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

Technical Report

Three Steps Towards Zero Emissions Buildings

ENGLISH VERSION

MAY 2024

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

中华人民共和国
住房和城乡建设部

IBEE 环能科技

intep

skat

让我们共同打造气候中和的未来
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.

Authors:

Roland Stulz, Intep Integrated Planning

Dr Feng Lu-Pagenkopf, Intep Integrated Planning

Jilong Zhu, Intep Integrated Planning

Prof. Adrian Altenburger, HSLU

Yin Li, UAD

Contributions and review:

Daniel Wyss, Skat Consulting

Design and layout:

Intep-Skat

Cite as:

Stulz, R., Lu-Pagenkopf, F., Zhu, J., Li, Y. (2024). Three Steps Towards Zero Emissions Buildings. Sino-Swiss Zero Emissions Building Project Technical Report. Intep-Skat: Zurich

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

WeChat:
SinoSwissZEB

Web:
zeb-china.org

Cover image. Gongchen Community Center of Fangshan District in Beijing (Beijing Demo Project of Sino-Swiss ZEB cooperation project. Courtesy of SUP Atelier at Tsinghua University ZEB.

Contents

Image: ZEB China Demonstration project. Training building, Long Shan Shu Yuan Middle School, Shoaxing, Zhejiang Province. Courtesy of Shaoxing Future Community Development and Construction Co.

List of acronyms

BIM	Building information modelling
CABEE	China Association of Building Energy Efficiency
CABR	China Academy of Building Research
DP	Demonstration project
HSLU	Lucerne University of Applied Sciences and Arts
HVAC	Heating, ventilation, and air-conditioning
Intep	Integrale Plannung GmbH
Low-Tech:	Low-Tech Lab GmbH
Mohurd	Ministry of Housing and Urban-Rural Development
SDC	Swiss Agency for Development and Cooperation
SIA	Swiss Society of Engineers and Architects
Skat	Skat Consulting Ltd.
SUP	SUP Atelier of THAD (Architecture Design and Research Institute of Tsinghua University)
UAD	Architectural Design & Research Institute of Zhejiang University
ZEB	Zero Emission Buildings

1. Introduction

Besides the reduction of carbon emissions through energy efficiency measures on the operational and embodied parts, there are several approaches that support the implementation of ZEB. While the planning and building cultures in China and Switzerland may differ, there are certain rules that help a stringent organization and implementation of implementing ZEB across all cultures. This training module presents the three necessary steps to reach ZEB independently of the world region. For instance, the approach of integrated planning is a target-oriented process of a group of professionals from different disciplines, which is applied when searching for solutions to complex technical matters. This holistic approach creates efficiencies all along the planning and construction process and demand the early involvement of different expert groups and stakeholders in the process. The early involvement in the concept and design phase is very important as the decisions made in this phase determine the emissions from the building, especially related to embodied emissions. In addition, the duty book and the balance sheet are further tools that help the effective implementation of a project, resulting often not only in less emissions, but also in less costs – why? Because a solid planning, clear responsibilities and good calculations avoid mistakes in the process.

Everyone who has been involved in constructions knows that small mistakes can be very costly.

This guideline supports planning and building according to the ZEB Zero Emission Standard of the China Academy of Building Research (CABR). To meet the high requirements of the ZEB standard, a new planning and building culture is necessary. Sustainable planning and building require an integral way of thinking and working. This also requires the use of the appropriate planning tools. These are:

Integral planning

Integral planning is no miracle, but it is very helpful for achieving better solutions. Used properly, it will create benefits for all involved stakeholders. However, it also requires the willingness of all team members to engage in a joint process and to collaborate in finding solutions in an open-ended manner.

ZEB duty book

The ZEB duty book defines the “rules of the game” in the form of technical, organizational, and general requirements. The ZEB duty book is the most important strategic working instrument for the integral planning and construction process. It defines the requirements and objectives for the project and the participants.

ZEB balance sheet

The ZEB balance sheet provides quantitative evidence for ZEB certification. There is no ZEB without calculations.

Future building sector must strictly adhere to ZEB standard, which will become the benchmark for sustainable buildings in China and worldwide. From a long-term perspective, future buildings will inevitably meet ZEB standard. This standard will become an important benchmark for promoting sustainable building development in China and globally.

The following graphic shows the implementation roadmap of three ZEB instruments through-out the whole project process.

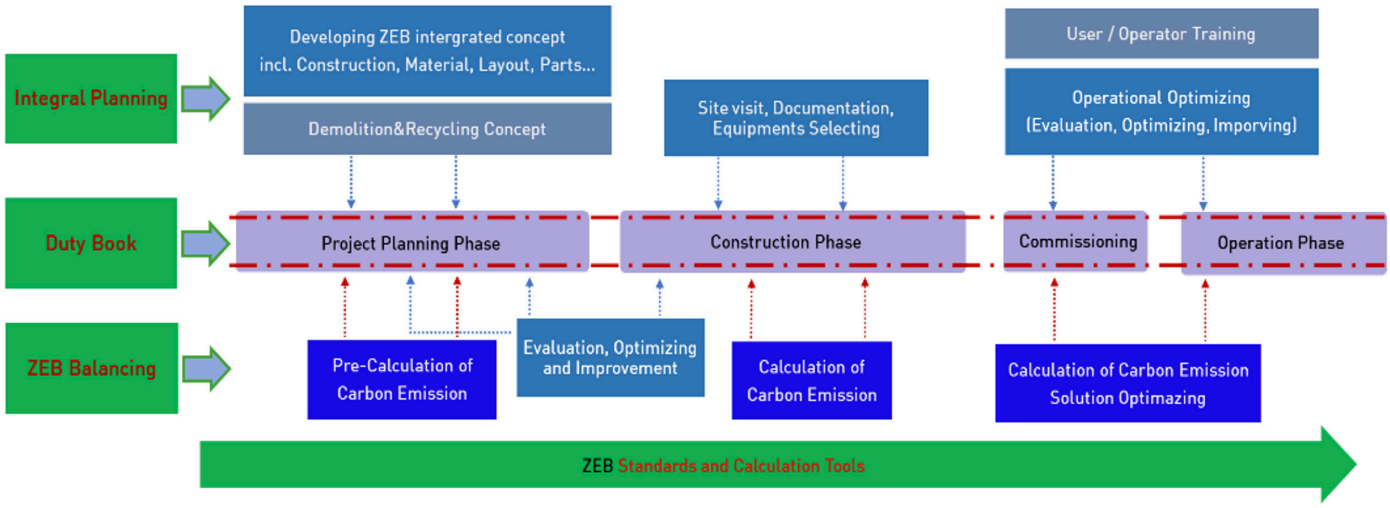


Figure 1. Implementation roadmap of the three instruments in project process. Graphic by intep.

2. Project background

About Sino-Swiss ZEB Project

In order 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 and 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 showcasingdemonstration 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 purpose

- 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

Project duration

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

Project impact on climate protection

The project goal is to reduce CO2 emissions in China' s building sector. China has defined its mitigation path towards a carbon neutral country until 2060 and has acknowledged the building sector as one of the main pillars of a zero-emission society and economy. The ZEB China project team has the unique chance and privilege to support Chinese partners on its ambition to reach this long-term objective - but how?

On the one hand, ZEB Demonstration Projects (DPs) will proof that Zero Emission Buildings are indeed possible – already today and in different building types. To gain that proof, solid and transparent calculations as well as CO2 balances are critical.

Only if the project can evaluate improvements from baseline concept to the built project, successful ZEB measures become visible and can be implemented in the industry and market on scale.

Image. Chinese Honeybee Museum, Liuba County, Hanzhong City, Shaanxi Province (Beijing Demo Project of Sino-Swiss ZEB cooperation project)

3. Integral planning

Integral planning is no miracle. But it is very helpful for achieving better solutions.

Interdisciplinary expertise is a prerequisite for a successful ZEB Zero Emission Building project. This also and especially applies to the first design steps, in which architects, engineers and specialist planners should work closely together in a team.

The method for this interdisciplinary ZEB planning process is INTEGRAL PLANNING.

Integral planning stands for a holistic approach to the planning of structures. Holistic, because integral planning requires the simultaneous participation of all disciplines and stakeholders involved in the planning process. The early involvement of all necessary experts in the planning team and their simultaneous and coordinated processing of the planning task are the central element. Their involvement, already in the conceptual phase, is of utmost importance, as this planning phase is crucial for the best possible design of the building' s life cycle.

Profitable for all stakeholders

Integral design is not easy, but it offers clear benefits for all stakeholders involved in a ZEB project, namely:

- Clients and investors know that the building they finance is more efficient and of better quality than with classical planning.
- The project managers can better lead the planning team because the individual planning services are optimally coordinated and because the planning team pursues clear common objectives.
- The planners and special experts are full members of the planning team, and their knowledge is optimally taken into account in the planning. Integral planning creates a better working atmosphere in the planning team and with the clients.
- The building authorities receive well-coordinated plans and proofs for the building permit. They have a very competent team as a discussion partner for queries in all specialist areas.
- The operators and users of a ZEB building receive a building that can be used and operated in a very sustainable manner. Erroneous planning and structural corrections are reduced to a minimum.

A construction related interdisciplinary planning methodology is geared towards synergetic effect and can thus generate significant added value. Overall, each planning step produces not the one right solution, but a plausible one.

This ensures that there is sufficient room for maneuver for the further steps.

ZEB buildings and districts can only be successfully realized with integral planning.

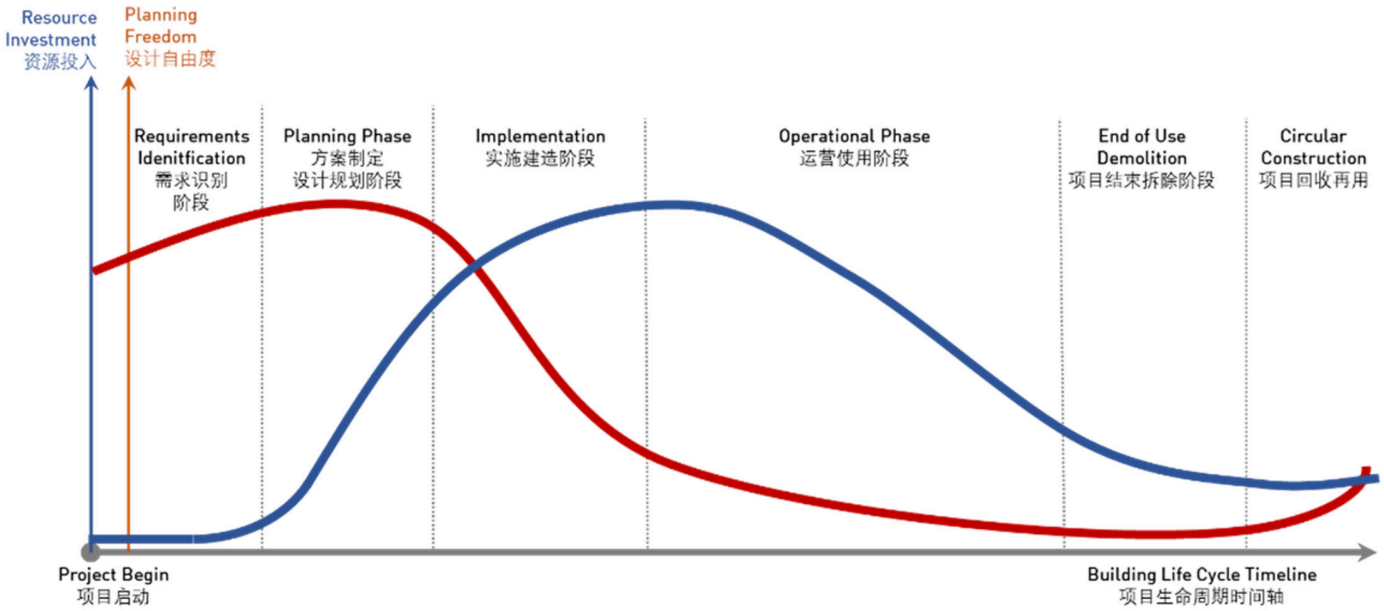


Figure 2. Resource investment and planning freedom in project life cycle. Graphic by intep.

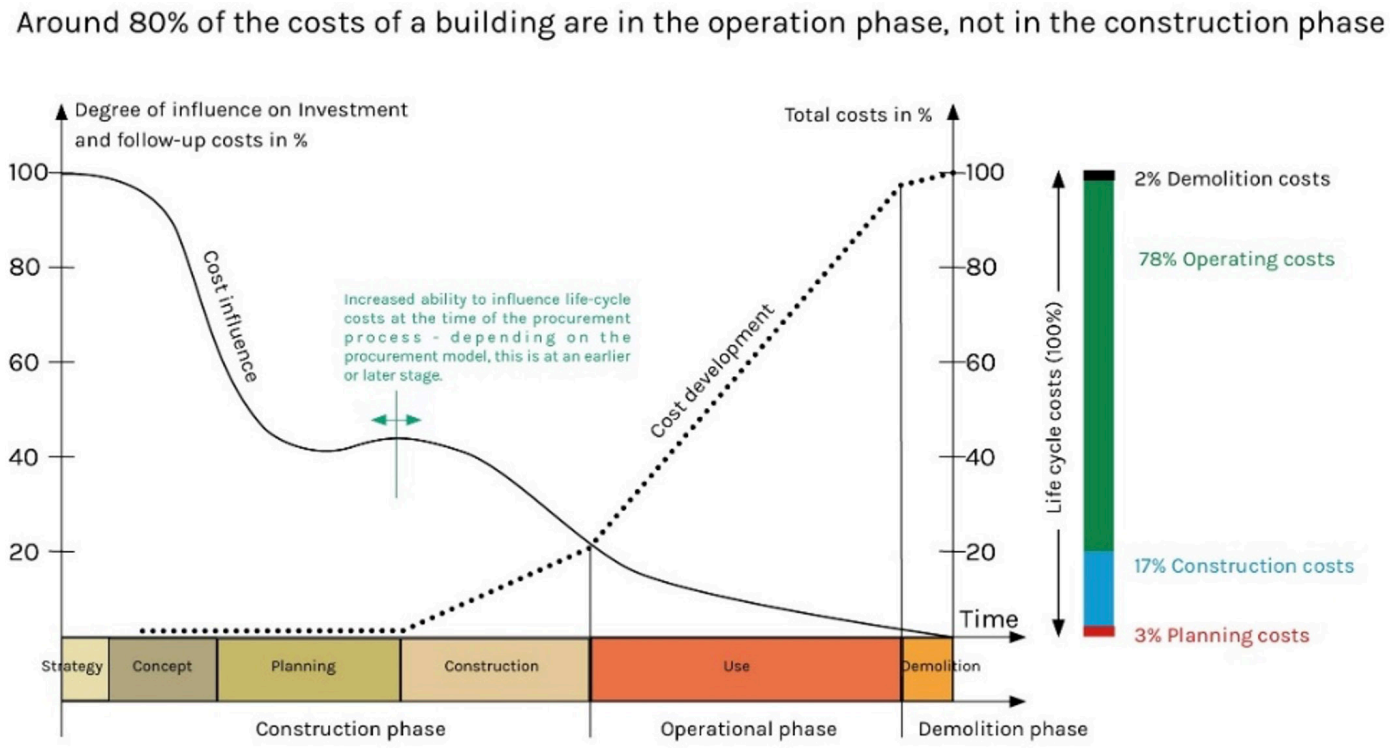


Figure 3. Cost sharing during the whole life cycle in Central Europe. Source: Nachhaltig Bauen heißt den Lebenszyklus von Immobilien von Beginn an mitdenken - M.O.O.CON | Die Strategieberater (moo-con.com), Stand 07.02.2023. Graphic by intep.

Two basic facts

The first steps in the design significantly shape the later development of a project. Solutions that deviate from the specifications can hardly be corrected later - or only with great effort. Therefore, cooperation among engineers, specialists and architects at an early stage is indispensable.

Planning freedom is greatest at the beginning of the planning process. The comparison of solution variants allows the selection of the best solution at optimal cost. Planning costs are marginal compared to construction costs. Therefore, planning must develop integrally well-coordinated solutions. This minimizes misunderstandings between specialists and later minimizes operating costs.

It is well-known that design and construction costs are not dominant throughout the life cycle of a building. In Central Europe, 50 to 80% of the life cycle costs of a building are incurred during the operating phase. Planning and construction of a building only causes 20 to 50% of the total costs.

How does the cost sharing in China' s building sector look like, requires detailed, regionally and on building-category dependent investigation.

In Central Europe, 50 to 80% of the life cycle costs of a building are incurred during the operating phase.

Two prejudices

Some prejudices often prevent integral planning. The most common - unfounded - prejudices are:

Integral planning is too expensive - FALSE.

The effort for integral planning may be somewhat higher in the beginning for the organization of a competent planning team. However, a well-organized integral planning team will subsequently work together much more efficiently and produce better solutions. In addition, misunderstandings between clients, architects, engineers, special experts, and users are avoided in integral planning. In addition, the interfaces between the technical solutions (facade, ventilation, lighting, IT, thermal mass etc.) are carefully coordinated. This avoids expensive repairs and faulty designs.

Anyone can do integral planning – FALSE.

Integral planning requires team members who think holistically, who take the other planners seriously and understand their proposed solutions, and who are prepared to integrate themselves into the team. Integral planning also needs clear leadership by an experienced person who is supported by the client in critical phases.

Seven prerequisites for how to organize integral planning

Integral planning does not organize itself. The client and project management must clearly decide in favor of this planning process and design the project organization accordingly.

Team composition

Depending on task and competences (core disciplines architecture, civil engineer, building services engineer and specialists such as building physicists, facade planners, etc.)

Team leadership

The team leader must be an experienced person with overall thinking and good communication skills. The essential requirements for the team leader person are:

- Professional competence: not specialty, but having an overview, recognizing connections, being able to take different perspectives.
- Methodological competence
- Leadership competence: know leadership principles and instruments.
- Have an understanding of social interrelationships.

Premises

Must be known to all and declared as such. No premises without comprehensible justification (also vis-à-vis the client).

Rules

Competencies and responsibilities must be clear. Optimal solutions require flexibility in the process (iterative solution finding).

ZEB objectives

Definition of ZEB objectives and their weighting (duty book)

Context

Disciplinary order and context analysis and confirmation in the team

Decision making

Definition of possible variants and utility analysis including sensitivity analysis (e.g. energy prices, capital interest, etc. The following graphic shows how the Chief ZEB consultant or Chief sustainability consultant coordinates the team leaders of different specialist teams to implement the integrated planning during the whole planning process.

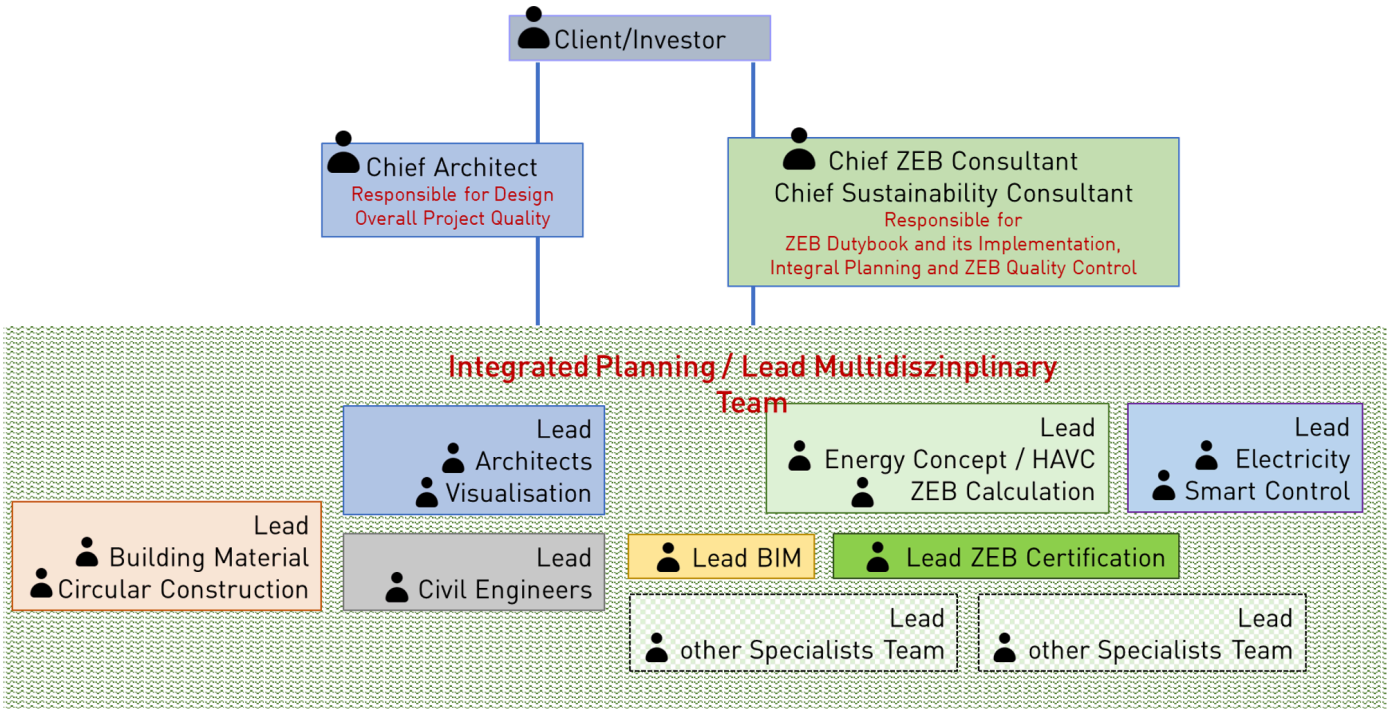


Figure 4. Integrated planning and disciplinary team of ZEB project that led by Chief architect and Chief ZEB consultant/Chief sustainability consultant. Graphic by intep.

Figure 5. Intensive exchanges and interconnections between planners, engineers, and other stakeholders. Graphic by intep.

How many and which kind of specialist teams working on the integrated planning under the general coordination of the Chief ZEB consultant or Chief sustainability consultant, depends on the project itself. Different building types, project volumes and areas require different teamwork to achieve its integrated planning. E.g., for the Beijing demonstration project, the ZEB consulting team of CABR is responsible for coordinating the architect team, building material team, circular construction team, HVAC team and the team for air circulation etc. to work together to achieve the goal of zero carbon emissions.

How to get started

Good experience in Integral Planning has been made with the following meeting rhythm:

- Initial meeting (aligning the team to the goal, generating design loyalty, information, effort budgets).
- Forward-looking team planning (identification of bottlenecks and timely initiation of measures).
- Team meetings with Jour-Fix (most important management instrument of the PL, information about decisions of the client, discussion of problems, reflection about the status of the work, next steps).
- Effort/benefit control (ensuring phase-appropriate processing, interface monitoring, budget monitoring, etc.)
- All project requirements must be entered in detail in the project duty book. These can be adapted to new findings in the course of planning and revised in the duty book with the agreement of all parties.

Integral planning requires the willingness of all team members to engage in a joint process and to collaborate in finding solutions in an open-ended manner.

The starting point is the joint negotiation of what a ZEB building should achieve. This involves the user' s perspective and the existing context, as well as the question of what effects can be expected from this on the design of the built environment.

This definition of a building' s services assumes that it must fulfill tasks in the sense of "services" over its entire useful life and support actions in a meaningful way for a sustainable part of building culture.

Integral planning requires the willingness of all team members to engage in a joint process and to collaborate in finding solutions in an open-ended manner. This only works in non-hierarchical teams as well as in discursive logic and requires an interdisciplinary negotiation of the means to be used (e.g. scope and type of technical means to be employed).

The formulation (by the team) of an appropriate objective with the users and the client, is an important prerequisite for a promising collaboration. The jointly defined project goals and specifications must be recorded in the project duty book.

How to define the ZEB objectives

The ZEB standard sets clear guidelines for the planning and operation of a ZEB building. The Chinese ZEB Standard (Technical standards for zero carbon buildings) can be viewed on following website: https://www.mohurd.gov.cn/. In order to achieve these demanding targets, many specific objectives as well as qualitative and quantitative targets must also be defined in each project. The objectives can be identified in the planning team and with the client using the following checklist.

In an initial phase, it is advisable for the client to define the general objectives together with the project management using a checklist. This avoids misunderstandings and later conflicts. Appendix A1 contains an example of such a checklist. However, the criteria and objectives must be selected individually.

The tools

Of course, different planning instruments can be used for integral planning. Besides all traditional tools, four overarching instruments have proven to be very useful and efficient for ZEB planning:

- The general target agreement checklist
- The ZEB duty book
- The ZEB technical concept
- The ZEB balance sheet
- The Chinese ZEB standard

These five planning tools complement each other ideally for the clear definition of the specifications, the precise presentation of the solutions, the communication within the planning team and with the client and authorities as well as for the quality control and the performance review.

Examples of these four tools are shown in appendix 1 to 4. These are examples from various projects. For a new project, the person in charge must adapt them to the specific circumstances.

- The ZEB target agreement checklist allows the project management to identify the most important objectives together with the client already in the strategic phase.
- The ZEB duty book defines the “rules of the game” in the form of technical, organizational, and general requirements.
- The ZEB concept shows how the requirements of the specifications are fulfilled.
- The ZEB Balance sheet provides quantitative evidence for ZEB certification.
- The Chinese ZEB Standard verifies if the project can reach ZEB standard in China.

Figure 6. the role and the development of duty book in the planning process. Graphic by intep.

4. The Duty Book

The ZEB duty book is the most important strategic working instrument for the integral planning and construction process. It defines the requirements and objectives (not solutions!) for the project and the participants. The duty book is the product of teamwork. It has a dynamic character and must therefore evolve according to the project phases (phase-related concept reports). The duty book should contain as little as possible and as much as necessary (do not formulate measures but goals!). Above all, it should contain verifiable and controllable goals and requirements.

The ZEB duty book is the most important strategic working instrument for the integral planning and construction process.

Profitable for all stakeholders

The ZEB duty book is of great benefit to all involved in the planning of a ZEB project because:

- The clients can clearly define their ideas and requirements in the ZEB duty book for all planners.
- The requirements of the ZEB standard for the project are recorded in detail and the responsibilities in the planning team are defined in a binding manner.
- Interfaces, dependencies, and mutual effects between the individual disciplines are discussed and identified at an early stage.
- Misunderstandings between the members of the planning team and the clients are identified and resolved at an early stage.
- The ZEB duty book is adapted to new requirements in the course of planning and the changes are recorded and confirmed for all.

The ZEB duty book is a valuable basis for quality control during the planning and building process as well as in facility management.

Basic facts

The clients and the planning team determine the value of the ZEB duty book. If they use the duty book as a binding basis for planning and strictly enforce it throughout the planning process, the duty book is very helpful for everyone and enables a significant improvement in project quality.

Planning using the duty book has led to a much-improved planning and building culture among leading clients.

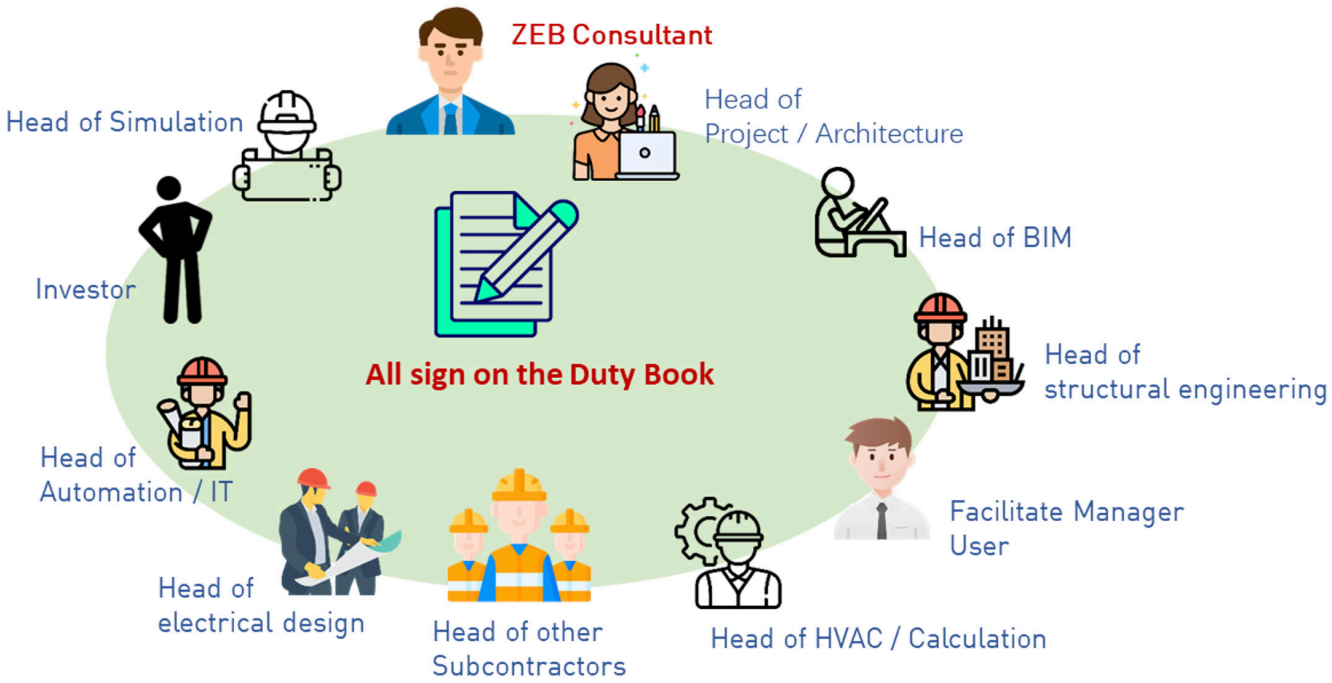


Figure 7. All Stakeholder should sign on duty book and are clear with their ZEB/Sustainability responsibility. Graphic by intep.

Image. Market Building and Exhibition Building Jiading, Shanghai (Beijing Demo Project of Sino-Swiss ZEB cooperation project)

Two prejudices

Some prejudices often prevent the application of a Project duty book. The most common unfounded prejudices are:

- The ZEB duty book means a lot of additional work and only increases the administrative work. FALSE. The development of the duty book means a certain additional effort at the beginning of the planning phase. Through the thorough, and in the team developed, clear definition of the "rules of the game", specifications and responsibilities, many misunderstandings and planning errors can be avoided. This avoids costly rescheduling and bad investments.
- The ZEB duty book can be written independently by the team members. FALSE. The development of the ZEB duty book must be led and coordinated by an appropriate professional. This person must be prepared to use competent arguments to discuss and push through even uncomfortable issues in the planning team.

Seven prerequisites for how to organize a duty book

- The client must assign a competent and experienced professional to develop and enforce the ZEB duty book.
- The head of ZEB duty book must be able to think integrally and communicate with all specialists.
- The client must fully support the head of duty book even in critical situations and insist on the enforcement of the duty book.
- The head of duty book must be able to understand the concerns of the specialists and convince them with competent arguments.
- Parallel to the development of the duty book, the planning team must also develop the ZEB Technical Concept and calculate the balancing of energy and emissions.
- If possible, the duty book should be used as a basis for quality control.
- The client can request embodied carbon emission data of each building material and installation from producer in the bidding process, in order to collect this important data for evaluation of ZEB building (especially for "whole process zero carbon building")

The client must assign a competent and experienced professional to develop and enforce the ZEB duty book.

The content and structure of a ZEB duty book are shown as an example in Appendix 2. The content must be redefined for each project.

5. The ZEB Balance Sheet

Background

Appendix 4 presents the Swiss accounting tool SIA 2040, which was used experimentally for the first three ZEB DPs (Beijing DP, Shaoxing DP and Shenzhen DP). The SIA 2040 tool will have to be replaced by the official ZEB calculation and balance tool published by CABR and Mohurd. The Swiss tool SIA 2040 is based on the sustainability program "2000-Watt Society" of the Swiss Federal Institute of Technology ETH.

The 2000-Watt Society considers the total primary energy use and total greenhouse gas emissions from all consumption sectors in Switzerland. Based on these overall and per capita goals the Swiss Engineer and Architect association (SIA) has developed a standard called SIA Energy Efficiency Path (SIA Instruction Sheet 2040). Its aim is to create the best possible preconditions for achieving targets for the building sector; the course should be set in such a way that the structural development proceeds in big steps in the right direction. As the most important sector in Switzerland in terms of energy consumption, the building sector takes on a pioneering role, showing that it is already possible to embark on the path towards the 2000-Watt Society today.

Target values

The target values were determined for the building categories residential, administration, school, specialized store, food store and restaurant, proceeding from the assumption that the proportional share of total energy use represented by energy use in the building sector remains constant during the period from 2010 to 2050. For this purpose, the current status was determined for each building category and reduced to the target status in the year 2050 using the reduction factors from the targets of the 2000-Watt Society.

The target values are related to the energy reference surface; the consumption values in the 2000-Watt Society are related to a per capita reference. It's converted by means of standard surface per person. In SIA Instruction Sheet 2040 it is assumed that the surface requirement per person remains constant during the period of validity of this technical specification. This simplification should be reviewed periodically. If the energy reference surface per person continues to increase in the future, the target values will need to be tightened accordingly.

The target values correspond to the average acceptable demand for primary energy use or the greenhouse gas emissions in buildings in 2050, including location-dependent daily mobility from the inhabitants. It shows that individual building categories cannot fully achieve the reduction targets. However, for the building categories considered in the SIA Instruction Sheet 2040 (which comprises around 80 % of the total energy reference surface in Switzerland), the overall implementation is possible.

Project values

The project values are always calculated using the data normally available at the relevant stage of the project. During the preliminary study and preliminary project phases there exists a calculation aid that can be used to arrive at an initial estimate of non-renewable primary energy use and greenhouse gas emissions for construction, operation, and mobility. For later planning stages different energy simulation softwares are available and must be used.

Assessment

If buildings including one or several building categories have a lower project value than the target value for the indicator's primary energy use and greenhouse gas emissions, they can be called ZEB Buildings.

Appendix 1 - General target agreement checklist

The ZEB target agreement checklist allows the project management to identify the most important objectives together with the client already in the strategic phase. This checklist is helpful in an early phase, e.g. strategy development or pre studies. It gives the possibility for the client and the planners to discuss and define together the basic and general objectives of the project. The result of the checklist can be used for the ZEB duty book.

The checklist presented here is an example from previous projects. It must be adapted for each project according to the specific situation and defined jointly in the team.

	CRITERION	TARGET
1	Society	
1.1	Integration/mixing	Optimum conditions for social, cultural, and age-related integration
1.2	Solidarity/Justice	Supporting disadvantaged people
1.3	Participation	High level of acceptance through participation
1.4	Spatial identity / Recognition	Orientation and spatial identity through design recognition / individual design
1.5	Basic supply, mix of uses	Short distances, attractive mix of uses in the neighborhood
1.6	Mobility	Non-motorized traffic and public transport. Good and safe accessibility and networking
1.7	Accessibility and usability for all	Design buildings and surroundings to be handicapped accessible
2	Well-being / Health	
2.1	Light	Optimized daylight conditions, good and efficient artificial lighting
2.2	Indoor air	Low levels of allergens and pollutants in the indoor air, fresh air only to keep a low CO2-level
2.3	Radiation	Low emissions due to ionizing and non-ionizing radiation
2.4	thermal insulation	High level of comfort due to good winter and summer thermal insulation
2.5	Noise, vibration	Low emissions due to noise and vibrations
2.6	Security and Safety	Measurements of security and safety
3	Economy	
3.1	Location	Ensure long-term economic use appropriate to the location.
3.2	Building fabric	Achievement of value and quality stability based on service life
3.3	Building structure, expansion	High flexibility for different space and use requirements
3.4	Life cycle costs	Make investments considering life cycle costs
3.5	Financing	Long-term secured financing of investment, maintenance, and deconstruction costs
3.6	External costs	Minimizing and internalizing external costs
3.7	Operation and maintenance	Low maintenance costs through early planning and continuous measures
4	Environment	
4.1	ZEB Standard	Fulfill requirements of ZEB Standard and get ZEB certification
4.2	Raw materials availability	Well available primary raw materials and high proportion of secondary raw materials
4.3	Environmental impact	Low environmental impact during production
4.4	Pollutants	Few pollutants in building materials
4.5	Deconstruction	Easily separable composites and constructions for reuse or recycling
4.6	Heat (cold) for indoor climate	Low heating/cooling and heating/cooling energy requirements due to structural and building services
4.7	Heat for hot water	Low heat and energy requirements for hot water through structural and building precautions
4.8	Electricity for lighting, appliances, and electrical supply	Low electricity demand through conceptual and operational measures
4.9	Energy demand	100% share of renewable energy
4.10	Water	Low drinking water consumption and low wastewater volumes
4.11	Circular construction	Concept for reuse, down- & upcycling
5	Landscape	
5.1	Open spaces	Large biodiversity
5.2	Waste from operation and use	Good infrastructure for waste separation
5.3	Green concept	Vertical and horizonal green concept to improve the microclimate.
5.4	Good layout	Good layout concept to enable natural air circulation, enough using of day-light and shading with natural shadow

Appendix 2 - ZEB duty book example

The duty book content presented here is based on the experiences from previous projects. It must be adapted for each project according to the specific situation and defined jointly in the team.

- Name of project: XXXXX
- Date: XX.XX.XXXX
- The undersigned persons confirm with their signature that they will in the ZEB Project:
  - Plan, implement and operate the building according to the objectives and specifications of the ZEB Standard to the best of their knowledge and belief.
  - Implement the values and measures defined in the duty book as fully as practicable in the realization of the project.
  - Comprehensively represent the technical and organizational specifications defined in the Duty book in the ZEB building concept.
- Signatures
  - Head of project
  - Head of architecture
  - Head of structural engineering
  - Head of HVAC
  - Head of sanitation / water
  - Head of electrical design
  - Head of automation IT
  - Head of coordination / BIM
  - Head of facility management planning
  - Head of energy / sustainability concept
  - Head of quality control
  - Contractors
  - Users

A: General project information for Demo building A

A.1 Name, background and general description of the project (filled in by architect)

- Background
- Location
- Location type (Urban, rural)
- Typology (Housing, Office, School, etc.)
- Project type (New, Conversion, Extension)
- Construction (Massive, Light, Hybrid, etc.)
- Building material
- Climate zone (I, II, III, IV, V)
- Access to public transport
- Parking

A.2 Goal of the project (filled in by architect)

- Urban planning
- Architectural design
- Program/Function

A.3 Project owner / developer (filled in by architect)

- Landowner
- Developer
- User

A.4 Project sustainability goals (filled in by architect)

- Energy label
- Carbon emission goal
- Quality goal
- Lifecycle (cost, repair, demolition, renovation…)

A.5 Project time schedule

- Concept design phase
- Preliminary design phase
- Construction design phase
- Tendering
- Awarding
- Construction phase
- Commissioning
- Occupation of building

B: Project facts and figures

B.1 Name, project size (filled in by architect)

- Building site (m2)
- Building dimensions (m)
- Building height (m)
- Number of floors
- Footprint area (m2)

- Building floor area ratio
- Building density %
- Green area ratio %
- Gross floor area (m2)
- Building volume (m3)
- Ratio envelope / volume(m2/m3)
- Conditioned floor surface ERA (m2)
- Parking (numbers of lots)

B.2 Mobility, transportation (filled in by architect)

- Public transportation
- Private transportation

B.3 Building envelop (filled in by architect)

- Building material for envelop (m2)
- Construction system (Ventilated Façade, Massive Façade, etc.)
- Envelop surface area (m2)
- Transparent/Opac ratio
- Drawings/Documents of site plans, floor plans, elevations, sections, details

B.4 Project cost (annual basis) (filled in by architect)

- Construction (RMB/a)
- Energy (RMB/a)
- Maintenance (RMB/a)
- Lifecycle (RMB/a)

B.5 Structural design (filled in by structural engineer)

- Structural system
- Building materials
- Seismic requirement
- Load requirement
- Prefabrication rate
- Drawings/Documents of structural design

B.6 Building physics and indoor comfort level (filled in by building physicist)

- U-values relevant elements of envelop
- Windows construction/material/G-Value
- Solar shading system
- Temperature (min. and max. for heating and cooling mode in °C)
- Air humidity (min. and max. relative humidity in %)
- Sound level (airborne and structure-borne sound in dB)

B.7 HVAC concept (filled in by HVAC engineer)

- Heating (generation/conversion, storage, distribution)
- Cooling (generation/conversion, storage, distribution)
- HVAC System
- Heating/Cooling resource
- Efficiency COP/EER/etc.
- Ventilation (centralized/decentralized AHU, distribution)
- Dehumidification (type of system)
- System separation
- Heat recovery
- Drawings/Documents of HVAC Concept

B.8 Water, sanitation concept (filled in by sanitary planner)

- Drinking water
- Sprinkler
- Water demand
- Drainage system
- Drainage volume
- Wastewater
- Rainwater
- Hot water
- Hot water energy resource
- Water saving valve
- Drawings/Documents of sanitary plans

B.9 Electricity, lighting, plug-ins concept (filled in by electrical planner)

- Lighting,
- Artificial light (Lux)
- Lighting Control System
- Supply (net, self-generated electricity)
- Transformation (high/low voltage)

- Storage/conversion (battery, power to x)
- Daylight/Artificial light (type, sensors, and automation)
- Electricity, PV, storage
- Calculation electricity demand
- Drawings/Documents of electrical plans

B.10 Building automation (filled in by automation planner)

- Shading control system
- Automation control
- Plug-in
- Security, safety
- Drawings/Document of automation plans

B.11 Source and CO2 factor of energy input

- Heating source (type and kgCO2/kWh)
- Cooling source (type and kgCO2/kWh)
- Electricity supply (type and kgCO2/kWh)

B.12 Energy consumption calculation (energy consultant)

- Total and specific heating capacity (kW and W/m2)
- Total and specific cooling capacity (kW, incl. dehumidification and W/m2)
- Total and specific electrical capacity (kW and W/m2)
- Total PV surface/peak load (m2, kW)
- Total and specific heating demand (kWh/a and kWh/m2a)
- Total and specific cooling demand (kWh/a and kWh/m2a)
- Total and specific electrical demand (kWh/a and kWh/m2a)
- Total and specific PV supply (kWh/a and kWh/m2a)
- Embodied energy
- Rate of renewable energy

C: Requirements of Chinese ZEB standards

The Chinese ZEB Standard is classified into two primary categories: building and district.

C.1 ZEB building

According to Chinese ZEB Standard, buildings can be categorized as follows:

- Low carbon building
- Nearly zero carbon building
- Zero carbon building (incl. The Whole Process Zero Carbon Building)

C.2 ZEB district

According to Chinese ZEB Standard, district can be categorized as follows:

- Low carbon district
- Nearly zero carbon district
- Zero carbon district

C.3 Requirement of ZEB Standard

The Chinese ZEB Standard distinguishes various factors as follows:

- There are five different climate zones: extremely cold zone, cold zone, hot summer and cold winter zone, hot summer and warm winter zone, and temperate zone.
  - Solar irradiance is rated into four distinct zones: I, II, III, and IV.
  - For individual buildings, there are seven different types: small office buildings, large office buildings, small hotel buildings, large hotel buildings, shopping mall buildings, hospital buildings, and educational buildings.
  - For districts, the standard identifies six different types: residential district, office district, hospital district, commercial district, primary and secondary school campus district, and university campus district.
- The calculation for buildings under the Chinese ZEB Standard is based on the annual carbon emission per square meter (kg CO2/m2a). On the other hand, for districts, the calculation is based on the annual carbon emission per person (kg CO2/p.a).

- The requirements under the Chinese ZEB Standard vary based on the aforementioned conditions. Specific details for each case can be found in the official Chinese ZEB Standard document.
- The Zero Emission Building (ZEB) design mandates the use of an integral planning method and a performance-based architectural design method. The optimization process during the planning phase is dynamic, necessitating multidisciplinary cooperation led by an architect or expert proficient in ZEB design.
- Efficient measures should be implemented to optimize carbon emissions during the construction phase. These can include on-site renewable energy, high rates of prefabrication, and waste recycling, among others.
- During the operational phase, carbon emissions should be monitored and optimized based on the actual operating conditions. It' s essential to integrate facility management for operation, maintenance, and optimization.
- Furthermore, promoting and guiding a low-carbon lifestyle is encouraged.

C.4 Evaluation of ZEB Standard

- Two distinct methods are available for assessing a building or district: one is based on the relative reduction rate of carbon emissions compared to a reference object, utilizing the GB55015 method, and the other is based on the absolute value of carbon emissions. This approach allows for flexible solutions tailored to the unique circumstances and conditions of each project.
- The evaluation primarily concentrates on the operational phase, reflecting the context of the Chinese building sector. For the whole process zero carbon building, the highest level in the Chinese ZEB Standard, the embodied carbon emissions of building materials and installations are also evaluated.
- The evaluation process distinguishes between design phase certification and operational phase certification. For the latter, the building or district must provide the necessary operational data for at least one year, with at least 60% of the building area in operation.
- Carbon offsetting, such as green electricity trading and carbon trading, serves as an alternative method to alleviate Carbon Emissions.

Appendix 3 - ZEB technical concept example

The ZEB technical concept shows how the requirements of the ZEB duty book are fulfilled. The ZEB technical concept is structured analogous to the ZEB duty book. The individual chapters are written by the responsible specialists (e.g. HVAC engineer, IT specialist, landscape architect). Each specialist is responsible for the content of his chapter. It is very important that the interfaces of the individual technical elements are well coordinated (e.g. facade construction with sun protection and HVAC planning). The ZEB Technical Concept is the basis for the execution planning and for the coordination meetings of the integral planning team. The concept can be led by a ZEB Chief consultant or sustainability Chief consultant.

The ZEB concept may include items such as:

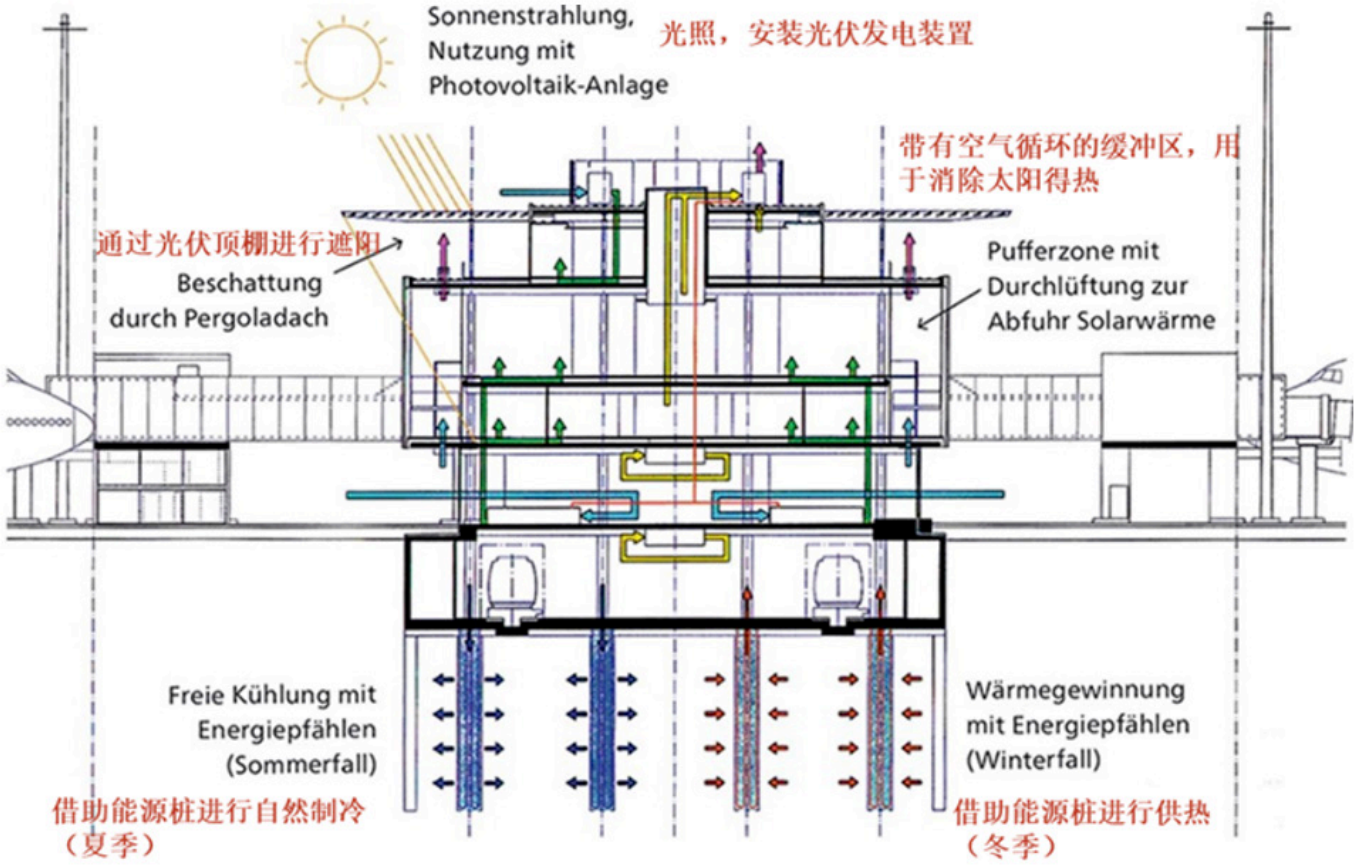
- Location / Environment
- Energy and power demand
- Energy supply
- Building envelope / construction
- Building services engineering
- Comparison of heat generation variants
- Variant comparison cooling generation
- Electricity. Energy Hub
- IT, automation, data management
- Water concept
- Facility management
- Commissioning procedure
- Lifecycle optimization
- Economic efficiency
- Environmental balance
- Measurement concept and operation optimization

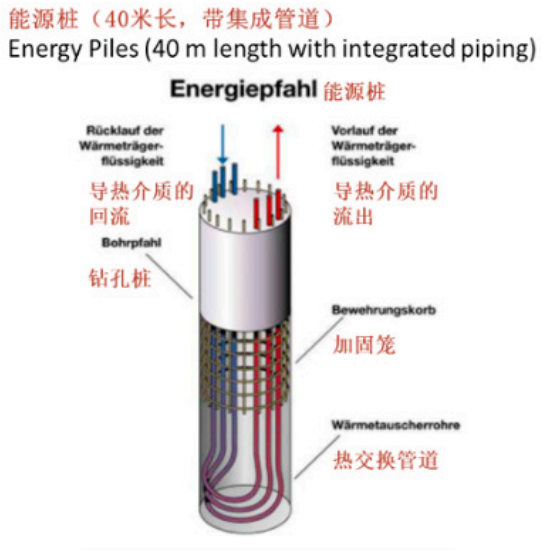
Very helpful are clear and easily understandable schematic representations of essential technical elements and their interrelationships and dependencies. This can be shown for an entire building or for individual rooms. This makes it possible to explain the concept variants in a comprehensible way to the planning team, the building owner and the authorities.

The following graphics show well-descripted ZEB technical concepts of the Zurich Airport, New Dock E Terminal Building which was implemented by Amstein + Walthert AG and the Lucerne University of Applied Sciences.

One of the Demo Projects of the Sino-Swiss ZEB cooperation project – Gongchen Community Center of Fangshan District in Beijing - prepared also well-descripted ZEB technical concepts which are shown in the graphics below:

Also, the Demo Project of the Sino-Swiss ZEB cooperation project – Gongchen Community Center of Fangshan District in Beijing - prepared a well-organized technical implementation of ZEB concept, especially on the renewable energy system and the ventilation system as shown in the graphics below.





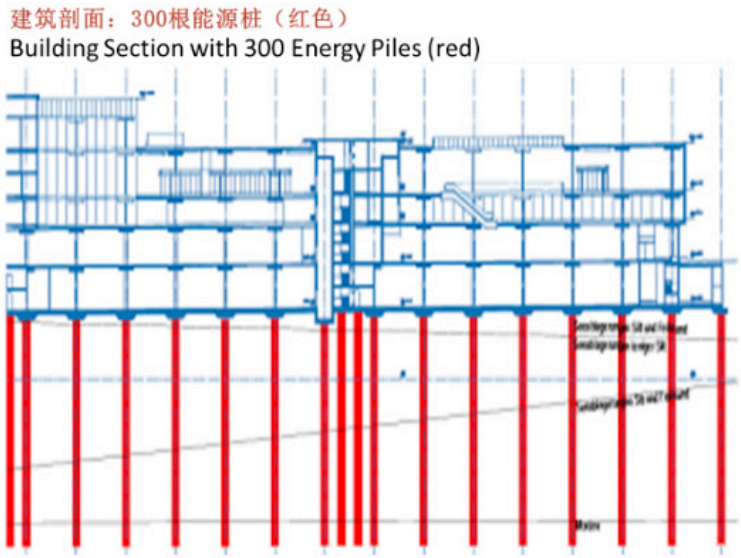
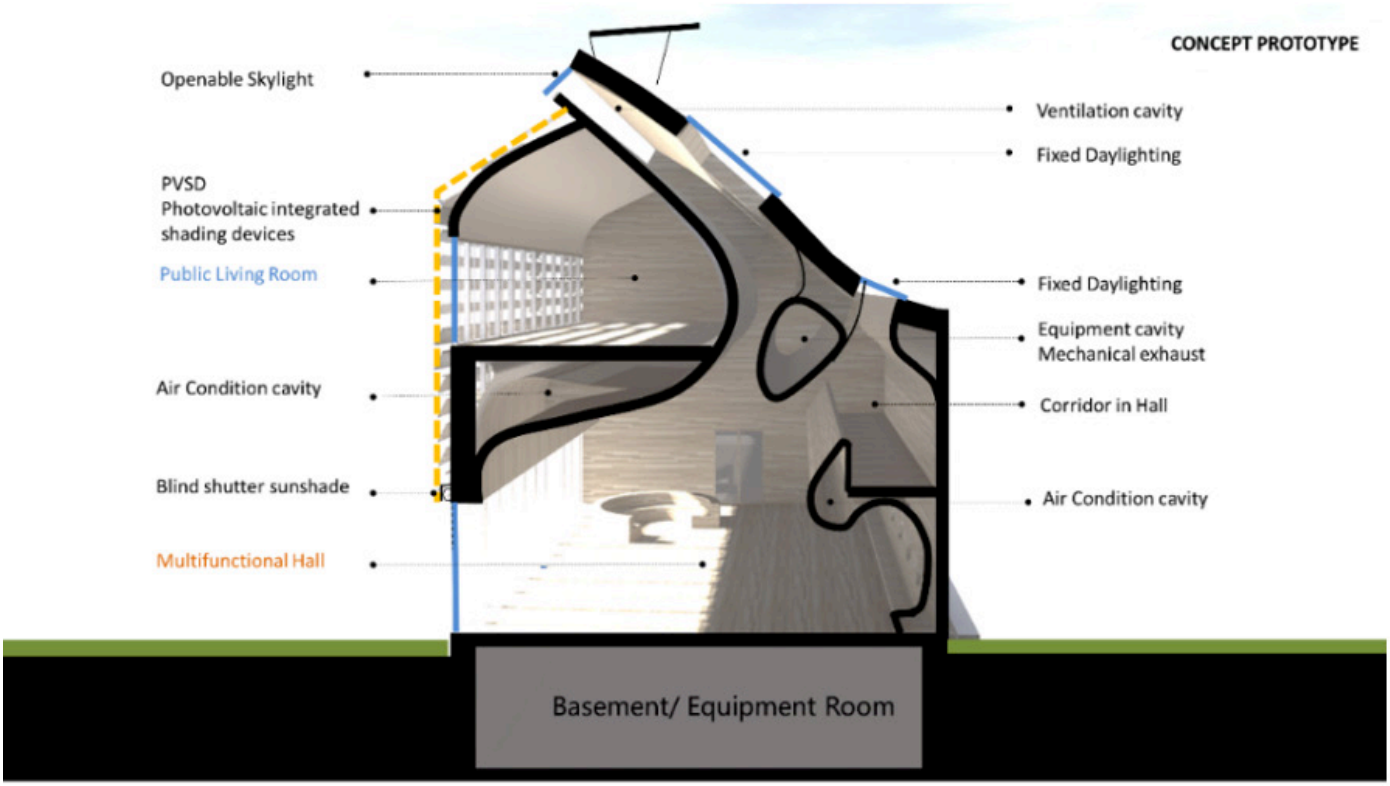


Figure 8. The ZEB technical concepts of Zurich Airport, New Dock E Terminal Building. Graphic by Prof. Adrian Altenburger and Amstein + Walthert AG.



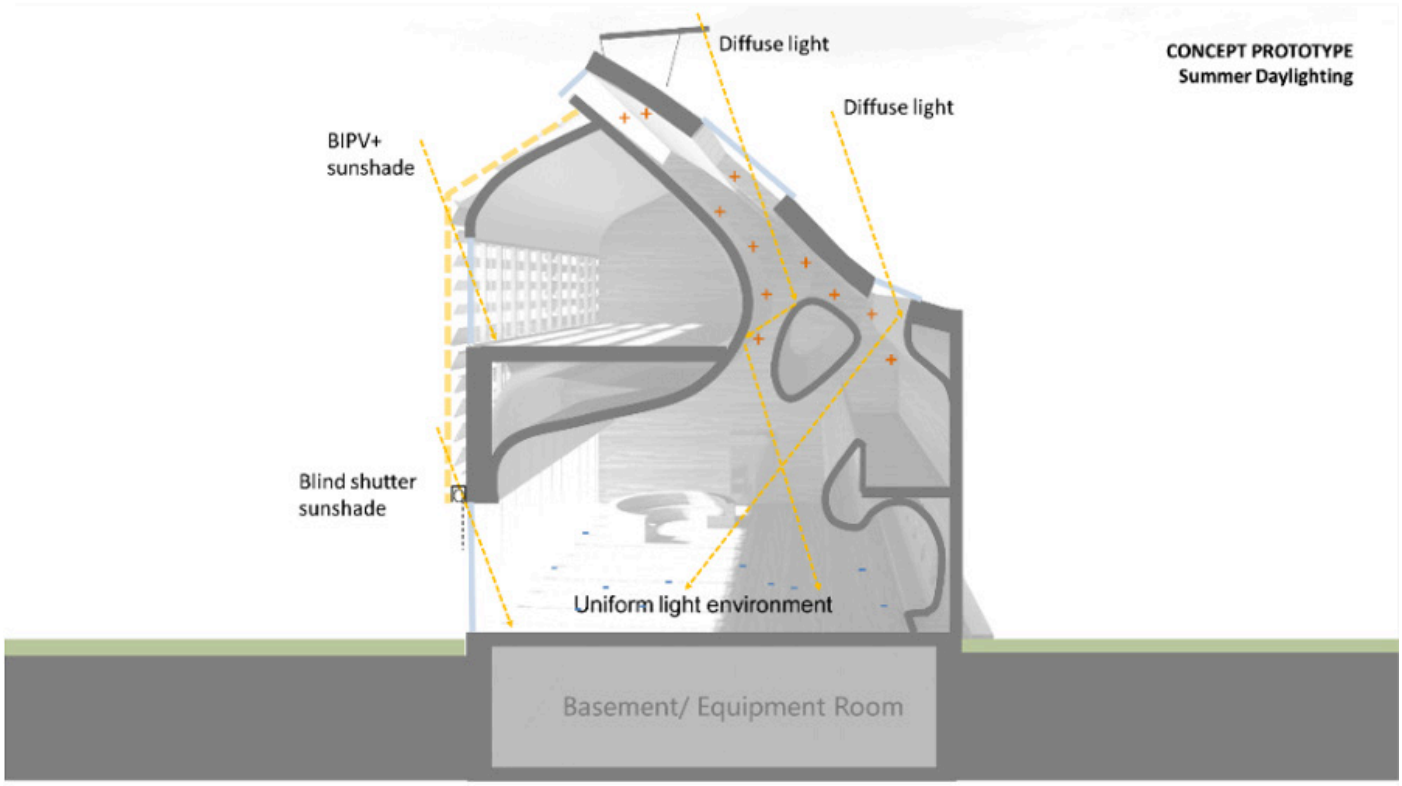


Figure 9. ZEB technical concepts

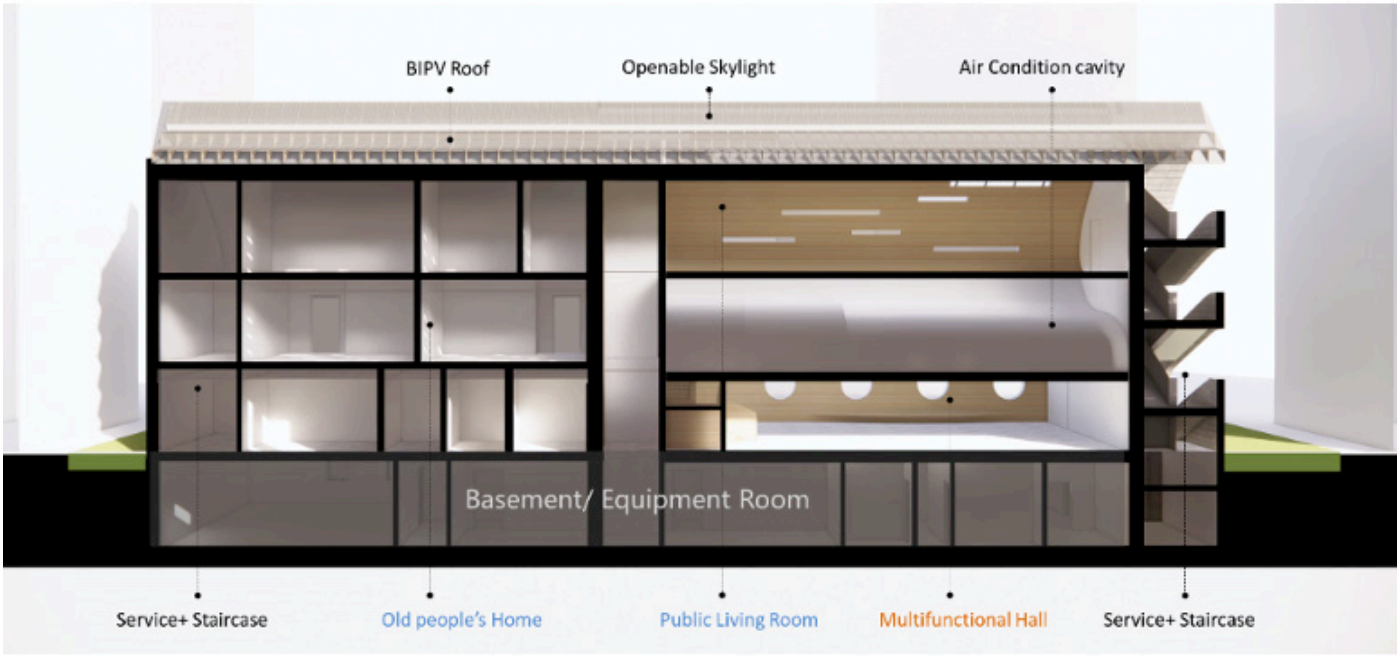


Figure 10. Energy concept description, Beijing Demo Project of Sino-Swiss ZEB cooperation project - Gongchen Community Center of Fangshan District in Beijing. Graphics created by SUP Atelier at Tsinghua University ZEB consulting team of CABR.

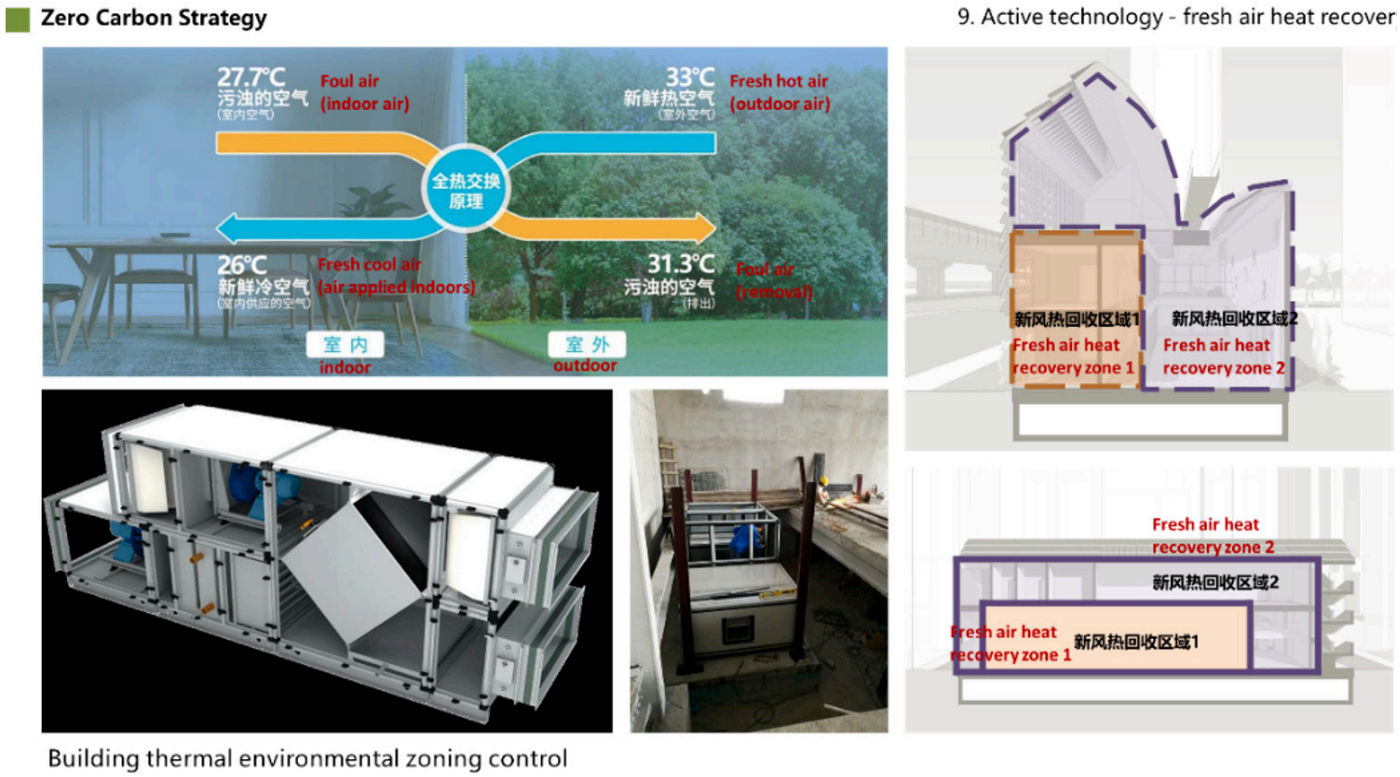


Figure 11. Zero carbon strategy – Active technology "fresh air heat recovery", Beijing Demo Project of Sino-Swiss ZEB cooperation project - Gongchen Community Center of Fangshan District in Beijing. Graphics created by SUP and ZEB consulting Team of CABR.

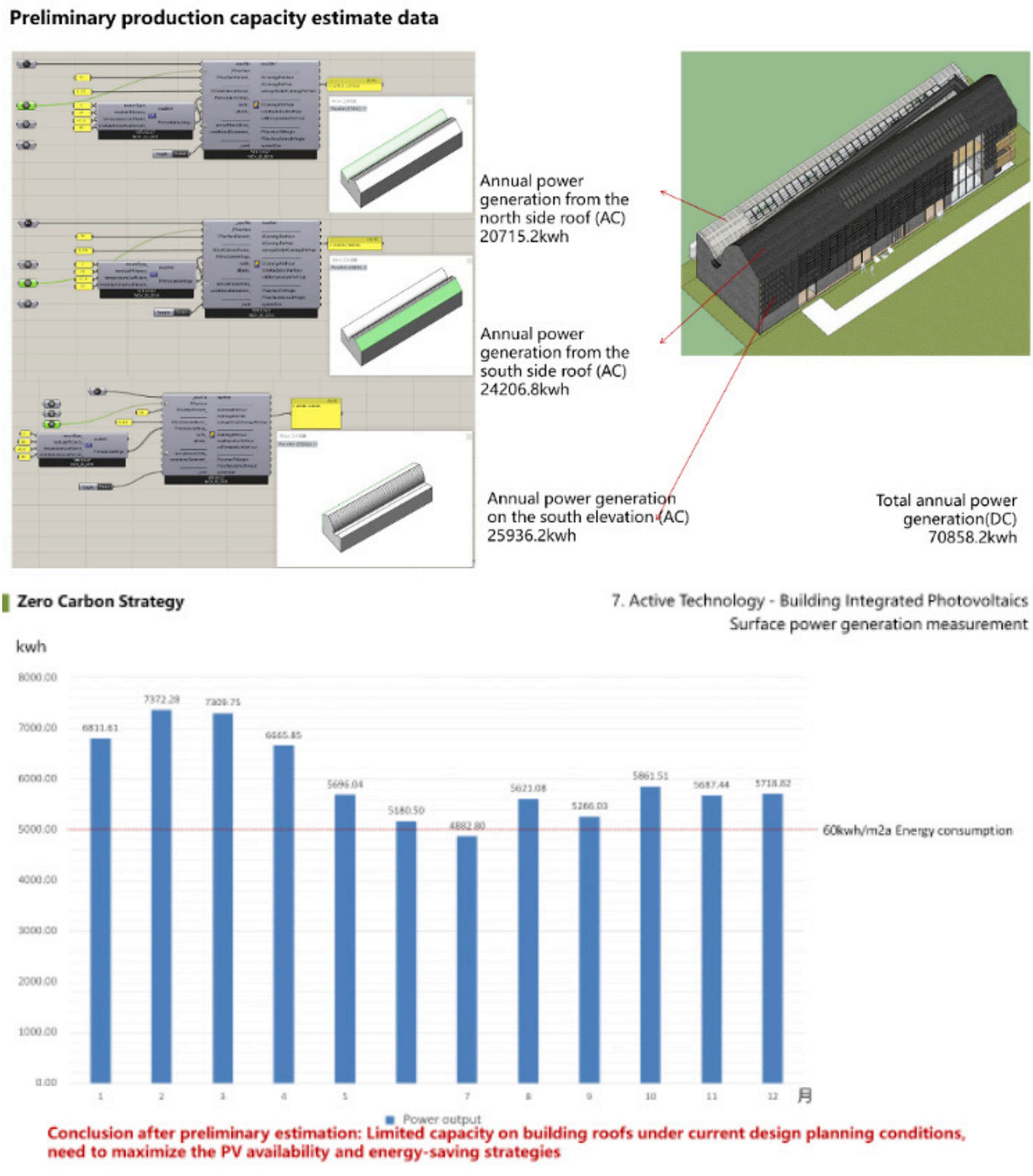


Figure 12. Zero carbon strategy – active technology – building integrated photovoltaics surface power generation measurement, Beijing Demo Project of Sino-Swiss ZEB cooperation project - Gongchen Community Center of Fangshan District in Beijing. Graphics created by SUP and ZEB consulting team of CABR.

Appendix 4 - Swiss ZEB balance sheet SIA 2040

Excel SIA2040_Tool_v300_lic_CN

Below is a cutout of the Excel SIA 2040 tool. The Chinese translated Excel SIA2040_Tool_v300_lic_CN can be acquired from Baidu account via Link:

https://pan.baidu.com/s/1hrqKphIXpT0pitGFGj091g?pwd=9k4e (Code: 9k4e).

This tool is intended for reference purposes only. For official certification of Chinese ZEB Buildings, please consult tools provided by CABR or Mohurd.

The instructions below shows the instruction of “how to use the tool”:

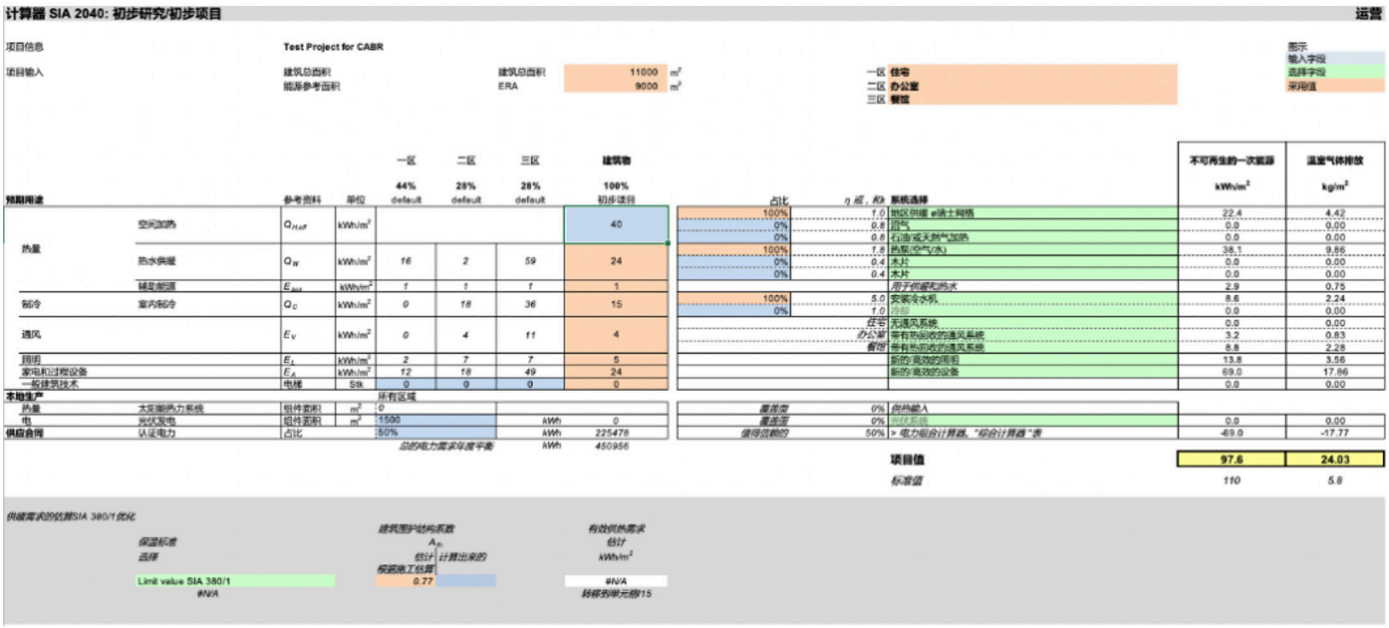


Figure 13. Cutout of the Excel calculator SIA 2040. Source: SIA

This calculation aid enables a first estimation of the target achievement for projects that are built according to SIA 2040 “SIA Efficiency Path Energy”. This estimate is made in the early phase of the preliminary study/pre-project in accordance with SIA 112 “Building design model”. Where calculated values are not yet available in this planning phase, the calculation aid is based on standard values. Procedure:

1. Worksheet “Building categories”: Select the building category and whether it is a new building or a conversion. Enter the floor area and energy reference area. You can enter up to three different zones.

2. Worksheet “Construction”: In the blue input fields, enter the corresponding component surfaces from your project. Select the intended construction method in the green selection fields.

3. Worksheet “Operation”: Here you must enter the heating requirement of your building according to SIA 380/1 (use heating requirement) taking into account the effective, thermally effective outside air volume flow). If you do not yet know this, you will find an estimation aid in the lower half of the sheet. Select the systems you want to use in all green selection boxes. If more than one heat generation system is used, you can enter their share of demand coverage as a percentage. In the lower blue fields, you are asked for the component areas of any solar systems for self-production of electricity or heat. The grey energy of the selected systems is automatically updated in the Creation sheet. If you want to use a long-term supply contract for electricity with ecological added value of the nature made star quality (or equivalent), you can enter this via a percentage share of the total electricity up to a maximum of 50%. You enter the composition of the electricity supplied in the integrated electricity mix calculator.

4. Worksheet “Mobility”: Here you will be asked for the municipality where your construction project is planned and for other location factors. Replace the default values with the project values where these are known. The calculations are based on assump-

tions that are not yet reality today. Calculations are based on the 2050 vehicle fleet, i.e. with reduced fuel consumption compared to today.

5. Worksheet “Results”: It is indicated whether the project meets the requirements of the SIA Energy Efficiency Path. If this is not the case, it is explained where optimization should be made.

6. Worksheet “Energy mix calculator”: Contains the district heating and electricity mix calculator.

7. Worksheet “Construction project”: Is designed for calculation in a later planning phase. The values for construction, operation and mobility are calculated separately according to the specified SIA standards and transferred to this worksheet.

Appendix 5 - Development of relevant standards in China

As of May 2024, one national standard has been developed (a review meeting has already been held), five standards by China Association for Engineering Construction Standardization (with review meetings for the four evaluation standards for whole-process zero carbon buildings, campuses, residential areas, and parks scheduled for May 24, 2024), and two group standards by CABEE (both of which have already undergone review).

Technical Standard for Zero Carbon Buildings (review meeting held)

On December 18, 2023, the review meeting for the national standard "Technical Standard for Zero Carbon Buildings" (draft for review) was held in Beijing, which was co-compiled by CABR and CABEE along with 49 domestic units related to design, scientific research, and higher education institutions. Closely integrating with China's energy structure adjustment trends, climatic characteristics, building types, energy use characteristics, and the development trends of low-carbon technologies, the "Technical Standard for Zero Carbon Buildings" determines the boundaries, scope, and calculation methods for building carbon emissions. It defines low carbon, near zero carbon, and zero carbon buildings/regions, proposes graded control indicators based on absolute carbon emission intensity and relative carbon reduction rate. It assigns values to carbon emission intensity from three dimensions based on building/regional types, climate zones, and solar radiation levels, clarifies the methods for determining the value of building electricity emission factors, and stipulates non-building technology carbon reduction measures such as green electricity trading and carbon emission trading. This standard is the first in the world to specify the absolute value of carbon emission intensity and relative value of carbon reduction rate for low-carbon and near-zero-carbon buildings/regions in the form of a national standard. It is comprehensive in content, reasonable in technical indicators, in line with China's national conditions, and has reached the international advanced level overall.

Series standards from China Association for Engineering Construction Standardization

The series of standards for zero carbon building evaluation is a crucial part of the "1+N" standard system for zero carbon buildings. Based on the currently developed national standard " Technical Standard for Zero Carbon Buildings" it refines scenarios and indicators, establishes accounting methods, and formulates evaluation methods and processes. This creates a comprehensive evaluation system for whole-process zero carbon buildings, campuses, residential areas, hospitals, and industrial parks, supporting and aligning with the national standard and facilitating the industry's low-carbon transformation. Among these, the four evaluation standards for whole-process zero carbon buildings, campuses, residential areas, and industrial parks are scheduled for a review meeting at the end of May 2024.

Standard type	Standard subject	Phase
National standard	Technical Standard for Zero Carbon Buildings	review meeting held
China Association for Engineering Construction Standardization standard	Evaluation Standard for Whole Process Zero Carbon Buildings	review meeting in May 2024
	Evaluation Standard for Zero Carbon Campuses	review meeting in May 2024
	Evaluation Standard for Zero Carbon Residential Area	review meeting in May 2024
	Evaluation Standard for Zero Carbon Park	review meeting in May 2024
	Evaluation Standard for Zero Carbon Hospitals	draft resolution for public comments
China Association of Building Energy Efficiency group standard	Evaluation standard for zero carbon buildings	review meeting held
	Evaluation standard for zero carbon community	review meeting held

Series standards from CABEE China Association of Building Energy Efficiency (review meeting held)

The “Evaluation standard for zero carbon buildings” has undergone extensive research and, in conjunction with the national standard “Technical Standard for Zero Carbon Buildings” has conducted eight thematic studies. These studies are closely aligned with trends in China’ s energy structure adjustments, climate characteristics, building types, building energy use characteristics, and the development trends of low-carbon technologies. The standard proposes evaluation methods and technical requirements for low-carbon buildings, near-zero carbon buildings, zero carbon buildings, and whole process zero carbon buildings. It establishes an evaluation system that encompasses control indicators and measures, clarifies the methods for calculating and accounting for building carbon emissions, and specifies the requirements for data acquisition. This provides technical support for the scientific evaluation of zero carbon buildings in China. The “Evaluation standard for zero carbon buildings” is effectively integrated with the national standard “Technical Standard for Zero Carbon Buildings” and other relevant standards, providing crucial technical support for promoting the evaluation of zero carbon buildings and accelerating the large-scale development of low carbon and near zero carbon buildings, ultimately advancing the development of zero carbon buildings.

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

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

中华人民共和国
住房和城乡建设部

IBEE 环能科技

intep

skat