of students in the planning process.

- Very nice project with special spirit in very rural environment. This is a good example to show ZEB as contributing to biodiversity. Easy to communicate. Can certainly meet ZEB goals.
- The environment and project context has similarities like comparable building physics as well as natural environment in Switzerland – this enables the easy adoption of Swiss experiences.
- The roof and façade can be easily equipped with integrated energy-saving solutions like PVs, shading-systems etc.
- The high interior spaces can be used flexibly. This is an important contribution to sustainability.
- The building is designed in honeycomb shape. This shape results in more building surfaces compared to a rectangular shape. The courtyard, the well orientated glass façade and the various bi-level open spaces, help the deep building to get enough natural light.
- Structure wise, the design provides high flexibility playing the floor plan. It can be easily adjusted to the needs of various exhibitions in different sizes or even other functions in the future.
- The structural adaptation of the building to the local winds against the formation of a heat pocket in the courtyard is well implemented.

Targeted topics that our Swiss team decided to give our focused inputs

- Design for disassembly (DfD)

3.3. First inputs and suggestions

- The shading is to be discussed in more detail. Especially when using transparent PV panels for shading, the change of light color in the interior spaces has to be considered.
- In the monitoring system, the storage, respectively feeding of electricity into the local grid should be examined for optimization possibilities.
- All windows should be equipped with glazing glass with $U = 0.5 \text{ W/m}^2\text{K}$, total performance of the windows with $U = 0.8 \text{ W/m}^2\text{K}$ (Chinese K-Value around $1.0 \text{ W/m}^2\text{K}$).
- The open roof structure of the 2. floor terrace could have PV modules integrated.
- The landscape architecture is in a very early design phase, which still needs to be embedded into the architectural concept. Especially the reference between indoor and outdoor, between nature and building should be well thought out.
- Some ecological friendly installations for birds and insects, integrated in landscape design, could underline its educational function in a playful way.
- The loadbearing structure is considered as steel structure. Even the minimized use of steel through precise design, leads to a relatively high carbon emission in production phase. The design for disassemble of the steel structure after 50 years life cycle needs to become an integrated goal for this project. In this case the mechanism for reuse and recycle building material in China should be examined in a specific case study.
- For the interior design the DP team is advised to provide a feasible and realistic way to use more recycled or reused materials.

3.4. Reaction of DP team and concept improvement

- Suggested doors/windows/folding doors from the above-mentioned RTIS will be considered.
- the design teams use the below principle to minimize the carbon emission of the building materials: build less, build light, build green, build wise, build integrally, build longevity.
- The potential of circular construction will be further tapped in the project:

- DfD concept and recycled building component are considered in the planning concept. For the interior design the DP team will consider to use more recycled or reused materials.
- Measures to increase biodiversity of the project site will be considered.

3.5. Further Swiss inputs and suggestion

- High performance window/door production with better K-Value (glass and frame)
- Greenery and PV combination
- Biodiversity and interactive neighborhood in landscape design
- compound ventilation system
- Current construction detailing of the Bee Museum is not compatible with the principles of design for disassembly (dfd) and circular economy. Some solutions considering dfd and sustainable construction needs to be implemented in the Project, for example .Prefab concrete slab, demountable composite beams.

3.6. Further improvement and knowledge received

Generally, the builders for this project are mainly without professional training, because it is in rural area and a small project, which is quite different from other DPs. In this case the DP teams take conventional construction to reduce the risk in implementation.

3.7. Calculations

Improvement of Calculation

- Reference building: $89.92 \text{ kWh/m}^2\text{a}$
- Design building: $57.33 \text{ kWh/m}^2\text{a}$
- Total energy demand: $79'700 \text{ kWh}$
- Yield of PV system: $153'700 \text{ kWh}$
or $110.49 \text{ kWh/m}^2\text{a}$
- Carbon intensity indicator (operation):
 $0 \text{ kg/m}^2\text{a}$



4. OUTCOME/REACHES

4.1. Testimonials from DP side

From Master Architect:

Lü Cheng, Chinese Master Architect, Chief Architect of China Northwest Architecture Design and Research Institute Co., Ltd.

The design of the Study Tourism Base Project of Rural Revitalization and Bee Research in Liuba, Hanzhong, Shaanxi integrates regional culture, ecological protection, and interactive experiences. It provides a comprehensive platform for visitors to deeply understand beekeeping culture and ecological conservation, making a positive contribution to sustainable development and the dual-carbon goals.

Chief Architect:

Luo Zhixing, School of Architecture, Xi'an University of Architecture and Technology

We explore the small scale, locality, and variability of public buildings in village and town, attempting the possibility of carbon neutrality in the building lifecycle through climatic architectural techniques. By achieving zero carbon emissions through full professional collaboration and comprehensive carbon assessment.

Constructor:

Dong Li, Liuba County Yunmu Rural Tourism Development Co., Ltd.

The Study Tourism Base Project of Rural Revitalization and Bee Research in Liuba, Hanzhong, Shaanxi is a leading zero-carbon building project. It combines the two major IPs of the Qinling ancestral vein and Chinese bee multiflora honey, embodying rural revitalization, study tourism, and zero-carbon concepts. It is also a practical action towards achieving the zero-carbon high-quality development goals of Liuba County.

4.2. Confirmation of ZEB Demo Project

It is confirmed, that the project reached the "Zero Carbon Building" goal as required in ZEB Standards, especially in the operational phase.

It is confirmed, that the project considered the carbon emission throughout the whole life cycle and did its best to reduce the embodied emission as much as possible.

5. LESSONS LEARNED

5.1. Management and organization

The short design phase in China is very challenging for the Swiss expert team. Effective and continuous communication with the DP team is crucial for the development of the project. The Swiss team was required to respond promptly to the DP team's enquiries and provide quick inputs to ensure swift integration of ideas into the project within the limited timeframe.

Concrete factors and numbers are more persuasive than words or theory. For instance, through the utilization of a calculation tool developed by a Swiss expert, the Swiss team communicated with the DP team in a very constructive way. The project effort is a common achievement of Sino-Swiss joint team.

5.2. Technical Solutions

BIPV is developing and very suitable for ZEB in the future. The Beijing demo project cooperate with local PV producer and develop a BIPV in a high quality of technology and aesthetic. This product should be widely spread in China and all over the world.

Timber structure is very difficult to be implemented in China, because of the strict regulation on fire protection standard on timber structure. The shortage of wood in China might be a reason for the unfriendly regulation for timber structure

5.3. Communication and Cooperation

The following formats and means of communication were actively used in the project procedure:

Charrettes incl. technical response by the Swiss team

- Kick-off charrette
- Update charrette
- Offline workshop and onsite visit
- Kick-off meeting on building automation and smart control

Joint charrettes with all three DPs from first batch

- ZEB Duty Book
- Circular construction

- Fire safety of timber structures
- Facility management and ZEB operation
- Zero Emission District
- Computational fluid dynamics (CFD) Simulation
- Green PV
- Swiss technologies and products

Rapid technical input sheets (RITS) about:

- BIPV solutions incl. façade PV and photovoltaic tiles, local product manufacturer recommendations
- KBOB – Swiss Coordination Conference of Building and Property Bodies of Public Sector Developers
- Low carbon cement LC3
- High performance windows and doors
- Facility management
- Shading systems and products
- Greenery and PV

Q&A sheet and further thematic inputs on:

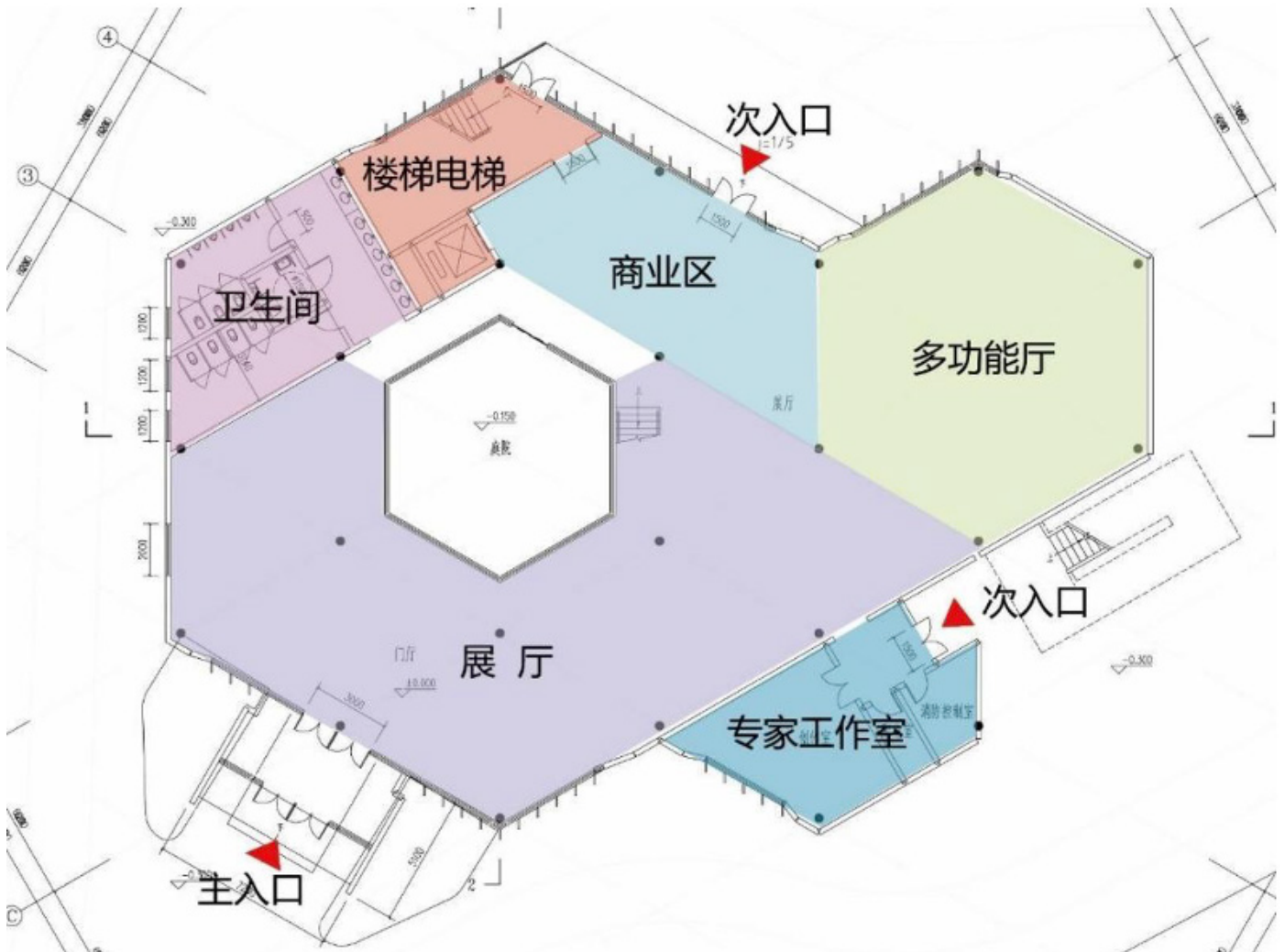
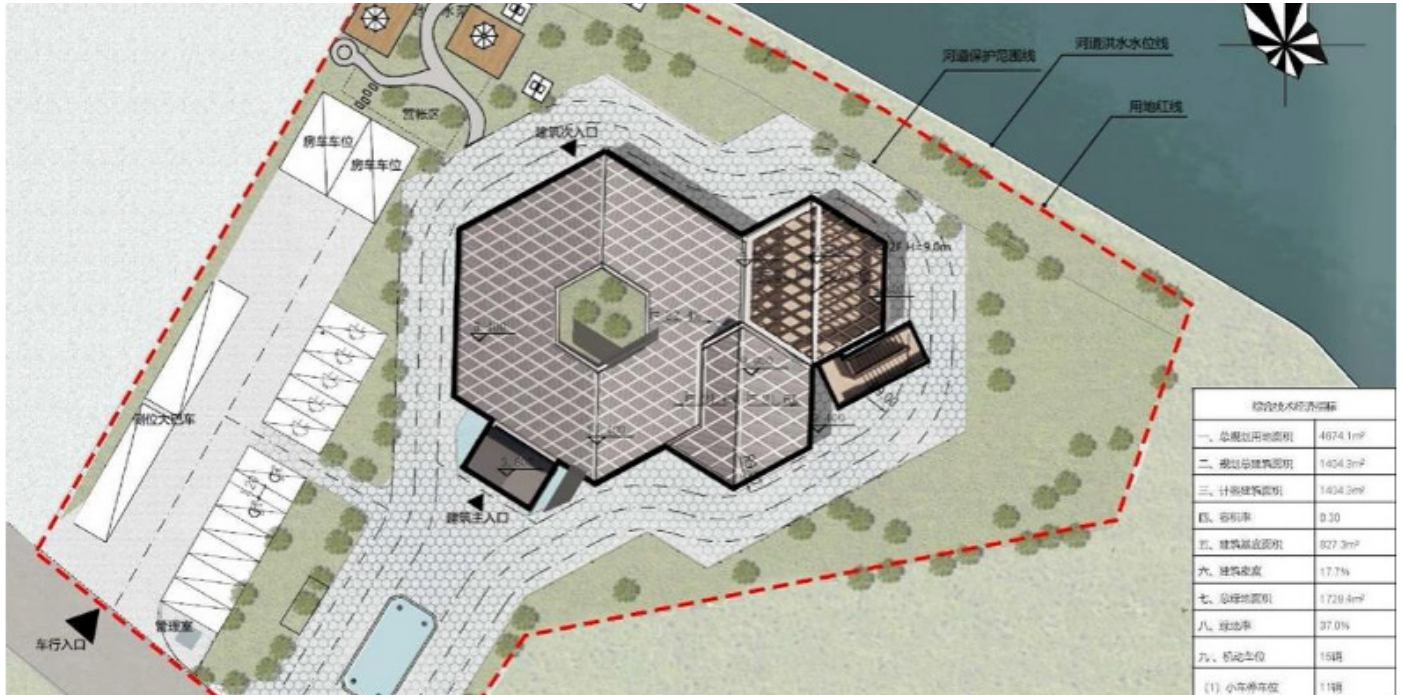
- ISO norm and SIA2040
- U-value / visible light transmission (VLT) 20
- Heat recovery / air handling unit / AC
- Earth tubes for ventilation system

Further performances:

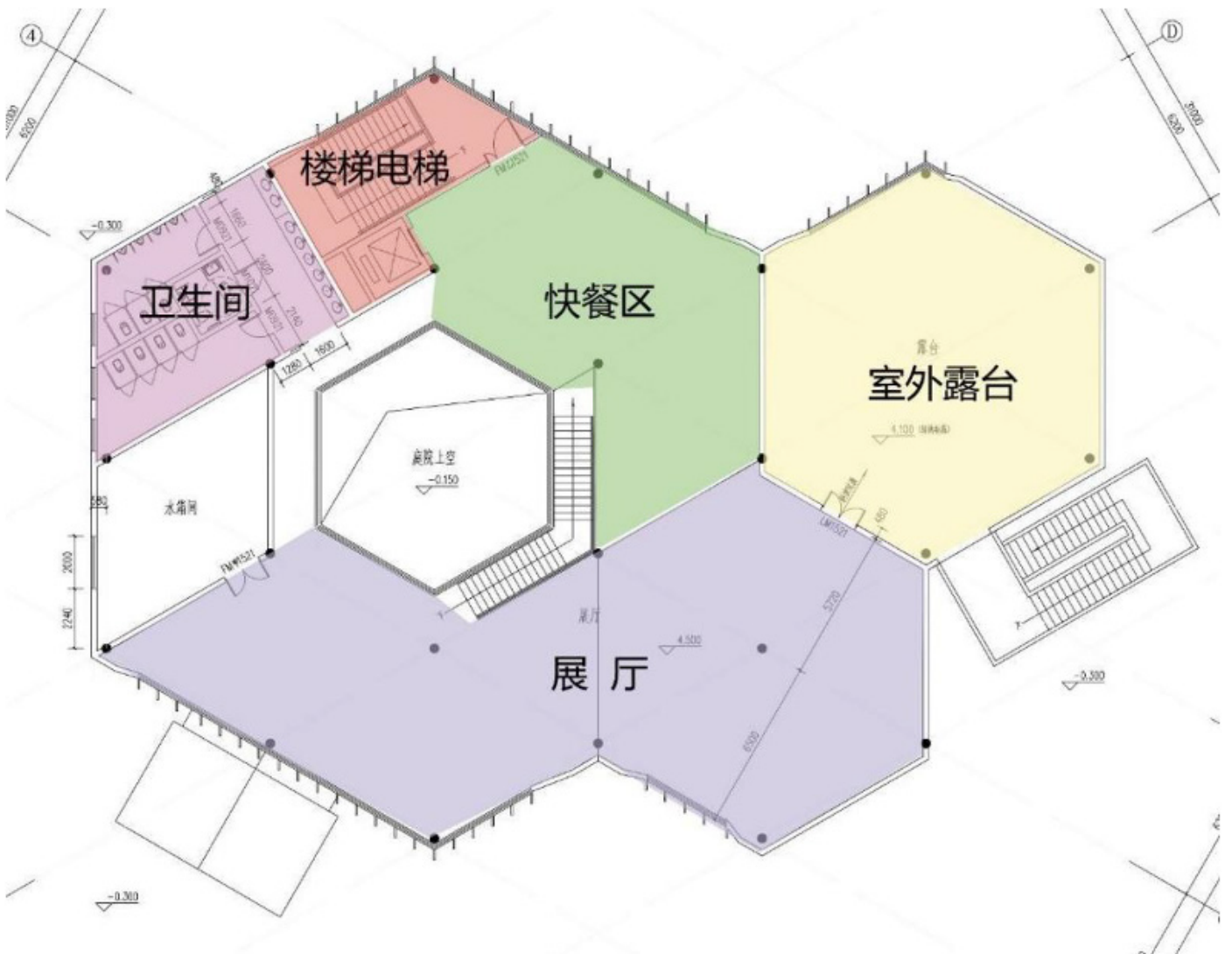
- ZEB Duty Book developed, shared and presented
- Regular exchanges and discussions per WeChat, telephone and email
- Site visit and technical exchange on construction site
- Public and internal ZEB Talks on various ZEB topics
- Booklet regarding ZEB policies, regulations, standards, concepts and techniques
- Exchanges and discussion on events like National NEZB Conferences and the Sino-Swiss Industry University Research Collaboration Forum on Zero Emission



Annex 1. Plans



Annex 2. Energy concept / Scheme principle





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