Designed Grids:
Integrating energy needs with the urban fabric

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In 2009, the German Federal Ministry for Building and Urban Development launched a competition to receive designs for a combined research and pilot project integrating energy concepts for residential buildings with e-mobility.

The research results gained through the competition were applied and expanded by the authors on concrete sites in Chemnitz, Saxony. The city proposed an empty site at the river Chemnitz in need for urban repair like so many blocks in this city that suffered from population loss and a subsequent real estate crisis after reunification. Chemnitz is the city with the most annual hours of sunshine in Germany. The goal of the prototypical homes designed and to be built and marketed by the authors is to test self-subsistent energy concepts on real sites, not under clinical laboratory conditions. Technology is understood as an adaptive system and flexibility in the energy management is key. Coordinating and tuning both energy grid and urban grid call for holistic solutions securing the long-term vitality of cities.

Keywords: Renewable energy, Urban design, architecture

CITY | ENERGY | AFFORDABILITY

Current concerns to find ways by which to limit climate change have brought every anthropogenic activity into the analytical purview of scientists and commentators.

This research project intends to structure and expand on these analyses such that future uses and designs of objects in the environment are understood in terms of their relative and absolute impact on the use of resources and the production of emissions.

Cities face overarching challenges in terms of maintaining their urban fabric, securing a long-term vitality and attractiveness as well as adapting their infrastructure and grids to the cultural shift in terms of energy consumption and reduction of emissions. The architectural and cultural problems related to the renewal and rehabilitation of building stock of the 20th century and previous decades to new energy standards is already well known amongst planners.

Ambitious concepts for new liveable mixed-use quarters with intelligent energy concepts are in realisation on prominent sites, yet under IBA-conditions or subsidized in other ways. The size of the projects usually allows for self-sustained energy concepts sponsored by substantial investments.

Building cooperatives and smaller scale self-organized multifamily apartment buildings keep the profession informed about state of the art avant-garde projects, yet serve mainly as role models and are not easily replicable or affordable.

The ordinary production of mid-priced apartment buildings and homes is little if not at all affected by such innovation, and individual house owners remain largely unimpressed and, above all, powerless. The production modes of the housing industry are largely inflexible to respond to those urban challenges, due to mass production and standardized norms. In this respect the housing industry operates similarly to the car industry based on serial standards, price categories and large numbers of repetition. The context-less object nature of those buildings is incapable and too rigid to provide individual and tailored solutions since this would require systematic research and communication with communal partners. A larger palette of individual extras would ruin the profit. The energy providers on the other hand in most larger cities are either defending economic monopolies or have become incapable to manage innovation due to obsolete technology and stiff political and economic bondages. Decentralized and local grids are still the exception. The urgent social and economic concern today is how to improve and integrate unexceptional ordinary urban development and renewal strategies with local energy grids and how to empower the individual to use and participate intelligently in those grids.

ENERGY PLUS HOUSE, COMPETITION 2009

In 2009, the German Federal Ministry for Building and Urban Development launched a competition to gain proposals for an Energy Plus House. Equipped with PV panels the house should produce more energy than consumable by a 4-person household. The surplus of energy should be either fed into the communal energy grid or used for the recharging of electric vehicles in use by the household or others: the house as a filling station.

In terms of construction the case study house should be fully recyclable, demountable and able to fit to various contexts. The specific site of the competition was chosen in the shadow of a high-rise office building in a central district of Berlin.

The design of the authors offered a prototype that gave priority to comfort, liveability and its adaptability to varying urban contexts. The house-constructed in timber-was based on a square plan composed by 18 m^2 modules allowing for flexible and neutral rooms.

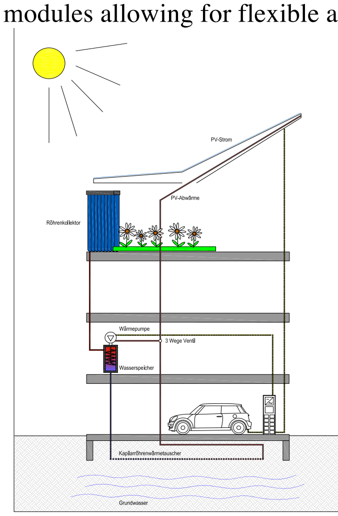

Figure 1: Diagram of energy concept, Competition entry 2009 author Kaiser Developments

The energy concept was calculated for an annual surplus of renewable and emission free energy created on the spot and should be an integral part of the design of the house. Since most of the energy was to be produced by a PV plant on the rooftop, the orientation and slope of the PV roof became a key element for the adaptability of the design to multiple contexts (Fig. 1).

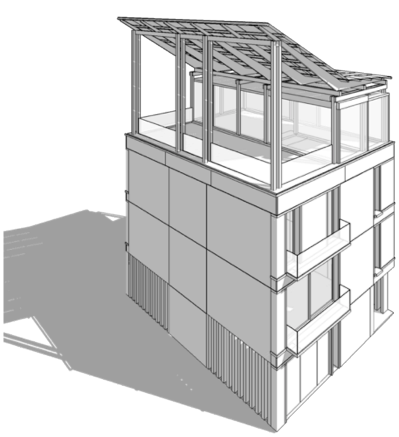

Figure 2: Competition entry Energy Plus House 2009, authors Hoidn Wang Partner, Norbert Kaiser

Optimal orientation of a floor plan and optimal south orientation for the PV roof plant can but do not necessarily match the urban grid and fabric in the traditional way. Thus the floor plan was developed as a neutral "Palladian cross" to adapt to any given site and its rules (being it a detached or serial house) while the roof may want to orientate itself independently towards the sun (Fig. 2).

Depending on the shading the PV roof is either the constructive flat or sloped roof of the insulated volume itself or a separate installation, thus adding an additional floor to the building that serves as a covered roof terrace, a not insulated winter garden, a place for urban farming or simply as reserve space. The roof becomes the visible and multiple use energy source of the house. It turns towards the sun or reaches out for her. It is more than just a fifth façade. The roof space is compensation for a dense context and introduces positive aspects of a suburban lifestyle to a denser and more formal urban context such as integrated outdoor spaces and individual expression (Fig.3)

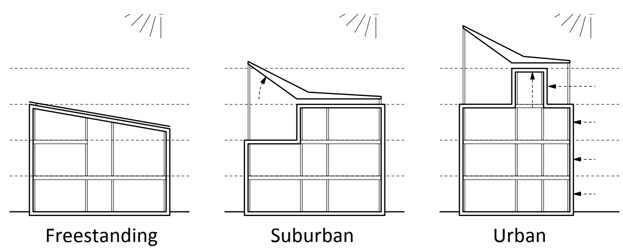

Figure 3: Diagram of ypical urban configurations of prototype, Competition entry Energy Plus House 2009, authors Hoidn Wang Partner, Norbert Kaiser

Renewable energy and renewable materials shape the design and construction of the house with visible natural surfaces and crafted details for a primary timber structure. Innovative energy concepts do not require special constructions or innovative materials. Conventional, inexpensive materials and unspectacular construction techniques are key for a broad acceptance of the cultural shift in energy technology towards renewable energy. This cultural shift will undeniably require a change of habits and will eventually have a similar irreversible impact on everyday life as experienced with the usage of Internet and communication devices.

The living areas in the house should feel as comfortable and practical as in a conventional house.

Yet, the materials should be expressive about the energy needed to produce, travel and assemble them. The energy spent for the construction itself matters.

Figure 4: Simulation of building in context of competition Energy Plus House Berlin 2009, authors Hoidn Wang Partner, Norbert Kaiser

ADAPTIVE BUILDING

A house is a long-term investment. To increase its value over time is still a main motivation for the individual house owner to start a construction.

Buildings (with the exception of purely functional buildings) are not objects of consumerism. Unlike a car a house is not measured in terms of its residual value. Instead, the main interest is to increase the value of a house, to eventually build a solid fortune over time. Besides the fact that the site is an important factor, we have to raise the question how the building itself and its equipment are to be priced in this equation.

Above all a house has to appeal; it has to be attractive, attractive for the user and for the neighbourhood. This attractiveness needs to be sustained over time in order to ensure its physical vitality and durability. Vitality in this context means the property of a structure to survive by being adaptive. The social challenge for a house is to continuously respond well and flexible to its environment (the built and the natural).

The reason to build a house is to inhabit it, to live and work in it. If one wants to save the environment one should better not build.

The typical bookkeepers of the environment usually set biased priorities by focusing on the consumption of energy only, especially for heating. Yet, the embodied energy in a construction is irreversible and it is spent today. As such the energy spent in the construction process itself represents a massive factor in the race against the climate collapse.

Technical innovations today can be expensive and might easily be the gimcrack of tomorrow. Clients know this and utter sceptically. The planner should offer what is tested, and common, what is affordable and manageable. That builds confidence and safety. That also means manageable risks for the bank. Innovation should happen eventually, once it is tested and approved. Cultural innovation occurs when it leads to a general change of habits.

Therefor it is crucial to design a building capable of later adaptation, one that allows for easy changes as soon as technology is ready. A building at the point of its completion is just a snapshot realized within a certain limited budget. It is rather a beginning than an end. The challenge is to organize this temporary state(s) in such a way that the house is already attractive in its first stage, with the diagrammatic rawness of a loft, a simplified frame and adaptive infrastructure.

The design scheme is paired with systemized technology, partially integrated into the primary construction and media and partially applicable individually and at a later stage.

DESIGNED GRIDS: CASE STUDY HOUSES IN CHEMNITZ

Chemnitz became known after reunification for two seemingly contradictory real estate phenomena:

1. On the one hand the city initiated one of the largest urban redevelopment projects for a downtown area in the *Neue Länder*, in fact in size comparable to the project *Potsdamer Platz* in Berlin. The master plan for the reconstruction of the area of the historic downtown was selected in an international competition. As a ramification 66.000 m^2 retail area was realized by renowned architects. The last building was inaugurated in 2010.
2. The ordinary housing market in Chemnitz simultaneously slid into a crisis due to a rapid loss of population after reunification with a dramatic abasement of entire quarters. The uneven refurbishment strategies for the large prefabricated settlements at the periphery and the costly and complex reconstruction of individual apartment buildings from the 19^{th} century in central quarters conglomerated to problems of urban scale and caused harsh public critique.

The once industrial heart of a thriving region in the 20^{th} century, proudly called Manchester of the East, found itself being labelled a shrinking city with all symptoms known from cities in crisis like Detroit e.g.

German Federal Housing programmes such as “Stadtumbau Ost” in fact favoured an uneven rehabilitation process by giving advantages to large housing companies owning the prefabricated housing stock at the periphery. These companies had little interest to tear down entire buildings since it would have forced them to redeem the accumulated debts loading the buildings. It was more opportune to keep them in the market. Attractive extras were offered to draw tenants into the large compounds.

The 19th century districts with individual buildings forming traditional blocks lost eventually their urban cohesion and started perforating. Buildings and entire blocks deteriorated, were emptied, torn down or left behind. Only “the gems and jewels” were renovated and were able to be marketed successfully. A tough competition of too many apartments for too few tenants rapidly ruined expectable revenues and led to bankruptcy, and as a result complicated property rights. The engagement of individual actors and small investors naturally came almost to a halt. In the central districts there is hardly a street or block left that is not characterized by voids or ghost houses and is not in need for infill projects.

Yet, due to unresolved restitution claims, lack of means of the owners or bankruptcy of fond managers and subsequent assignment of claims to creditors, it was and is also very difficult for the city to implement a coordinated urban strategy to stabilize the urban fabric as a whole and to modernize the infrastructure and communal building stock. Now, mini-master plans are required block by block to resolve ownership issues and to renew neighbourhoods and the urban fabric.

At the same time paradoxically there is a need to offer affordable homes and live/work spaces in central areas for a younger generation that begins to study at the University of Chemnitz. This new and mobile population prefers an urban life style and is willing to choose Chemnitz as the jumping board for their mid term maybe long term existence if investors would offer tailored and attractive environments addressing the social and political paradigms of this emerging society. Squatters were unfortunately not taken very seriously as a newly articulating voice. The big players in the housing sector in the city do not see a necessity to change strategy.

The city of Chemnitz is a challenging and needy context when it comes to questions how to renew the urban grid: a prefect urban laboratory.

HOUSE | URBAN GRID | SOLAR SPRAWL

The city planning department of Chemnitz proposed for such a case study project a site along the river Chemnitz in a central location. The site is part of an ensemble under preservation and needs repair of the street silhouette along the river. Its location is 10 minutes away from the central train station and 5 minutes away from a leisure park. The university is also nearby.

The lot is an end condition of a street with aligning buildings. The site is oriented east west with an exposed tip to the south. The site is suffering from regular flooding of the river that results in legal limitations how to build on the ground floor (Image 5)

Reconsidering the flaws of the 2009 prototype, the case study houses for Chemnitz were modified and the main parameters were clarified:

a. The Energy Plus standard for the buildings is no end in itself.
b. The energy sources have to be adaptive to the site ´s orientation
c. The urban and architectural adaptability to its context is key
d. Vitality and attractiveness for the neighbourhood is key
e. Affordability of construction and energy concept

The site chosen is not the perfect site to optimize the technology for an Energy Plus house like under virtual and ideal conditions, which always call for “no shading”.

Yet, those ideal conditions do not exist in cities. To demand them as an initial situation would lead to a solar sprawl in the long run. It is more realistic to only build on the highest energy standards achievable on a respective site, which requires a careful analysis and simulation of the parameters of the site at the very beginning (legal, natural, economic conditions).

All criteria in the design decision process have to be factored in equally.

In this case it was decided not to optimize the possible annual PV output. Instead of a 32º roof slope towards south, a traditional 45 º slope east west slope of the PV roof was preferable combined with a 90º southern façade with PV panels because it was the better fit for the neighbourhood. But at the same time it also increases the solar earnings for immediate individual consumption.

In wintertime the earnings on the vertical PV panels are larger, even more so if there is snow, due to the enlarged reflection area. In spring, summer and fall there are reduced earnings, but also less interesting economic surpluses, since electricity is available earlier in the morning and later in the evening which is beneficial for the typical consumption profile in the season anyway. Thus this profile supports the decentralized immediate consumption and helps to reduce peak loads in the communal grid.

This can be underlined by a simple economic comparison:

Currently electricity created by PV costs 14€ C/KWh. The reimbursement for power fed into the communal grid is compensated with the same amount, yet buying electricity from the grid is calculated with 23€ C/KWh.

So, it cannot be the primary goal to produce as much electricity as possible but to replace as much communal electricity as possible by immediately consumable energy on site = Using better electricity in a better way!

Investments in rechargeable batteries are similarly economically questionable in an urban context where dense energy grids are possible and sufficient consumers are in reach at once. Orientation can help to shift

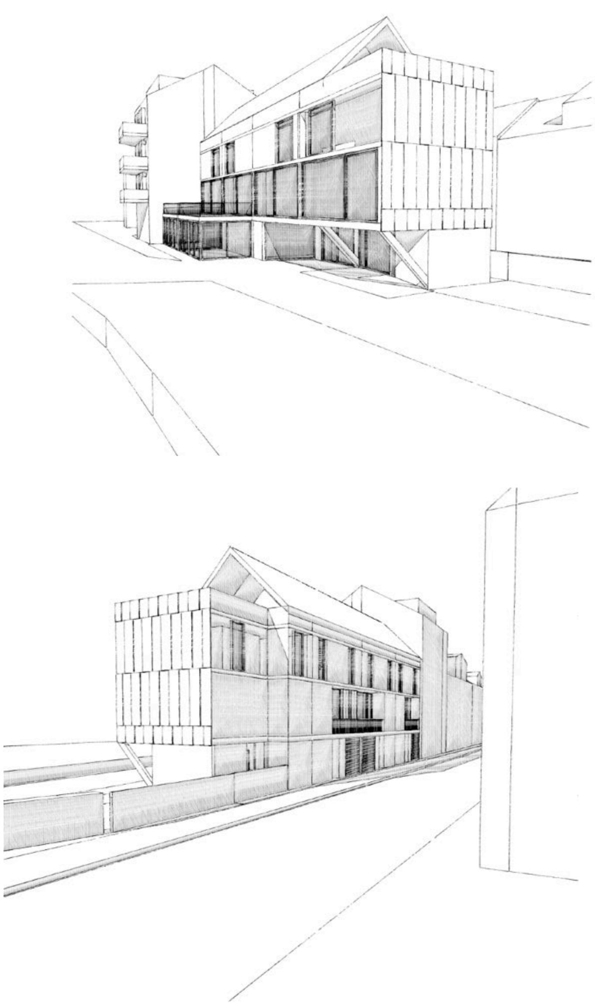

Figure 5: Case study Homes 1-4 in Hauboldstr. Schloßchemnitz, Autoren Hoidn Wang Partner, Kaiser Developments

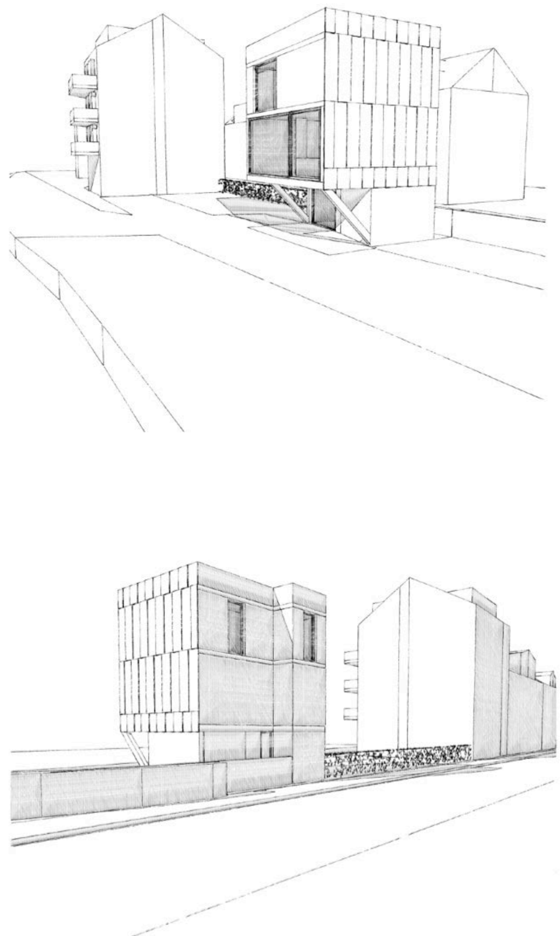

Figure 6: Case study Home 1 in Hauboldstr. Schloßchemnitz, Autoren Hoidn Wang Partner, Kaiser Developments

production towards demand. In addition thermal storage concepts in combination with heat pumps are more economically. DHW e.g. can be produced all year through by PV energy.

HOUSE | ENERGY GRID | COMFORT

a. Programme

In a field study only one house will be built first to test the interest in such a house on the local market and the acceptance of the design. The case study house is a typical town house with a little bit of addible reserve space. The prototypical qualities of the plan and section guide the design principles. The plan is flexible and least determined. Only the “wet rooms” organize each floor. The prototype shall work in a series as well as a solitaire.

The program for each floor is the same. On the ground floor there is space provided for the vehicles, storage, and multipurpose garden room directly related to the outdoors. This room can be used for working, for guests or as an additional family room with direct access to a small bathroom. The upper levels can be used for living, cooking, sleeping or also for office or studio functions.

The programme on each floor is exchangeable or can easily be remodelled without professional help. Each unit has access to a private outdoor space. One floor can be separated as a kitchenette apartment.

b. Construction

Structural timber frames on concrete walls on the ground floor, wood ceilings

c. Building physics

Comfort has priority: meaning most comfortable surface temperatures, no uncontrolled airflow, protection against moist, ability to adapt to climatic conditions and storage or protection against summer heating. Coming close to passive house standards is good enough.

d. Energy concept

Warm water will be provided by an air/water recuperator that can also be used for mechanical ventilation. The heat pump will function like a smart meter of PV energy available and tariffs. Fresh air is fed to the building only as tempered air (using the PV heat and the heat of the floor) in order to secure a winter air temperature of 5º C and in the summer time dry and cooled air. The warm water reservoir comprises 300 l and will use the water from the shower for heat recovery.

Space heating will be provided by the air/water recuperator in combination with a biomass stove that is also used for cooking. This concept makes the user autarchic and independent from technology and maintenance. If need be one can heat the entire house with a couple of billets of wood.

e. Affordability

The homes will be planned to meet KFW 40 standards in order to allow the owner to apply for a loan. The ambitious goal is to build at app. 800 € /m^2.

Planning approval process is underway.

The city of Chemnitz has started a network amongst owners and institutions to coordinate e-mobility initiatives that have been started by students and faculty of the electrical engineering faculty at the University in Chemnitz.

This concept regulates the system for the first house. In case the entire group of townhouses will be realized this concept is adapted to a geothermal/solar route serving all buildings by a central heat pump.

Image 5: Site in Hauboldstraße, Chemnitz, 2013 before

Image 6 : Site in Hauboldstraße, Chemnitz, 2013 before after