



SOLAR DECATHLON 2009

**Building Industry Day Workshop
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**Integrated Design – Delivery and Operations
of Net-Zero Energy Buildings**

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National Renewable
Energy Laboratory



bp



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Outline

- Definitions
- Principles
- Methodology
- Tools
- Examples
- Conclusions
- Q&A





Integrated Design – Delivery and Operations of Net-Zero Energy Buildings

Definitions





Integrated Building Design

ASHRAE Definition

Integrated Building Design (IBD) is a **collaborative process** of preparing design and construction documents that **result in optimized project system solutions**. For IBD to succeed and be beneficial to the project, the **entire project delivery team** must be committed to understand, and remain engaged and involved in the process **from project inception through operation and maintenance**.

An integrated design process discourages sequential philosophy and **promotes holistic collaboration** of the project team members **during all phases of project delivery**. Emphasis is placed on **optimizing system solutions** that are **responsive to the objectives** defined for the project. Optimizing system solutions requires the **participation of all team members**.





Integrated Building Design

AIA Definition

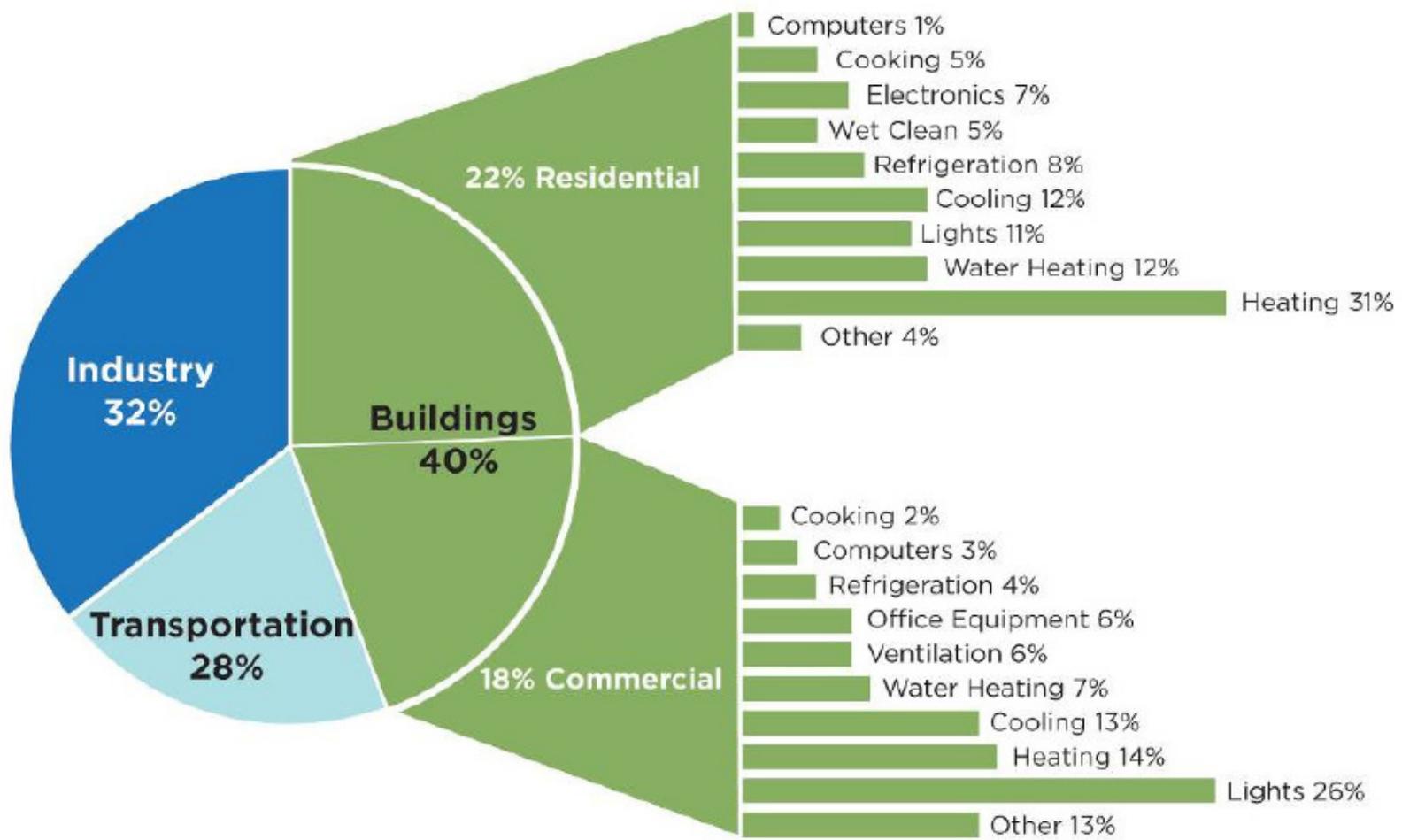
Integrated Project Delivery (IPD) is a project delivery approach that **integrates people, systems, business structures and practices into a process** that collaboratively harnesses the talents and insights of all participants to **optimize project results**, increase value to the owner, reduce waste, and maximize efficiency **through all phases** of design, fabrication, and construction.

IPD leverages **early contributions of knowledge and expertise** through **utilization of new technologies**, allowing all team members to better realize their highest potentials while expanding the value they provide throughout the **project lifecycle**.





Primary Energy Consumption

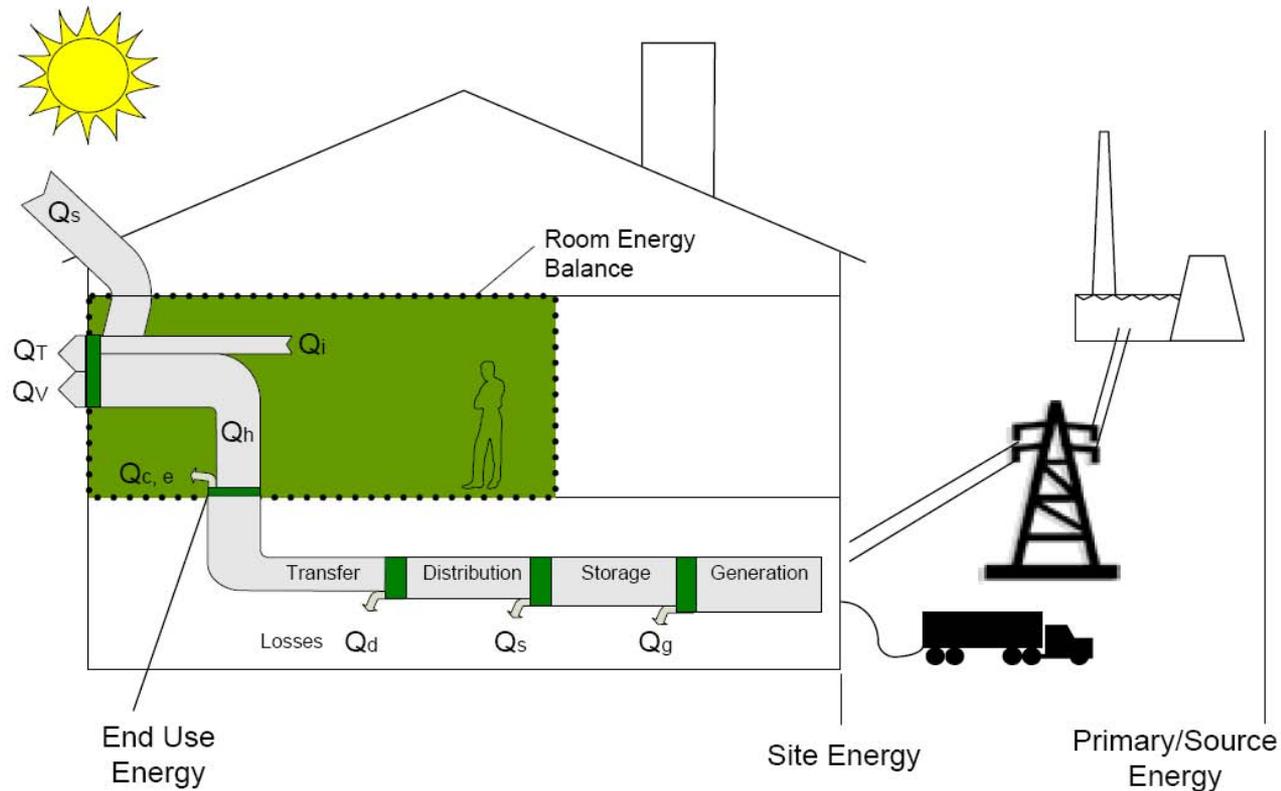




Net-Zero Energy Buildings

ASHRAE Definition

Net-Zero Energy Buildings (NZEBS) are buildings which, on an **annual basis**, use no more energy than is provided by **on-site renewable energy sources**.

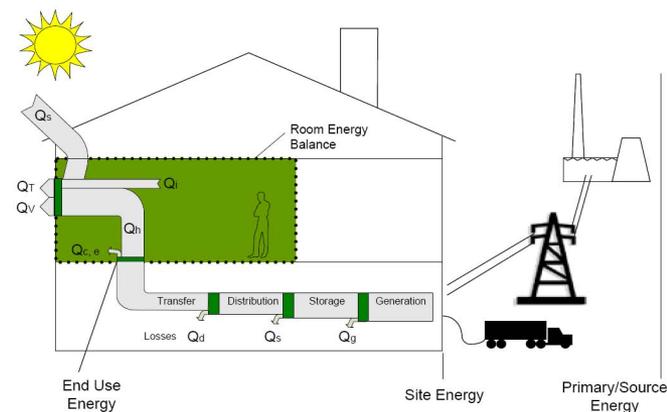




Net-Zero Energy Buildings

Despite sharing the name zero energy building, there are several definitions of what ZEB means in practice, with a particular difference in usage between North America and Europe.

- Net zero site energy use
- Net zero source energy use
- Net zero energy emissions
- Net zero cost
- Net off-site zero energy use
- Off-the-grid





Net-Zero Energy Buildings

Net zero site energy use

In this type of ZEB, the amount of energy provided by **on-site renewable energy sources** is equal to the amount of energy used by the building. In the United States, “zero energy building” generally refers to this type of building.

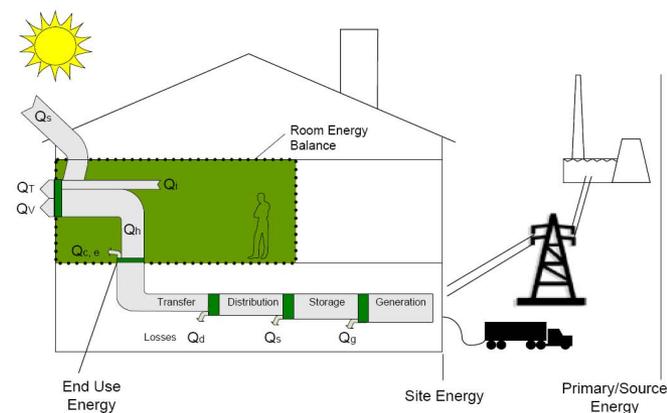
Net zero source energy use

Net zero energy emissions

Net zero cost

Net off-site zero energy use

Off-the-grid





Net-Zero Energy Buildings

Net zero site energy use

Net zero source energy use

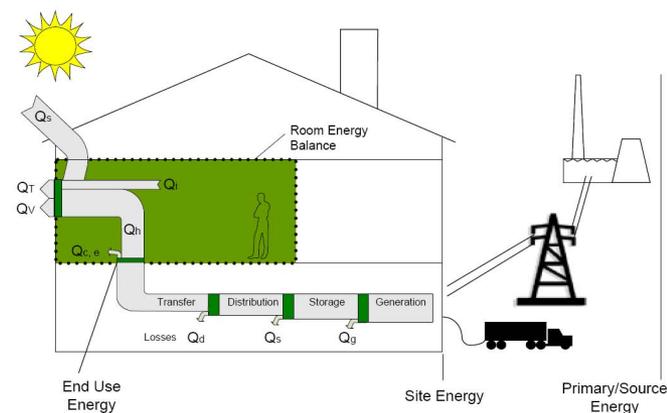
This ZEB generates the same amount of energy as is used, **including the energy used to transport the energy to the building.** This type accounts for losses during electricity transmission. These ZEBs must generate more electricity than net zero site energy buildings.

Net zero energy emissions

Net zero cost

Net off-site zero energy use

Off-the-grid





Net-Zero Energy Buildings

Net zero site energy use

Net zero source energy use

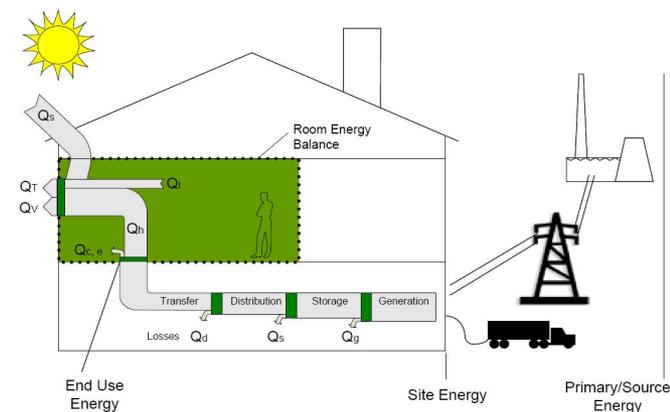
Net zero energy emissions

Outside the United States and Canada, a ZEB is generally defined as one with **zero net energy emissions**, also known as a **zero carbon building** or **zero emissions building**. Under this definition the **carbon emissions generated from on-site or off-site fossil fuel use are balanced by the amount of on-site renewable energy production.**

Net zero cost

Net off-site zero energy use

Off-the-grid





Net-Zero Energy Buildings

Net zero site energy use

Net zero source energy use

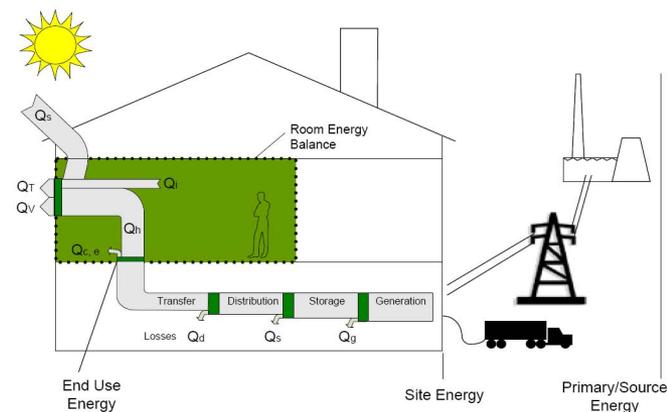
Net zero energy emissions

Net zero cost

In this type of building, the **cost of purchasing energy is balanced by income from sales of electricity to the grid of electricity generated on-site**. Such a status depends on how a utility credits net electricity generation and the utility rate structure the building uses.

Net off-site zero energy use

Off-the-grid





Net-Zero Energy Buildings

Net zero site energy use

Net zero source energy use

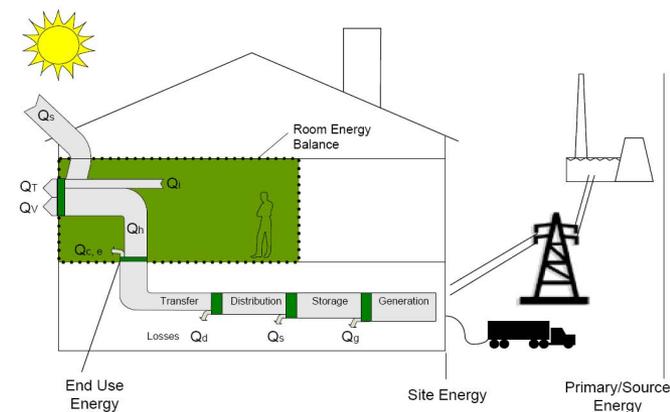
Net zero energy emissions

Net zero cost

Net off-site zero energy use

A building may be considered a ZEB if **100% of the energy it purchases comes from renewable energy sources**, even if the energy is generated off the site.

Off-the-grid



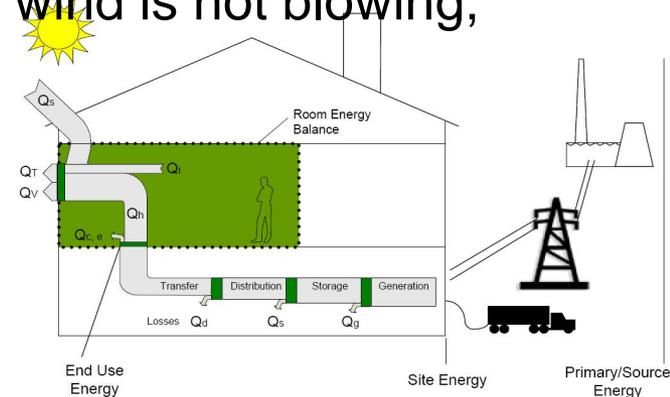


Net-Zero Energy Buildings

- Net zero site energy use
- Net zero source energy use
- Net zero energy emissions
- Net zero cost
- Net off-site zero energy use

Off-the-grid

Off-the-grid buildings are **stand-alone ZEBs that are not connected to an off-site energy utility facility**. They require distributed renewable energy generation and energy storage capability (for when the sun is not shining, wind is not blowing, etc).





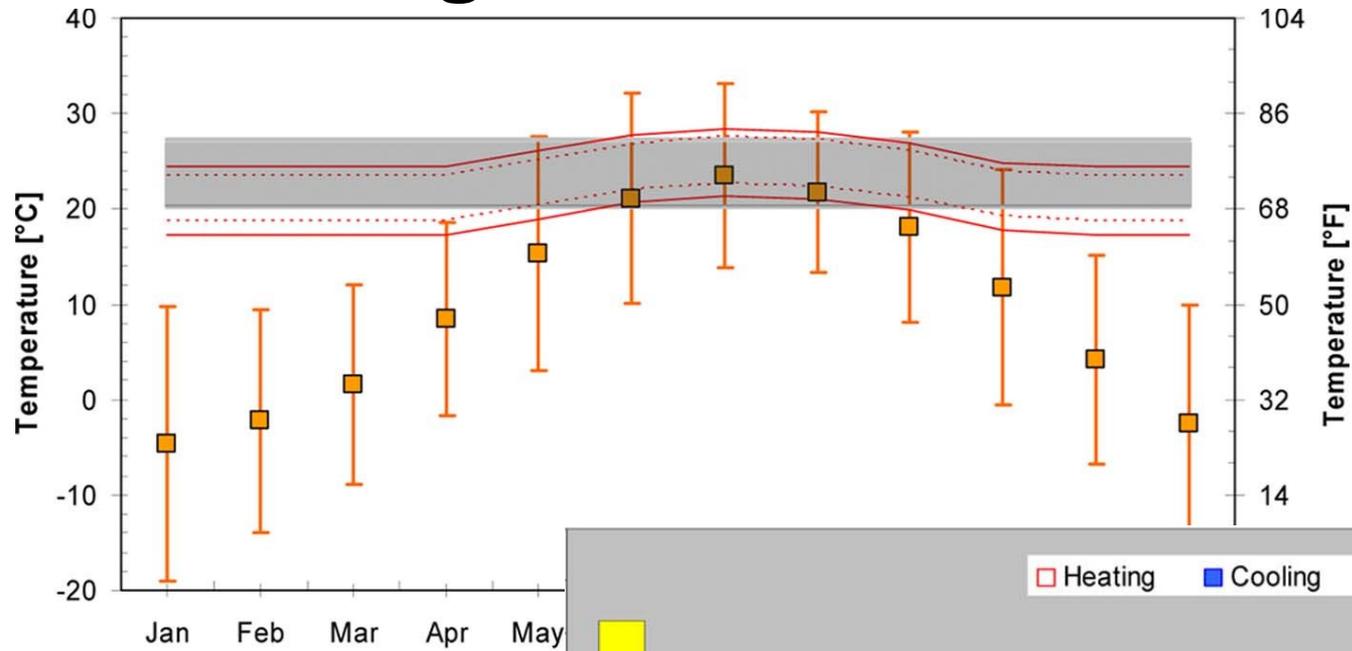
Integrated Design – Delivery and Operations of Net-Zero Energy Buildings

Principles

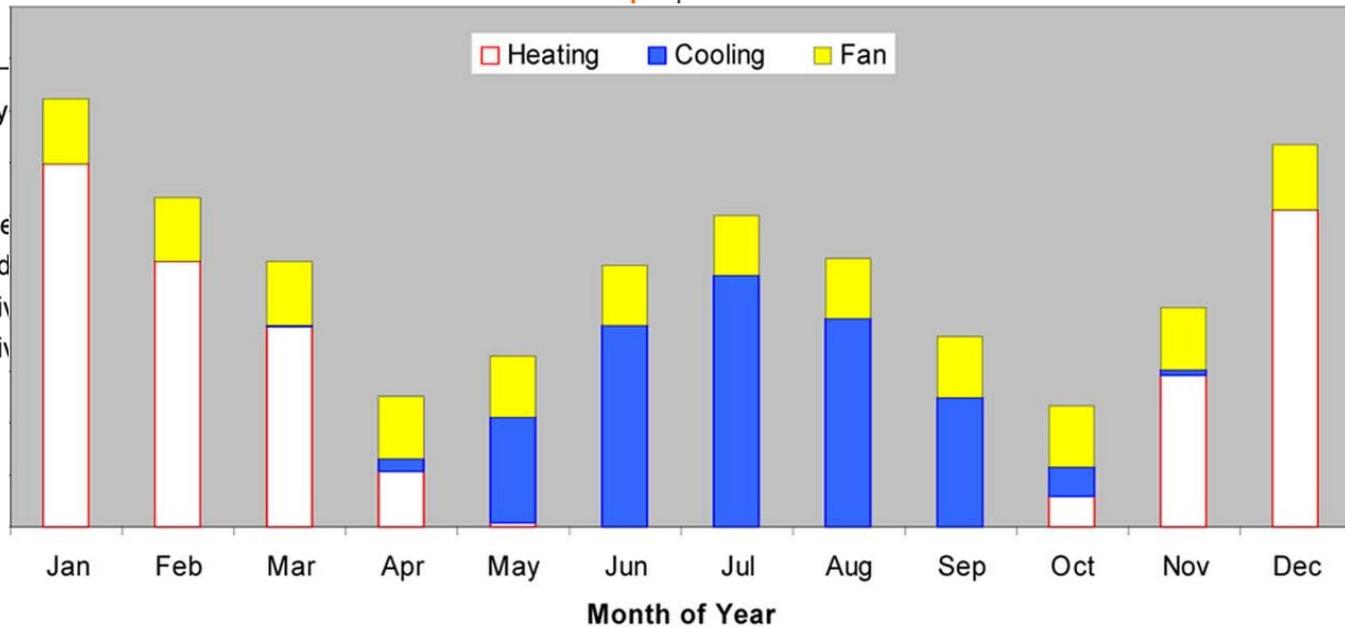




Building Performance

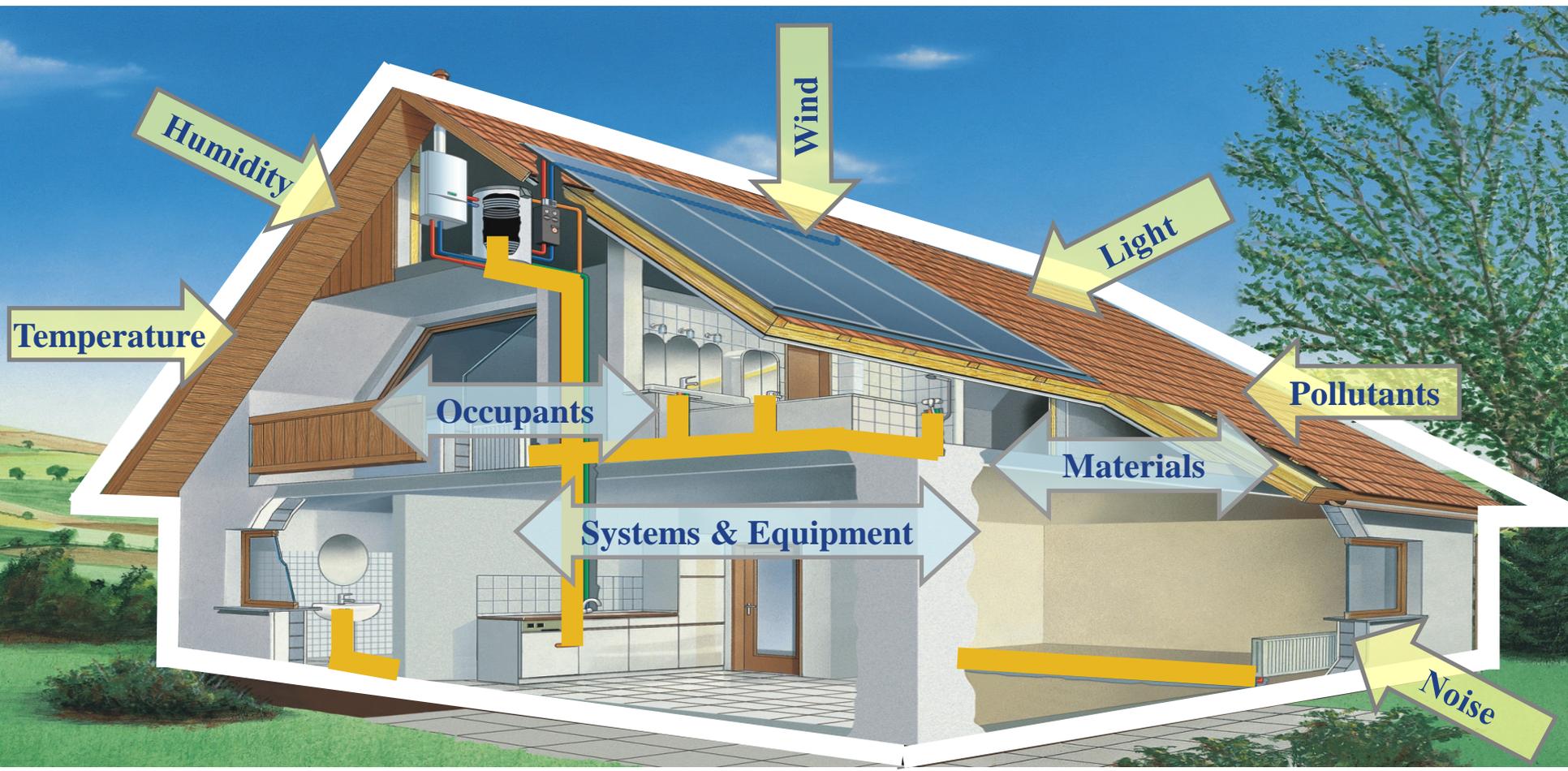


- Monthly outdoor temperature
- ASHRAE standard
- ASHRAE alternative 1
- ASHRAE alternative 2



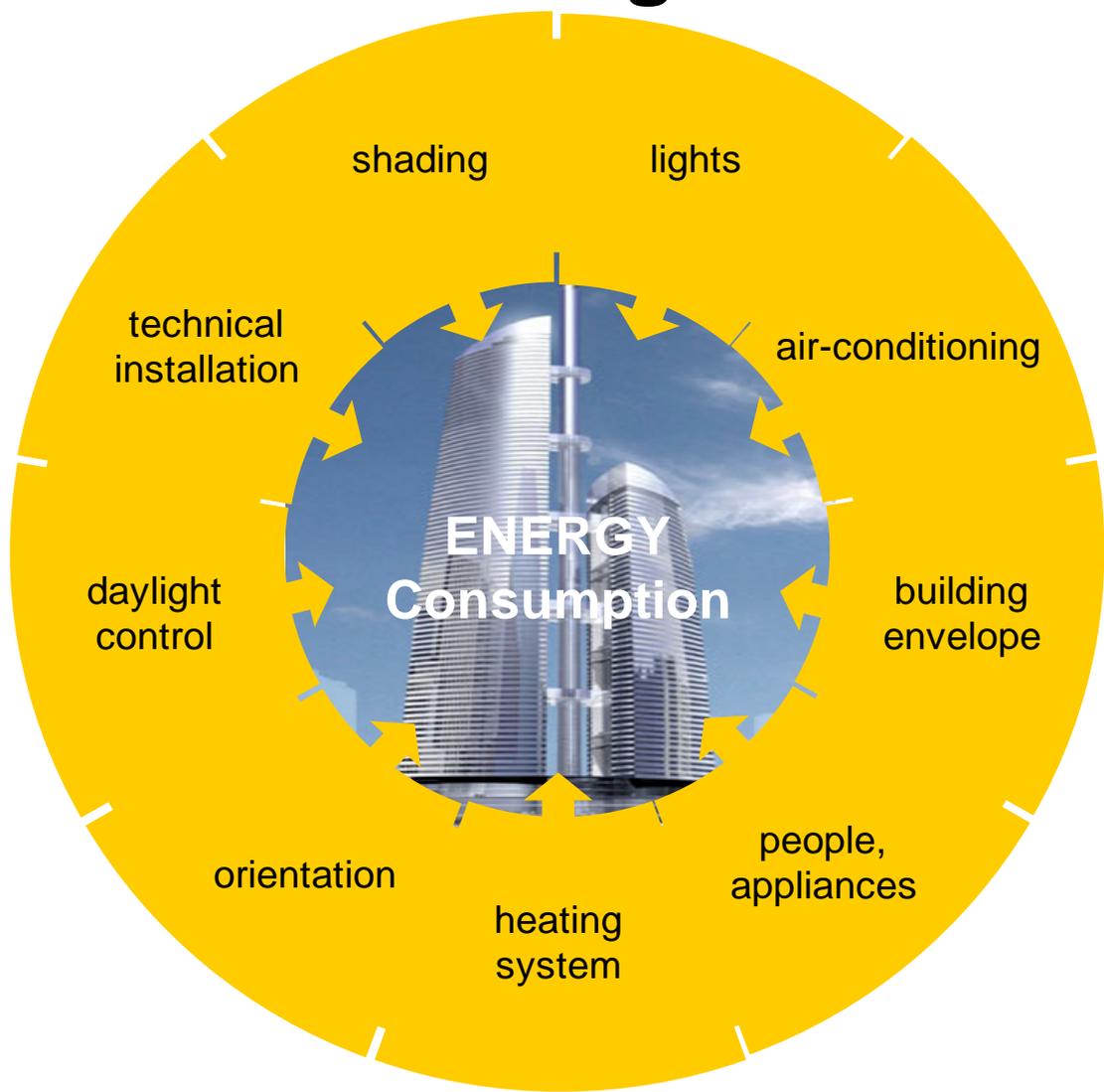


Influences on Building Performance



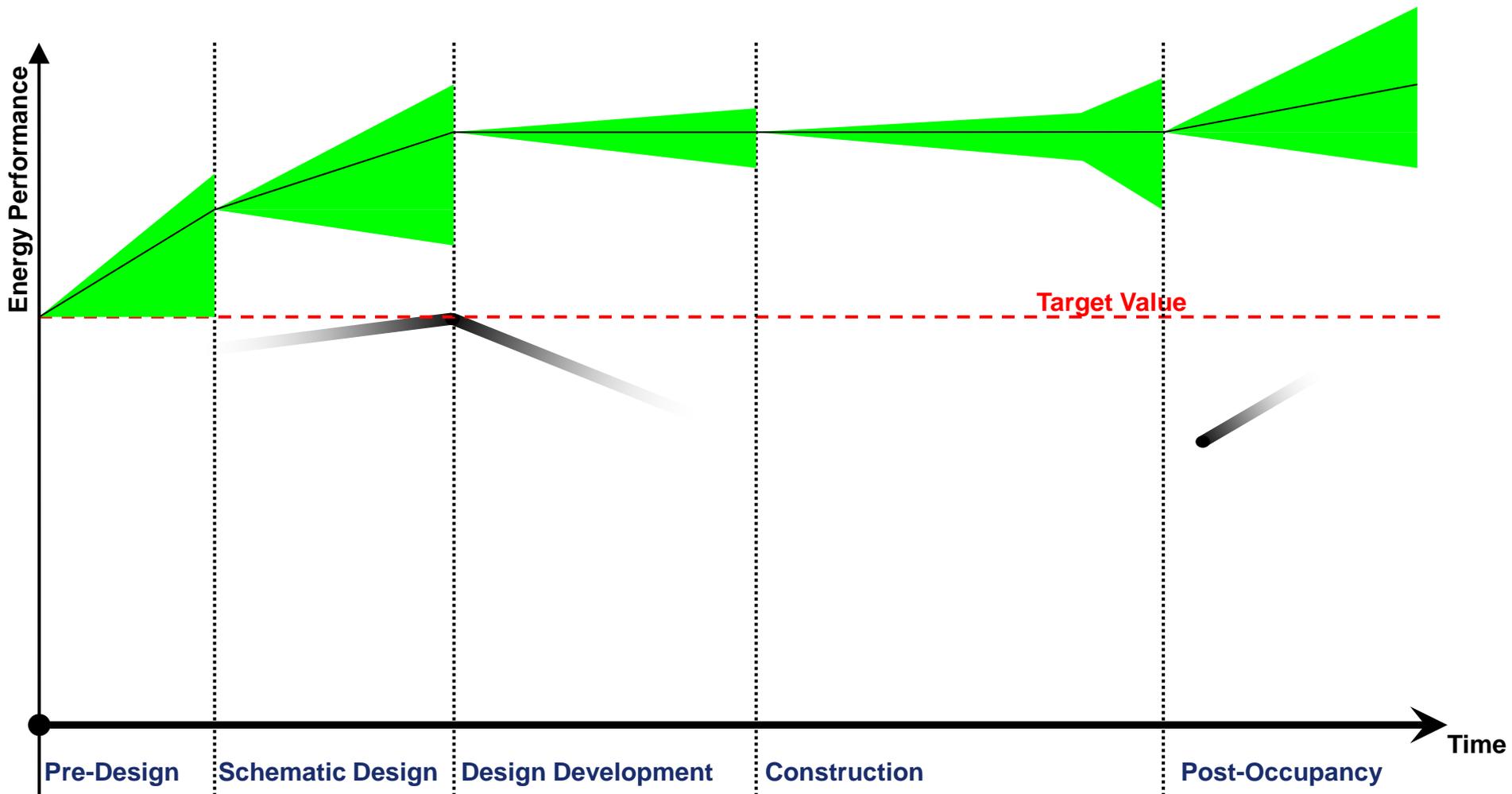


Influences on Building Performance





Impact During Project Phases





Project Team

Owner

Architect



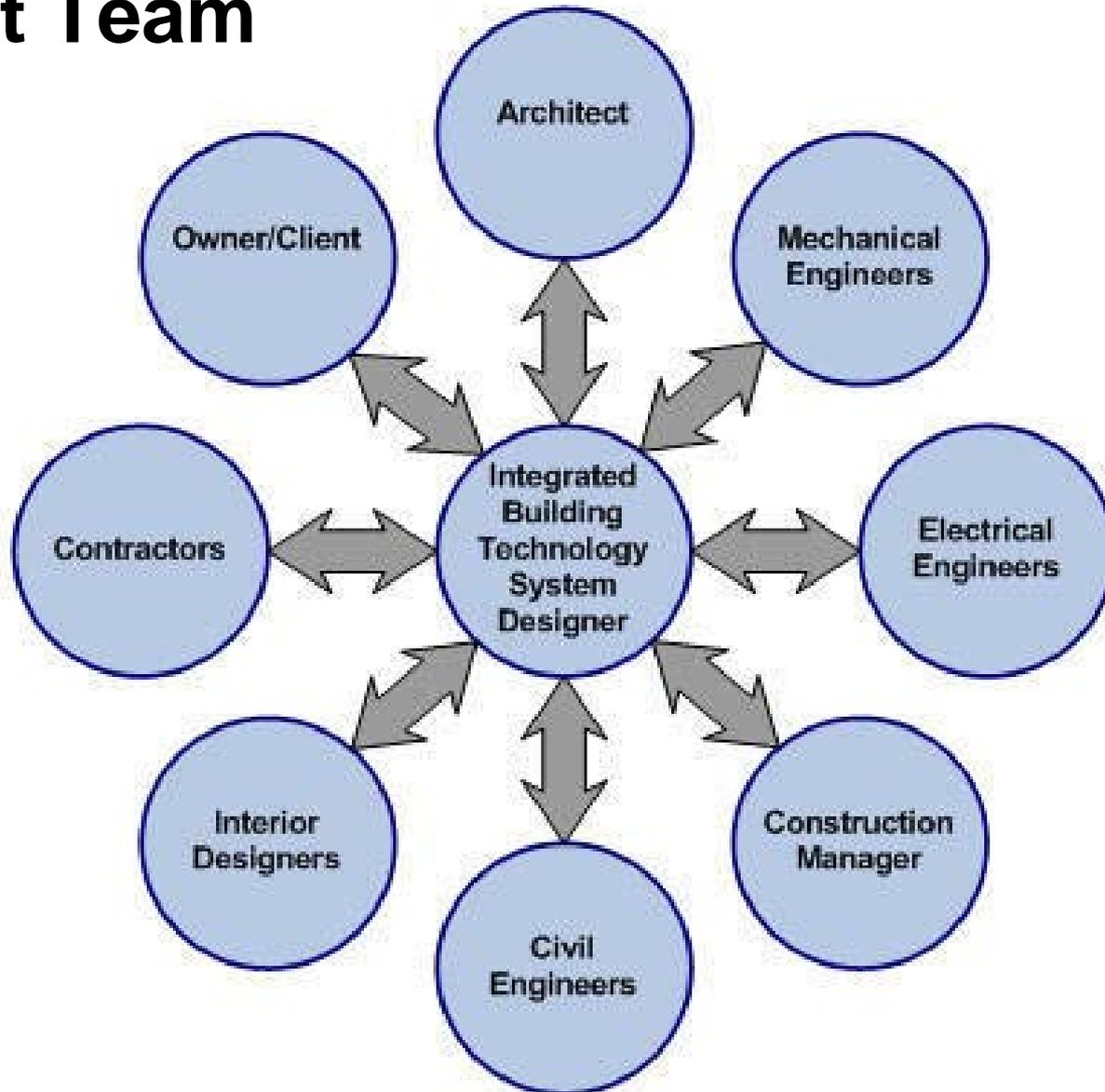
Contractor

Consultants



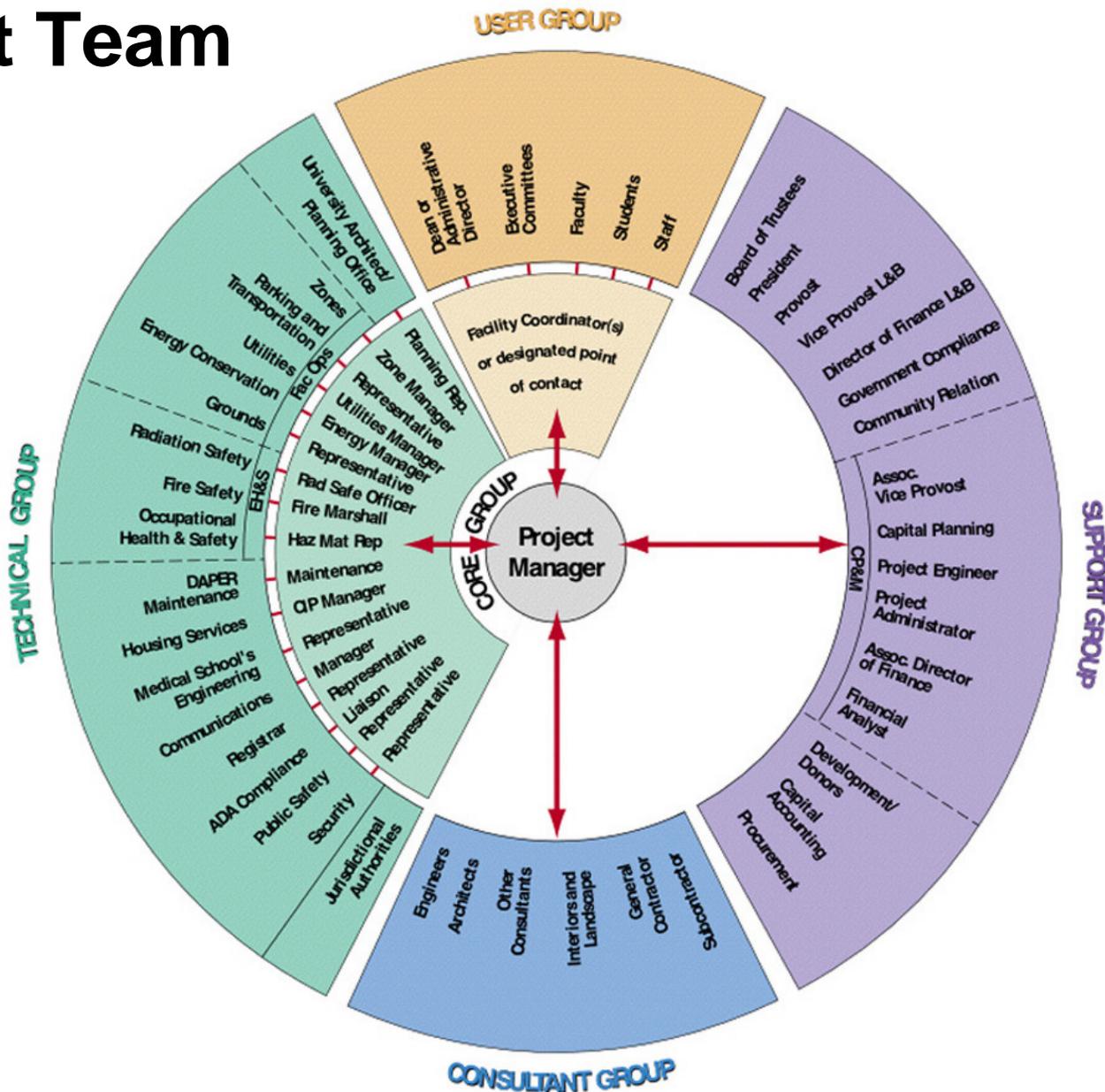


Project Team



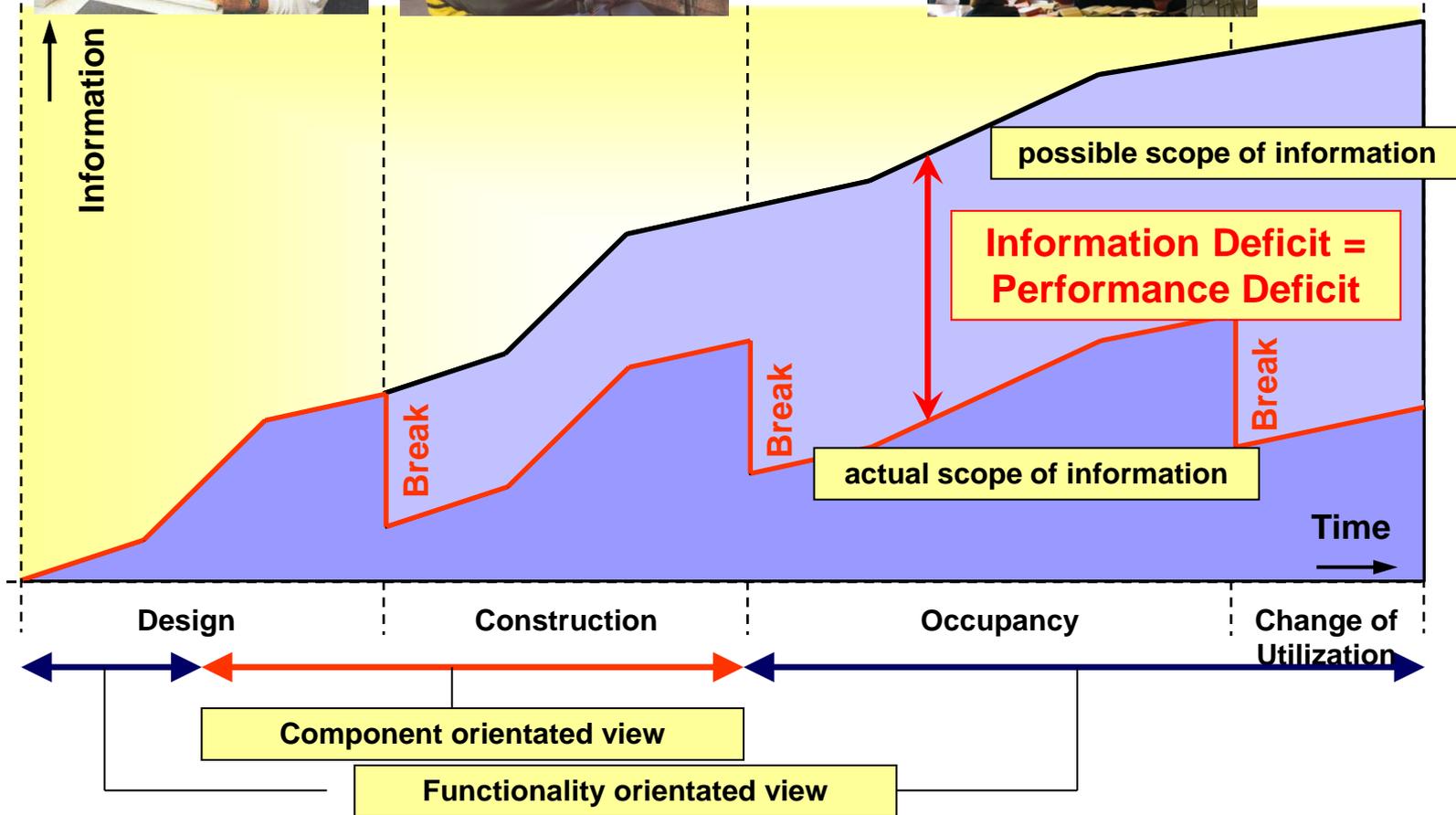


Project Team





Need for Information Flow





Integrated Design – Delivery and Operations of Net-Zero Energy Buildings

Methodology & Tools

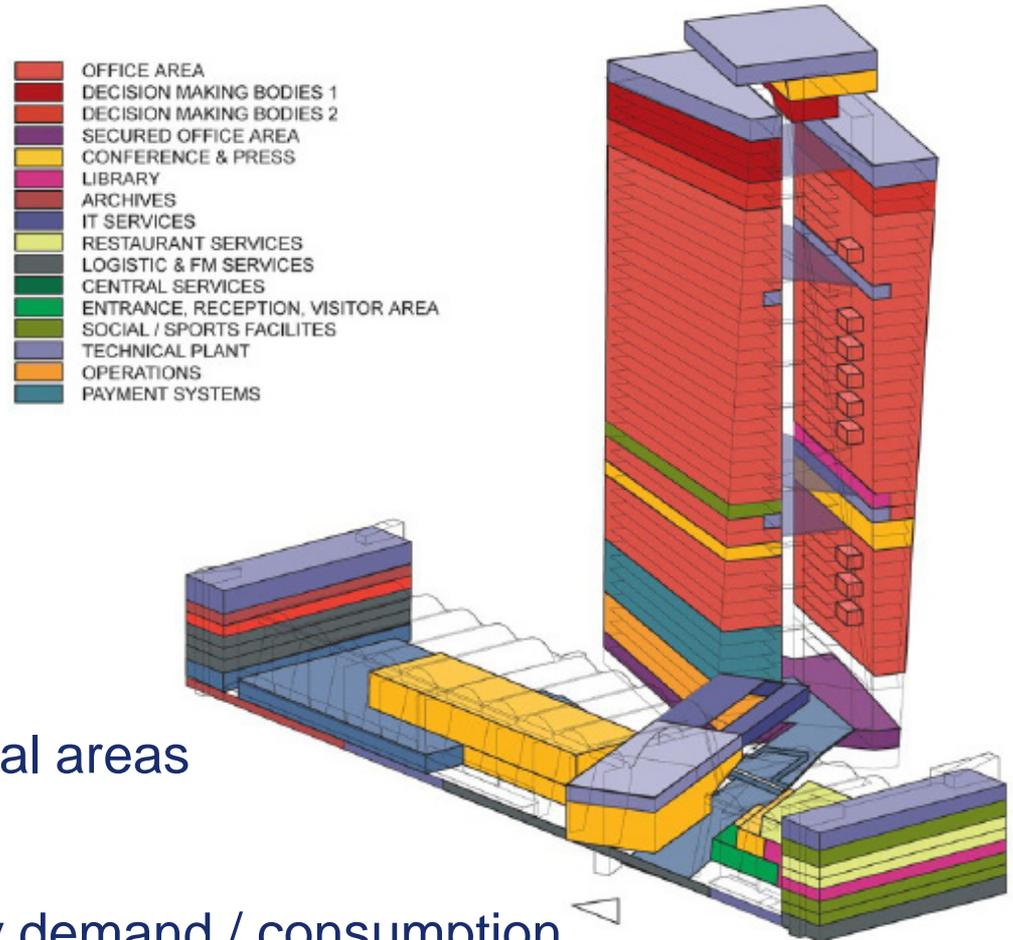




IBD Process

Owner Project Requirements

- ☑ Location
 - ☑ Size
 - ☑ Occupancy
 - ☑ Budget
 - ☑ Comfort?
 - ☑ Functionality?
 - ☑ Performance?
-
- ➔ Specify functionalities / functional areas
 - ➔ Specify comfort criteria
 - ➔ Specify target values for energy demand / consumption

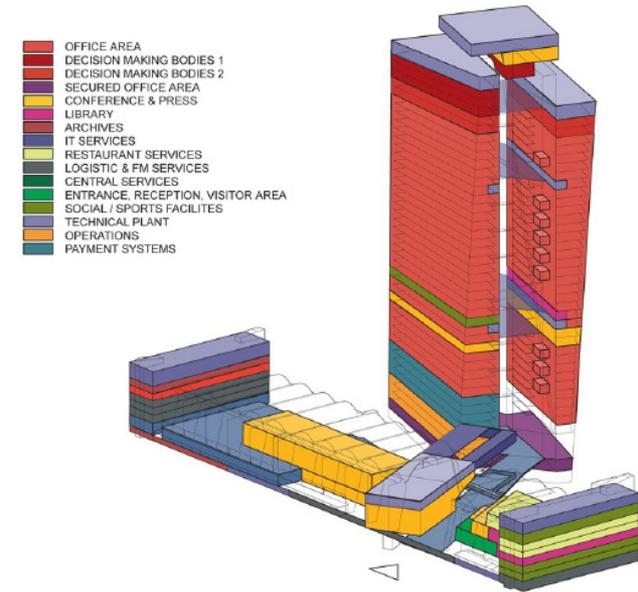




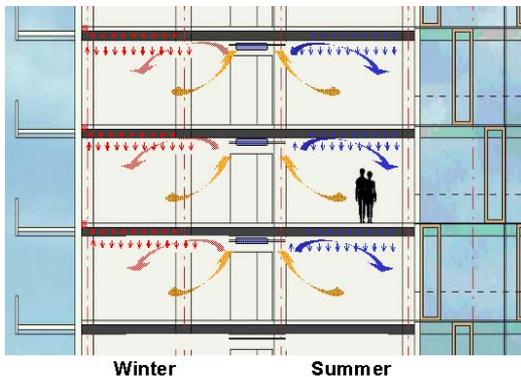
IBD Process

Conceptual Design

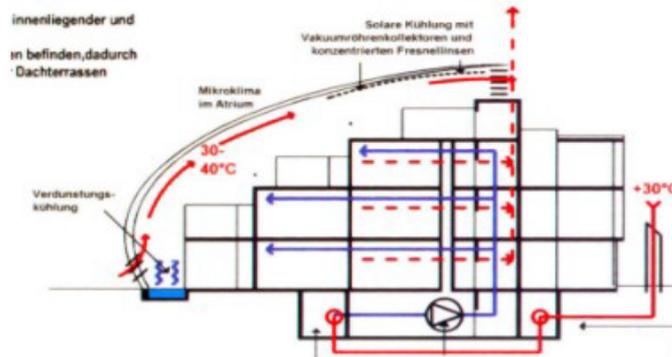
- ➔ Define functional areas / program areas
- ➔ Define scenarios for room climate
- ➔ Specify quality of building structure
- ➔ Define general technical systems (integrated HVAC concept)
- ➔ Evaluate general energy flow



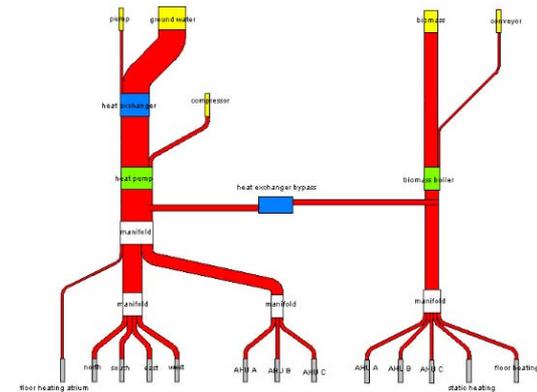
Functional Areas



Climate Scenario



HVAC Concept



Energy Flow

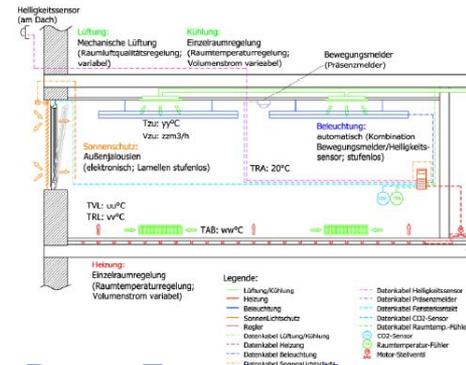




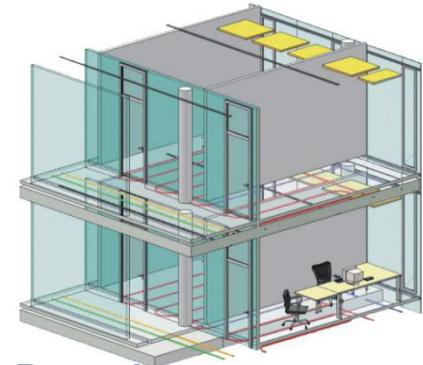
IBD Process

Schematic Design

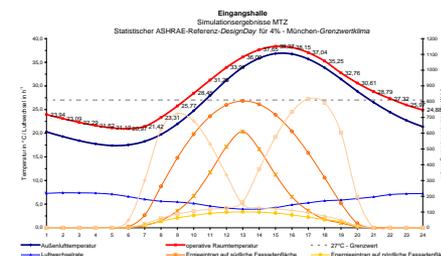
- ➔ Define room functions and equipment
- ➔ Define quality and performance of systems
- ➔ Calculate detailed energy balance
- ➔ Verify performance of building and systems and identify sensitivity of energy performance
 - building simulation
 - system simulation
 - daylight simulation
 - CFD simulation
- ➔ Perform cost-benefit estimation



Room Functionality



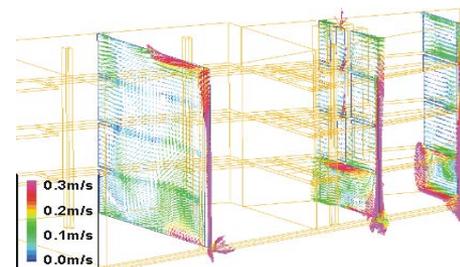
Room Layout



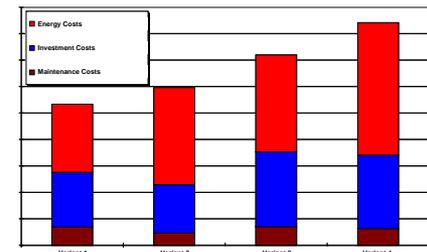
Building Simulation



Lighting Simulation



CFD Simulation



Cost-Benefit Estimation





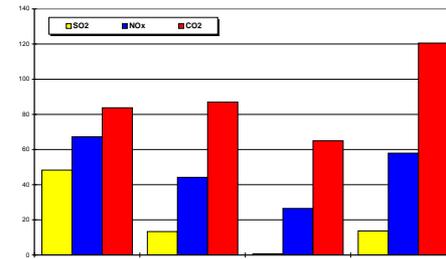
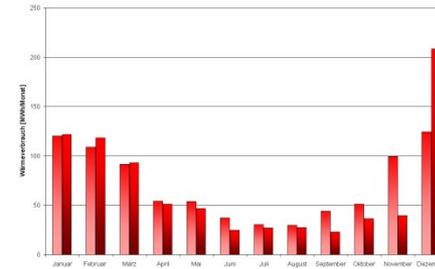
IBD Process

Design Development

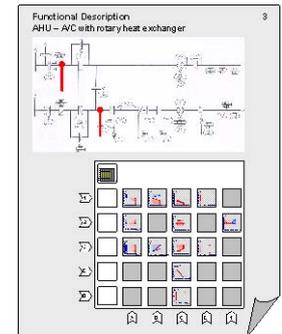
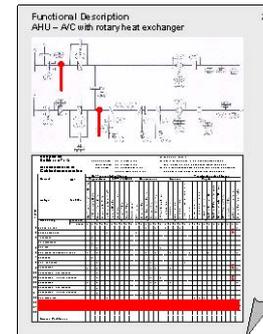
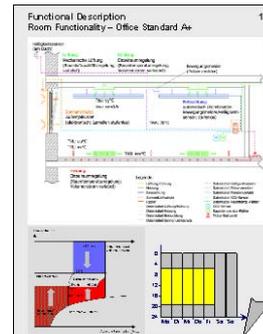
- ➔ Design integration
 - evaluate the influence of detailed design solutions on energy performance (e.g. cold bridges, pressure drop calculation, etc.)
 - update cost-benefit evaluation

- ➔ Operation Prognostics
 - produce and document control strategies
 - develop metering and monitoring concept

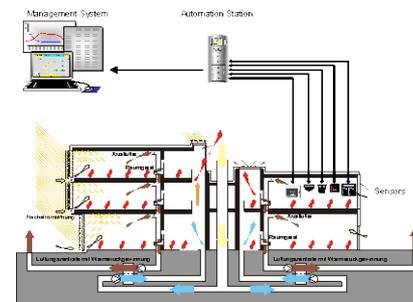
- ➔ Design verification
 - interference check
 - prove feasibility, practicability, and maintainability of technical installations



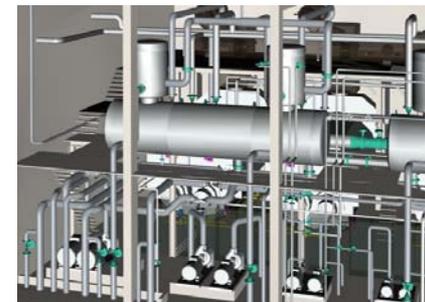
Cost-Benefit Evaluation



Operation Prognostics



Metering Concept



3D-Design / BIM





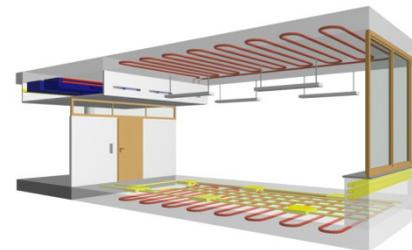
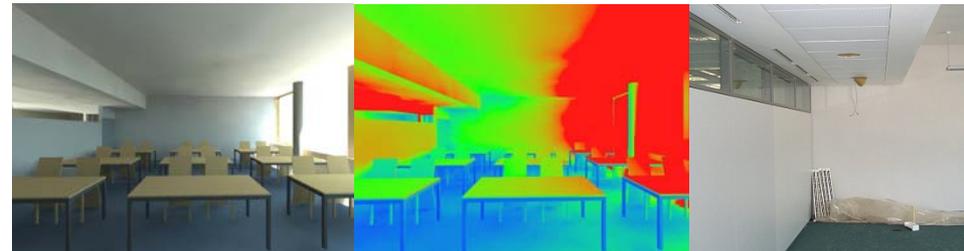
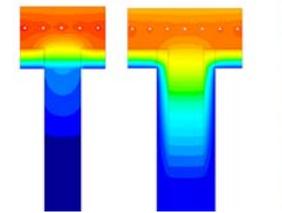
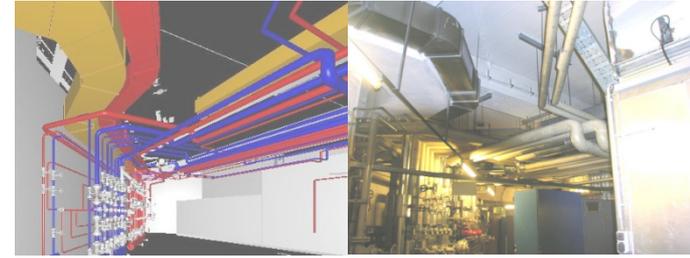
IBD Process

Construction Documents / Construction

- ➔ Design integration
 - sampling of chosen equipment
 - quality and performance evaluation of components

- ➔ On-site building inspections
 - verification of components and materials
 - verification of installation

- ➔ Acceptance & Commissioning
 - testing, adjusting, balancing (TAB)
 - testing of building structure (blower door, infrared thermography)
 - functional performance tests (FPT's) for technical equipment and systems (automated FPT's)





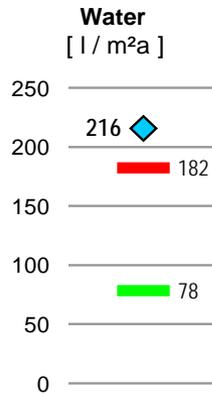
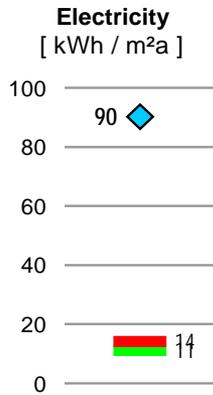
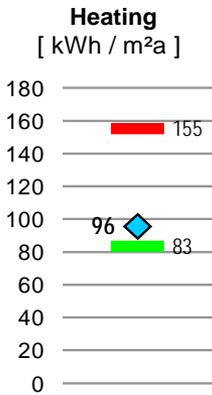
IBD Process

Post-Occupancy

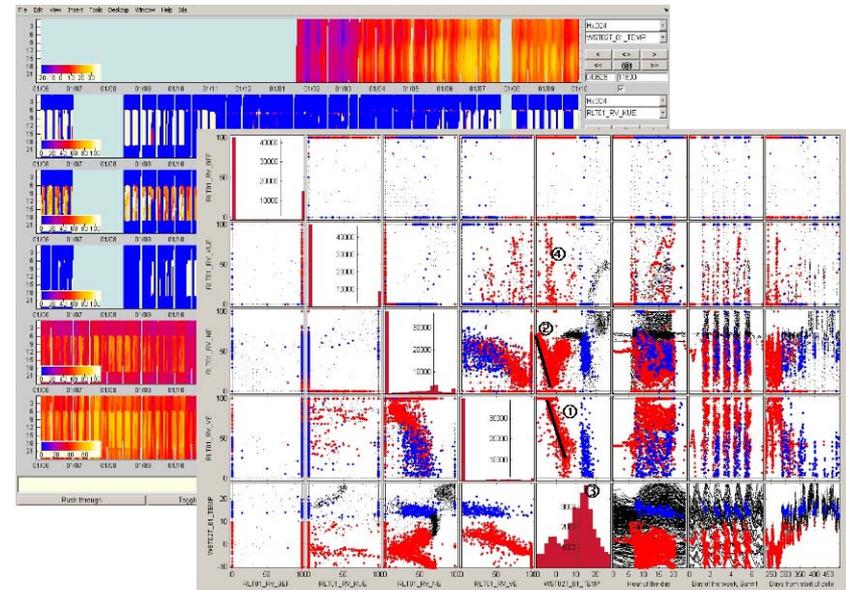
- ➔ Training of operational personnel (system & operation handbook)
- ➔ Briefing for occupants (occupants guideline)
- ➔ Energy check / monitoring
- ➔ Operation Diagnostics



Operation Training / Occupants Briefing



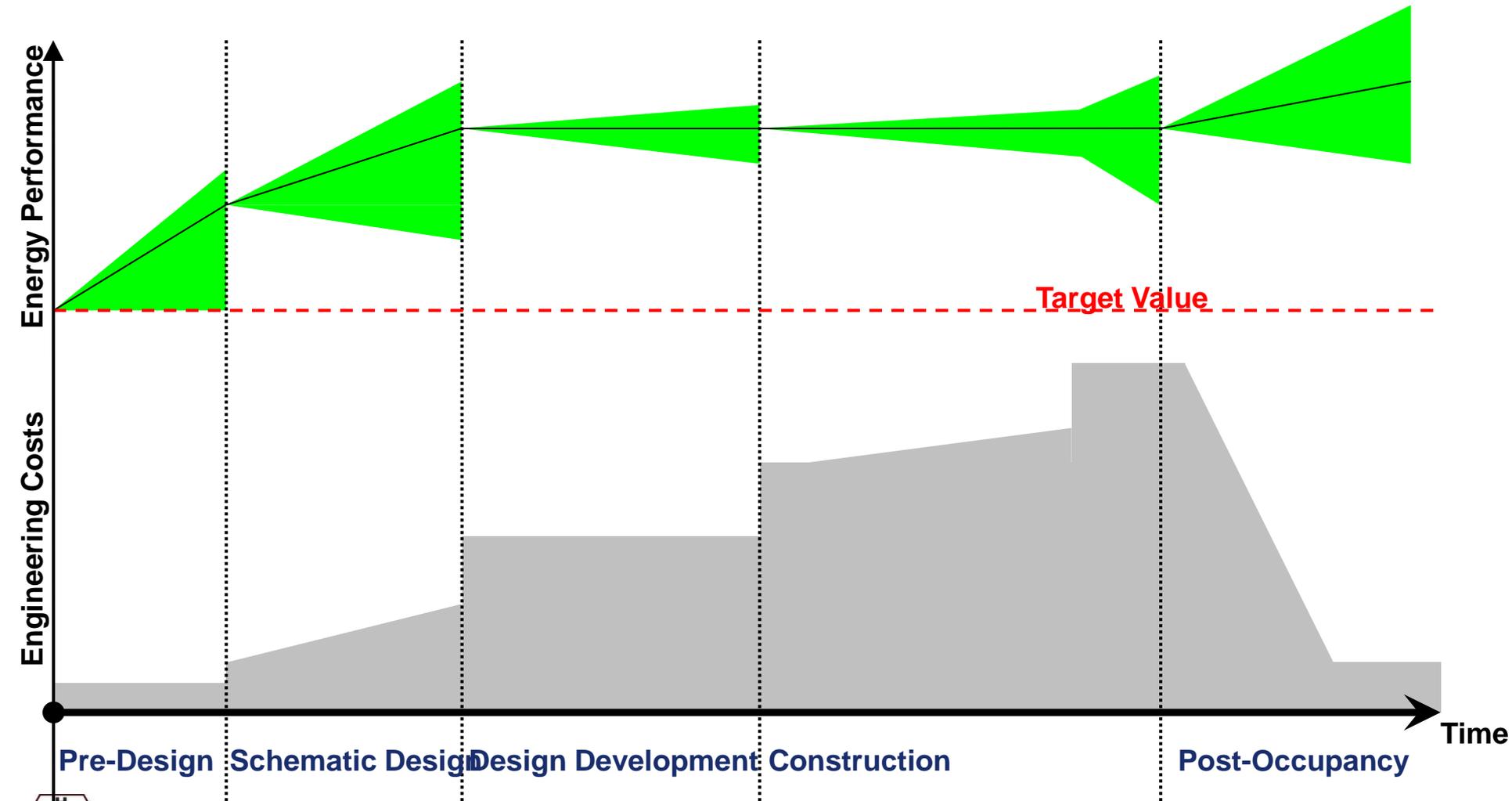
Energy Check



Operation Diagnostics

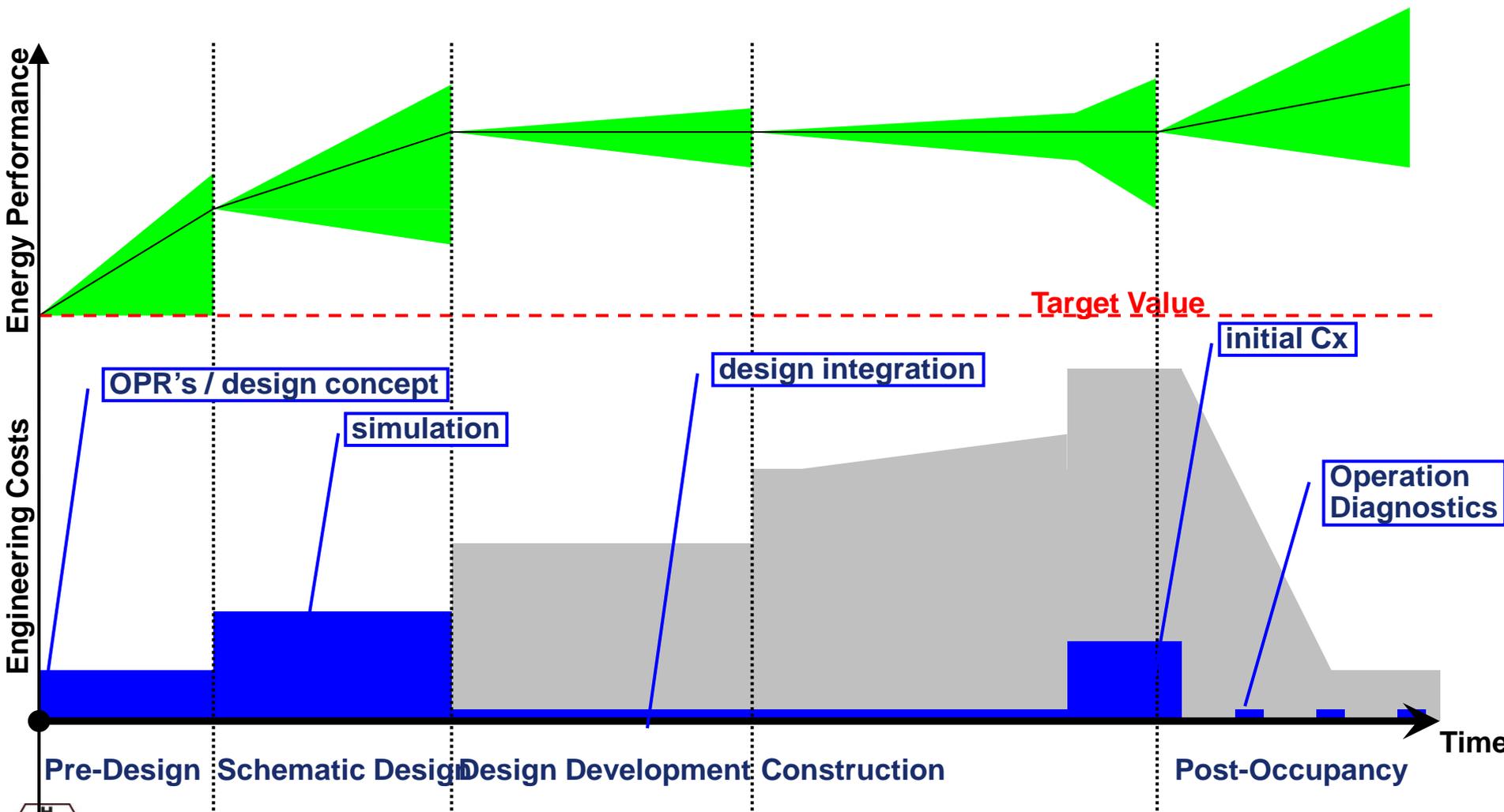


IBD Costs & Benefits



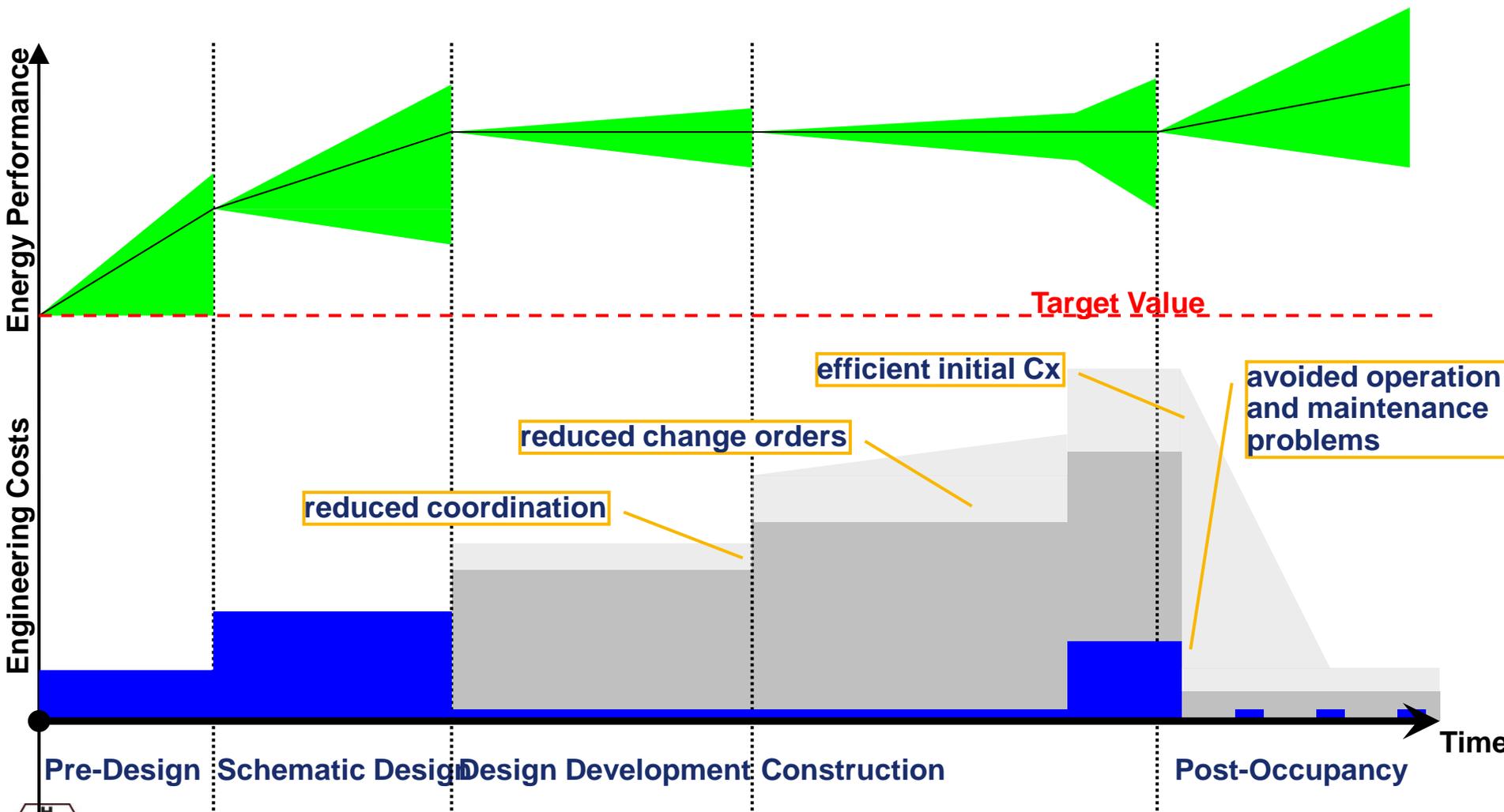


IBD Costs & Benefits





IBD Costs & Benefits





Integrated Design – Delivery and Operations of Net-Zero Energy Buildings

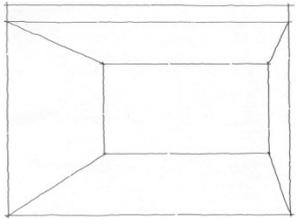
Examples



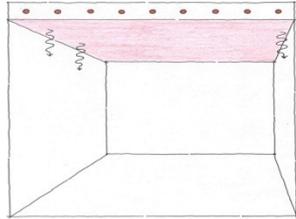


Gebhard-Muller School in Biberach, Germany

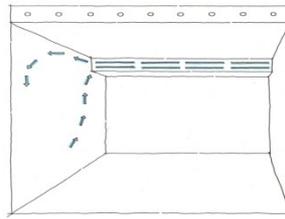
Modular Room Concept



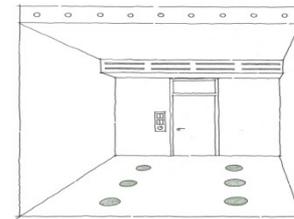
Room Module



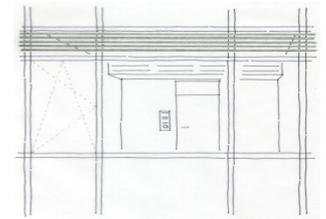
Slab Heating and Cooling



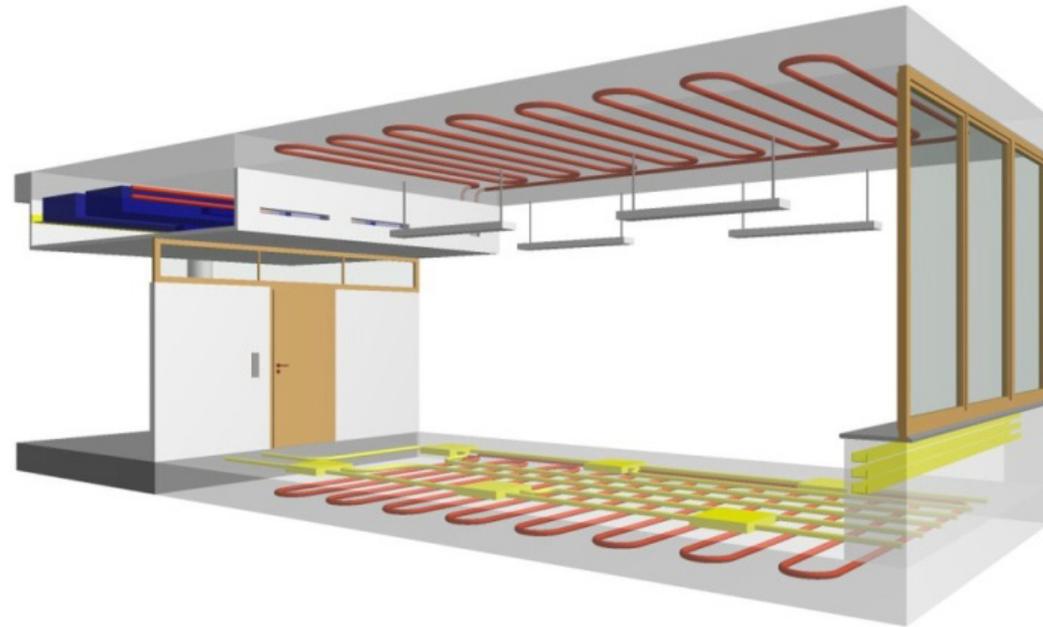
Mechanical Ventilation



Electrical Installation



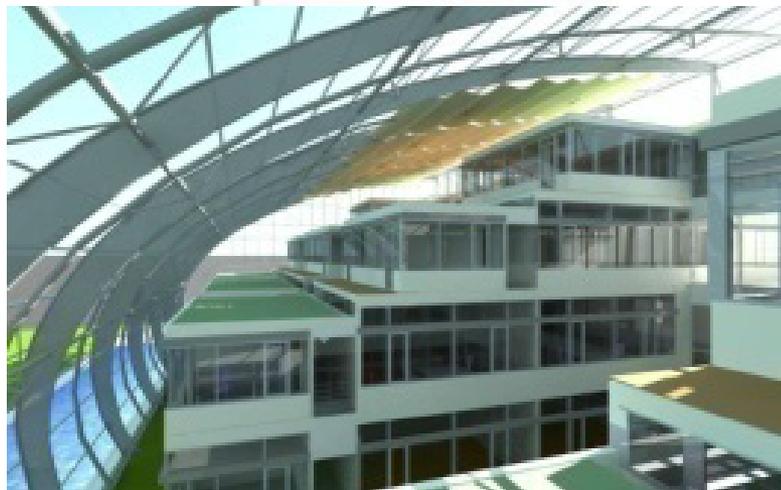
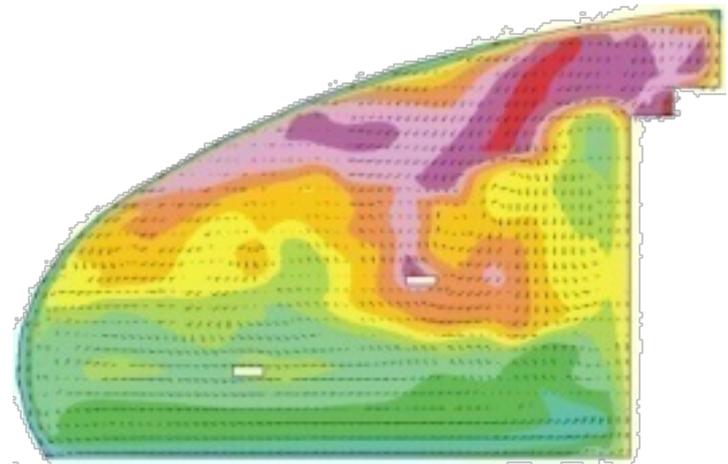
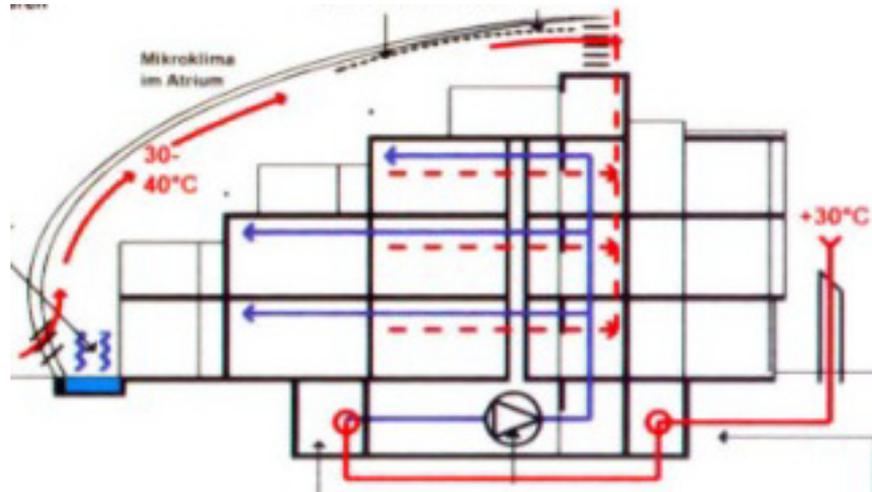
Facade and Shading System





Degussa Laboratory Building in Trostberg, Germany

Comfortable Climate with Natural Resources





Integrated Design – Delivery and Operations of Net-Zero Energy Buildings

Conclusions





Conclusions

- High performance and low / zero energy buildings require an integrated building design and delivery process
- Integrated building design requires a new approach with focus on communication and documentation.
- Advanced integrated building design tools are available and state-of-the-art.
- Integrated building design has the potential for optimized buildings – in regard of energy consumption, comfort, functionality, and costs.





Integrated Design – Delivery and Operations of Net-Zero Energy Buildings

Questions?

