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零碳建筑-ZEB

零碳建筑(ZEB)指导手册

实现零碳建筑(ZEB)的三个步骤

- **综合规划**
- **零碳建筑(ZEB)责任手册**
- **零碳建筑(ZEB)平衡计算表**

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编辑信息

零碳建筑（ZEB）指南 — 实现零碳建筑建筑（ZEB）的三个步骤，版本 1， 2023 年 4 月

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鸣谢中瑞零碳建筑项目北京示范工程-北京市房山区拱辰社区中心的投资方和规划团队为本指南提供项目数据。

关于中瑞零碳建筑项目

当今的中国已明确了到 2060 年要实现碳中和的国家减排目标，并确认建筑行业是实现零碳社会和经济的主要支柱之一。中瑞零碳建筑项目很荣幸有机会为中国的合作伙伴提供支持，帮助他们实现这一长期目标。那么，我们如何才能实现这个目标呢?

零碳建筑（ZEB）示范工程（DP）将证明零碳建筑在今天是确实可行的，且不同建筑类型均可满足零碳建筑标准。为了得以证明，这里，详实和透明的能耗和二氧化碳平衡计算是至关重要的。

只有当一个项目从初始方案到实际落地都能够证明其减排先进性时，成功的零碳建筑（ZEB）措施才会被清楚地获得展示并得以认同，且才能在行业和市场上得到大规模的实施。

如何使用本指南

我们想通过本指南介绍一些能支持实施零碳建筑的方法和工具。中国和瑞士在建筑领域的规划和建造文化虽有差异，但有些规则是可以在所有文化中在组织管理和实施层面上都能力助零碳建筑实施的。本指南中我们将向您展示适用于所有文化和国家的打造零碳建筑的三部曲。其中，综合规划是一个目标导向的，由来自不同专业领域专家共同参与的规划方法，它的目的是要在复杂的技术问题上寻找最优的解决方案。这个整体的工作方法能为设计和建造阶段带来很多工作效益，并在项目早期可以让不同的专家和利益相关方参与项目。早期参与是非常重要的，因为很多影响后期发展的决策都是在早期设计阶段形成的，特别涉及隐含碳的问题。此外，零碳建筑责任手册和能耗或碳排计算平衡表也是帮助项目有效实施零碳目标的两个工具。这里我们不仅能在低碳方面，而且也可在经济性方面获益。因为一个成熟的规划，清楚的责任，精准的计算可以避免项目进程中的很多错误。众所周知，在建筑项目中小小的错误都会诱发额外的开支。

本指南意在以中国建筑科学研究院有限公司（CABR）编制的<<零碳建筑技术标准>>和瑞士工程师与建筑师协会标准 2040 为依据，旨在为建筑的规划和建造提供支持。为了满足零碳建筑（ZEB）标准的高要求，我们需要一种新的规划和建筑文化。此外，可持续的规划和建造需要一种整体而综合的思维和工作方式，这也需要使用适当的规划工具。这些工具包括:

- 综合规划
- 零碳建筑（ZEB）责任手册

- 零碳建筑（ZEB）平衡计算表

未来的建筑必须符合零碳建筑（ZEB）标准，零碳建筑（ZEB）标准是中国和世界各地可持续建筑的基准。

未来的建筑都将是零碳建筑（ZEB）

下图表显示了三个零碳建筑（ZEB）工具在整个项目过程中的实施路线图。

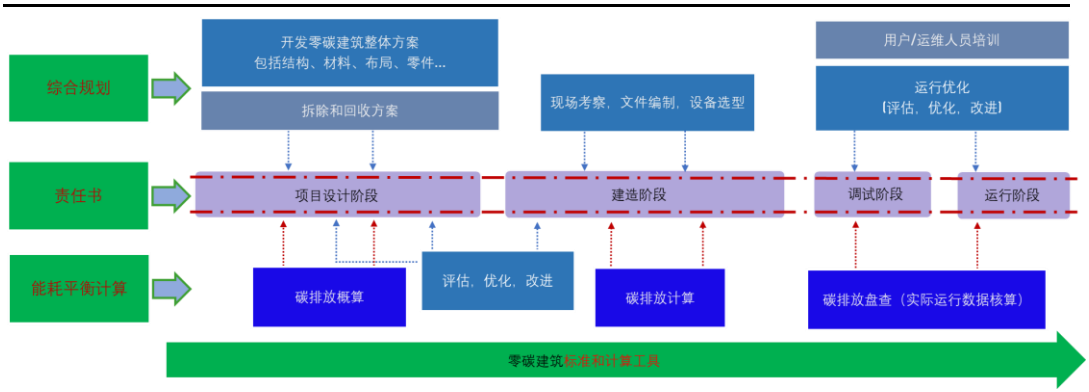

图 1：项目过程中三种工具的实施路线图，图片由 intep 制作

1 综合规划

使用综合规划并非奇迹
但它对于实现更优解决方案非常有帮助。

跨学科的专业知识是一个零碳建筑（ZEB）项目成功的先决条件，特别是在最初的设计阶段。建筑师、工程师和专业规划师应该在一个团队中紧密合作。

跨学科的零碳建筑（ZEB）规划方法 - 综合规划

综合规划代表了规划构架方面一种整体考量的方法，它需要所有相关学科的专业人员和参与规划过程的利益相关者同时参与。其核心要素是所有相关的专家需要尽早加入规划团队，并同时协调处理规划任务。他们在初期方案阶段的参与尤为最重要，因为规划阶段的最佳设计对于建筑的整个生命全周期来说时至关重要。

1.1 让所有项目参与者受益

综合规划并不容易，但它为零碳建筑（ZEB）项目的所有参与者都带来了明显的好处，包括：

- 客户和投资者可以安心地投资，因为他们知道他们投资的建筑比传统规划更有效，质量更好。
- 项目经理可以更好地领导规划团队，因为各个规划服务得到了最佳的协调，而且规划团队追求的是明确的共同目标。
- 规划师和特别专家是规划团队的正式成员，规划过程中可以最佳地采纳他们的专业意见。综合规划为规划团队和客户创造了更好的工作氛围。
- 建筑当局可以收到协调良好的计划和建筑许可证明，有一个非常有能力的团队作为在所有专业领域的咨询和讨论对象。
- 零碳建筑（ZEB）的运营方及用户拥有一个非常可持续的方式使用和运营的建筑，可以将错误的规划和不必要的结构修正减少到最低限度。

一个与建筑相关的跨学科规划方法应以协同效应为导向，从而为项目带来显著的增值。尽管，综合规划不一定会让每个规划步骤都产生唯一的正确解决方案，但该方法可以确保找到可靠的解决方案。

这也确保了在后续规划及项目实施步骤中仍有足够的回旋，改善和补救余地。

只有通过综合规划才能实现
零碳建筑（ZEB）和零碳园区（ZED）

1.2 两个基本事实

设计的初始阶段会对项目后续的发展产生极大的影响。一旦偏离规范，很难再进行修正，或者只有经过巨大努力才能得到纠正。因此，在早期，工程师、专家和建筑师的合作是必不可少的。设计的初始阶段会对项目后续的发展产生极大的影响。一旦偏离规范，很难再进行修正，或者只有经过巨大努力才能得到纠正。因此，在规划早期，工程师、专家和建筑师的合作是必不可少的。

设计阶段初期的规划自由度是巨大的。各种解决方案的比较和筛选让我们得以选择成本最低的最佳方案。与建造阶段成本相比，规划阶段的成本是非常低廉的。因此规划工作必须能打造出整体综合，协调良好的解决方案。这将能大大减少专家之间的意见分歧以及后续运营阶段的成本。

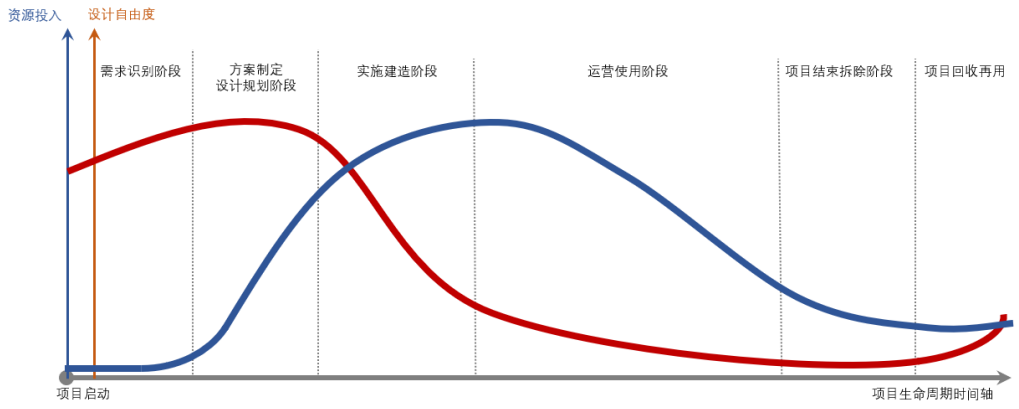

图 2： 项目生命周期中的资源投入和规划自由，图片由 intep 制作

规划过程的初始阶段的规划自由度是最大的。

这里，鲜为人知的是，在建筑的整个生命周期中，设计和施工成本并不占大量比重。在中欧地区，建筑物的生命周期成本的 50-80%发生在运营阶段。建筑物的规划和建设只占总成本的 20-50%。

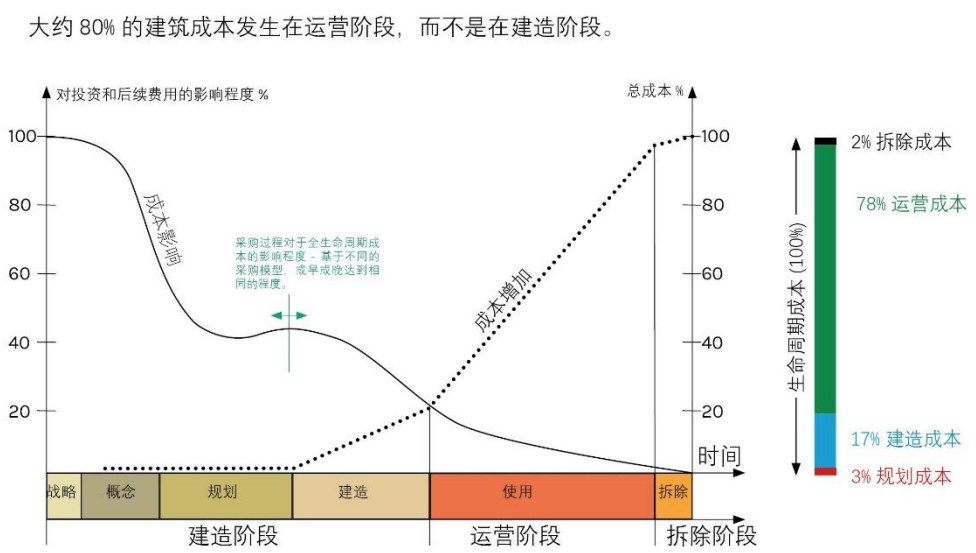

图 3：在欧洲中部，建筑物的全生命周期成本分配情况。图片来源：https://www.moo-con.com/unser-wissen/blog/lzk-nachhaltig-bauen-heisst-den-lebenszyklus-von-immobilien-von-beginn-an-mitdenken/, 2023.07.02, 英文/中文版本由 intep 提供

中国建筑业的成本分配情况会因地区和建筑类型而异，因此需要进行详细的调查才能得出结论。

在中欧地区，建筑物的生命周期成本有 50-80%
发生在运营阶段。

1.3 两种偏见

一些偏见往往会阻碍综合规划。最常见的且毫无根据的偏见是：

综合规划过于昂贵 - 这是错误的

虽然建立一个能力强的综合规划团队一开始可能需要一些高昂的成本，但是这个团队会更有效地合作并产生更好的解决方案。此外，综合规划可以避免客户、建筑师、工程师、特别专家和用户之间的误解。另外，技术解决方案（如外墙、通风、照明、IT 和热量）之间的协调也会被仔细处理，从而避免昂贵的维修和设计错误。

任何人都可以进行综合规划 – 这也是错误的

综合规划需要团队成员具备整体思维，认真对待其他规划者，理解他们提出的解决方案，并准备将自己融入团队。此外，综合规划还需要一个有经验的人的领导者，且能在关键阶段得到客户的支持。

1.4 组织实施综合规划的 7 个先决条件

综合规划不会自行组织实施，需要由客户和项目管理人员决定并明确支持，以此设计项目组织。

团队组成

应根据任务和能力组建团队，包括建筑师、土木工程师、机电工程师以及建筑物理和外围护结构等方面的专家。

团队领导

团队领导必须是具有整体思维和良好沟通能力的经验丰富认识，应满足以下基本要求：

- 专业能力：不必过于深入，而是有全局观，认识到各个学科的联系，能够从不同的角度出发
- 方法论能力
- 领导力：了解领导的原则和手段
- 对社会不同群里的相互关系有所了解

前提

必须明确和公开规划的前提条件和基本规则。如果没有明确规则，也就没有前提条件，对客户也是如此。

规则

必须明确能力和责任。最佳的解决方案需要规划过程中的灵活性（往往需要反复寻找解决方案）。

零碳建筑（ZEB）目标

零碳建筑（ZEB）目标需要详细定义及明确权重（责任手册）。

背景

团队中的纪律和背景需要进行分析和确认。

决策

定义可能的方案，并对其进行效用分析，包括敏感性分析（如能源价格、资本利息等）。

下图显示了在整个规划过程中，首席零碳建筑（ZEB）顾问或首席可持续发展顾问如何协调不同专业小组的组长来实施综合规划。

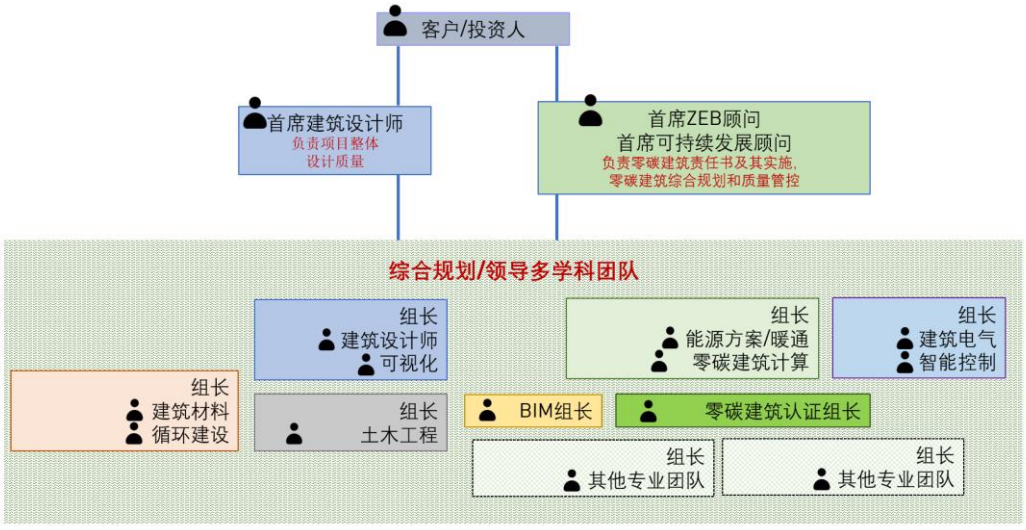

图 4: 零碳建筑（ZEB）项目的综合规划和学科团队，由总建筑师和零碳建筑（ZEB）首席顾问/可持续发展首席顾问领导，图片由 intep 制作

在实施综合规划时，需要根据项目的具体情况，由首席零碳建筑（ZEB）顾问或首席可持续发展顾问进行总体协调，组织多个专家团队从事规划工作。例如，在中瑞零碳建筑项目的北京示范项目-北京市房山区拱辰社区中心，CABR 的零碳建筑（ZEB）咨询团队负责协调建筑师团队、建筑材料团队、循环建造团队、暖通空调团队和通风技术团队等，以共同努力实现零碳目标。

1.5 如何开始实施综合规划

根据以下实施流程，综合规划将顺利进行：

- *1* 初次会议（使团队向目标看齐，增强设计忠诚度、交流信息、确定工作预算）
- *2* 前瞻性的团队规划（识别瓶颈并及时启动措施）
- *3* 定期团队会议（项目领导最重要的管理工具，传达客户决定，讨论问题，反思工作现 状，然后规划和布置下一步工作）
- *4* 成本/效益控制（确保阶段性的适当处理、合作方对接把控、预算监测措施等）
- *5* 所有项目要求都必须在项目责任手册中详细记录。这些要求可以根据规划过程中的新发现的问题进行调整，并在征得各方同意后在责任手册中进行修订。

图 5： 设计人员、工程师和其他利益相关者之间的深入交流和相互联系，图片由 intep 制作

综合规划要求所有团队成员都愿意以开放的方式参与到共同的规划过程中，合作寻找解决方案。

出发点是共同商讨零碳建筑（ZEB）应达到的效果。

这涉及用户观点和现有的环境，以及由此对建筑环境的设计所产生的影响。

这种对建筑服务的定义是，假定它必须在整个使用寿命内完成 "服务 "意义上的任务，并以有意义的方式支持建筑文化中可持续部分的行动。

综合规划要求所有团队成员都愿意以开放的方式参与到共同的规划过程中，合作寻找解决方案。

这只会在无级别团队以及话语逻辑中起作用，并且需要通过跨学科的协商来确定要使用的技术手段（例如要使用的技术手段的范围和类型）。

与用户和客户一起（由团队）制定一个适当的目标，是有效合作的重要前提条件。共同确定的项目目标和规格必须记录在项目责任手册中。

1.6 如何定义零碳建筑（ZEB）目标

零碳建筑（ZEB）标准为零碳建筑（ZEB）的规划和运营提供了明确的指导方针。为了实现这些严格的目标，每个项目还必须确定具体的目标以及定性和定量的指标。这些目标可以在规划团队中和客户一起使用以下检查表来确定。

建议在初始阶段，客户与项目管理部门一起使用核对表确定总体目标，以避免误解和冲突。附录 A1 提供了一份通用目标协议核对表的示例，但标准和目标必须根据每个项目进行单独选择。

1.7 工具

当然，实施综合规划可以采用各种不同的规划工具。除了传统工具外，已证明有四种总体性工具对于实现 ZEB 规划非常有效。

- 1《一般目标协议》核对表
- 2 零碳建筑（ZEB）责任手册
- 3 零碳建筑（ZEB）技术方案示例
- 4 零碳建筑（ZEB）平衡计算表

这四种规划工具相互补充，可以在以下方面发挥理想作用：明确定义规范、精确展示解决方案、促进规划团队内部沟通、与客户和主管部门沟通，以及进行质量控制和绩效审查。

这四个工具的示例详见附录 1 至 4。这些都是不同项目的案例。对于新项目，负责人必须根据具体情况对其进行调整。

图 6： 责任手册在规划过程中的作用和发展，图片由 intep 制作

- 零碳建筑（ZEB）目标协议核对表允许项目管理部门在战略阶段就与客户一起确定最重要的目标。
- 零碳建筑（ZEB）责任手册以技术、组织和一般要求的形式定义了 "游戏规则"。
- 零碳建筑（ZEB）技术方案示例 显示了如何满足规范的要求。
- 零碳建筑（ZEB）平衡计算表为 ZEB 认证提供量化依据。

2 零碳建筑（ZEB）责任手册

零碳建筑（ZEB）责任手册是综合规划和建设过程中最重要的战略工作工具。它定义了项目和参与者的要求和目标（不是解决方案！）。 零碳建筑（ZEB）责任手册是团队合作的产物，具有动态的特点，必须根据项目阶段（与阶段有关的概念报告）而不断发展。责任书应包含尽可能少且必要的内容（不要制定措施，而是目标！）。 最重要的是，它应该包含可核查和可控制的目标和要求。

图 7： 所有利益相关者都应在责任书上签字，并明确其 ZEB/可持续发展的责任，图片由 intep 制作

零碳建筑（ZEB）责任手册是综合规划和建设过程中最重要的战略工作工具。

2.1 让所有项目参与者受益

参与零碳建筑（ZEB）项目规划的所有人都可以从 ZEB 责任手册中收益，因为：

- 客户可以在零碳建筑（ZEB）责任手册中清楚地定义他们的想法和要求，供所有参与者参考。
- 零碳建筑（ZEB）标准对项目的要求被详细记录，规划团队的责任也以约束的方式被定义。
- 各个学科之间的接口、依赖性和相互影响在早期阶段就被讨论和确定。
- 有助于在早期阶段发现和解决规划小组成员和客户之间的误解。
- 在规划过程中，零碳建筑（ZEB）责任手册会根据新的要求进行调整，并对这些变化进行记录和确认，供大家参考。

零碳建筑（ZEB）责任手册是规划和建设过程中质量控制以及设施管理的宝贵基础。

2.2 基本事实

客户和规划团队决定了零碳建筑（ZEB） 责任手册的价值。如果他们把责任手册作为规划的约束性依据，并在整个规划过程中严格执行，那么责任手册将对每个人都非常有帮助，并能使项目质量得到明显的改善。

使用零碳建筑（ZEB）责任手册进行规划，可以使得领先的客户在规划和建筑文化方面取得显著的改善。

2.3 两种偏见

在使用零碳建筑（ZEB）责任手册进行规划时，一些偏见往往阻碍了其应用。其中最常见且毫无根据的偏见包括：

- 零碳建筑（ZEB）责任手册意味着大量的额外工作，只会增加行政工作 - 这是错误的。责任手册书的制定意味着在规划之初要做一定的额外工作。通过在团队中制定明确的、

彻底的 "游戏规则"，来规范和定义责任，可以避免许多误解和规划错误，进而可以避免昂贵的重复规划和不良投资。

- 零碳建筑（ZEB）责任手册可以由团队成员独立编写 - 这也是错误的。零碳建筑（ZEB）责任手册的制定必须由一个适当的专业人员领导和协调。这个人必须准备好有说服力的论据来推动规划团队去讨论一些充满挑战的问题。

2.4 组织实施好责任手册的 6 个前提条件

- 客户需要指定一位有能力且有经验的专业人士来制定和执行零碳建筑（ZEB）责任手册。
- 零碳建筑（ZEB）责任手册的负责人需要具备综合思考并与所有专家沟通的能力。
- 客户需要在任何情况下都全力支持 ZEB 责任书的负责人，坚持执行 ZEB 责任书的规定。
- 零碳建筑（ZEB）责任手册的负责人需要理解专家的关切，并用有力的论据说服他们。
- 在制定 ZEB 责任书的同时，规划小组还需要制定 ZEB 技术方案，并进行能源和排放的平衡计算。
- 在可能的情况下，应将零碳建筑（ZEB）责任手册作为质量控制的基础。

客户必须指定一个有能力且有经验的专业人员来制定和执行零碳建筑（ZEB）责任手册。

零碳建筑（ZEB）责任手册内容和结构参见附录 2 中示例。实际过程中，需要为每个项目重新定义具体内容。

3 零碳建筑（ZEB） 平衡计算表

背景介绍

在这里，我们在附录 4 中介绍了瑞士的核算工具 SIA 2040，该工具被实验性地用于前三个 ZEB 示范项目。之后，SIA 2040 工具将被 CABR 和 MoHURD 发布的中国官方零碳建筑（ZEB）计算和平衡工具所取代。SIA 2040 是基于瑞士联邦理工学院（ETH）的可持续性计划 "2000 瓦社会"开发而来的。

2000 瓦协会考虑了瑞士所有消费部门的一次能源使用总量和温室气体排放总量。基于这些总体目标和人均目标，瑞士工程师和建筑师协会（SIA）制定了一个名为 SIA 能源效率路径的标准（SIA Instruction Sheet 2040）。该标准旨在为实现建筑行业的目标创造尽可能好的先决条件，并以正确的方向引导其发展。作为瑞士最重要的能源消耗部门，建筑部门在这里发挥了先锋作用，表明今天已经有可能踏上通往 2000 瓦社会的道路。

目标值

针对住宅、行政、学校、专业商店、食品店和餐馆等建筑类别，我们设定了目标值，前提是建筑部门的能源使用比例在 2010 年至 2050 年间保持不变。为此，我们确定了每个建筑类别的现状，并利用 2000 瓦社会目标的减少系数将其减少到 2050 年的目标状态。

目标值与能源参考面有关。2000 瓦社会的消费值与人均建筑面积有关。它是通过人均建筑面积进行转换的。在 SIA 2040 中，假定在本技术规范的有效期内，人均建筑面积保持不变。这种简化应进行定期审查。如果未来人均建筑面积继续增加，目标值将需要相应收紧。

目标值对应于 2050 年建筑部门一次能源的平均消费值或温室气体排放，包括建筑相关的交通能耗。这意味着个别建筑类别不能完全实现减排目标。然而，对于 2040 年 SIA 指令表中考虑的建筑类别（包括瑞士总能源参考面积的 80%左右），整体实施是可能的。

项目值

项目值总是使用项目相关阶段通常可获得的数据进行计算。在初步研究和初步项目阶段，存在一种计算辅助工具，可以用来对建设、运营和交通的不可再生一次能源使用和温室气体排放进行初步估算。对于后期规划阶段，则需使用不同的能源模拟软件。

评估

如果包括一个或几个建筑类别的建筑的项目值低于一次能源使用和温室气体排放指标的目标值，就可以称为零碳建筑（ZEB）。

4 总结语

综合规划其实并不难，它对我们找到一个较好的方案很用。如果使用得当，那么它会给所有参加项目的利益相关方带来利益。另外，它需要团队成员有意愿共同热情投入相互间的合作，用一种开放的心态来共同寻求目标。

零碳建筑责任手册则在技术，管理和一般性要求方面定义了游戏规则。零碳建筑责任手册是综合规划和施工阶段最重要的策略工具。它定义了项目和对参与方的要求和目标。

零碳建筑平衡计算表为零碳建筑的认证提供了量化的证据。零碳建筑是离不开计算的。

未来建筑必须达到零碳建筑标准。零碳建筑标准是中国和全球可持续建筑的基准。

A1 附录 1：一般目标协议核对表

零碳建筑（ZEB）目标协议核对表可在战略阶段帮助项目管理部门与客户确定最重要的目标，如战略发展或前期研究。这个核对表允许客户和规划者共同讨论和确定项目的基本和一般目标，并将结果用于零碳建筑（ZEB）责任手册的制定。

这里提供的核对表仅为先前项目的一个示例，实际应用时需要根据每个项目的具体情况进行调整，并由团队共同确定。

	指标	目标	影响力
1	社会		
1.1	整合/混合	创造适应社会、文化和年龄的最佳条件	
1.2	团结/正义	支持弱势群体	
1.3	参与	通过参与获得高度认可	
1.4	空间认同/识别	采用个性化设计实现定位和空间识别	
1.5	基本供应，混合使用	提供社区内短距离且有吸引力的用途组合	
1.6	流动性	实现非机动车和公共交通的良好和安全的可达性网络	
1.7	为所有人提供无障碍和实用性	将建筑和周围环境设计为无障碍环境	
2	舒适/健康		
2.1	照明	优化日光条件，提供良好且有效的人工照明	
2.2	室内空气	保障室内空气处于较低的过敏源和污染物水平，供应新鲜空气并保持低 CO2 水平	
2.3	辐射	控制电离辐射和非电离辐射的低排放	
2.4	保温	通过良好的冬季和夏季隔热性能，提高舒适度	
2.5	噪声、振动	控制噪声和振动的低排放	
2.6	安全	符合保安和安全的标准	
3	经济		
3.1	地点	确保长期经济可行性，适应当地需求	
3.2	建筑结构	注重价值和质量的稳定性，考虑使用寿命	
3.3	建筑结构、扩建	注重价值和质量的稳定性，考虑使用寿命	
3.4	全生命周期成本	在考虑到生命周期成本的情况下进行投资	
3.5	融资	确保长期的融资、投资、维护和拆除费用	
3.6	外部费用	最小化和内部化外部成本	
3.7	操作和维护	通过早期规划和持续措施降低维护成本	

	指标	目标	影响力
4	环境		
4.1	零碳建筑（ZEB）标准	满足 ZEB 标准的要求并获得零碳建筑（ZEB）认证	
4.2	原材料供应	使用良好的初级原料和高比例的二级原料	
4.3	环境影响	降低生产过程中对环境的影响	
4.4	污染物	降低建筑材料中的污染物含量	
4.5	拆除	使用易于分解、便于再利用或回收的复合材料和结构	
4.6	室内气候的气温	得益于结构和建筑设备，制热/制冷的能源需求很低	
4.7	热水消耗量	通过结构和建筑方面的预防措施来降低热水的热量和能源需求	
4.8	照明、电器和和电力供应	通过理论和实践措施来降低电力需求	
4.9	能源需求	100%的可再生能源份额	
4.10	水	低饮用水消耗量以及废水量	
4.11	循环搭建	采用再利用、降级和升级回收的概念	
5	景观		
5.1	开放空间	促进大型生物多样性	
5.2	运行和使用废品	提供完善的垃圾分类基础设施	
5.3	绿色概念	采用纵向和横向的绿色概念，以改善微观气候	
5.4	良好的布局	优化空间布局，促进自然通风和充分利用日光和阴影效应。	

A2 附录 2：责任手册范例

这里介绍的责任书内容是基于以往项目的经验。它必须根据每个项目的具体情况进行调整，并在团队中共同确定。

项目名称: XXXXX

日期: XX.XX.XXXX

签字的有关负责人用他们的签名确认他们将在零碳项目中：

- 以他们最佳认知和诚信来按照零碳建筑标准的目标和技术规范来设计，施工和运营建筑。
- 在项目实施过程中尽可能充分实施责任手册书里定义的数值和措施。
- 在零碳建筑方案中全面体现责任手册里定义的技术及管理方面的规范。

签名

- 项目经理
- 建筑师
- 结构工程师
- 暖通空调工程师
- 水环境工程师
- 电气工程师
- 自动化 IT 工程师
- BIM 工程师
- 设施管理工程师
- 能源/可持续发展工程师
- 质量控制工程师
- 承包商
- 用户

A: 示范项目的一般信息

A.1 项目名称、背景和一般描述（由建筑师填写）

- 背景
- 地点
- 位置（城市、农村）
- 建筑类型（住宅、办公、学校等）
- 项目类型（新建、转换、扩展）
- 建筑构造类型（大型、轻型、混合型等）
- 建筑材料
- 气候区(I , II, III, IV, V)
- 公共交通可达性
- 停车场

A.2 项目目标（由建筑师填写）

- 城市规划
- 建筑设计
- 设计任务书/功能

A.3 项目业主/开发商（由建筑师填写）

- 土地所有者
- 开发商
- 用户

A.4 项目可持续性目标（由建筑师填写）

- 能源标签
- 碳排放目标
- 质量目标
- 生命周期考量（成本、维修、拆除、翻新……）

A.5 项目时间安排

- 概念方案设计阶段
- 初步设计阶段
- 施工图设计阶段
- 招标
- 授标
- 施工阶段
- 调试
- 建筑使用阶段

B: 项目信息和数据

B.1 项目规模（由建筑师填写）

- 建筑场地面积（m^2）
- 建筑尺寸（米）
- 建筑高度（米）
- 楼层数
- 占地面积（m^2）
- 建筑流量或面积比
- 建筑密度 %
- 绿地率 %
- 建筑面积（m^2）
- 建筑体积（m^3）
- 体型系数（m^2/m^3）
- 气候边界内建筑面积 ERA[1]（m^2）
- 停车场（车位数量）

B.2 移动性、交通（由建筑师填写）

- 公共交通
- 私人运输

B.3 建筑围护结构（由建筑师填写）

- 围护结构建筑材料 (m^2)
- 围护结构构造方式（干挂式，实体外墙等）
- 围护结构表面积 (m^2)
- 建筑窗墙比
- 总平面图，各层平面图，立面图，剖面图，立面构造大样图等建筑图纸

B.4 项目成本[2]（按年计算）（由建筑师填写）

- 建造成本（元人民币/年）
- 能源成本（元人民币/年）

[1] 单位面积能耗值的计算参照 SIA 2040 工具中定义的建筑面积

[2] 基于资本利息（%），通货膨胀（%），寿命（a）

- 建筑维护（元人民币/年）
- 生命周期成本（元人民币/年）

B.5 结构设计（由结构工程师填写）

- 结构选型
- 建筑材料
- 抗震要求
- 荷载要求
- 预制构建装配率
- 结构设计图纸

B.6 建筑物理和室内舒适度（由建筑物理顾问填写）

- 建筑围护构件 K 值
- 建筑外窗构造/材料/透射比
- 遮阳系统
- 温度（供暖和制冷工况下的最低和最高温度，，单位为 °C）
- 空气湿度（以 % 表示的最小和最大相对湿度）
- 噪声级（空气传播和结构传播的声音，以 分贝为单位）

B.7 暖通方案（由暖通工程师填写）

- 供暖（生成/转换、储存、分配）
- 制冷（生成/转换、存储、分配）
- 暖通空调系统_
- 热源/冷源
- 设备能效
- 通风（集中式/分散式空气处理单元 、分配）
- 除湿（系统类型）
- 系统分离
- 热回收
- 暖通设计图纸

B.8 水、卫生设施方案（由给排水工程师填写）

- 饮用水
- 消防喷淋装置

- 用水需求
- 排水系统
- 排水量
- 废水
- 雨水
- 热水
- 热水热源
- 节水阀_
- 给排水设计图纸/文件

B.9 电力、照明、电器方案（由电气工程师填写）

- 照明系统
- 人工照明照度（Lux）
- 照明控制系统
- 供电（净用电、自发电）
- 转换（高/低压）
- 存储/转换（电池，其他电力存储）
- 日光/人造照明（类型、传感器和自动化）
- 电力、光伏、储能
- 电力需求计算
- 电气设计图纸/文件

B.10 建筑自动化（由楼宇自控工程师填写）

- 遮阳控制系统
- 自动化控制
- 电器选型
- 安保、安全
- 自动化设计图纸/文件

B.11 输入能源及其二氧化碳因子（由节能顾问填写）

- 热源（类型和 千克二氧化碳/千瓦时）
- 冷源（类型和 千克二氧化碳/千瓦时）
- 电力供应（类型和 千克二氧化碳/千瓦时）

B.12 能源消耗计算（由节能顾问填写）

- 总的供热功率（kW）和单位面积的供热功率（W/m²）
- 总的制冷功率（kW）和单位面积的制冷功率，包括除湿（W/m²）
- 总的用电功率（kW）和单位面积的用电功率（W/m²）
- 总的光伏面积（m²）和峰值负荷（kW）
- 总供暖需求（kWh/a）和单位面积的供暖需求（kWh/m²a）
- 总制冷需求（kWh/a）和单位面积的制冷需求（kWh/m²a）
- 总电力需求（kWh/a）和单位面积的电力需求（kWh/m²a）
- 总光伏发电量（kWh/a）和单位面积的光伏发电量（kWh/m²a）
- 隐含能耗
- 可再生能源利用率

C: 零碳建筑标准的要求

A3 附录 3：零碳建筑（ZEB）技术方案示例

零碳建筑（ZEB）技术方案示例

展示了如何满足零碳建筑（ZEB）责任手册的要求。该方案的结构类似于零碳建筑（ZEB）责任手册，各个章节由专业的负责人（如暖通空调工程师、IT 专家、景观建筑师）编写。每位专业负责人对其章节的内容负责。同时，各个技术要素之间的接口需要协调好（例如，具有防晒功能的外墙建筑和暖通空调规划）。零碳建筑（ZEB）技术方案是执行综合规划团队协调会议的基础。该方案可以由 ZEB 首席顾问或可持续发展首席顾问领导。

零碳建筑（ZEB）技术方案包括以下内容

- 地点/环境
- 能源和电力需求
- 能源供应
- 建筑围护结构/建筑设计
- 建筑机电设备
- 供暖能源方案
- 制冷能源方案
- IT、自动化、数据管理
- 水资源管理方案
- 设施管理
- 调试过程
- 生命周期优化
- 经济效益
- 环境平衡
- 监测方案和操作优化

清晰易懂的基本技术要素及其相互关系的示意图是非常有用的。它可以展示整个建筑或单个房间的情况。这样就有可能在规划团队中以一种可理解的方式解释不同方案，并与建筑所有者和当局进行沟通。

以下是苏黎世机场的零碳建筑（ZEB）技术方案示意图，它描述了由 Amstein+Walthert 股份公司和卢塞恩应用科技与艺术大学（HSLU）实施的新的 E 号航站楼。

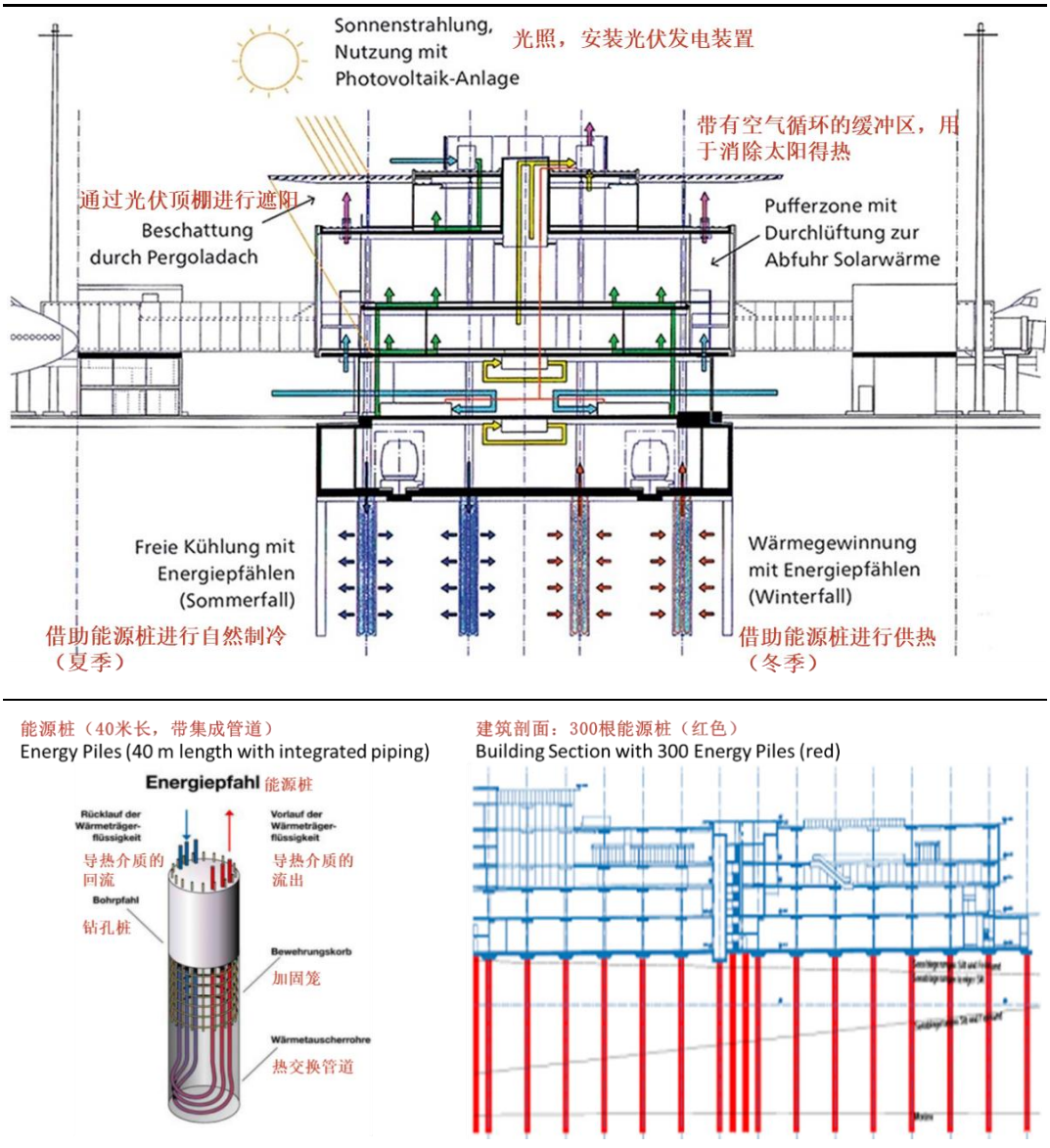

图 8： 苏黎世机场的零碳建筑（ZEB）技术方案，New Dock 的 E 号航站楼，图片由 Adrian Altenburger 教授和 Amstein + Walthert 股份公司制作

作为中瑞零碳建筑项目的示范项目之一，北京市房山区拱辰社区中心也打造了很好的零碳建筑（ZEB）技术方案，如下图所示。

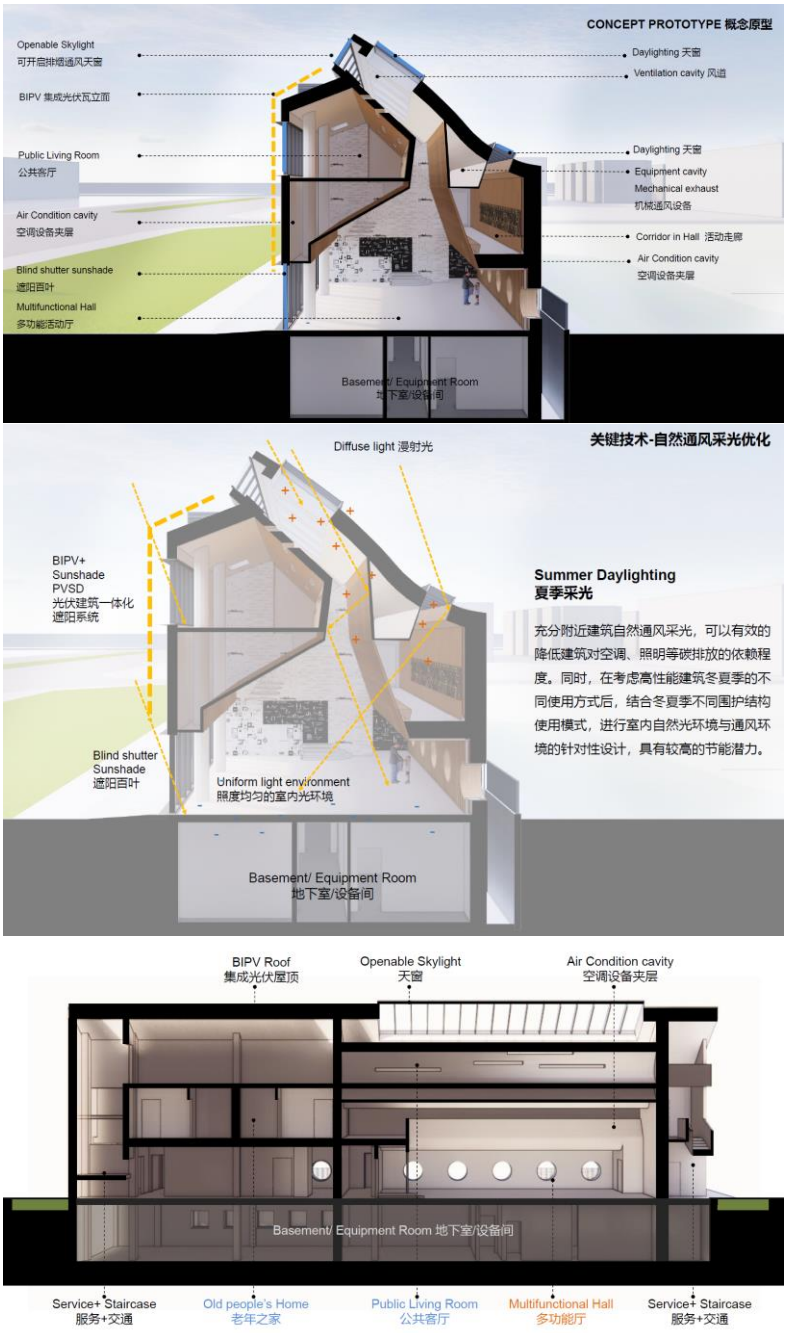

图 9 ： 中瑞零碳建筑项目北京示范工程-北京市房山区拱辰社区中心的方案原型，图片由 SUP 素朴建筑工作室提供

此外，北京市房山区拱辰社区中心可再生能源利用和新风热回收方面也做了充足的准备，如下图所示。

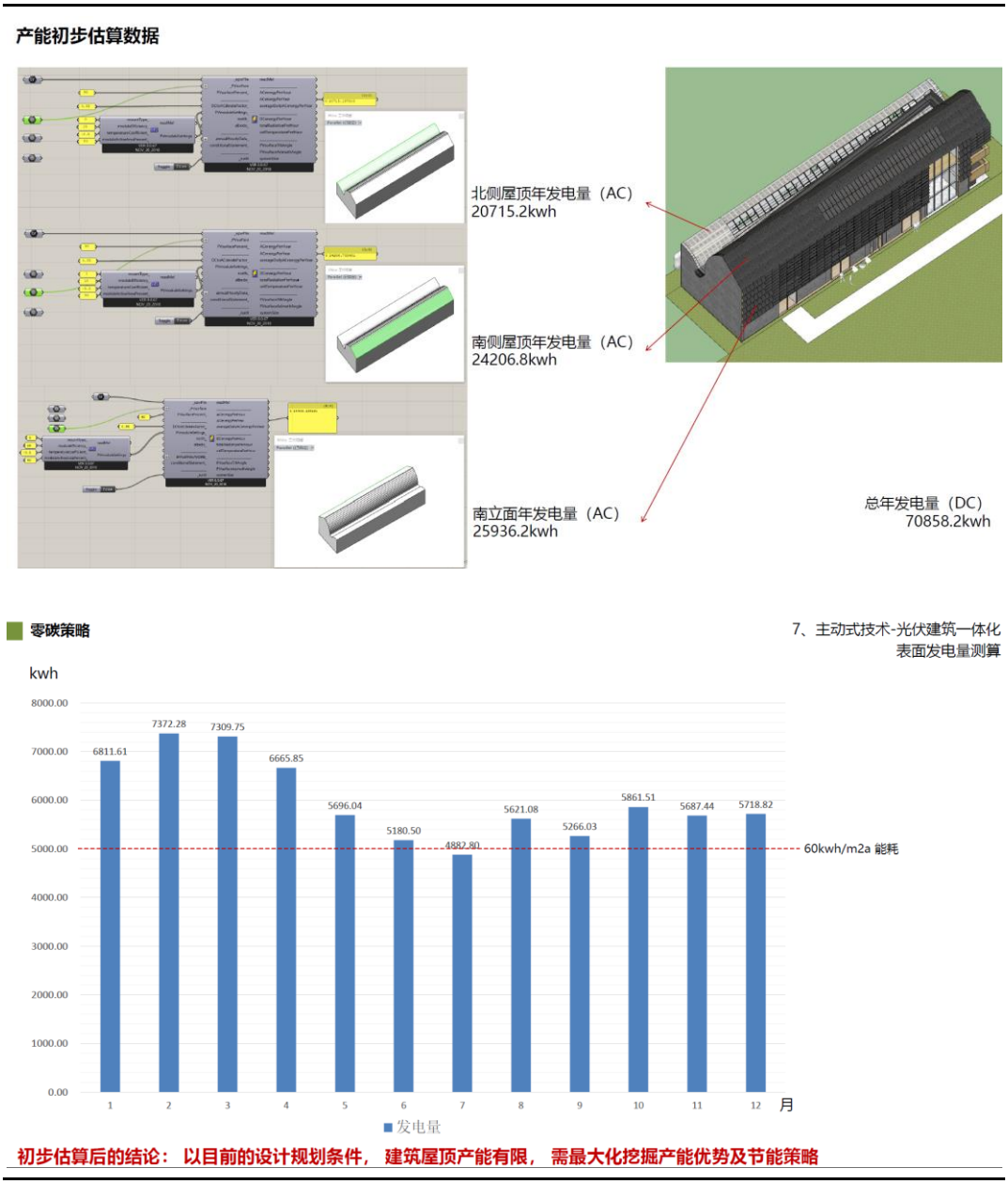

图 10：零碳策略：主动技术-光伏建筑一体化 BIPV 屋顶和表面发电量测量，中瑞零碳建筑项目北京示范项目-北京市房山区拱辰社区中心，图片由 SUP 素朴建筑工作室和中国建筑科学研究院 ZEB 咨询团队制作。

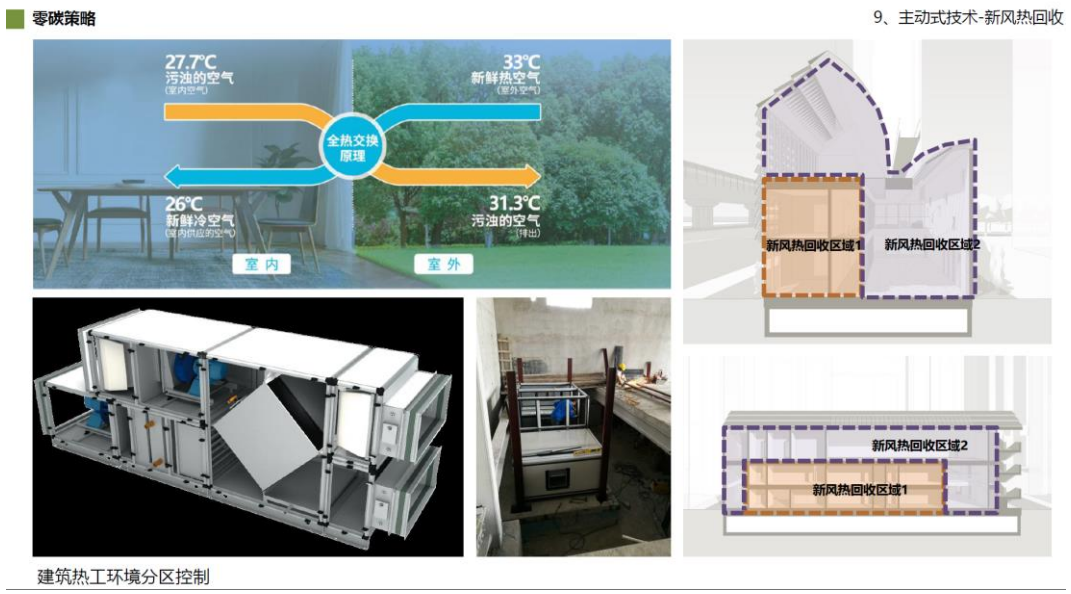

图 11：零碳策略：主动技术 "新风热回收"，中瑞零碳建筑项目北京示范工程-北京市房山区拱辰社区中心，图片由 SUP 素朴建筑工作室和中国建筑科学研究院 ZEB 咨询团队制作。

A4 附录 4：瑞士零碳建筑（ZEB）平衡计算表 SIA 2040

下图为瑞士 SIA2040 能耗平衡计算工具，主要用于项目初期，用于初略评估项目的能源消耗和温室气体排放，包括建造阶段、运营阶段和交通。

计算器 SIA 2040: 初步研究/初步项目 — **建造**

项目信息: Test Project for CABR

图示: 输入字段 / 选择字段 / 采用值

项目输入:
- 建筑总面积 — 建筑总面积 — m^2 — 11.000
- 能源参考面积 — ERA — m^2 — 9.000

组件面积 组件面积

	名称	参考资料	单位	数量	设计变量	不可再生的一次能源 kWh/m² 以能源参考面积为基础一年的摊销	温室气体排放 kg/m²
建筑物 地下	挖方	Volumen	m^3	4500	无地下水	0,3	0,08
	地基、底板	组件面积	m^2	1500	有保温层	1,1	0,37
	外墙	组件面积	m^2	1800	有保温层	1,4	0,50
	屋顶	组件面积	m^2	2000	有保温层	2,6	0,80
建筑物 地上	外墙：承重结构	组件面积	m^2	2600	混凝土墙	1,0	0,34
	(备用)	组件面积	m^2		混凝土墙	0,0	0,00
	外墙：建造	组件面积	m^2	2500	有保温层的外墙抹灰	1,6	0,34
	(备用)	组件面积	m^2	0	有保温层的外墙抹灰	0,0	0,00
	有遮阳功能的窗户	组件面积	m^2	1300		3,1	0,76
	内墙	组件面积	m^2	6967		3,0	1,01
	天花板：支撑结构	组件面积	m^2	8000	混凝土天花板(25厘米)	3,3	1,19
	(备用)	组件面积	m^2	1500	木质天花板	0,5	0,11
	天花板：建造	组件面积	m^2	8500	针对未供暖空间的保温板	1,3	0,28
	(备用)	组件面积	m^2	0	屋顶结构	0,0	0,00
	阳台	组件面积	m^2	0		0,0	0,00
	屋顶：支撑结构	组件面积	m^2	1500	混凝土天花板(25厘米)	0,6	0,22
	(备用)	组件面积	m^2	0	混凝土天花板(25厘米)	0,0	0,00
	屋顶：建造	组件面积	m^2	1500	保温的（平屋顶）	1,5	0,33
	(备用)	组件面积	m^2	0	保温的（平屋顶）	0,0	0,00
建筑设备	电气系统	ERA	m^2	9000	包括配电系统电气系统	3,0	0,65
	光伏系统	最大功率	kWp	210	(在 "运营 "表中输入)	5,7	1,52
	热电厂	ERA	m^2	9000	供暖系统，包括配电系统	2,2	0,51
	太阳能集热器	组件面积	m^2	0	(在 "运营 "表中输入)	0,0	0,00
	通风系统	ERA	m^2	5000	(在 "运营 "表中输入)	2,1	0,51
	水厂	ERA	m^2	9000	卫生系统包括分配网络	1,3	0,32
					项目值	**36**	**9,8**
					标准值	*30*	*7,9*

参数	*体型系数（SIA 380）*	*1,0*	*(地面以下和以上的总建筑围护结构面积/楼层面积)*
	窗墙比	*33%*	*(窗户面积/地面以上的立面面积)*

图 12： SIA 2040 Excel 计算器局部图示，版权归 SIA 所有

中文翻译后的 Excel SIA2040_Tool_v300_lic_CN 可以通过以下链接下载：
https://pan.baidu.com/s/1hrqKphIXpT0pitGFGj091g?pwd=9k4e（代码：9k4e）

SIA2040 能耗平衡计算工具使用说明：

该计算辅助工具可以对根据 SIA 2040 "SIA 能效路径"建设的项目的目标实现情况进行初步估计。这一估算是在初步研究/项目前期的早期阶段根据 SIA 112 "建筑设计模型 "进行的。如果在这个规划阶段还没有计算值，则根据标准值进行辅助计算。

- 工作表 "建筑类别"：选择建筑类别是新建筑还是改建建筑。输入建筑面积和能源参考面积。最多可以输入三个不同的区域。

- 工作表 "建筑"：在蓝色的输入栏中，输入项目中相应的组件表面。在绿色的选择栏中选择预定的施工方法。
- 工作表 "运营"：在这里，你必须根据 SIA 380/1 输入建筑的供暖要求（使用供暖要求 QH,eff，考虑到有效的、热效的外部空气量流量）。如果你还不知道，你可以在表格的下半部分找到一个估算帮助。在所有的绿色选择框中选择要使用的系统。如果使用一个以上的制热系统，你可以以百分比的形式输入它们的需求覆盖份额。在下半部分的蓝色区域，你被要求提供任何用于自产电力或热能的太阳能系统的组成区域。所选系统的灰色能量会在创建表中自动更新。如果你想使用具有生态附加值的 naturemade star 质量（或同等质量）的电力的长期供应合同，你可以通过总电力的百分比份额来输入，最多不超过 50%。你在综合电力组合计算器中输入所供电力的构成。
- 工作表 "交通"：这里，你会被问到你的建筑项目计划所在的城市和其他位置因素。在已知的情况下，用项目值替换默认值。计算可被看为是当下尚未实现的假设。这里计算的是 2050 年的用车，也就是说，与今天相比，车辆燃料消耗会减少。
- 工作表 "结果"：它指出该项目是否符合 SIA 能源效率路径的要求。如果不符合，则会说明应在何处进行优化。
- 工作表 "能源组合计算器"：包含区域供热和电力混合计算器。
- 工作表 "建筑项目"：是为以后规划阶段的计算而设计的。根据规定的 SIA 标准，分别计算建设、运营和移动性的数值，并转到这个工作表。

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

ZEB - Zero Emission Buildings

ZEB GUIDELINE

THREE STEPS TOWARD ZEB BUILDINGS

. INTEGRAL PLANNING

. THE ZEB DUTYBOOK

. THE ZEB BALANCE SHEET

Content

Imprint

Editiorial Information
ZEB guideline – Three steps towards the ZEB Buildings, Version 1, April 2023

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Many Thanks to the Investor and Planning team of the Beijing Demo Project of Sino-Swiss ZEB cooperation project – Gongchen Community Center of Fangshan District in Beijing, to provide the project data to this guideline.

ABOUT THE SDC ZEB PROJECT

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 CO_2 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.

HOW TO USE THIS GUIDELINE

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 organisation 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 matter. 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
- ZEB Dutybook
- ZEB Balancing

The buildings of the future must meet the ZEB standard, ZEB standard is the benchmark for sustainable building in China and around the world.

THE BUILDINGS OF THE FUTURE WILL BE ZEB BUILDINGS

The following Graphic shows the implementation roadmap of three ZEB instruments throughout the whole project process.

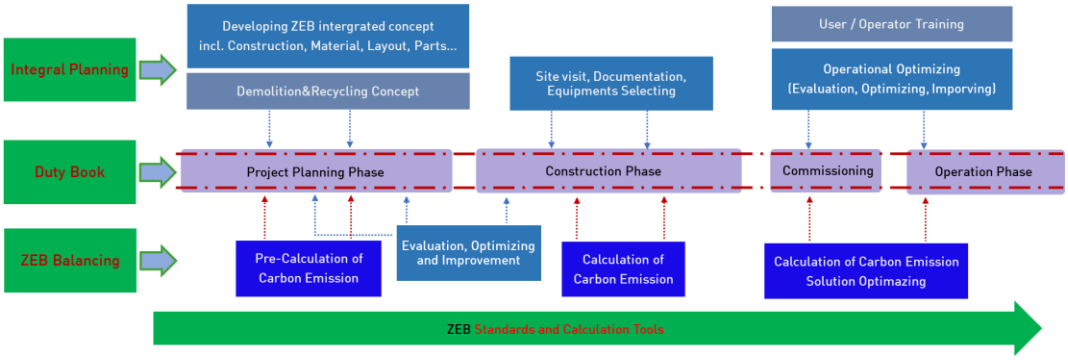

Figure 1: Implementation Roadmap of the three instruments in project process, graphic by intep

1 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.

1.1 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

1.2 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.

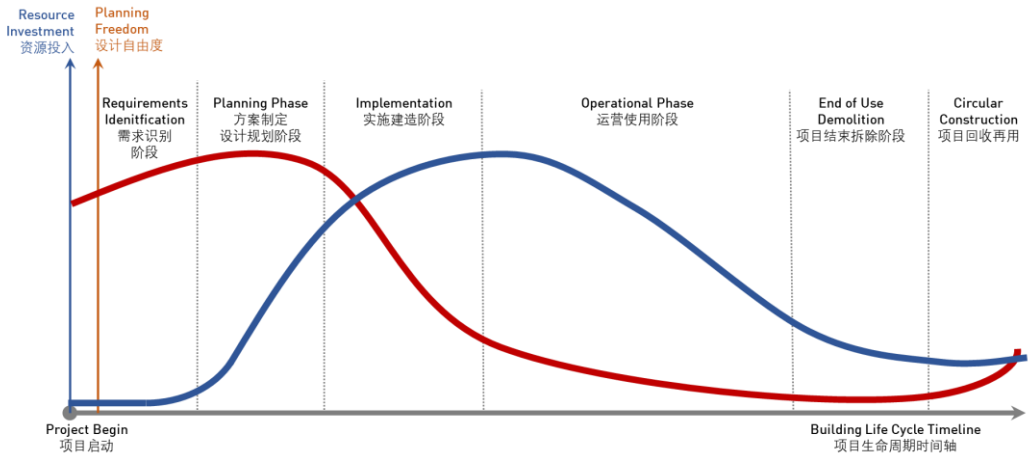

Figure 2: Resource investment and planning freedom in project life cycle, created by intep

Planning freedom is greatest at the beginning of the planning process

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.

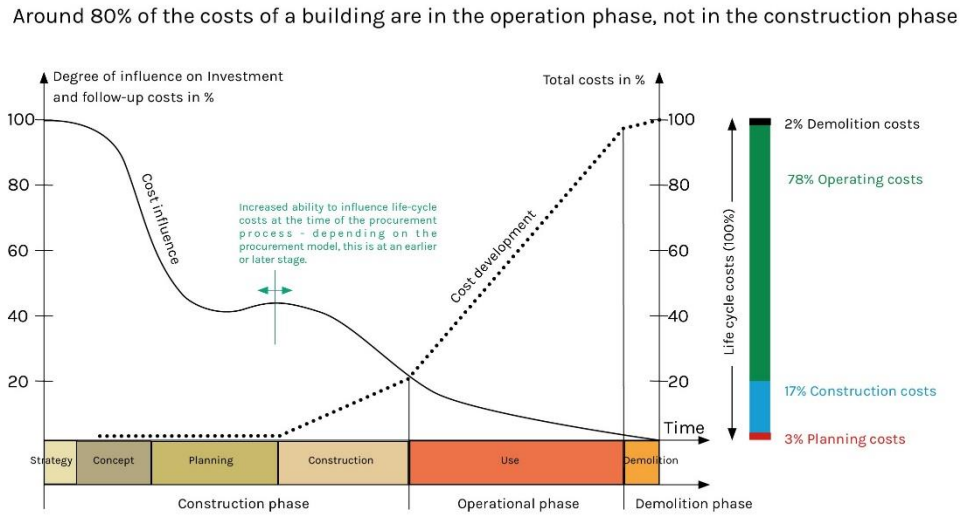

Figure 3: Cost sharing during the whole life cycle in Central Europe. Source: https://www.moo-con.com/unser-wissen/blog/lzk-nachhaltig-bauen-heisst-den-lebenszyklus-von-immobilien-von-beginn-an-mitdenken/, Stand 07.02.2023, English/Chinese Version by intep

How does the cost sharing in Chinas 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

1.3 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 - WRONG

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.

1.4 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.

1 Team Composition

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

2 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 speciality, 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.

3 Premises

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

4 Rules

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

5 ZEB objectives

Definition of ZEB objectives and their weighting (Duty Book)

6 Context

Disciplinary order and context analysis and confirmation in the team

7 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 coordinate the team leaders of different specialist teams to implement the integrated planning during the whole planning process.

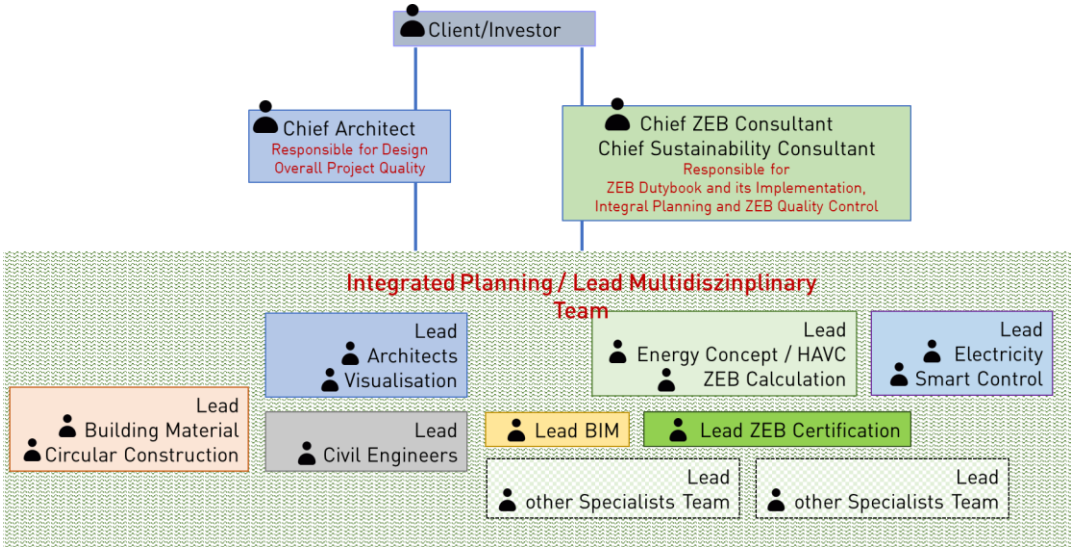

Figure 4: Integrated Planning and Disciplinary Team of ZEB Project that led by Chief Architect and Chief ZEB Consultant / Chief Sustainability Consultant, graphic created by intep

How many and which kind of specialist teams working on the integrated planning under the general coordination of Chief ZEB Consultant or Chief Sustainability Consultant, are dependent on project itself. Different building type, project volume and area need different team work to achieve its integrated planning, e.g. for the Beijing Demo Project of Sino-Swiss ZEB cooperation project – Gongchen Community Center of Fangshan District in Beijing, the ZEB Consulting team of CABR is responsible to coordinate the architect team, building material team, team for circular construction, HAVC team and team for air circulation etc. to work together on the goal of Zero Carbon.

1.5 How to get started

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

- *1* Initial meeting (aligning the team to the goal, generating design loyalty, information, effort budgets)
- *2* Forward-looking team planning (identification of bottlenecks and timely initiation of measures)
- *3* 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)
- *4* Effort/benefit control (ensuring phase-appropriate processing, interface monitoring, budget monitoring, etc.)
- *5* 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.

Figure 5: intensive exchanges and interconnections between planers, engineers, and other stakeholders, graphic created by intep

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.

1.6 How to define the ZEB objectives

The ZEB standard sets clear guidelines for the planning and operation of a ZEB building. 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 General Target Agreement contains an example of such a checklist. However, the criteria and objectives must be selected individually for each project.

1.7 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:

- **1 The General Target Agreement Checklist**
- **2 The ZEB Dutybook**
- **3 The ZEB Technical Concept**
- **4 The ZEB Balance Sheet**

These four 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.

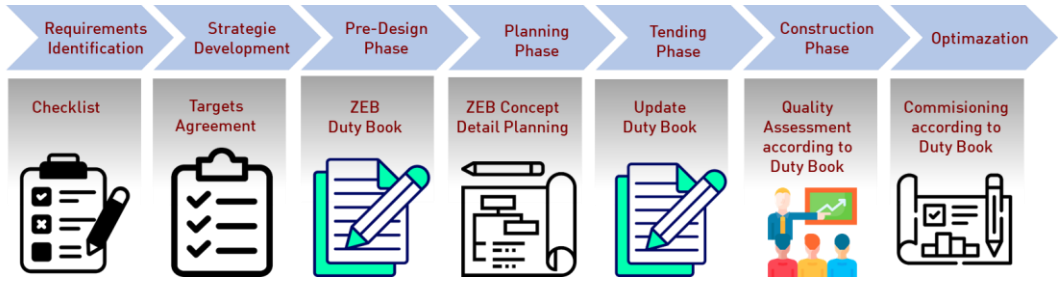

Figure 6: the role an development of Duty Book in planning process, Graphic created by intep

- **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 Dutybook** 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.

2 THE ZEB DUTYBOOK

The ZEB Dutybook 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 Dutybook is the product of teamwork. It has a dynamic character and must therefore evolve according to the project phases (phase-related concept reports). The Dutybook 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.

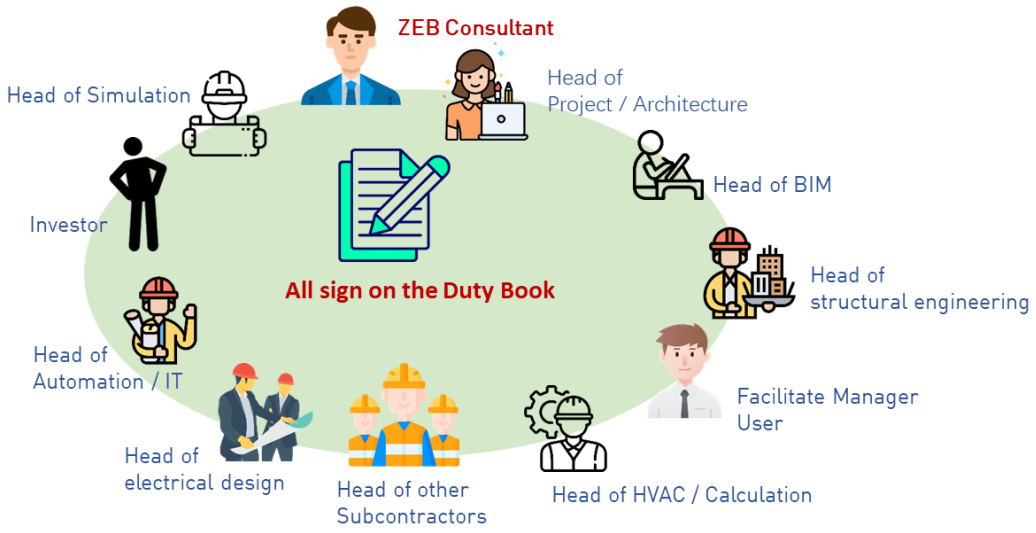

Figure 7: All Stakeholder should sign on Duty Book and are clear with their ZEB/Sustainability responsibility, created by intep

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

2.1 Profitable for all stakeholders

The ZEB Dutybook 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 Dutybook 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 Dutybook is adapted to new requirements in the course of planning and the changes are recorded and confirmed for all.

The ZEB Dutybook is a valuable basis for quality control during planning and building process as well as facility management.

2.2 Basic Facts

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

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

2.3 Two Prejudices

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

- The ZEB Dutybook 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. 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 Dutybook can be written independently by the team members. FALSE. The development of the ZEB Dutybook 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.

2.4 Six prerequisites for how to organize a Dutybook

- The client must assign a competent and experienced professional to develop and enforce the ZEB Dutybook.
- The head of ZEB Dutybook must be able to think integrally and communicate with all specialists.
- The client must fully support the head of Dutybook even in critical situations and insist on the enforcement of the Dutybook.
- The head of Dutybook must be able to understand the concerns of the specialists and convince them with competent arguments.
- Parallel to the development of the Dutybook, the planning team must also develop the ZEB Technical Concept and calculate the balancing of energy and emissions.
- If possible, the Dutybook should be used as a basis for quality control.

The client must assign a competent and experienced professional to develop and enforce the ZEB Dutybook

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

3 THE ZEB BALANCE SHEET

Background
At this point we present in Appendix 4 the Swiss accounting tool sia 2040, which was used experimentally for the first three ZEB Demo projects. 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 here, 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, Specialised 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 software 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 indicators primary energy use and greenhouse gas emissions, they can be called ZEB Buildings.

4 Conclusion

Integral planning is no miracle, but it is very helpful for achieving better solutions. Used properly, it will create benefits to 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.

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.

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

The buildings of the future must meet the ZEB standard, and the ZEB standard is the benchmark for sustainable building in China and around the world.

A1 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 Dutybook.

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	RELEVANCE
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	Spacial 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 CO_2-level	
2.3	Radiation	Low immissions 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 immissions 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	

	CRITERION	TARGET	RELEVANCE
3.3	Building structure, expansion	High flexibility for different space and use requirements	
3.4	Life cycle costs	Make investments taking into account 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 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 micro climate.	
5.4	Good layout	Good layout concept to enable natural air circulation, enough using of day-light and shading with natural shadow	

A2 APPENDIX 2 - ZEB DUTYBOOK EXAMPLE

The Dutybook 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 Dutybook as fully as practicable in the realization of the project.
- Comprehensively represent the technical and organizational specifications defined in the Dutybook 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)

- Land owner
- 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 Project size (filled in by architect)

- Building site (m^2)
- Building dimensions (m)
- Building Height (m)
- Number of floors
- Footprint Area (m^2)
- Building Floor Area Ratio
- Building Density %
- Green Area Ratio %
- Gross Floor Area (m^2)
- Building volume (m^3)
- Ratio envelope / volume(m^2/m^3)
- Conditioned floor surface ERA[1](m^2)
- Parking (numbers of lots)

Mobility, Transportation (filled in by architect)

- Public transportation
- Private transportation

Building Envelop (filled in by architect)

- Building Material for Envelop (m^2)
- Construction System (Ventilated Façade, Massive Façade, etc.)
- Envelop Surface Area (m^2)
- Transparent/Opac ratio

- Drawings/Documents of Site Plans, Floor Plans, Elevations, Sections, Details

Project Cost[2] (annual basis) (filled in by architect)

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

[1] Relevant m^2 for specific values (ERA according to SIA 2040 tool)

[2] Based on specific interest on capital (%), inflation (%), lifetime (a)

Structural Design (filled in by structural engineer)

- Structural System
- Building materials
- Seismic Requirement
- Load Requirement
- Prefabrication Rate
- Drawings/Documents of Structural Design

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)

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 (centralised/decentralised AHU, distribution)
- Dehumidification (type of system)
- System separation
- Heat recovery
- Drawings/Documents of HVAC Concept

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

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

Building automation (filled in by automation planner)

- Shading Control System
- Automation Control
- Plug-in
- Security, safety
- Drawings/Document of Automation Plans

B.2 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.3 Energy Consumption Calculation (Energy Consultant)

- Total and specific Heating capacity (kW and W/m^2)
- Total and specific Cooling capacity (kW, incl. dehumidification and W/m^2)
- Total and specific electrical capacity (kW and W/m^2)
- Total PV surface/peak load (m^2, kW)
- Total and specific Heating demand (kWh/a and kWh/m^2a)
- Total and specific Cooling demand (kWh/a and kWh/m^2a)
- Total and specific electrical demand (kWh/a and kWh/m^2a)
- Total and specific PV supply (kWh/a and kWh/m^2a)
- Embodied energy
- Rate of renewable energy

C Requirements of ZEB standard

A3 APPENDIX 3 - ZEB TECHNICAL CONCEPT EXAMPLE

The ZEB Technical Concept shows how the requirements of the ZEB Dutybook are fulfilled. The ZEB Technical Concept is structured analogous to the ZEB Dutybook. 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 in the planning team and with the building owner and the authorities.

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

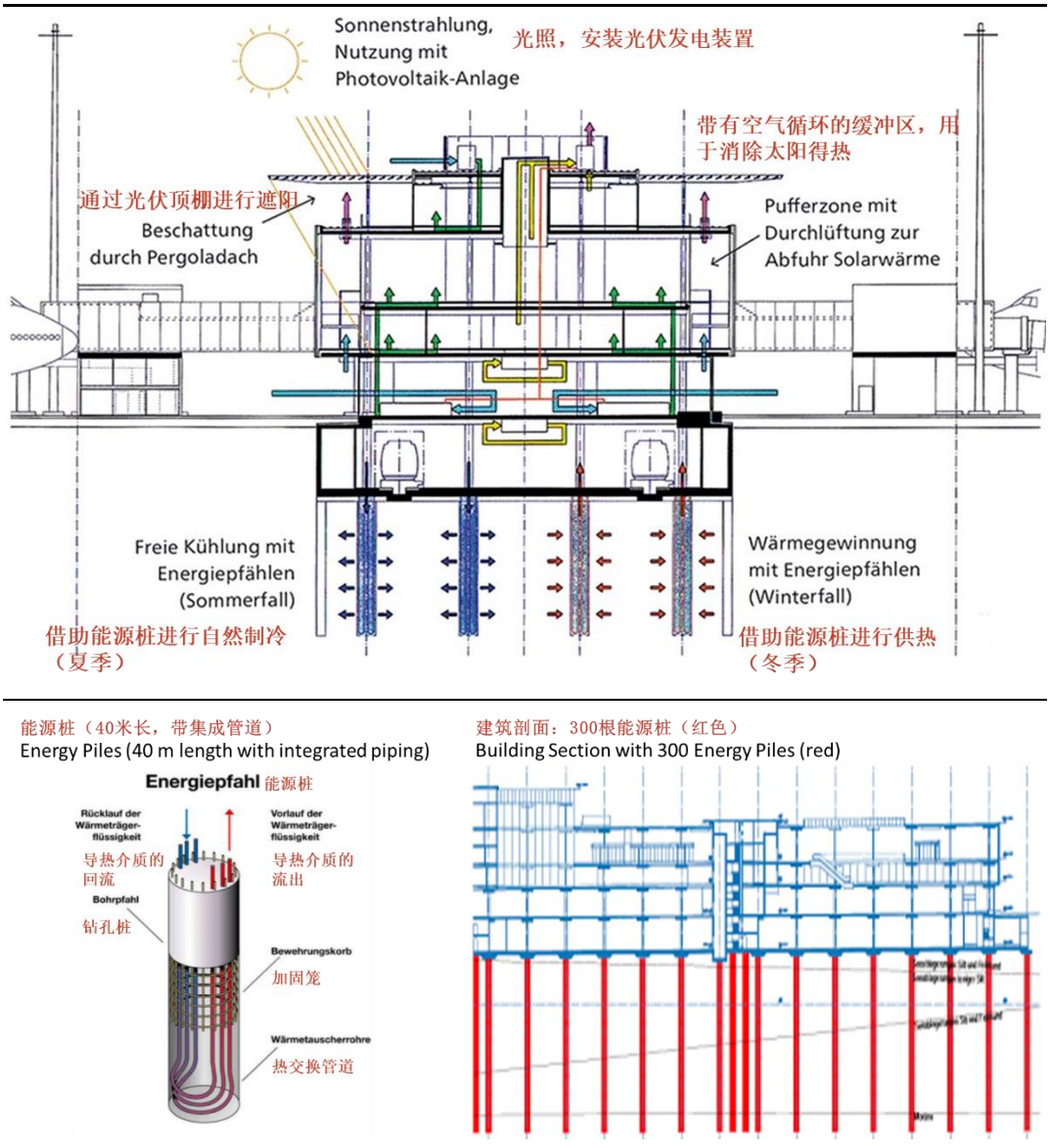

Figure 8: The ZEB technical concepts of Zurich Airport, New Dock E Terminal Building, graphic created by Prof. Adrian Altenburger and Amstein + Walthert AG

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

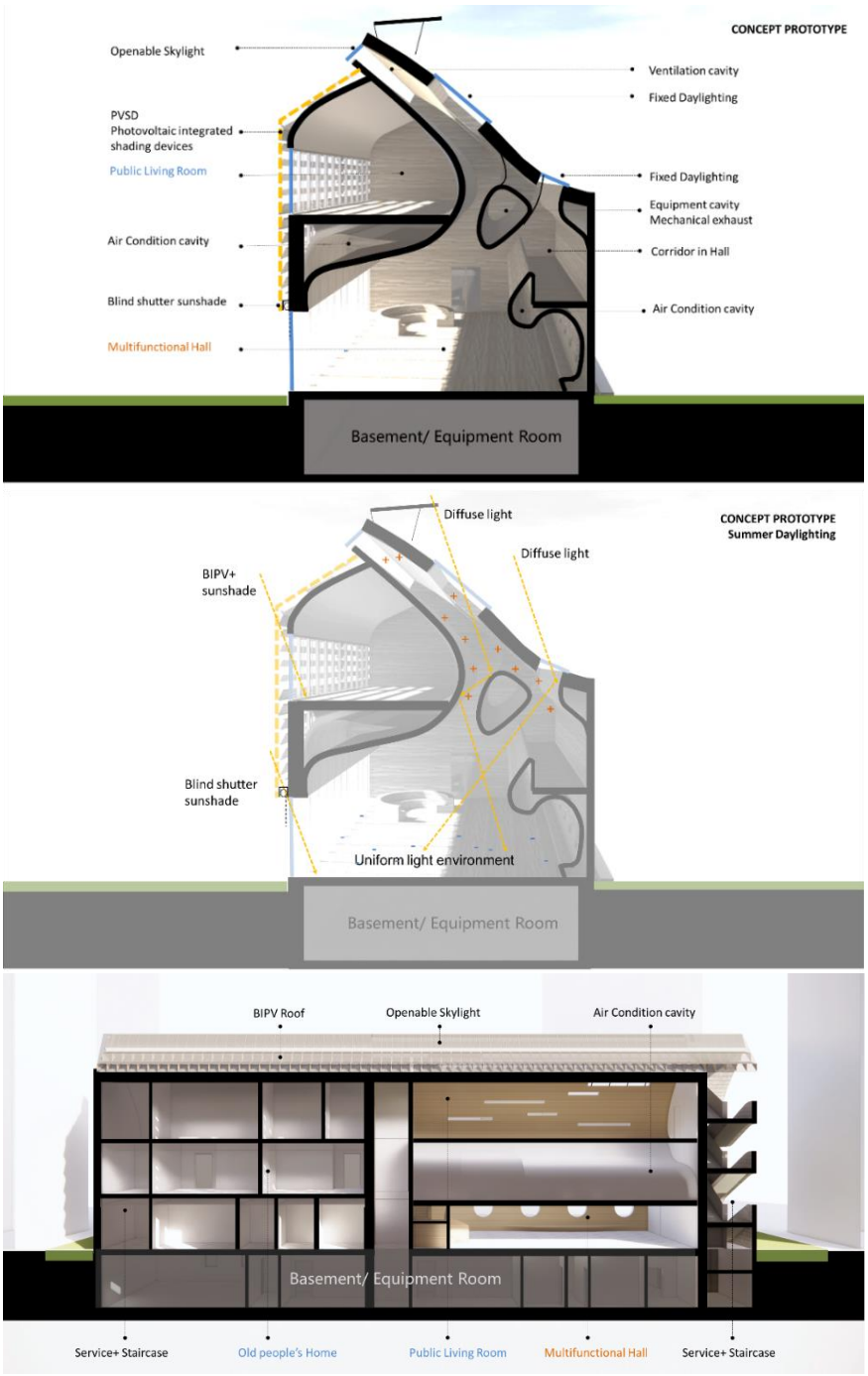

Figure 9: Energy Concept Description, Beijing Demo Project of Sino-Swiss ZEB cooperation project – Gongchen Community Center of Fangshan District in Beijing, Graphics created by SUP Atelier at Tsinghua University ZEB consulting Team of CABR

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

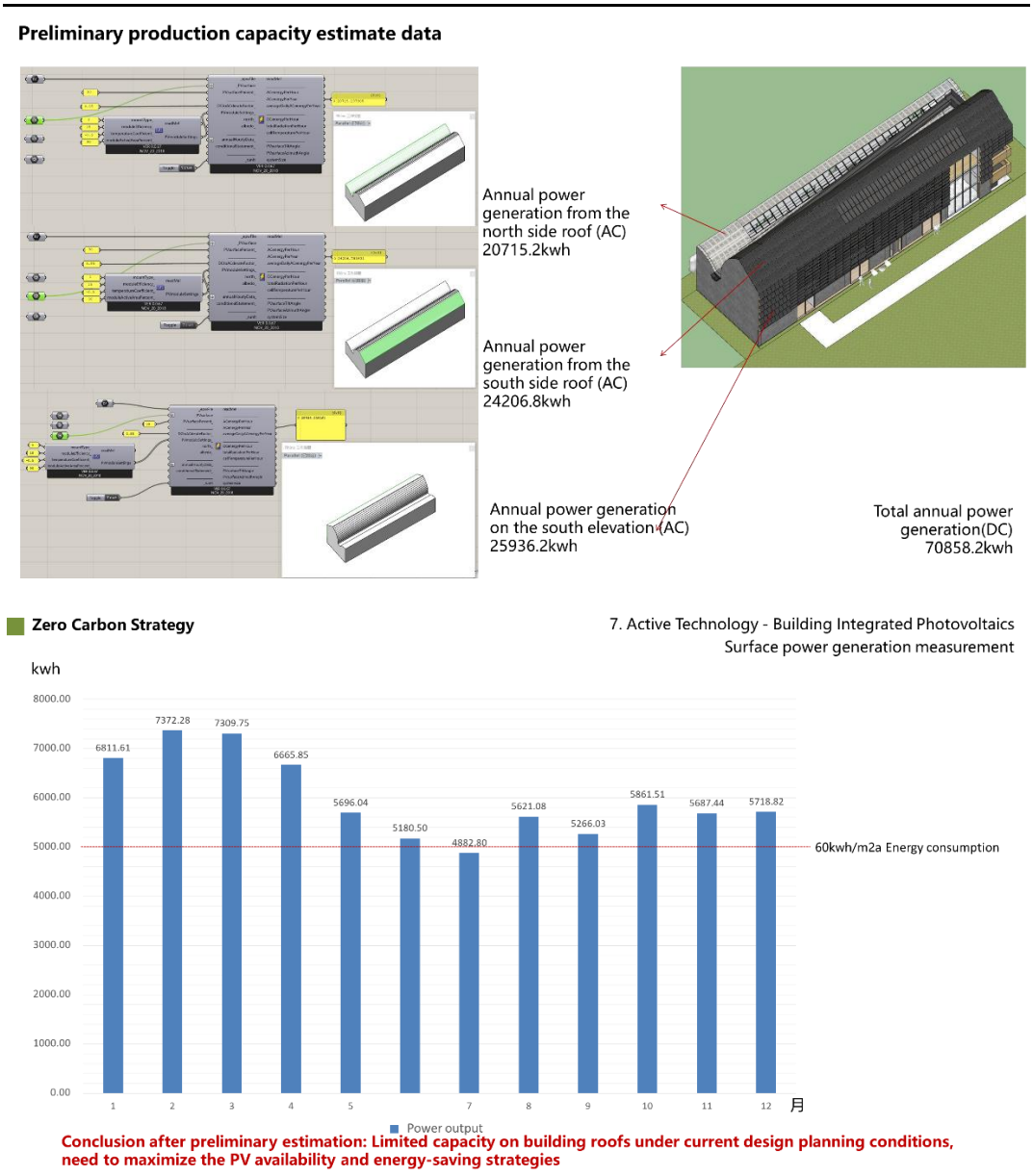

Figure 10: Zero Carbon Strategy – Active Technology – Building Integrated Photovoltaics Surface power generation measurement, Beijing Demo Project of Sino-Swiss ZEB cooperation project - Gongchen Community Center of Fangshan District in Beijing, Graphics created by SUP Atelier at Tsinghua University and ZEB consulting Team of CABR ZEB consulting Team of CABR

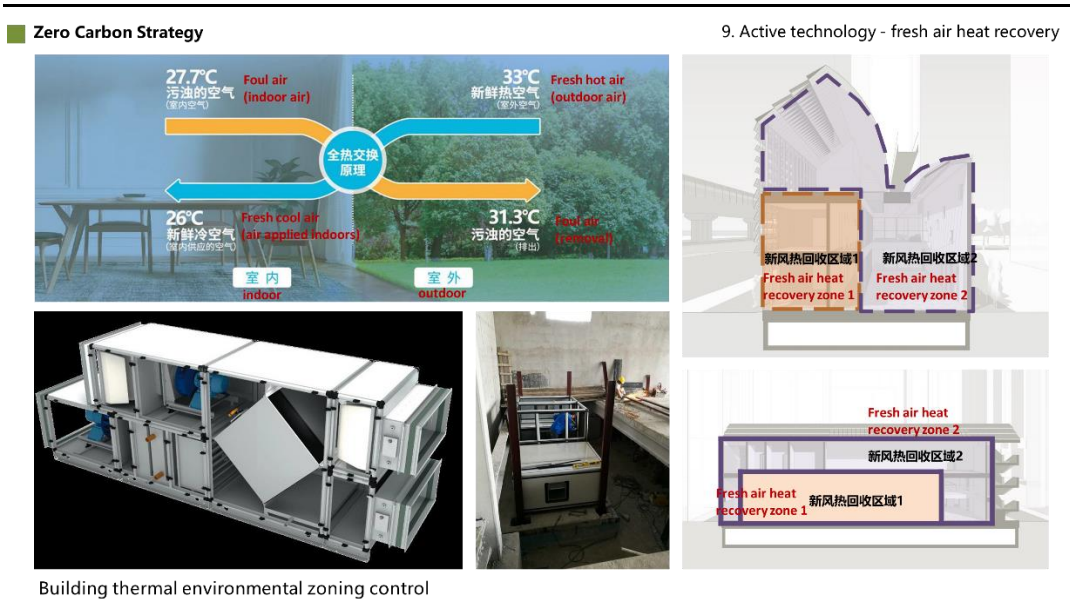

Figure 11: Zero Carbon Strategy – Active technology "fresh air heat recovery", Beijing Demo Project of Sino-Swiss ZEB cooperation project - Gongchen Community Center of Fangshan District in Beijing, Graphics created by SUP Atelier at Tsinghua University and ZEB consulting Team of CABR ZEB consulting Team of CABR

A4 APPENDIX 4 - ZEB BALANCE SHEET SIA 2040

Here below is a cutout of the Excel SIA 2040 tool:

Calculator SIA 2040: Preliminary study / preliminary project — **construction**

Project information: **Test Project for CABR**

Legend: Input fields; Selection fields; transferred values; CES Component area

						Primary energy non-renewable kWh/m²	Greenhouse gas emissions kg/m²
	Designation	*Reference*	*Unit*	*Quantity*	*Design variant*	amortized over one year, based on EBF	
Object input	Gross Floor Area	GFA	m²	12'500			
	Energy Reference Area	ERA	m²	10'000			
Building below ground	Excavation	Volumen	m³	4500	without groundwater	0.3	0.07
	Foundation, base plate	CES	m²	1500	uninsulated	0.7	0.26
	Exterior wall	CES	m²	1800	uninsulated	0.8	0.28
	Roof	CES	m²		uninsulated	0.0	0.00
Building above ground	Outer wall: supporting structure	CES	m²	2600	Insulating concrete	3.5	0.86
	(reserve)	CES	m²		Exterior wall Supporting structure:	0.0	0.00
	Exterior wall: superstructure	CES	m²	2500	Cladding light, ventilated	1.3	0.25
	(reserve)	CES	m²	0	Medium cladding, ventilated	0.0	0.00
	Windows incl. sun protection	CES	m²	1300		2.8	0.69
	Interior walls	CES	m²	10000		3.9	1.30
	Ceiling: supporting structure	CES	m²	8000	Wooden element ceiling	2.4	0.53
	(reserve)	CES	m²	1500	Concrete ceiling (25 cm)	0.6	0.20
	Ceiling: superstructure	CES	m²	8500	Underlayment and floor covering	3.8	0.85
	(reserve)	CES	m²	0	Ceiling structure:	0.0	0.00
	Balcony	CES	m²	0		0.0	0.00
	Roof: supporting structure	CES	m²	1500	wooden element ceiling	0.5	0.10
	(reserve)	CES	m²	0	roof, supporting structure:	0.0	0.00
	Roof: superstructure	CES	m²	1500	insulated (flat roof)	1.4	0.30
	(reserve)	CES	m²	0	Roof structure:	0.0	0.00
Building services	Electrical system	ERA	m²	10000	Electrical system including distribution	2.9	0.63
	Photovoltaic system	max. performanc	kWp	210	(input in the sheet "Operation")	5.1	1.37
	Thermal plant	ERA	m²	10000	Heating system including distribution	2.3	0.53
	Thermal solar collectors	CES	m²	0	(input in the sheet "Operation")	0.0	0.00
	Ventilation system	ERA	m²	10000	(input in the sheet "Operation")	1.9	0.45
	Water plant	ERA	m²	10000	Sanitary system incl. distribution	1.3	0.30
					Project value	**35**	**9.0**
					Standard value	*35*	*9.0*

Parameters	*Compactness factor (SIA 380)*	*0.7*	*(total building envelope below and above ground level/floor area)*
	Window proportion on facade	*33%*	*(window area/facade area above terrain)*

Figure 12: cutout of the Excel Calculator SIA 2040, copyright belongs to SIA

Excel SIA2040_Tool_v300_lic_CN

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).

The table below shows the instruction of "how to use the tool":

Calculator SIA 2040: Preliminary study / preliminary project — **Instruction**

Language **English**

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.

Calculator SIA 2040: Preliminary study / preliminary project **Instruction**

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 QH,eff 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 naturemade 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 assumptions 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.