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The cybernetic principle – the other method of energy efficiency

The change in climate will become ever more perceptible and all the more visibly noticeable: High tides and flooding of never-before-seen proportions, surface erosion and its consequences in the form of huge landslides.

Apart from that, costs for supplying energy are multiplying. By the year 2050, usage of primary energy sources will have nearly doubled according to current prognoses. That will have repercussions on every aspect of daily life: on food and everything else we need for survival. In the industrialized nations of Europe, a new consciousness about the effects of climate change has developed. Unfortunately, the advances made in this sector are in no way coordinated or aligned globally.

In Switzerland, the search is on for a method of energy use that is completely CO2 neutral; meanwhile in Germany, provisions for energy reduction are the response to the topic of energy efficiency. An energy-saving law has been enacted that calls for insulating and sealing our buildings in order to ameliorate our current situation.

The identities of various cultures have evolved out of their respective social and cultural contexts. The act of living has always been an immediate and direct display of this fact, because it is a direct intersection of differing forms of religious behavior, the habits displayed by the opposite sexes living together as well as those of young and old. Beyond that, the personal aura of a resident can be read from their housing; and so can the physical situation of a *place*, its climate, flora and fauna – though this requires some reading between the lines.

One who looks into these factors with an exacting eye will realize that the context from which certain architecture originates has always been the identity of people who lived there. Building types and kinds of dwellings have shaped the history of architecture in a very special way.

There were differing types of farmhouses in Germany: The Schwarzwaldhaus (Black Forest House) combined barn with house in the southern Alemannic speaking areas. The weather resistant Haubarg house is found in northern, coastal areas where Low German was spoken. The country courtyard houses known as the Hofreite variations were also among these, along with the Hallenhaus of Görlitz, and many more.

In southern Europe some types of courtyard houses are: The Andalusian house, the courtyard houses of Abruzzo, the Tschardak houses of Macedonia or those of the Safranbolu in Turkey.

In the arid climate zones of the Muslim world, courtyard houses were built with wind towers and reflecting pools to allow for adiabate cooling which is stored up in their limestone structures.

The humid, easterly climate shaped the types of houses build in Japan with the Engava, the Ondol houses of Korea and the courtyard house types of China – the could go on without end.

Evaluation of Architecture

Over centuries, architecture has developed from one generation to the next. Each one learned from the last and passed their knowledge on. For each new catastrophe, such as wildfire, flood, hurricane or period of intense heat, building techniques were changed and improved. A simple example is the astounding wind resistance exhibited by Black Forest House roofs. According to measurements taken in modern wind tunnels, these roof formations and constructions can stand wind speeds of up to category 12, i.e., hurricane-force winds. It is an interesting question to ask: How did the original builders in the 16th Century manage to come up with such good results? The answer can be found in an untold history, in which the roofs of the Black Forest Houses were damaged time and time again. The ones that withstood the winter storms, however, could teach the builders something about the orientation and location, the kind of construction and roofing materials. The builders learned to improve then spread their knowledge and applied it to other rural architecture. Coping with climate was in the same way – hard, cold, long winter months plus sometimes too hot sunny, summer days as well as serious and abundant failures taught them many things – the process was the same. Thus, a system for heating was developed with the "smoke kitchen" and its adjacent rooms and spaces for ulterior uses like "smoking chambers". At the same time, a the building became arranged in layers with zoning for heat transfer in the winter and ventilation in the summer

Every step of development was built on the experiences based on previous steps. Yet moving away from the architectural principal of continual evaluation, we have applied technology at every step of the cycle of change since the Industrial Revolution. The focus has been on forward moving technical developments such as the urban infrastructure for supply of needs and removal of waste: new sanitary systems, central heating and the lately the development of artificial cooling systems. All these have made the architectural elements take a step back or even be forgotten.
The basis for a technique can be traced back to a previously existing practical application, which lead to that technique. These practical applications in turn became part of a larger societal developmental process. The same technique would then become the starting point for practical applications to follow and would define a new or different area in which the practical applications could come to fruition.

The debate, which takes place under the catchword "sustainability", is above all a technological debate. This debate is almost entirely devoted to energy efficiency. As such, sustainability has not been able to develop into a kind of architectural program as of yet. It is not an immanent part of architecture. With the increasing techologization of architecture, we have lost the ability to solve the problem of comfort by architectural means. If we let building equipment have priority in all areas of construction, the future of building equipment engineering will have more or less dispatched with all of our architectural experiments. We begin to build with oversized windows or very small or no windows at all. At some point we will realize that this uses a lot of energy. With ever sparser resources, material prices have spiraled upwards and will continue to do so in the coming years.

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Methods of construction have been hindered by economic constraints for all climate zones of the globe. Thin walls with thick insulation have spread throughout Europe. Cement walls are inexpensive to produce and simple to construct. The same goes for many building materials, which carry no souvenirs as to the climatic conditions that gave rise to them.

For instance, cement has no place in arid climatic zones because it has no sorption capacity, which is a necessary prerequisite for storing the humidity appropriate for living space. The unhealthy conditions within the rooms, resulting from inadequate building materials, lead to the addition of machines to counteract those conditions; this consumes even more primary energy.

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We have to search for systems that transform older, climate-specific constructions and adapt their structural principles to meet today's needs. The transformation will have to change the shape, form or structure without changing the value of the building's substance.

In my field of study, Design and Residential Architecture at the Darmstadt Technical University, as well as in my architecture firm in Freiburg, we have made it our task to analyze and make further developments in Transformation areas of autochthon typology and its situation in the urban context. The resulting learning process can indicate paths to contemporary solutions, using various Transformation designs that can also act as models for other areas. As such, it is less about single buildings than about the culture of a whole city.

A city's architecture has always been an expression of its inhabitants' identity. It has also always been embedded in the unseen world of the location's physical properties, inspired by the landscape and climate. Its rather subcutaneously perceivable existence is divided up, and more or less hidden in the proportions of the buildings themselves and open spaces between them, i.e. the surface areas created by streets and plazas, the colors and structures of the materials.

For many cities, a sort of architectural acronym represents their particular architectural reality, and thus display a special connection. Every village, every town and every urban space in the European cultural area has autochthon style elements that – however insignificant they might seem – must be retained when dealing with Transformation. Among these elements are wall-sill additions of various materials, stone window frames and boxes, profiles, decorative sills, combinations of stone embellishments out of plaster or other building materials. Window types and profiles belong in this category; as do roofing materials, eave and bargeboard extensions, and projections such as porches and entranceways. These are some examples of the style elements that characterize the identity of a village, town or city.

For a long period in Germany, laws have been intensifying and government sponsored public campaigns have been expounding the idea that the problem of climate change could somehow be tackled by properly insulating our buildings. *But, shell of Styrofoam is not an aesthetic or practical answer.* It seems as if no one wants to acknowledge the existence of solar and geothermal potential. *Sure, there are solar panels:* As if mounting photovoltaic and thermal solar panels on the roofs of churches and other old buildings is the final extent to which we can integrate contemporary energy technologies. *As if these aesthetic-technical decorations were somehow acceptable in terms of restoration, whereby they completely change the character* *of a building, defeating the purpose of conservation.*

Furthermore under the guise of integration, it is often suggested that technical systems could not only be built into architecture, but that they could be come a part of the architectural tectonic.

So, does climate protection stop at the protection of historic buildings or should historical preservation trump the climate?

We cannot get around the energy problems associated with older building materials without dealing with differentiated instruments. This calls for a fundamentally different working method. Typological character and particularities would have to be considered as part of the energy potential immanent to any building type. Only then could an intervention be conceptualized, planed, simulated and tested. All this can only take place in a trans-disciplinary working process in which preservationists, architects and a staff of specialized engineers coordinate with a common aim in sight. The target is a model exactly opposite of the "insulate it and seal it up" method.

In fact, there are many more planning modules that can guide us than one would initially imagine.

The five elements of energy efficient building are: collection, distribution, storage, protection and discharge. These can be projected onto any existing building.

Among these are:

- 1. the building's zoning according parameters that take solar and geothermal energy gains into account. Basically, these are the tried and trusted rules, which dictate the orientation of living spaces to the building's sunny side. Whereas working spaces, openings, storage, and if necessary sleeping spaces should be oriented away from the sun. Often on larger plots, there are areas reserved for energy gain and are separated into energy gardens. Balconies and alcoves could also be transformed in this capacity if they are facing the right direction.

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- 2. Elements built for energy gain are among these, such as energy gardens and air collectors in a roof or wall: Energy gardens can be added onto a structure as a new element. It is sometimes beneficial to collect the varying heat signature values from the facade. Some assume that an attic is not being used to its full extent, so they build air collectors into the roof. But under some circumstances glass roofing tiles might be sufficient.

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- Box-type windows can be counted among air collectors because, if they are built and applied correctly, they direct pre-warmed air into a room's interior and provide for cooling at night.

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- 3. Dispensation elements for distributing the collected energy though the house are to be counted, such as circulation systems built into floors and walls in the form of simple secondary layers.

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- 4. Storage of gained energy is also an important component. Older buildings have very thick walls and thus plenty of storage capacity. In the cellars of such buildings, we often see a multiplicative factor, especially in vaulted cellars. These masses of stone should be appreciated for their energy potential and be calculated into the equation when making thermodynamic simulations.

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- 5. Cooling elements have a natural thermal conducting character and can usually be found in any existing building. Stairwells that are connected to cellars are typically positioned inside walls that are facing away from the sun. This creates a "thermal chimney" and serves to cool the building. Directing thermal transfer can often be done by making small improvements to the connections between rooms and by installing expanding/contracting openings, chutes or other thermal conduits.

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- 6. The use of process energy: in linking the aforementioned elements, the energy produced by the people and machines and their effect on the entire circulation of energy within the system must be taken into account and thus will have a calculable influence on the energy balance.

With that, we have covered all of the basic passive elements. These could be or would need to be technologically supported according to the type of building. Motorized systems could be used for thermal support such as the usual heat exchange systems used today. In larger cellars, water tanks could be installed to act as storage devices. Whether or not they are sufficient to cover all the heating and warm water needs of any particular building will be dependent upon the building itself, the available investment volume, and how intensively the project is planned. Skeptics from the "insulate it and seal it" camp can be countered simply by pointing out that there is an abundance of solar energy that must be used in every possible way. Thus we need to pay attention not only to the collection of solar energy – and the undeniable fact that there is energy to be won even on cold but sunny January days – but we also need to think about storing this energy.

The most important aspect, however, is the perfect connection between all the passive elements – solar and geothermal collection, distribution, storage, protection and discharge – and with the necessary technological possibilities. All these partial elements have to be fine-tuned to each other in a careful interdependent process. Each one of these elements can stand alone, but none is independently effective. This principle, which we call "cybernetic", refers to a system of interdependence in which the elements are directly and reciprocally connected. Thus not only is system efficiency important, the connections between parts in the system are fundamental. In this type of interconnection, the system is able to react to conditions in the surrounding environment, such as daily and annual cycles.

With the help of a few examples, I can illustrate these principles for you:

Built for a Patchwork family, this small duplex in the southern Black Forest needs absolutely no artificial insulation. Air collectors on the southwest and northeast sides of the roof and the walls below provide for a very good energy balance. Solid wooden walls that are 15cm thick lend their storage capacity. Between the air collectors and the inside energy garden, solar heat is collected and dispersed throughout the house via simple, natural thermal distribution. In the summer, six skylights (roof windows) provide for ventilation and circumvent any overheating.
The Institute of Environmental Health Services of the Freiburg University is heated via a large air collector, which faces south, and building component activation coupled to a geothermic ground collector. In the summer the building is also kept cool by this method, without ventilators and without air conditioning!

As opposed to building completely new structures, the work involved in transforming existing structures is more difficult and more

complex. This is because an exacting analysis of the building must take place. The climatic conditions of the site as well as the materials and wall thickness, foundation configuration, orientation and window sizes – just to name a few – must all be taken into account. We would need to have an "energy fingerprint", which could look much like a DNA Analysis. This fingerprint would serve as a foundation for the "design" intervention before any building would take place. Thus we have a working method, which calls for a certain amount of experience in system and circulation on the one hand, but a great deal of inventiveness and design capabilities on the other. In addition to all this, a thermal simulation and consultation in building material technology must take place at the earliest possible stages of conception. Only with this trans-disciplinary working method, will it be possible to combine design strategies for older buildings with alternative exploration.
I also can also show you a few examples of this:
The old city hall in Lörrach, German was remodeled in 1995. On the south-facing façade, an air collector was placed to provide heating. Further insulation was no longer necessary. The old windows were kept as well as the entire north-facing façade.

Work done on the Catholic church in Kaltental, Stuttgart moved the air collector into the inner space so as to combine energy from the sun as well as any other elements that produce heat in a circulatory system, which keeps the church at a constant 8º C. A further 4-6º can be achieved by weather conditions or by using fossil fuel heating.

We had a similar experience with the church in Heilbronn, where a new inner shell now provides additional insulation of the roof. The air heated by the southern-facing window is redirected back into the church with a ventilation device. In the summer, the shell is ventilated from behind and the warmth directed outside.

This strategy touches the boundaries of historical preservation and finds itself in the middle of a debate over protective conservation or the retrospective viewpoint that forbids any sort of alteration. The prospective viewpoint, which I understand to be a cautious modification of certain parts, often falls into misunderstanding and creates conflict. What is basically important here is that all of the elements that arise from the Transformation of the structural principles are not drawn from the technical or technocratic parameters. Much more important are the elements from the architectural tectonic and design theory. These principles can be complimented with simple physical measures, mostly from the field of thermal building.

For the Spitalkirche in Mannheim, small roof projections with glass hoods are enough to transfer solar energy gain into the church. It is a gain that pays off: the energy bill has sunk from 8000 euros to 500.

A small pastor cottage with brickwork facing from the 30s was given an energetic makeover without the need for (external) insulation. The energy balance was improved by 85% with an air collector in the roof, a narrow energy garden facing south and a new box type window constructed in conjunction with a swimming pool sun collector placed in the roof.

Improvements in using energy will always require architectural intervention. If, for example, the addition of an energy garden proves necessary, any consequential insertions or extensions have to respect the existing structure. However, it must also be clear that the contemporary interventions have to be solved by architectural means. Time has always been a subject when speaking about preservation because an existing building is continually altered over the decades of its existence.

This is a general rule for all buildings, regardless of their usage. This is especially important, however, in the reconstruction of old and historical buildings. Here we see one of the most important tasks for architecture in the future: the reconstruction of cities that have been destroyed by earthquakes. Using the aforementioned strategies, site-appropriate buildings can be successfully rebuilt for every climatic zone on Earth. These reconstructed buildings will be of a type bound to the climate of the region in the way that they are constructed, as mentioned earlier, configured with passive methods to maximize energy efficiency. However, it would be necessary to integrate ductility specific to the requirements of each earthquake zone in reconstruction.

It is obvious that the Italian city of L'Aquila has been rebuilt twice already over the centuries. In 1976, an earthquake destroyed the cities Gemona and Venzone in Friuli-Venezia Giulia. The buildings were rebuilt without a thought for whether or not the earthquake-resistant reconstruction was in harmony with the typology of their energy efficiency.

For the 12th Architectural Biennale in Venice, we showed that with reconstruction according to methods appropriate for the energetic and typological signature of the region, the city of L'Aquila could be rebuilt with energy efficient buildings that need no artificial cooling. The requirement being that we align the building type and material in a cybernetic way.

If energy simulations accompany the measures for reconstruction, the calculation of stone mass for energy storage can be harmonized with the ductility of the construction. Thus the thermal capabilities of the interior courtyards and conduits can be considered and will then create the opportunity to bring something together which seems

almost paradoxical.
With new realizations and possibilities of technical rationally, we can advance a transformation of architecture. On the one hand it will be retrospective because the (traditional) architecture is maintained. On the other, it is extremely prospective because it ushers in a self-renewal by architectural means that takes climate change into account.