Chapter 9
Bioclimatic Design and Environmental Impact

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Abstract The paper focuses on the relationship between bioclimatic design and environmental impact in the evolution of what is called a "solar city". Since the ultimate goal of a sustainable project should be to reduce the overall environmental impact, it is appropriate to reflect on the relationship between building and site, considering that, from the settlement point of view, it cannot be said that many of the most famous interventions, from the 80s to today, are to be considered successful.

Keywords Settlements · Solar city · Environmental impact

9.1 Introduction: Bioclimatic Design and Solar Technologies, a Misunderstanding

When it comes to bioclimatic design, we cannot fail to refer to the text that has trained all the scholars of this design approach, i.e.: "Design with Climate. Bioclimatic approach to architectural regionalism" by Olgyay (1963). Olgyay explicitly proposes an inter-disciplinary approach, in which biology, meteorology and engineering skills are applied to building design. The aim of bioclimatic design is to make buildings manageable from the point of view of hygrothermal comfort, using strategies and construction technologies that take into account the local climatic characteristics, reducing the intervention of heating and air conditioning systems as much as possible. In the 1960s, there was a tendency to make the environmental problem coincide with the problem of the fossil fuels. The issue was how to reduce oil and gas consumption by carefully designing these aspects. Olgyay spoke of "architectural regionalism", highlighting how, in pre-industrial times, vernacular construction was clearly characterised, in forms and construction methods, by available resources, climate and, consequently, socio-economic structure. It was clear that he did not want to re-propose the building types of ancient peoples but to indicate the need to employ adaptation principles that reduced the consumption of resources with limited

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availability (even if the reference to vernacular construction was taken as a starting point by many "bio-architects" also from a lexical point of view).

This important text guided the entire first season of design experiments inspired by the bioclimatic approach and, in particular, by "solar" architecture, often in a "didactic" way, being oriented towards experimenting with technological solutions. A great misunderstanding in the transfer of this approach to professional practice was to match the bioclimatic approach to the use of passive solar technologies, which led to a new "international movement" of greenhouses and roof pitches facing south. In the 1990s, solar greenhouses also flourished in climatic zones where what is gained in winter is abundantly thwarted by the risk of overheating in summer. This misunderstanding, while being understandable given that solar energy is a much better distributed and manageable resource even with minimal equipment compared to other free sources (wind, etc.), has often shifted bioclimatic design away from more complex concept of "designing with the climate" simplifying it into "designing with the sun".

If we review those experiments, particularly those on an urban scale, it is evident that it had been forgotten that a human settlement was born not only to repair man from bad weather (Olgyay speaks several times of "shelter") but to create a favourable social environment, with interactions influenced partly by spatial organisation (but probably spatial organisation is a mirror of the inhabitants' relational modalities). Living is more than just an energy problem, although this cannot be ignored, and a city is not a set of buildings, but a "place of opportunities". But perhaps we are at the end of the city and distinguishing it from differently organized territory (Benevolo and Erbani 2011) is increasingly difficult.

9.2 Solar Cities

The concept of "solar city"—a city that owes its energy supply mainly to local production using solar energy—has changed slightly over time, shifting gradually from prevalently passive to active energy, particularly photovoltaic (PV). The first interventions experimented with different technologies for the exploitation of solar energy but calling these agglomerations cities is extremely misleading. The name city in the English-speaking world is a large town of considerable importance. This term can hardly be used with reference to settlements that are mainly residential and peripheral. The city was born as a meeting place, for commercial exchange and social interaction; the city was born around communication routes, be they roads or rivers. The first generation of solar cities, on the other hand, seems to refer more to the garden city of Ebenezer (1898) than to the Roman civitas. In 1991, Jeffrey Ross Cook, a Canadian-born professor and researcher known for his studies on bioclimatic construction and Native American vernacular architecture, was "Searching for the bioclimatic city" (Cook 1991). It is clearly from bioclimatic design that the first concept of Solar City was born.

Solar City Linz is one of the first constructions of settlements guided by the reduction of energy consumption. Designed in the late 90 s and built at the beginning of the new millennium, it was considered a reference model, having achieved energy values that were very low for the time, thanks to the bioclimatic strategies implemented. It can be considered a success story from several points of view. Despite its structure, it cannot be considered a case of urban sprawl. It is rather small and is located in the immediate outskirts of the city, on former agricultural land intended for industry, which hit recession, resulting in the area's reassignment for residential expansion (Castelli 2010). Its settlement layout is typical of the US and more recent northern European peripheral expansions. It has their mono-functional destination and configuration, dictated more by the desire to experiment with design strategies and technological solutions than to constitute a real urban fabric. Possibly also due to its name, it was an initial model of "solar city" which, if replicated on a large scale, configures a settlement mode (as has actually happened in many places), potentially heralding impacts due to the extension of infrastructure and consumption due to transport. A slightly more "radical" version can be found in Denmark's ecovillages (Magliocco 2004), where passive solar solutions and increasingly mature energy production technologies (solar thermal vacuum, micro-wind, etc.) combine with morphological references taken from the first experiments of the American counter-culture—remember the "zomes" of Drop City? (Sadler 2006)—in small peripheral urban areas made up of one-two-storey houses.

Williams (2016) illustrates how experiments conducted on the construction of entire low-energy neighbourhoods—with additional features aimed at reducing the impact of human activities such as water consumption, waste management etc.—limited themselves to innovating technologies and reference standards (on energy consumption but also on other environmental aspects) without, however, making a transformation in the approach to the development model. Nonetheless, they have created replicated models, even in countries other than those in which they were developed. In the three examples brought by Williams—BedZed in England, Hammarby in Sweden and Vauban in Germany—it is evident that, between the beginning and end of the first decade of the 2000s, a process of technological updating developed. Within this process, active and passive solar technologies work side by side and become more and more present, applying a model of solar city in transition. "These projects incorporated several innovative concepts which had become popular within Swedish government (national and local) over a 30 year period—systems thinking, holistic solutions, circular metabolism, integrated infrastructure planning and low carbon development—but had not yet materialised".

Regarding BedZed, a project that has had great echo in the media and is considered the first zero-energy district, Chance (2009) from Bioregional (the non-profit company that promoted the operation), analysed it during the seven-year follow-up and wrote "…BedZED residents live and work outside of the boundary of the site, so most of their lifestyle choices are affected by the infrastructure, products and services that enable (or frustrate) their ability to adopt sustainable lifestyle choices". The ecological footprint calculated in 2009 (Hodge and Haltrect 2009) was 4.67 ha per inhabitant, compared to an average 5.32 ha per inhabitant in the suburb of Sutton,

where BedZed is located. This is due to the weight of transport (most of the inhabitants, at least that year, were professionals) and the failure of the biomass central heating system. In the file published by Bioregional, from which Chance took the data, it is interesting to see how, in the face of a reduction in energy consumption for space heating, the environmental weight of transport increased, despite a reduction in the parking spaces that should have discouraged inhabitants from owning their own car, preferring a car sharing system. The neighbourhood looks pleasant and the evaluation revealed an appreciation by the inhabitants, also in terms of social cohesion. The architecture of the buildings mediates between tradition (thanks to the use of exposed brick) and contemporaneity. The defect is one shared by all these interventions: life in the suburbs needs new infrastructural networks and bioclimatic buildings need inhabitants who are willing to learn how to manage their home. It isn't merely a matter of using a remote control to turn a system on and off. However, the countries that began addressing environmental problem a few years ago refer specifically to projects like this (Xue and Meng 2013).

Both these experiments and the resulting rules and regulations mainly affect new buildings, having only a marginal influence on extensive renovations. Williams (2017) also reminds us that, in the three examples, a cultural change was also hoped for (especially in the cases of Hammarby and Vauban, with participatory forum processes etc.), shared and supported by public bodies. This change, however, is not always transferable to other social and political contexts. The three cases in question were built on a brown field—on land to be redeveloped—making one wonder if it is possible to take them as a model, imagining a total renewal of the existing buildings and a substantial transformation of the urban fabric and the image of the consolidated city, or imagining a continuous expansion in the face of uncertain demographic trends. In both cases, the risk is the shift of the impact from energy consumption during operation to the production and construction phases (in relation to installation equipment and construction methods. See, for example, Goggins et al. 2016).

9.3 The Environmental Impact of the Construction Sector

The bioclimatic project was created in order to re-propose an "intelligent" approach to construction, in an era in which a globalising approach to construction design—which seemed to ignore place and climate due to the availability of fossil fuels at low prices—began to seem absurd. And if the focus was on controlling the consumption of energy resources, which seemed to be the main environmental impact, it was necessary to ask ourselves today how interests in this area have changed. The technologies used for the exploitation of energy sources have evolved and their use extended. The dependence of the price of oil on issues related to international politics and competition among producers is increasingly evident and there is no longer any talk of exhaustion of the availability of raw materials. The environmental crisis seems to have shifted to aspects more closely related to the phenomenon of climate change, such as the availability of food and water, and environmental quality in a

broad sense, in relation to anthropic activities: effect of the heat island phenomenon, particulates, ozone, etc.

To have a sufficiently shared vision in the technical-scientific world of what the environmental impact indicators of civil construction are, we can refer to the environmental certification systems of buildings and, more specifically, the evaluation systems for settlements (Neighbourhood Sustainable Assessment NSA). Numerous parameters are considered in the current vision of controlling the environmental impact of settlement processes. They are linked particularly to the site identification. The buildability of a site is usually defined in municipal urban plans, so the characteristics of the areas should be assessed in Strategic Environmental Assessment processes (SEA—Directive 2001/42/EC). It would appear that the scientific communities that deal with the environmental certification systems of buildings and settlements also consider evaluation a posteriori, probably considering that the construction of a site, despite the obligation (at least in Europe) to apply the SEA, is often influenced by political reasons rather than environmental protection. Although these systems are developed by large groups of scholars and have evolved over time, they tend to offer a rather standardised vision, often outside of local specifications, exporting a specific cultural model. In this regard, and referring above all to the well-known LEED system, Claire Doussard (2017) writes about these evaluation systems. "Some of these systems aim to be universal through the use of standards, while paradoxically contributing to the certification of projects in culturally diverse contexts". Nonetheless, these systems offer a rather broad overview of the points of attention of a sustainable project that goes well beyond issues related to bioclimatic design and energy saving.

According to the LEED evaluation system, the most widespread in the world, in the edition "for Neighbourhood Development" (2018), while this certification system identifies many alternative solutions to obtain a good score, attention to the choice of site is high and there are many unavoidable prerequisites. The "Smart Location and Linkage" parameter, for example, assigns a score of 1 or 2 points to a new settlement on a brownfield, instead of a maximum of 10 points obtainable from a combination of settlement situations aimed at the requalification of abandoned areas within the urban body or immediately adjacent to it. Up to 3 points are assigned if the site is able to provide "Housing and Job Proximity" in order to limit the need for mobility. Proximity to public access systems—"Access to Quality Transit"—assigns up to 7 points. Respect for natural habitats is also very important. There are criteria for the organisation of the building fabric so that it can also be travelled safely on foot, criteria for density, as well as criteria relating to energy consumption, the use of water, and comfort in confined and open spaces.

Referring to the Italian cultural and technical sphere, the areas of assessment are not very different. Obviously, the weight that is credited to the individual parameters may be different. The ITACA interregional protocol has now become a Reference Practice of the UNI body i.e. UNI/PdR 13.1: 2019 and this makes it a reference also for private construction. This system—more easily applicable by designers than LEED which, due to its characteristics, requires the use of certified experts—similarly pays

attention both to settlement criteria and to energy consumption criteria, but also to the choice of materials and the definition of conditions of hygrothermal comfort.

Another factor to consider as an impact parameter is the loss of the urban fabric in its characteristics as a socio-economic relational system, closely correlated with the settlement structure. In the transition from constructive experimentation to the construction of a settlement, there should be a process which, besides considering the aforementioned biological and meteorological aspects, also considers relational and perceptive aspects between the elements and consequently between the hosted organisms: the inhabitants. In the project for the Ecolonia district—in the municipality of Alphen aan den Rijn (Netherlands), in the early 1990s—Lucien Kroll, who organised the structure to then entrust the construction of the buildings to several designers, proposed a dense settlement, not by elevation but by proximity between the building bodies (Bakker and Thijssen 1991; Magliocco 1996). Kroll renounces "solar gain" in many buildings by adopting other hygrothermal control strategies, with the aim of creating a "human" fabric, in which it is easy to meet the neighbours and possibly develop relationships with them. The criticism is not so much of solar architecture as peripheral urbanisation (which is what Ecolonia was considered at the time of its realisation), organised only through hierarchical road layouts, in which the car-garage-home model defines the living space as a complete refuge, in which to shelter overnight. These settlements organised according to the principle of "solar access" promote a functionalist approach (in the worst sense of the term), combining building hygiene and low density. However, it is to this model that many of the "sustainable" design experiments refer.

9.4 Solar Cities Today, Goodbye to the Bioclimatic Model?

It is possible today to notice a sort of dissociation between the new solar city models and the bioclimatic approach. The passive house model promoted by the research centre founded in 1996 by Dr. Wolfgang Feist (The Passive House Institute -PHI) has defined new consumption standards and construction methods. In Italy, CasaClima certification (a brand managed since 2002 by the South Tyrolean Energy Agency) defines very similar criteria. The European Directive on Nearly Zero-Energy Buildings (NZEB, Directive 2010/31/EU) in a certain sense has validated—albeit not explicitly—a constructive approach that makes hyperinsulation the main strategy for reducing energy consumption. The bioclimatic approach requires great multi-inter disciplinary skills to be applied in different climates; the new reference model, on he other hand, is based on a conservative approach (hyperinsulation), impermeability to air and the use of small heat pump systems with heat recovery for air exchange. It was initially thought that it could be applied anywhere, varying only the transmittance of the opaque and transparent elements and the power of the heat pump. Consumption is so low that it allows the feeding of the heat pump with small photovoltaic systems. However, a resource consumption monitoring system that does not take the entire production process into account cannot detect its real

performance. An approach that promotes efficiency—of technologies, of building performance—instead of considering the effectiveness of solutions and strategies, does not necessarily lead to important results.

All this has led to a new business, photovoltaics, first pushed and supported with various forms of incentives and then placed in the hands of large industries. Byrne et al. (2016) talks about the Solar City strategy as an operation to maximise production from solar sources through photovoltaic systems which, without waiting for private initiatives (with all the pertinent constraints and difficulties) could contribute strongly to the needs of large cities as well, using infrastructure and publicly owned real estate as support surfaces. The calculation he proposes, for six case studies—Amsterdam, London, Munich, New York City, Seoul, and Tokyo—obviously ignores architectural results. Consequently the model of the solar city changes, becoming increasingly a mere technical-economic issue. Currently, the term seems to be used to describe large new generation agglomerations, like Chinese or American cities (Hosseini 2019), in which the "solar" adjectivation is linked mainly to the production of solar thermal and, above all, photovoltaic energy. The development of the solar city concept is now strongly influenced by industrial development, particularly in large-scale production in Asian countries, when most of the active solar systems (SWH and PV) distributed throughout the world come from. One of the cases that can be cited is the city of Dezhou in China, which has become the seat of a large industrial district for the production of solar systems, initially created on the initiative of the Himin industry. In 2005, the Dezhou government implemented a Solar City Strategy and introduced a series of preferential policies and plans to provide comprehensive technological and financial support to the solar industry. Dezhou boosted its international reputation when it hosted the International Solar City Congress in 2010 (Yu and Gibbs 2017). This can be seen from a positive perspective, as in the aforementioned paper, because "green" entrepreneurs are able to boost processes that would otherwise take much longer to develop due to various types of resistance, or to a negative perspective, as urban development is subjected exclusively to the interests of industry. Both aspects are true. At building scale, the Solar Valley Micro-E International Hotel is an obvious expression of this combination: each person evaluates the results.

9.5 Conclusions

The bioclimatic approach to design has been an important step in defining contemporary building models, demonstrating that it is possible to severely limit energy consumption in the civil sector starting with construction methods, while maintaining a strong link with the place. The simplification of the bioclimatic approach in a simple exploitation of solar energy has led to the contradiction of a new globalising model, that of the solar city, which is less and less a habitat for man and more and more a machine for energy production. This model is essentially unable to dialogue with the consolidated urban fabric (under penalty of its distortion) and is strongly focused on the definition of urban agglomerations where construction is influenced

by the goal of maximising the use of solar energy. The risk is that the control of energy consumption may be unable to coexist with the other requirements of what, even today, in the European city, we consider as human space.

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