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Building a climate-neutral future together

Sino-Swiss Cooperation on Zero Emissions Building

Zero Emissions Building Demonstration Project Report

Cold Land Building Science Research Institute - Harbin, Heilongjiang

Retrofit of an ultra-low energy building innovation complex

ENGLISH VERSION

OCTOBER 2024

中华人民共和国
住房和城乡建设部

Schweizerische Eidgenossenschaft
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Building a climate-neutral future together

This report has been produced within the framework Sino-Swiss Zero Emissions Building Project; an international collaboration funded by the Swiss Agency for Development and Cooperation in partnership with the Chinese Ministry of Housing and Urban-Rural Development.

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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 neural 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

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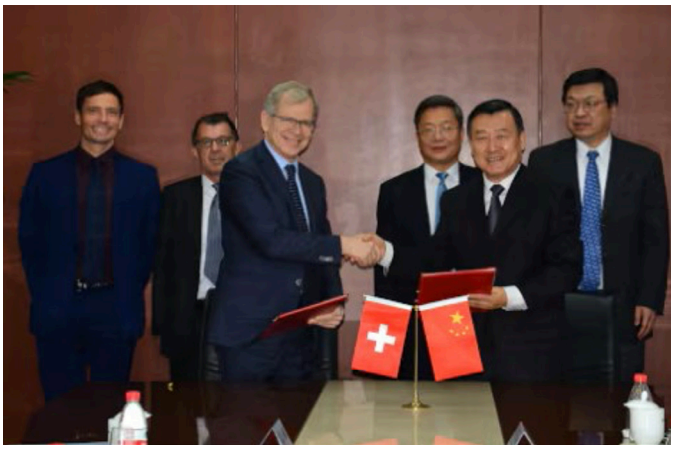
1. PROJECT BACKGROUND

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 emission 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 is about the development of cooperation in the field of building energy efficiency. Within the framework of this MoU, the Swiss Agency for Development Cooperation (SDC) initiated and funded the Sino-Swiss Zero Emission Building Project. The project aims to support China in formulating the technical standard of zero carbon buildings and long-term roadmaps for reducing carbon emissions in the construction industry. Switzerland contributes by sharing know-how and use cases of zero emission building demonstration projects in different climate zones, while carry-ing out various forms of capacity building activities, so as to ultimately promote the carbon-neutral development of China's construction industry.

Project Purposes:

- Upgrading existing building energy efficiency standards to Zero Carbon technical Standards
- Implementing demo projects in 4 typical climate zones for testing the new ZEB standards and finding optimization potentials
- ZEB capacity building and knowledge dissemination



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

Project duration:

- Phase I: 15. Mar. 2021 – 28. Feb. 2025

Project impact on climate protecting:

- Reduce CO2 Emission in building sector

1.2. Selecting process of Demo Project

Demo project goals

- To reach the requirements of China's national technical standards for zero carbon buildings.
- To Serve as case study to guide and educate more projects to achieve the ZEB goal
- Evaluation committee and selection process
- CABR collected applications by an official call
- A project presentation meeting with Q&A and afterwards evaluation, participated by Chinese and Swiss experts
- Separately evaluation with selecting criteria by Chinese and Swiss experts
- With Sino-Swiss joint Feedback and recommendation, 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%), Lighthouse potential (20%), Incentives by local government (20%)
- PILOT- PROJECT SUITABILITY (1st Batch): Quick-Starter, Compatibility with Draft ZEB-Standards, Pilot Characteristics, Availability of Data

Selection time

June 2023

Why selected – ZEB potiential

- Potential as ZEB demo project, potential for designing and technical improvement, as well as emission reduction
  - This is currently the only one renovation

project as Sino-Swiss ZEB Demo Project
  - This is the only one project in China' s severe cold region.
  - There are a lot of Swiss experiences can be adopted to this project, especially because of the similar climate.
  - Because the architect himself is at meantime the investor and the land was given by the local government, so the condition for additional cost and expansion of time schedule looks quite good.
  - The project could be a good example of solid construction, interior insulation and tightness at windows and doors.
  - Because the project needs no new construction and less new material, so it will have less negative impact to the environment and biodiversity.
  - The building is located at a main street in Harbin, so the visibility is quite good.
  - It could be a very good demo project for the further 10 Mio m2 retrofitting buildings which we are also interested to give our Swiss inputs.
- possible inputs for improvement of Swiss experts
  - Support to the renovation concept through leading Architectural office with expertise in reuse topics.
  - Swiss Inputs in Reuse, Circular Construction/Economy and City mining through the supports of Swiss leading universities and professors
  - Innovative isolation system inside and outside of the façade can be introduced by special Swiss specialists.
  - Special Swiss experiences in using air-source heat pump in very low temperature e.g. -30-40°C can be introduce by special Swiss specialists.
  - Swiss experience in handling with warm/ cold bridge can be introduce by special Swiss specialists.
  - Swiss total energy renovation project of comparable building can be introduced.
  - Swiss experience in handling with renovation of cultural heritage building can be introduced.
  - Swiss experience in calculation of renovation of retrofitting building can be introduced by Swiss standards experts
  - Minergie certificating for retrofitting office building can be introduced.
  - Project can be used with special developed calculation tool to proof the achievement of ZEB.

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 zero- carbon 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.

Project Duration

Oct. 2022 - Dec. 2024

2. PROJECT INITIAL STATE

2.1. Project organization

In July 2023, the “Retrofit ultra-low energy building innovation complex in Harbin” was selected as one of the 3rd batch Demonstration Projects of Sino-Swiss ZEB Project. This project is a minis-terial-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 October 2022 and is tend to be officially completed with its construction on April 2024.

Investor

- Heilongjiang Province Academy of Cold Area Building Research

Lead planning team

- Heilongjiang Province Academy of Cold Area Building Research

Sino-Swiss ZEB international joint consulting team

- Intep, Skat, CABR, Low-Tech, UAD, HSLU, EMPA, etc.

2.2. Project initial data

Location

- Guogeli Street No. 33, Haribin City, Heilongjiang Province / China (climate zone Ex-tremely Cold B Zone; Solar resource area III)

History

- Built in 1990s as office building, converted as a hotel till 2020

Area

- Gross building area 8610m2, consisting of 9 above-ground floors(7490m2) and 1 below-ground floor (1120m2).
- Energy Reference Area 8610m2
- Heating period: 20. October – 20. April
- Cooling period: 01. July – 31. August

Highlights of architectural concept:

- Retrofit of an existing building
- Office building after renovation, with a portion of it dedicated to building material research.

Highlights of Energy concept

- Internal insulation on street façade
- External insulation on courtyard façade
- Air heat pump / air cooled chiller for space heating and cooling
- Mechanical ventilation with heat recovery (optional with natural ventilation through roof windows in transition season)
- Various types of high-performance doors and windows
- PV on the roof, cadmium telluride power generating partially on facade

Figure 1: Photo before renovation and rendering after renovation. Source: Project Presentation 16.10.2023

3. SINO-SWISS COOPERATION

3.1. About the Demonstration Project

The leading team of the Harbin Demonstration Project is the Heilongjiang Cold Region Building Research Institute, which is an institution directly under the Department of Housing and Urban-Rural Development of Heilongjiang Province and an important scientific research institution specializing in building research in cold regions in my country. Remarkable achievements have been made in the fields of building energy conservation, green buildings, wall insulation materials, cultural repairs, and renovation of old communities; a large number of researches have been made in areas such as exterior wall insulation, high-efficiency insulation and energy-saving exterior windows, building carbon emissions, and high-efficiency fresh air heat recovery technology. As a result, many achievements have entered the transformation and incubation period; at the same time, technical practices such as engineering consultation and design were carried out, integrating design, consultation, diagnosis and evaluation, and a number of preliminary consultation and design work for ultra-low energy consumption buildings were completed, promoting the transformation of scientific and technological achievements.

3.2. First evaluation of Swiss team

General impression

- This Demonstration Project is of great importance for four reasons:
- First retrofit project under ZEB standard
- Façade on street side under preservation of historic street features
- Prominent urban location in city center
- First ZEB demonstration project in extremely cold zone

Thus, several demanding challenges have to be mastered, which can serve as a model for future retrofit projects in China. The project requires great expertise and very careful attention to detail in planning and execution. As a ZEB demonstration project, the Harbin Historical Building Retrofit can become a true beacon of building renovation in China.

3.3. First inputs and suggestions

A list of inputs and consulting activities that delivered by Swiss team (see rapid technical inputs sheets, webinars, workshops and special coordination etc.):

Figure 2: Rendering of office space in upper floors after renovation, Source: Project Presentation 16.10.2023

- Certain experimental elements for thermal insulation and HVAC: It' s important to highlight that these elements, if not adequately tested, could potentially result in defects, which need a backup plan. For example swift replacement of any faulty pilot elements.
- Vacuum panels for internal insulation only in one or two rooms as pilot element. Based on Swiss experience, vacuum panels are challenging to install, prone to damage, and have restrictions for decoration such as hanging pictures. Fur-thermore, vacuum panels are generally much more expensive than conven-tional thermal insulation.
- For internal insulation, the building physics calculations must be ensured to avoid moisture damage. However, the low humidity in Harbin is advantageous in this respect.
- The substitution of current windows with new triple-glazed windows is crucial, as it significantly improves air tightness and consequently increases indoor humidity. If the existing window frame is of exceptional quality, replacing only the glazing could be an option. This approach would help lower the embodied energy.
- Window shading is recommended for an optimal balance between passive solar heat gain, glare reduction, and solar control while promoting effective daylight harvesting. If feasible, the solar shading should be installed on the exterior of the facade. Furthermore, it should be compatible with the preservation of historical monuments.
- The demonstration team pointed out that the information on carbon emissions from building materials in China is not comprehensive. Swiss experts suggest mandating manufacturers to provide carbon emission data in their bidding documents as a significant criterion for procurement selection. This will not only offer a reliable foundation for calculating the project' s embodied carbon emissions but also contribute to the gradual accumulation of carbon emission data for the building materials database.
- Measurement and smart control are recommended, in order to collect reliable data for the operation optimization.
- Hybrid system with air-sourced heat pump for baseload and additional boiler for the peak load or when the outdoor temperature drops below 30°C, and fresh air preheating.
- Ventilation concepts with so-called “compound ventilation” (=Verbundlueftung) for low ceiling area. No suspended ceilings are required, so that the thermal heat storage capacity of the ceilings also remains effective.
- The Swiss experts recommend considering active natural ventilation at night in summer to reducethe overall temperature of the building, and using the thermal inertia and heat storage capacity of the building materials such as bare concrete to reduce the need for cooling in summer (for example, using natural ventilation at night to reduce the indoor temperature to 18-20°C in advance. In this case the building can function without cooling before noon for 1.5-2 month cooling demands)
- Potential on circular construction (re-use and design for disassembly) such as reusable interior partition wall without load bearing function and refurbishing existing furniture.
- Technical support on elevator renovation will be provided by Schindler Swiss and Chinese Team.
- The limited production of photovoltaic (PV) energy is insufficient to meet the estimated electricity consumption.
- Swiss experts suggest to collect tracking data for 1-2 years after completion to compare simulation data and actual operating data

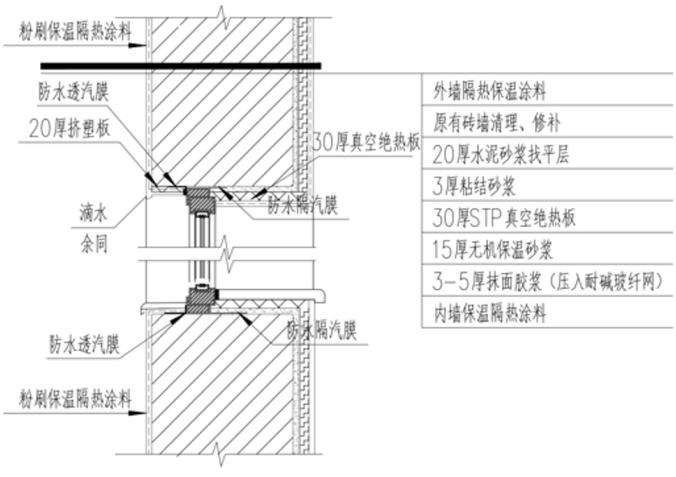


Figure 3: Detail of internal insulation with 30mm vacuum panel. Source: Plan on 15.12.2023

3.4. Reaction of DP team and concept improvement

After receiving the first inputs of Swiss team, the DP team gave the following responses:

- The current building has limited space available for internal insulation, making vacuum insulation panels the only viable solution. While implementing this on the construction site, the DP team encountered challenges with correct installation and gained valuable insights from the experience.
- The existing high-quality fixed windows on the first floor will be retained, and a new double glazing will be installed on the inner side. This double-layer window system can meet the requirements and reduce embodied carbon emissions.
- The building, with minimal southeast exposure and being surrounded by tall structures, doesn' t have a significant need for sun shading. The decision to install external sun shading will be made after assessing the conditions in the summer of 2024.
- Hybrid heating system: Air source heat pump + electric boiler.
    - Radiator(50°C->40°C) with thermostatic ventil
    - The indoor temperature 20°C in winter
    - 1/3 of the area has heating but no cooling
    - 2/3 of the area has both heating and cooling
    - ultra-low temperature air-source heat pump (extreme weather -30°C)
- The compound ventilation technology can be considered. Swiss inputs are delivered via workshops.

3.5. Further swiss inputs and suggestion

- Gas boiler as supplementary heat sources to address extreme winter condition
- Interior wall covering vacuum panel to prevent damage by users during operation phase.
- The Swiss side will "redesign" the project based on the Swiss experience. The outcome will be a showcase for design ideas and experience for future projects.
- And more…

Figure 4: Replacement of old windows into triple glazing glass. Source: Project Presentation 21.12.2023

Figure 5: Air-sourced heat pump on roof, Source: Project Presentation 21.12.2023

Figure 6: Compound ventilation system is suitable for low floor height (3.00m), Source: Project Presentation 21.12.2023

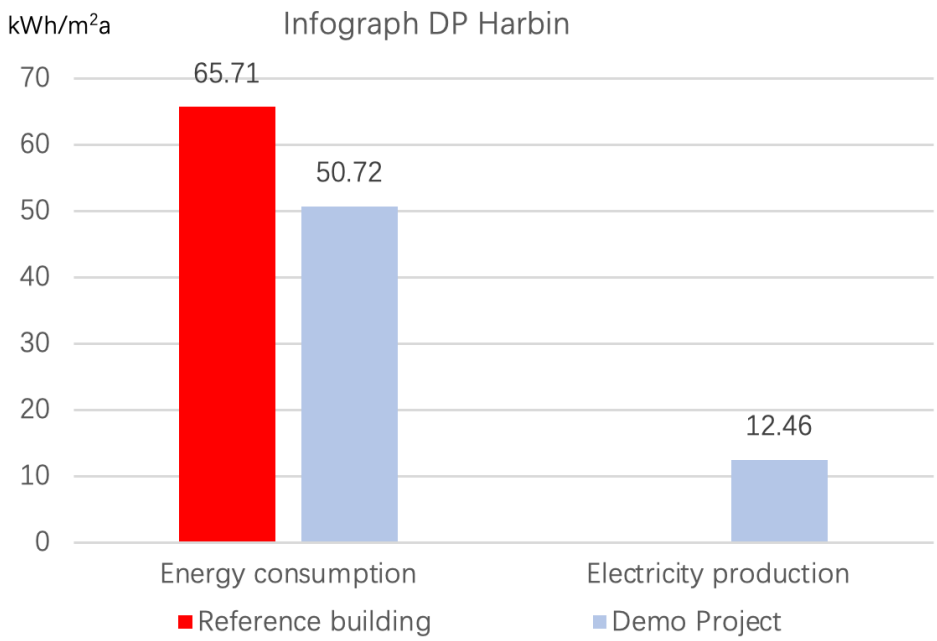


Figure 7: Comparison to reference building , source: Sino-Swiss ZEB Project

3.6. Further improvement and knowledge received

District Heating Center: District heating centers are common in Northern China. The cost of district heating is determined by the floor area, not by the amount of heat consumed. This is due to potential heat transfer between close quarters, such as two neighboring apartments (where one apartment might reduce its heat demand by utilizing heat transferred from the neighboring apartment via poorly insulated walls). This pricing policy discourages retrofit projects, which have lower heat demands but are still required to pay the same amount for central heating usage. Alternatively, they might need to rely on independent heating systems.

3.7. Calculations

Improvement of Calculation

- Reference building: 65.71 kWh/m2a
- After optimization: 50.72 kWh/m2a
- Total electricity production: 12.46kWh/a
  (PVs on the roof)
- Carbon intensity indicator: 16.3kg/m2a
  (operation)

4. OUTCOME/REACHES

4.1. Testimonials of the demo project side

Architect: Li Hongfan, Chief Architect of Heilongjiang Province Academy of Cold Area Building Research

The project successfully integrates the climate conditions of severely cold regions. Utilizing the existing building without altering its main structure and respecting the original traditional European-style facade, it employs the most advanced ultra-low energy consumption technologies. From project planning to the design and operation of the ultra-low energy building system, it has achieved outstanding results in creating a fresh style, mature technology, and green energy efficiency. This project provides an excellent example for leading zero-carbon building design, renovating existing buildings in cold regions, and enhencing local architectural styles.

Energy Consultant: Li Xiaodong, Professor at Harbin Institute of Technology

The construction of zero-carbon building projects in cold regions poses a significant challenge for HVAC engineers. By adopting high-performance building envelopes, efficient clean heating and ventilation systems, and intelligent operation and maintenance control technologies, the project has achieved energy savings and carbon reduction throughout the entire lifecycle of the HVAC system. The demonstration of these technologies can provide strong technical support for the promotion of zero-carbon buildings in cold regions, advancing the low-carbon transformation of the building sector in severely cold areas and contributing to the achievement of dual carbon goals.

User: Lu Tong, Chief Planner of Heilongjiang Province Academy of Cold Area Building Research

The high-performance insulation system and efficient clean energy utilization provide us with a healthy and comfortable environment and economically reasonable operating costs. This innovative complex is not only a demonstration project for zero-carbon buildings but also a comprehensive experimental platform for low-carbon building research, providing strong technical support for continuous research and innovation..

4.2. Confirmation of ZEB Demo Project

The experts of Sino-Swiss ZEB Project can confirm that the project has potential to reach the ZEB-goal as required in ZEB Standards for retrofit project.

4.3. Pictures after renovation

Figure 8: Hall after renovation, source: Harbin DP

Figure 9: entrance after renovation, source: Harbin DP

Figure 10: meeting room after renovation, source: Harbin DP


Figure 11: meeting room after renovation, source: Harbin DP


Figure 12: Solar panels on the roof after renovation, source: Harbin DP


Figure 13: Outlook from street after renovation, source: Harbin DP


Figure 14: Air-source-heat pumpe on the roof after renovation, source: Harbin DP

5. LESSON LEARNED

5.1. Management and Organization

The short design phrase in China is very challenging for Swiss expert team. The in-tensive and constant communication with DP team is crucial for project develop-ment. The Swiss team needs to response DPs team as soon as possible and give quick inputs so that the ideas can be adapted into the project in such a short time.

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

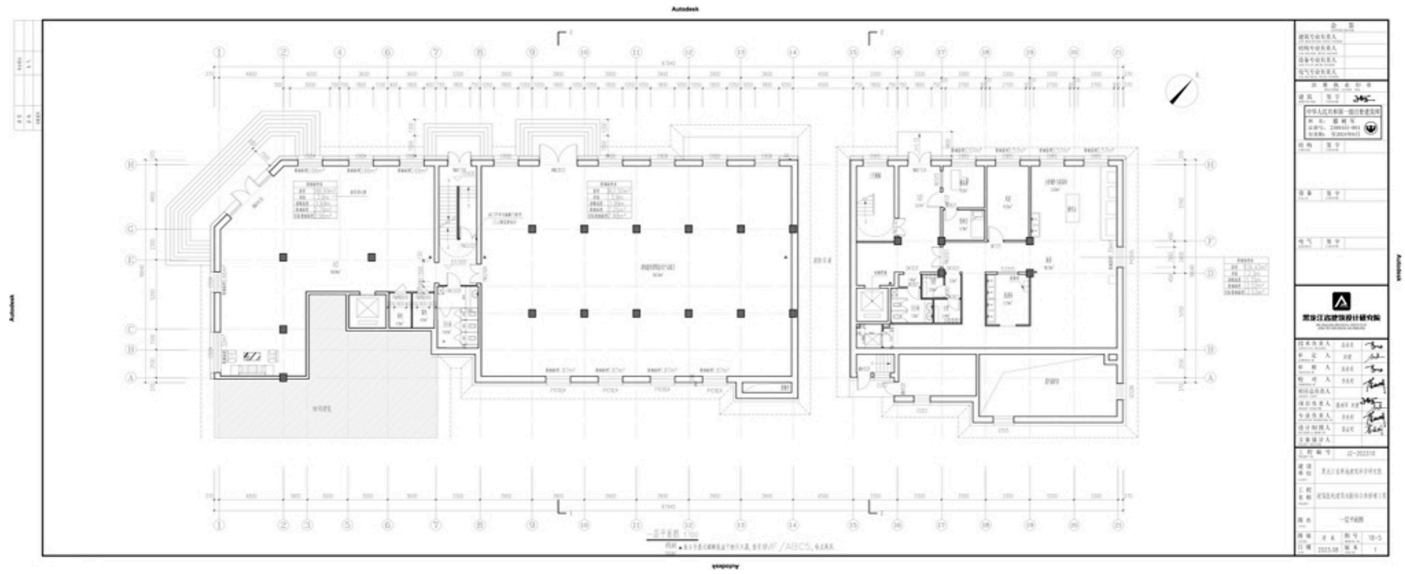
This project will become a demonstration for a large number of retrofit projects in China in the future, so a comprehensive summary is needed. On the one hand, it summarizes the design and construction experience of the Harbin project itself, and on the other hand, it expands potential technical paths and lessons learned based on the Swiss experience. As a reference for architectural design and technology path, this “Swiss Design” serves as a demonstrative lighthouse project for such renovation projects in the future.

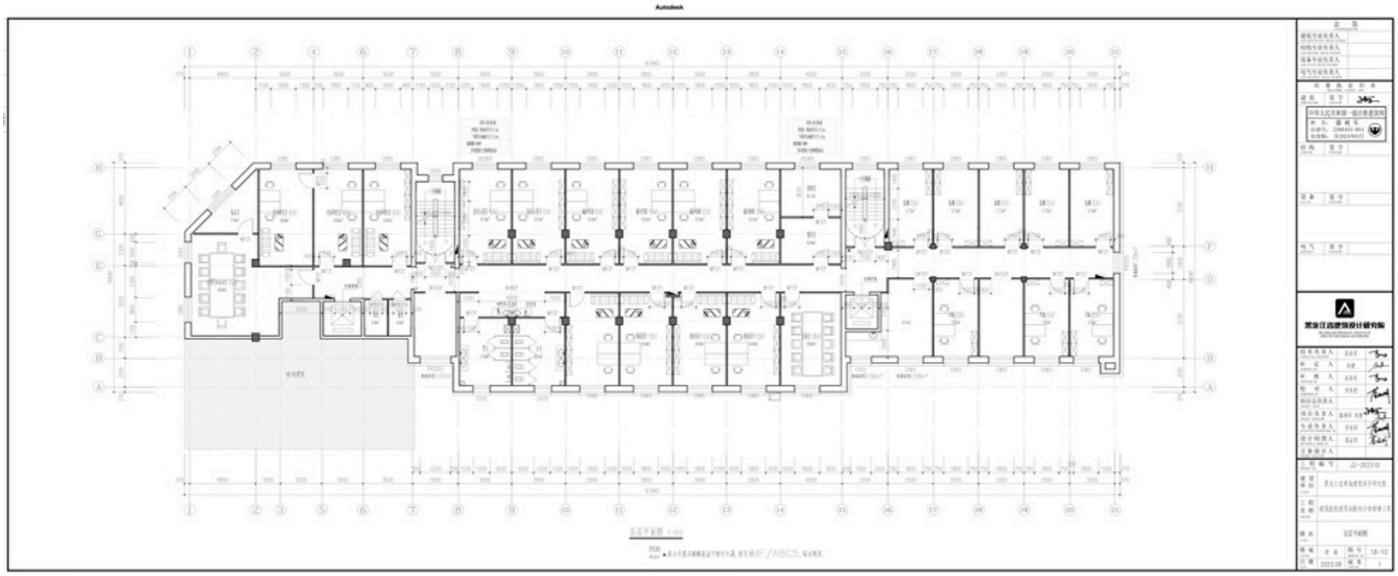
5.3. Communication and Cooperation

The following formats and means of communication were actively used in the pro-ject procedure:

- Charrettes incl. technical response by the Swiss team
  - Kick-off Charrettes
  - Update Charrettes
  - Offline workshops
  - Workshops “compound ventilation” (Verbundlüftung)
  - Material and components reuse
- Joint Charrettes with all three DPs from first batch
  - Efficient Elevator
  - Storage and use of renewable energy generated on site
  - Anergienetz
- Rapid technical input sheets (RITS) about:
  - Biodiversity in landscape planning
- ZEB Duty Book developed and shared
- Regular exchanges and discussions per WeChat, Telephone and email
- Public and internal ZEB Talks on various ZEB Topics
- Booklet regarding e.g., ZEB policies, regulations, standards, concepts and techniques.

Annex 1. Drawings





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