IEA Task 40 – Annex 52 STC

Chapter 3 – Design Challenges and Opportunities **Author: DI Tobias Weiß**

The role of the architect

To describe the changes in architecture when it comes to designing net zero energy buildings, one has to clearify the role and responsibilities of the architect - the design team first.
In the design process it is extremely important to define the project goals in a very early stage. Achieving "net zero" with today's technologies and occupant behavior is hard. First and foremost, to get there a holistic approach is necessary.
This task requires commitment, special expertise and collaboration in an integrated design process from all the members of the project team including the building owner, developer, architect, project consultants and even the future building occupants. In most cases contacts with energy supply companies, contractors have to be established before the actual planning process can be started. This integrated design phase involves a lot of people, might take longer and cost more, but will lead to a more sustainable and cost-effective project that can achieve the zero energy balance in the end.
Architects need to know about the energy demand of the future building in a very early stage, and have to compare it with the kilowatt hours that can be supplied on site by renewable technologies. Contractual arrangements and feed in tariffs depending on the degree of the overlap between solar energy supply and load profiles need to be made. The missmatch between energy supply and demand - the energy exchange between the building and the power grid will become very important in the future.
If the kilowatt-hours for the buildings energy demand are allocated into the areal requirement for large scale solar thermal and photovoltaic panels, the surface needed for solar technologies is huge. For example, to reach net-zero with an "all-electric approach: photovoltaic panels in combination with a heat pump" a minimum of 0,4-0,8 m2 photovoltaic area per m2 net foor area is needed. For dense urban sites with insufficient solar potential, architects will have to find creative ways of improving solar access. In some cases the planning team might even abandon the idea of achieving the NZEB goal. Every site and design task is unique and calls for it's own solution.
Once the aim to achieve a Net Zero Energy Building is settled, most of the decisions during the design process will be made in the context of their impact on energy demand.
A real comparison of different building design solutions can not be judged by the Zero Energy Balance alone. Designers also need to take into account the dependency between energy demand in relation to the internal environment quality. The quality of the internal thermal environment in a building and the quantity of energy consumption required to maintain this environment has to be considered. For Example, there are people living in huts, yurts, tents or even caves exposed to temperature extremes, without access to the electricity grid. These buildings might reach the zero energy building goal by definition, but would be considered uncomfortable in the developed countries. A NZEB-Design should therefore be certified by the zero energy balance on the level of primary energy, the architectural-urban quality and the internal environment quality measured over the whole life cycle of the building.
The responsibility for the design team will also expand into the post occupancy period. To truly reach net zero, the planners will need to pay close attention to electric meters as well

as the demand for thermal energy, according to the occupant behavior. This will take a minimum of one year of effort, after the construction is complete and the building is fully inhabited. On the behavior side, identical units in terms of size, orientation, and equipment show huge differences in electricity consumption from the predicted values. Consultants need to encourage building users need to lower plug loads and increase the efficiency standards of their electronic devices.

Shapes & Performances: A New Language?

New shapes, particularly when it comes to large scale solar building integration will arise if Near Zero Architecture becomes building standard in 2020. These ideas need to be considered in the early design process. NZEBs are traditionally characterized by two components: highly energy efficient building design and renewable energy generation.
Energy efficient building design strategies for different climate zones are well known and become building standard in most countries. Integrating large scale solar technology into building skins is the true architectural challenge.

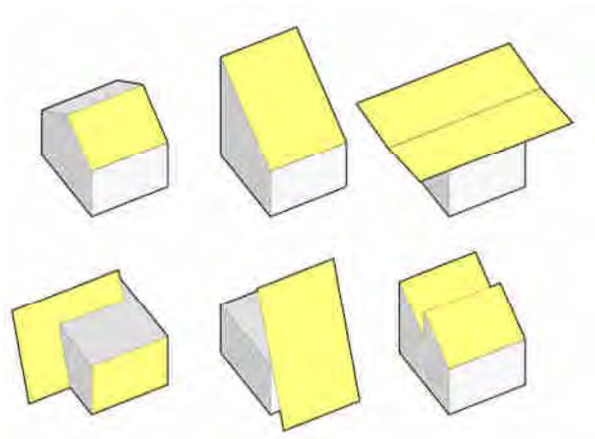

Figure 1: Architectural shape to maximize the roof area

Architects are exploring possibilities of maximizing roof shapes according to solar access for electricity- as well as heating and cooling supply. Facades that are orientated with a good solar exposure are used for solar energy supply as well. This fact becomes more important for non-residential buildings than for housing. Most of the modern residential buildings need their sun facing facades for maximizing daylight access as well as passive solar heat gain, balconies or these façade areas are shaded by plants in front of the building. There is hardly any space left for mounting PV panels or solar thermal collectors.
But we should also not forget that building shapes are governed by many constraints other than energy efficiency such as functional demands, quality of of live, social, cultural aspects as well as government regulations and most important: cost effectiveness.
By analyzing more than fifty zero energy buildings within the "IEA Task 40 – Annex52" it seems that for most cases little attention was given to aesthetic concerns in relation to the commitment of achieving net zero.
The shift from single minded building standards like the "passive house" to a"near zero energy building standard" could also bring greater architectural freedom. Although NZEBs use multiple well known passive solar building design concepts, they are able to balance intelligent energy flows, from energy supply to energy consumption and are not evaluated

by heating demand only. As a result, a greater variety of architectural diversity could be achieved on the scale of a building. Designers have more freedom to choose weather they want reduce their energy demand drastically and become super efficient (passive design strategies) or if they are willing to use more renewable energy (active energy generation) to reach the zero energy balance in the end.

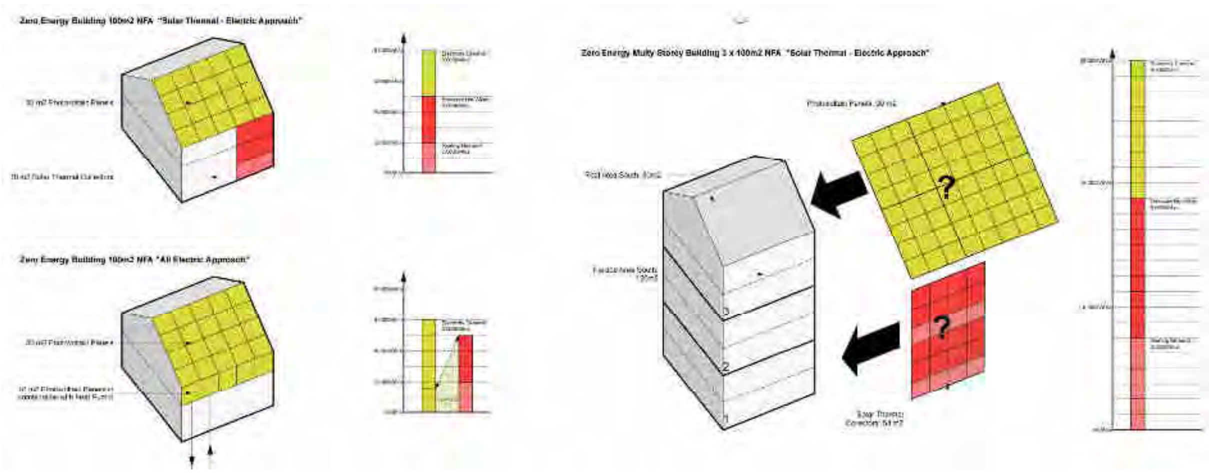

Figure 2: NZEBs: Areal requirement for active solar energy usage

Urbanity versus Sprawl – Limits of NZEBs

If we imagine a future new urban development in which all buildings need to be net-zero, one problem arises on urban scale: Most buildings generate their own energy with photovoltaics and solar thermal collectors. Keeping in mind that a building has only its roof area, and parts of the south facade available for solar energy conversion, then a one or two-story building is more able to achieve net-zero than a high-rise or multi storey building. Getting to net-zero is quite difficult for buildings that have more than two or three stories. Until some huge technological breakthrough in solar PV efficiency or change in how people behave and operate the building, it will be hard to build more than tree storeys in a central european climate. This conclusion is assuming that comfort issues, as well as indoor climate are at an optimum level.

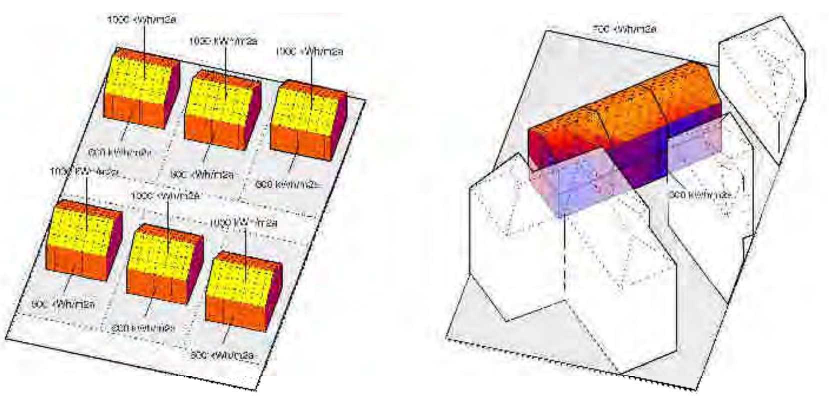

Figure 3: Single family home vs. dense urban bloc

This statement becomes more clear when you look at the yet known and already monitored examples of NZEBs. These are low-rise buildings situated on low-density sites. Since they are placed on suburban or rural sites they have a fair chance of being net-zero with onsite renewables. Areas that are also known as “urban sprawl.” The lower the urban density, the greater the environmental burdens it seems. When people are spread out, public transportation and infrastructural systems loose their effectiveness, private vehicle use rises, pollution increases, etc. Individual high-performing buildings are not the solution if this encourages solutions that lead to urban sprawl where the neighborhood as a whole is wasteful.

In dense, inner city urban situations another solution to the problem has to be found. In these areas it is more important to work toward net-zero energy communities rather than net-zero buildings. This becomes very important if we keep in mind that more than half of the population worldwide lives in dense urban regions. It is important to get entire communities to reach net-zero, even if the individual buildings within it are not.

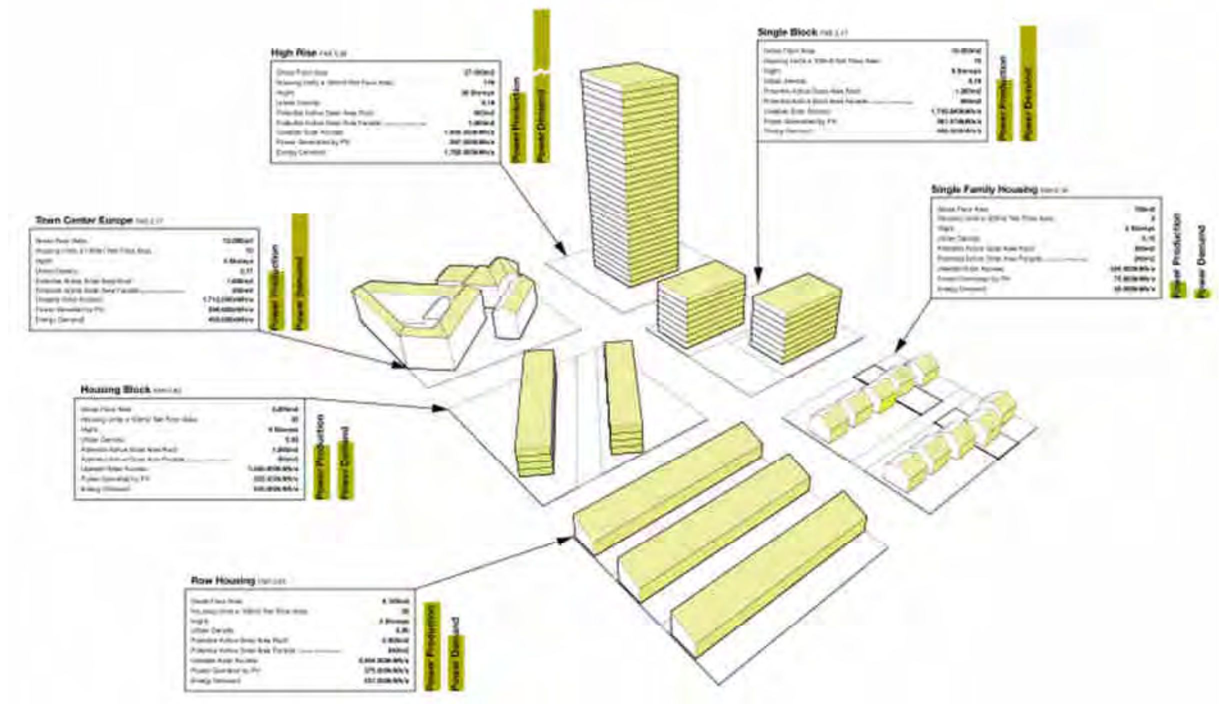

Figure 4: Zero energy potential in relation to urban desity