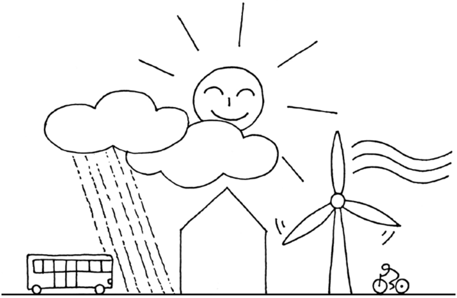
CLIMATE CHANGES DESIGN

A GUIDELINE TO INTEGRATE CLIMATE
INTO THE DESIGN PROCESS



01 LOCATION / MOBILITY

INFRASTRUCTURE: Supply networks are the roots of cities. New buildings must be planned to easily connect to the existing infrastructure, avoiding expansion of roads and networks. Good access to infrastructure and supplies ensures short transport routes and reduced costs in the construction process. **>** Adapt to existing infrastructure and avoid any further expansion.

WALKABILITY: The location and connectedness of a building directly translate into the users' mobility choices. To avoid motorized traffic (cars), essential functions of daily life (work, school, shopping, civic and medical services, leisure, etc.) must be present nearby or be easily reachable by foot, bike or public transport (non-motorized traffic, NMT). Tool: www.walkalytics.com. **>** Assure diverse and comprehensive walkability for all user types.

PUBLIC TRANSPORT: The closer and the more comfortable the access to means of public transport, the higher the probability that people use them instead of their private cars. Shared infrastructure reduces energy use and CO_2 emissions per capita as well as traffic jams. Tool: ÖV Güteklassen. **>** Optimize access to public transport and urban amenities.

MIXED USE: Mixed-use development can take the form of a single building, a city block or entire neighborhoods. In contrast to mono-use zoning, the combination of residential, commercial, cultural, institutional or industrial uses reduces travel distances and provides pedestrian and bicycle-friendly environments. **>** Assure diverse and attractive uses, at least on ground floor levels.

ENVIRONMENT: A building must be thought of as an integral part of its built and natural environment. Projects are not only directly generating energy usage, but also indirectly through the presetting of user mobility due to the location and connectivity of a building and the organization of its neighborhood. **>** Plan your building so as to capitalize on existing infrastructures while simultaneously significantly improving its environment.

02 VOLUME / ORIENTATION

BUILDING ENVELOPE RATIO (BER): The BER describes the ratio between a building's thermal envelope (A_{TH}) and its energy reference area (ERA). This factor translates directly into the demand for construction materials and energy, as it represents the compactness of a building and the rate of surface exposed to the exterior.
> Aim for a BER ⩽ 1.0.

SIZE AND SHAPE: The bigger the building, the smaller its BER: large, compact buildings can reach a BER far below 1.0, whereas single family homes have a BER around 2.0 or more, even if their form is very compact. Complicated forms (terracing, loggias, projections, etc.) drastically increase the BER compared to simple, cuboid or spherical forms. **>** Avoid small volumes and aim for an optimally compact form of the thermal envelope.

DAYLIGHT: Optimizing natural daylight (effective to about 6 m from outer walls) reduces artificial lighting and thus energy usage. Intelligent zoning of floorplans and allocation of uses according to needs and availability of natural light allows for greater building depth, size, compactness and energy savings. Make use of skylights (zenithal daylight is 5-7 times stronger than lateral daylight) as well as light wells, patios, interior courts, etc. to optimize access of natural light and glass them in as the optimization of the thermal envelope requires. **>** Aim for optimized direct and indirect natural daylight usage.

ORIENTATION: Minimizing openings on the side facing away from the sun significantly reduces energy usage. Orienting the primary usages towards the sun increases the possibility for passive solar gains. However, expanding their surface at the expense of compactness does usually not lead to a decrease of the total energy requirements. The orientation of a building and its openings as well as the size and compactness of the external surfaces have a decisive influence on the projects' overall energy demand. They must be optimized in unison, together with the access of natural daylight.
> Maximize solar gains for winter and minimize them for summer.

03 THERMAL ENVELOPE

EXTERIOR INSULATION: The insulation layer must enclose the entire building with as few interruptions as possible. Thus, it is useful to place the insulation layer on the outside of the building's structure. This critically reduces planning and construction difficulties and durations, costs and manifold types of potential mistakes and damage. **>** Plan a continuous insulation layer on the building exterior.

U-VALUE: The rate of heat transition through an element of the thermal envelope is represented in the U-value (W/m^2K). The smaller the U-value, the lower the thermal transmittance, the better the thermal insulation and the less energy is needed for heating and cooling. The U-value is mostly defined by the insulation layer. Tool: www.u-wert.net. **>** Aim for low U-values.

THICKNESS: The thicker the insulation layer, the smaller (better) the U-value. However, the first few centimeters of an insulation layer are the most efficient ones, because the thicker an insulation material, the less additional centimeters can improve the U-value. In the Swiss climate, a reasonable thickness for a typical insulation is currently around 20 to 25 cm. **>** Insulate ⩾ 20 cm everywhere.

THERMAL CONDUCTIVITY: The U-value results from thermal conductivity (Lambda) and thickness of a material. The thermal conductivity (W/mK) depends upon the material density and its air inclusions. In other words, the thermal conductivity of an insulation material determines its necessary thickness to reach a certain U-value. **>** Choose insulation materials with low thermal conductivity.

THERMAL BRIDGES: Constructive circumstances (impairments, penetrations, etc.) that weaken the insulation layer are called thermal bridges. The more a building is insulated, the more critical the thermal bridges become in terms of heat loss (up to 15%) as well as structural damage. Cold interior surfaces and locally resulting humidity surges create condensation, mold and further damages. **>** Avoid all kinds of thermal bridges.

04 WINDOWS / SHADING

WINDOW TO WALL RATIO (WWR): Windows easily account for half of the energy loss in a building. Openings must maximize passive solar gains in winter, but simultaneously minimize the high heat loss ratio and grey energy content of windows. For Switzerland, the ideal WWR is 30-40% for residential buildings and 40-50% for office buildings. **>** Aim for a window to wall ratio of 40%.

PLACEMENT: Glazing within the usual balustrade height is energetically useless, as the additional solar gains cannot compensate for the increased thermal loss. Daylight, on the other hand, benefits from higher windows as it can reach deeper into the building or can be better redirected (light shelves) above human lines of sight.
> Place windows high in your spaces.

GLAZING: Thermally, glazing and glass spacers have undergone significant improvements since 1970; glass U-values of 0.6 or 0.5 W/m^2K are now common and must be installed. Even then, the U-value of a good window is still about 6-8 times worse than that of a good wall. **>** Define glass U-value ⩽ 0.6 W/m^2K.

FRAME RATIO: Most of the energy loss of a window occurs through the frame and its connection to the glass, so the frame surfaces should be kept to a minimum by choosing few, compact windows without complex shapes and rungs. **>** Simplify window shapes and numbers, minimize frames.

SHADING: As modern buildings are more likely to overheat in summer than to undercool in winter, sun protection (shading) becomes imperative for any glazed surface (including skylights) to avoid heat buildup in summer. Shading devices are preferably automated and weather-controlled for optimal balance of sun protection, solar gains and daylight. Correctly dimensioned blinds (gtot ⩽ 10%), overhangs, vegetation, balconies, pergolas, etc. can control solar incidence throughout summer on windows, roofs, and facades.
> Shade all transparent components of the building envelope.

05 GREY ENERGY

TRANSPORT: Using materials that are locally sourced and processed reduces the technology and energy use for their transport. Furthermore, this can stimulate the local economy and craftmanship. **>** Use materials sourced within 25 km of the project.

PROCESSING: The requirement of complex technology and high temperatures or pressure to process a material increases its amount of grey energy. The most energy per cubic meter is typically used in the production of metals (aluminum, steel), followed by synthetic materials (pvc, polyurethane) and glazing, after that fired materials (bricks), then unfired materials (sand-lime bricks). Recycling can save up to 95% (aluminum) of virgin production energy. A useful database of the life cycle assessment data (LCA) of building materials can be found at eco-bau.ch/Instrumente/Ökobilanzen. Tools: bauteilkatalog.ch or energytools.ch. **>** Verify grey energy content of the entire project early.

THERMAL MASS: The thermal storage capacity of a room is defined by the mass of the first 6-10 cm of its inner surfaces. The more mass the surfaces contain, the slower the room warms up from solar gains or heating, and the slower it cools down again. The room's surfaces absorb the incoming heat during the day and release it during the cool night. To minimize interior temperature extremes in summer, a phase shift of about 12 hours is optimal for human comfort. **>** Assure that every room for long-term occupancy features dense inner surfaces (min. 6 cm) of twice its floor area.

RECYCLING: The recycling of each employed material at the end of its lifecycle must be ensured. Low processed materials like clay can easily be returned to nature with absolutely no harm or processing. Highly processed, synthetic or bonded materials (polystyrene insulations, epoxy layers, polymer sealants and adhesives etc.) are typically difficult to return to nature in an environmentally sound manner and can only be recycled with technology- and energy-intensive processes, incineration, or not at all. **>** Employ renewable, unprocessed materials and assemble them mechanically.

06 BUILDING SERVICES

HEATING: It is important that the heating system depends on renewable energy sources and works with a high efficiency. Climate friendly systems operate on geothermics, wood combustion, renewable district heating or environmental heat pumps. **>** Avoid fossil fuels at all costs.

HOT WATER: In a well-insulated building, warm water will account for approximately 30% of residential energy use. Using solar collectors, around 70% of the warm water demand can be covered, depending on location and use. Tool: sonnendach.ch (BFE). **>** Produce hot water with solar energy.

VENTILATION: In a well-insulated and airtight building, wrong ventilation will be responsible for bad air quality and/or up to 50% of the energy loss through the envelope. In combination with a heat exchanger, a controlled ventilation system can prevent up to over 90% of the thermal loss compared to manual ventilation. **>** Plan controlled ventilation with heat exchangers.

COOLING: Due to climate change, thick insulation and the heat emission of people and devices, cooling is becoming an increasingly important topic, foremost in office buildings. Via thermal mass of materials, automated night cooling and cooling via geothermal systems, indoor spaces can be conditioned ecologically. **>** Integrate natural, low-tech cooling solutions.

LIGHTING: Using LED lamps reduces the energy demand for artificial lighting significantly. Due to their high luminance efficiency, they save up to 85% of electricity compared to usual light bulbs. **>** Allow solely LED lighting.

ELECTRICITY: Using energy efficient devices with the EU Label A+ (or better) saves a lot of energy. PV systems, decentral power production with renewable sources and consumer networks are growing and viable options today. **>** Plan a self-sufficient project.

CLIMATE CHANGE AND ARCHITECTURE

Climate change is primarily caused by greenhouse gas emissions, predominantly from burning fossil fuels for human energy needs. The building sector has a huge impact on the climate, since it is accountable for about half of the world's energy consumption. Indirectly, it also influences around 25% of the global energy use for transport, due to the positioning of buildings and the organization of neighborhoods or cities. It is therefore important that architects realize their responsibility and rediscover climate as a relevant design factor, as it has been in vernacular architecture. Climate must be an integral and elemental part of the design process, instead of being handed over to the building physicist or the technician at the end of the design process.

This booklet is not a recipe for your design but describes the relevant aspects to reduce the greenhouse gas emissions of buildings, as well as their overall energy demand. Even though the guideline is phrased in general terms and can be consulted for many situations, it mainly refers to the central European climate. However, building more climate-friendly and using more efficient technologies is not enough to tackle climate change. Just as important is a change of our lifestyles towards sufficiency, a constant questioning whether something is really necessary or not.

++G+P

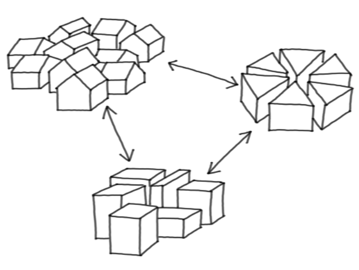
INGENIEURE

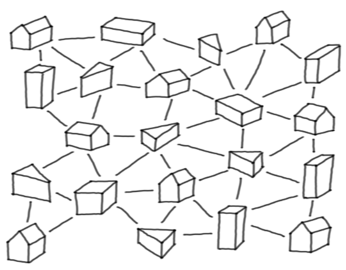
CLIMATE CHANGES DESIGN

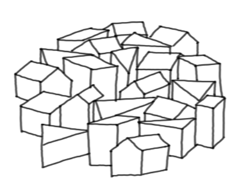
++G+P INGENIEURE

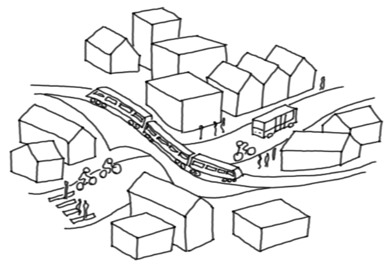
A GUIDELINE TO INTEGRATE CLIMATE INTO THE DESIGN PROCESS

01 LOCATION / MOBILITY

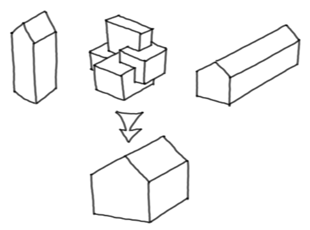

Functional separation comes along with long traffic routes...

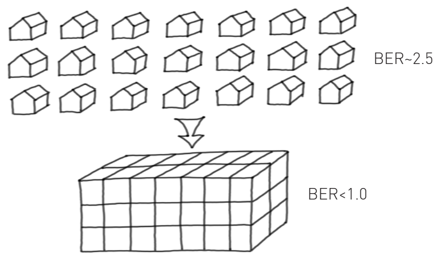

...so try to mix uses to create a delicate mesh of connections...


...and densify the built structure in order to shorten distances...

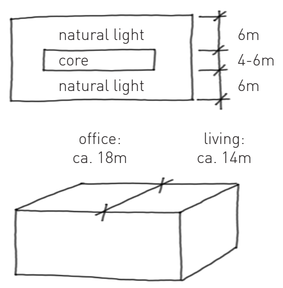

...so that the car becomes redundant.

02 VOLUME / ORIENTATION

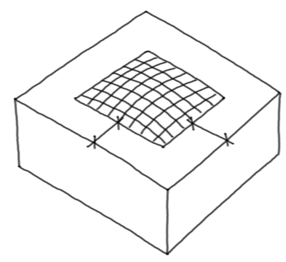

Build compact to reach a small building envelope ratio (BER)...



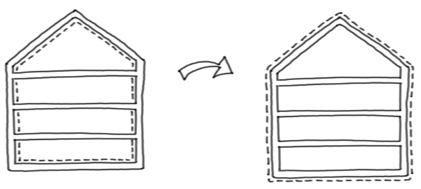
...and lower it even more by building rather big...

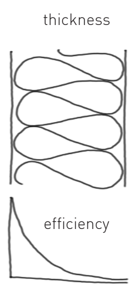


...however, the depth of a building is limited by the natural lighting...

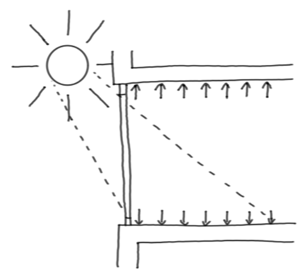

...a patio makes sense for big buildings or if it is covered by a roof.

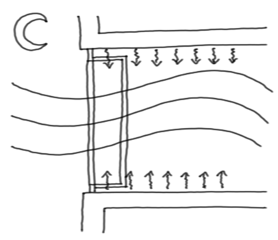
03 THERMAL ENVELOPE


Insulate the building on the exterior to avoid thermal bridges...

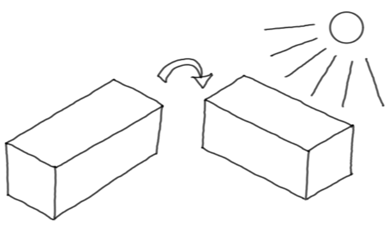


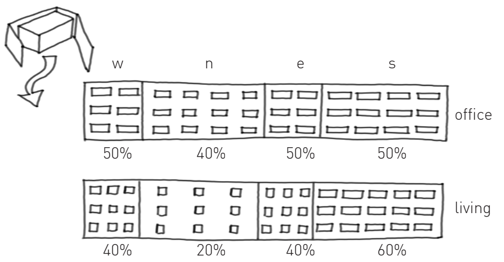
...do not only plan a thick layer of insulation...


...but also think about thermal storage and...

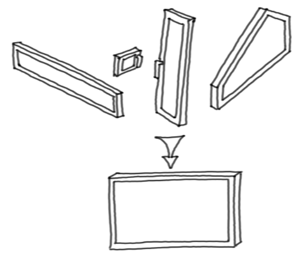

...night cooling ventilation to avoid summerly overheating.

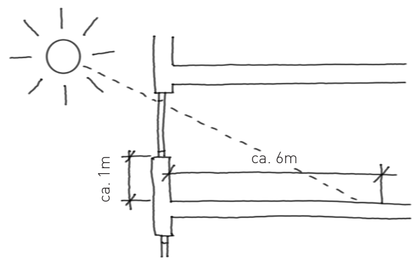
04 WINDOWS / SHADING


If the urban setting allows it, orientate the main facade to the sun...



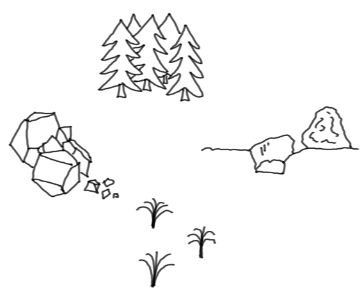
...and try to reach an ideal window to wall ratio (WWR) for your climate...

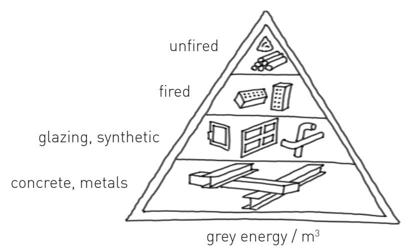

...use rather big and compact window shapes...



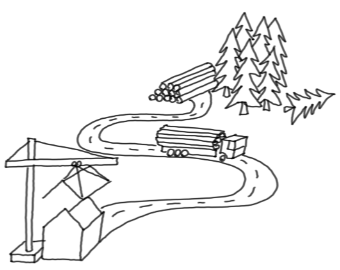
...but avoid unnecessary glazing underneath the usual breastwork height.

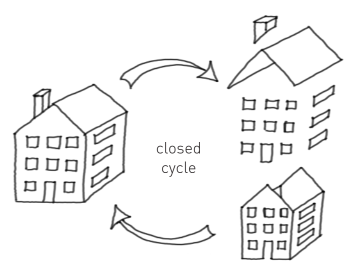
05 GREY ENERGY


Use natural building materials...



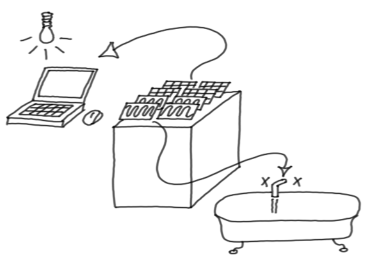
...that are only minimally processed...

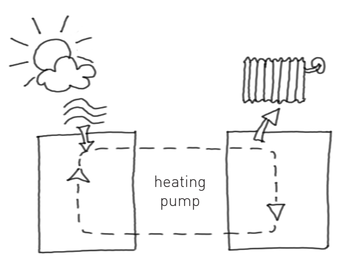

...sourced locally...



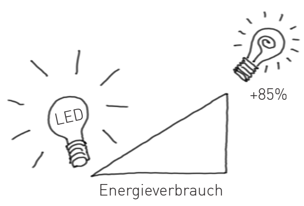
...and in a way, that they can easily be repaired, reused or recycled.

06 BUILDING SERVICES

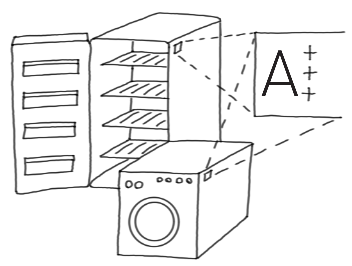

Make use of renewable energy sources for warm water...



...the electric devices, the heating- and cooling-system...

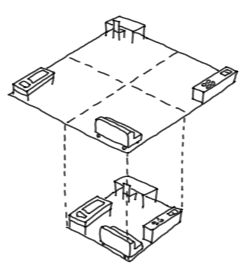


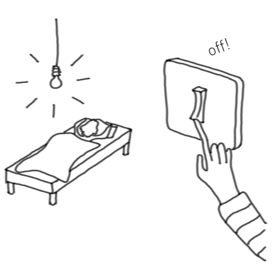
...use efficient LED-light bulbs...



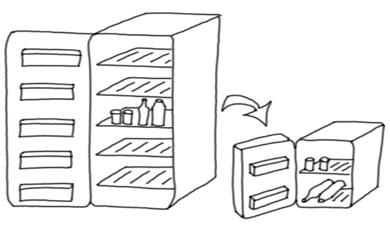
...and household devices.

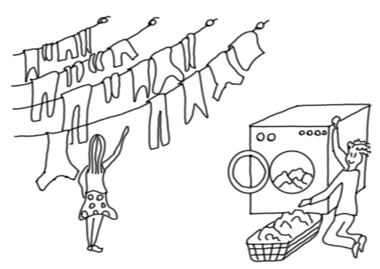
07 SUFFICIENCY


First of all, consume less space...



...use artificial lighting and other technology consciously...


...think about what is really necessary...


...and try to share things instead of owning them.