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## ECOLOGICAL CONSTRUCTION AND NEW TECHNOLOGY. DISCUSSION OF SOME TECHNOLOGICAL INNOVATIONS WHILE IMPROVING THE BUILDING'S PERFORMANCE

### BUDOWNICTWO PROEKOLOGICZNE A NOWOŚCI TECHNOLOGICZNE. OMÓWIENIE WYBRANYCH NOWINEK TECHNOLOGICZNYCH PRZY POPRAWIANIU WŁAŚCIWOŚCI UŻYTKOWYCH BUDYNKU

#### Abstract

This paper is a collection of solutions, which when used in construction would allow for improvements in living conditions and reduce costs, while adhering to regulatory and consumer requirements. The proposals presented apply to single-family houses, tall buildings, but also entire urban agglomerations. There is also a multitude of solutions resulting from the revitalization of urban areas. All of the above is presented in terms of new technologies which support zero-energy and environmentally friendly construction.

*Keywords: green construction, ecology, new technologies, non-standard design*

#### Streszczenie

Praca stanowi zbiór rozwiązań, których wykorzystanie w budownictwie pozwala na poprawę warunków bytowych oraz obniżenie kosztów wynikających z przystosowania do rosnących wymagań prawnych oraz konsumenckich. Przedstawione propozycje dotyczą zarówno budynków jednorodzinnych, wysokich, jak i całych aglomeracji miejskich. Nie brakuje również rozwiązań wynikających z rewitalizacji obszarów zurbanizowanych. Wszystko pod kątem nowości technologicznych wspomagających budownictwo zeroenergetyczne i proekologiczne.

*Słowa kluczowe: budownictwo zielone, ekologia, nowe technologie, nietypowe projekty*

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## 1. Introduction

The modern construction industry faces many problems, most of which have appeared relatively recently, thanks to growing awareness and consumer expectations. Users don't just want their houses and apartments to be a place of accommodation, but they also want them to be a place to hide from the everyday hustle and bustle, a place for social meetings and for the education of their future children.

The second aspect, which cannot be overlooked in all modern facilities currently built is the energy issue, and more specifically, how much energy the building consumes during its life. Investing their entire savings, often accumulated over many years, the user needs to know if they can afford to maintain their dream house. This is even more important in the case of high-rise buildings, because the scale of the operating costs results from the number of companies occupying the building.

## 2. Energy deficits

An energy shortage could cripple an entire country. With the constantly growing demand on resources, the total paralysis of transport and communication is already a real threat. Meanwhile, commonly applied ways of generating energy are either harmful to the environment, or do not provide sufficient supply. It is therefore necessary, not only to generate energy, but also to find a better use the resources that we have. What's more, it is important to minimize transmission issues that generate additional costs.

Assuming pro-ecological solutions, every building is a potential source of savings. Changes in Polish regulations concerned with the thermal insulation of buildings are a good example. However, it is never possible to insulate a barrier completely. Any discontinuity such as ventilation, windows and door openings, cause heat losses. These, in turn, translate into operating costs. One way to solve this problem is recuperation; however, this raises a lot of controversy. The problem is the issue of the placement of individual rooms and their volume. This solution is not always cost-effective. Additional costs associated with annual maintenance do not improve the situation. Another issue is the education of residents who very often do not know how to properly ventilate the premises without large heat losses. An alternative might be to design a buffer space in the building to warm the rooms, while maintaining proper ventilation. This solution is all the more interesting, as it does not require the use of sophisticated technology, and the whole structure is based on the fundamental principles of physics. At the same time we need to pick the right solutions for a specific building.

However, irrespective of savings, energy consumption is steadily increasing. When looking for green energy sources, we can immediately see that a much more efficient solution is to obtain energy from the sun and wind. In this case we are dealing with dependence on the weather, but you can apply more than one panel or a turbine in a building. Specifically, the development in the field of solar cells allows for almost limitless architectural solutions, and with increasing performance, it is no longer necessary to cover the entire roof with panels. In turn, replacing classic wind turbines with vertical one minimizes solutions to only 0.5 m in height. These new designs can also be installed in places that were considered inaccessible

until now (Fig. 1). The large tracts of flat industrial roofs, which generally are placed on open spaces, are particularly promising. Moreover, the weight of such turbines means they can also be mounted upon light structures, and the amount of electricity produced in this manner may be sufficient to power lighting. They are very efficient, use magnetic bearings and pose no threat to birds.



Fig. 1. An example of vertical turbine  
(source: <http://www.folkecenter.net>)



Fig. 2. Philips Blossom lamp  
(source: <http://www.worldchanging.com>)

However, there are more possibilities. Philips has developed a design for Blossom smart solar lamps, also equipped with wind turbines (Fig. 2). This type of element can decide whether it is able to get more energy out of wind or the sun, and adjusts to the most efficient position. Moreover, the use of LED lamps led to a significant reduction in energy consumption at night, when they have the task of illuminating the streets. The special paving, which generates energy by pressure, is also noteworthy. Installing these panels around a bus or tram stop can produce sufficient electricity to light it through the night. Savings will be enormous, given the amount of such shelters exist in each major city.

There are many more similar solutions. Separately, they hardly have a serious impact on the energy balance, but together they help to create a smart home system that uses every possible way to produce and save of valuable energy.

The savings in terms of energy can be found not only in the exploitation of a building, but also in all stages of its existence. Thus, when designing and building we should pay special attention to the materials used, their production, origin, and location in the facility. Everything completed according to sustainable development. The very concept of sustainability doesn't only apply to the ecological aspect (which, however, appears most frequently in the press), but also to issues arising from social and economic relationships. Achieving the "golden mean" between these three aspects must occur in such a way as to guarantee free development not only in the present, but also in the future for the next generations.

### 3. Floating structures

The world has a limited land suitable for casual building. Land only occupies 29.8% of our planet's surface, and even then there are a lot of mountainous areas or regions deprived of normal conditions for life and growth. It therefore became necessary to search for new solutions to deal with this issue.

The first solution, already used in some areas on a large scale is the construction of artificial islands. The most picturesque examples of this type of construction can be seen in Dubai, where the Palm Island project includes a set of the World's largest artificial islands. Their surface is so large that it allowed for the construction of airports, hotels and high-rise buildings. This unusual design, however, is still dependent on the substrate and its position relative to the sea. Although this is a solution, it also requires constant monitoring, mainly due to surging water, which constantly erodes the first couple of meters. Another problem may be the level of the sea is systematically increasing due to melting glaciers, therefore projects such as Palm Island remain a temporary solution.

Due to this situation, it might make sense to make better use of areas already inhabited. The consequence of such thinking results in building higher, and then the problem may be the materials themselves.

Thus, it became necessary to find a solution that would allow builders independence from soil. As it turns out, this was not that difficult. Based on the fundamental laws of physics, it was possible to create the first floating structures, which incidentally have also been established in Poland. Unfortunately, Polish construction law remains a problem because of the lack of foundations, which are an integral part of the design. Meanwhile, floating homes are already being created on a large scale in the Netherlands, where not only are they popular, but there are also areas in which no different type of buildings can be erected. This primarily involves all kinds of flood zones, located along the major rivers and lakes. In case of an emergency situation or a flood, the house just drifts in place, safely anchored to prevent it from floating away.



Fig. 3. A model of the Lily Pad floating complex (source: <http://www.powrotnik.eu>)

Most importantly, these do not have to be small buildings. Some of the houses can compete with free-standing houses in terms of their clever design and size. Interestingly, there are even designs for high-rise buildings equipped with drifting systems. However, this is not a complete solution. If designers can create designs for floating buildings with a significant number of floors, then bolder designs might also be completed.

This notion is confirmed by the Lily Pad project, which, as the name suggests, comes from a great water lily leaf, easily able to support a person's weight (Fig. 3). Lily Pad not only can support a person, but it is a floating district with its own sources of renewable energy, filtration systems and water recovery systems. Furthermore, it also uses biologically active partitions in the form of green walls combined with wind turbines of various sizes, adapted to the wind force. Furthermore, the very structure of the walls is varied and by rotation allows for the adjustment of cool air flowing to the center of the complex from above the water. It is one of the first steps towards zero-energy housing and self-sufficient cities.

#### 4. Biologically active partitions

One of the leading trends in the twenty-first century is the revitalization of urban areas. Large poorly designed developments with cramped buildings characterized by poor living conditions and poor efficiency. These developments tend to have a higher perceived temperature associated with heat radiation and heat reflectivity from the smooth surfaces of such buildings. These are so-called Urban Heat Islands (Fig. 4). Another threat is the air pollution including greenhouse gases and fly ash. Information about standards being exceeded several times, which prevent taking children for a walk, shows an example of how serious this issue is.

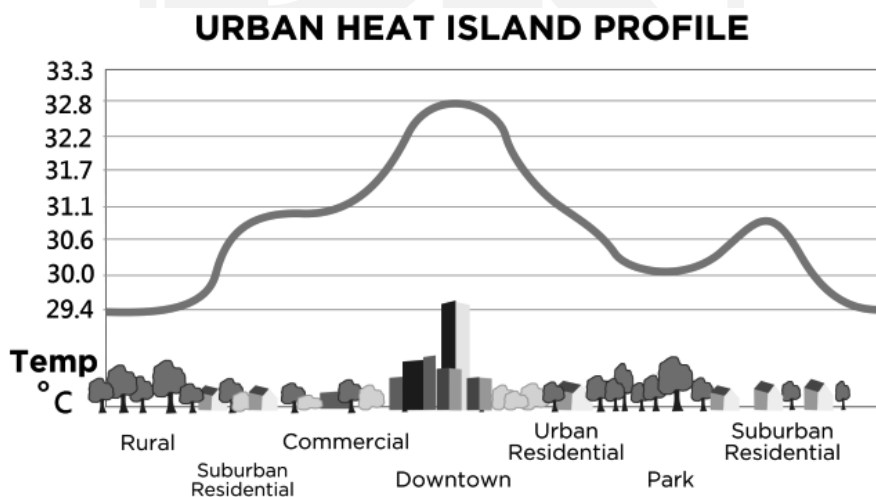


Fig. 4. Urban heat island (source: <http://www.wikipedia.org>)

To fight such a strong pollution, we should not only reduce the number of vehicles, because they are not the only cause of the production of exhaust gases, but also introduce as many green urban areas as possible. Unfortunately, at this point we would face the issue of the required undeveloped space, which might become a basis for a park or square with plants. This is impossible to achieve in most cities. In turn, only creating green areas in the suburbs does not solve the problem. We have to find another solution that will save space, while introducing a significant amount of green.

The solution lies in green roofs and green walls (Fig. 5). These form large expanses of green, which are isolated from the rest of the structure and allow for a changing the level of humidity and reduces pollution. In addition, it is also the perfect sound-absorbing surface to fight another threat of the present day – noise.

In contrast to solar panels or wind turbines, their use should be adapted to the climate in which such barrier is to be built. We also have a wide variety of structures, which can be used depending on the dimensions of the building and the additional loads that the structure can transfer. These solutions can also be used selectively on parts of the roof or facade; therefore it in no way limits the vision of the architect, who can integrate green areas according to their vision.

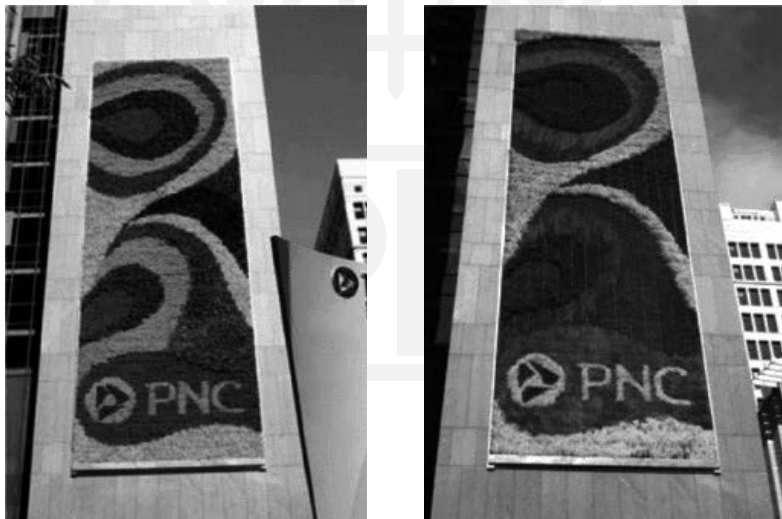


Fig. 5. Green wall and its evolution throughout the year (source: <https://www.pnc.com/>)

It must also be noted that these structures can also be used inside buildings, creating interesting interior elements and guaranteeing comfort to users. Green panels are ideally suited as natural air filters, which are able to lower the temperature by two to three degrees Celsius. It has also been proven that the presence of vegetation has a positive effect on the user's mood. We also should also consider impact on the environment. The use of green walls and green roofs on a larger number of buildings could change the microclimate around the city, helping to improve the air quality and living conditions.

## 5. Zero-energy buildings and cities

This is just one of the variants of our future, and in part also our present. However, zero-energy balance does not mean lack of power, but the ability of a building or complex of objects to produce the at least the amount of energy required for its operation. This only means that the building does not have any additional consumption beyond systems which are self-contained. This type of building not only uses solar panels and turbines, but also geothermal sources, biogas processing plants, as well as recuperation. In suitable areas, you can take advantage of the proximity of rivers, or the ocean. This can be complete with additional options, such as modern types of self-cleaning windows, or biomechanical coatings that respond to the intensity of solar radiation by adjusting the surface tension to the amount of light and heat supplied through the barriers. The proper deployment of rooms and vegetation relative to the compass can lead to a situation, in which buildings will not need air conditioning systems. This, however, again characterizes solutions for people who know how to benefit from them.

The Clay Fields project showed exactly how important the education of users is. It is a passive social housing estate, the main objective of which is to assume a low cost of construction along with the use of biodegradable materials found in the vicinity of the construction site. This minimizes transport costs and also reduces the production of emissions. As for the residents, they were carefully instructed when to open the selected windows and in what order to minimize heat losses while ventilating. Indeed, the proper use has allowed reducing operating costs appreciably. And this is still merely a passive house.



Fig. 6. Masdar – bird's-eye view (source: <http://www.fosterandpartners.com>)

While applying a similar method in more modern designs, one should keep in mind that an eco-friendly building does not depend solely on the conditions of use, or the raw materials used. It is also a matter of logistics of the entire project, its implementation, clean-up, and therefore the whole life of the building, from the creation of the design through its operation and future demolition and recycling.

The importance of the zero-energy building issue is best presented by countries that have already started the construction of such facilities, which include: The United States, China, Germany, Ireland, Canada, Norway, Sweden, and the United Kingdom. In fact, the list is much longer, and also includes Poland. It all boils down to using the solutions applied in specific projects, on an industrial scale. For this reason, more attention is paid to modular solutions, which are much cheaper to produce than individual projects, even though they are not always very picturesque.

Thus, all possible issues related to energy and emissions have been taken into account in the Masdar City (Fig. 6) a design by the Norman Foster architectural studio on behalf of the Emir of Abu Dhabi. It is a leading indicator of pro-environmental thinking in the world in which even machines are powered by solar energy. The project in its simplicity does not assume many extremely futuristic solutions, but it is the very scale of the solution which makes it interesting; it is to occupy an area of 6 km<sup>2</sup>. Besides solar energy produced here in the largest quantities in the world, the city will also use geothermal sources, as well as additional systems to be integrated, which include water treatment and recycling systems, smart umbrellas for protection against the sun, which open depending on the level of sunlight, water floating turbines off the coast, and finally a compact, low development that primarily assumes walking and cycling. There is also a solar powered public transport system. In addition, the city will process all waste, providing an almost one hundred per cent recycling, and carbon dioxide is to be filtered and collected in special chambers where it had been formed, preventing the emission into the atmosphere. This creation has been under development since 2006, but the details of some of the solutions are changing along with the project, constantly improved and developed. An additional indicator of the grand scale with which the whole project is implemented may be presented by the open fund created towards the construction of this fully self-contained city – \$ 300 billion. The projected earnings, related not only to the complex, but also advances in solar cell technology accompanying the whole project are estimated to be at least twice that amount.

## 6. Expectations and reality

Most of the solutions presented above are still futuristic and despite excellent assumptions, require a lot of effort and funds in order to be realized. It is therefore necessary to create appropriate development strategies. A perfect example of this might be “Europe 2020” which demonstrates the basics of sustainable construction, improving the quality of lives and investment in technology. For skeptics, this may seem like a utopia, but in reality, it is possible to achieve. Meanwhile, Malmö in Sweden has become the first energy independent city in Europe. Here total energy production comes from renewable sources with public transport is implemented through bicycles and buses powered by biofuels. Interestingly, it is a self-sufficient structure, but still has a connection to the general net, allowing for the donation of the excess of generated energy to be used by other entities. In this way it is possible to use the full potential, while maintaining the economic balance.

It should be noted that producing devices intended to collect excess energy is exceptionally expensive, therefore efficient use of such devices requires proper planning in order to fully benefit from the energy they produce throughout the whole year.



In order to achieve this educating the user will be a vital pre-condition.

By increasing the environmental awareness of users, it has been proved that it is already possible to make savings in the consumption of water, electricity and gas. Campaigns for turning off the water while brushing your teeth, is a small example of what we should strive for. It should be noted that such changes still require a lot of time.

## **7. Reduction of CO<sub>2</sub>**

The European Union is currently pushing through policies aimed at rapidly cutting down the level of CO<sub>2</sub> emissions across the region: “Concretely, the Union has set five ambitious objectives – on employment, innovation, education, social inclusion and climate/energy – to be reached by 2020. Each Member State has adopted its own national targets in each of these areas. Concrete actions at EU and national levels underpin the strategy”. These words, spoken by President José Manuel.

Currently however, a forced reduction of CO<sub>2</sub> emissions, could lead to an economic crisis, companies would not be capable of rapid reorganization of all workstations and machines. A complete reduction may require another 20 years, however, this does not mean the abandonment of ecological thinking, on the contrary, sustainable development is a long-term action, to ensure appropriate conditions of many generations.

Firstly we should take the differences requirements of various regions into account. Thus, the assessment of the effectiveness of the proposed solutions should be carried out by scientific groups from different fields of science, industry and economics, specifying which of them will get a reduction in harmful emissions or to arrange jobs needed to sustain proper economic development. Construction as one of the largest sectors of the economy must also be subject to these changes.

In accordance with taking all aspects generating expenditures related to using resource and energy into account, it was necessary to use complex computing systems based on multi-criteria evaluation. The hardest part of the implementation has been, and it still is proper reflection parameters, each of which expresses a different unit. Currently known systems are LEED (U.S.), BREEAM (United Kingdom), DGNB (Germany) and HQE (France). However, in Poland, the most popular are the LEED and BREEAM systems. The DGNB system is also starting to only gain recognition in Poland. The list of solutions also includes other forms of certification (often dedicated to specific countries). Currently, the LEED and BREEAM systems are recognizable brands in more than 120 countries around the world, created dedicated programs (in the way of understanding and negotiation), which can be described as regional programs. An example of this is LEED in Canada or LEED in Poland. In this way it is possible to take individual aspects related to the geographical location, climate, or the mentality of society into account. Although individual assessment systems differ in many respects, such as the method of administration result of the evaluation, the scope and accuracy criteria and the nature of the buildings for which they are intended, they still have similar mechanisms of action. What was initially targeting only aspects related to saving energy, now also includes broad sociological aspects, referring to comfort and what was already mentioned, to education. The same points in the evaluation of gains for gray water circuits, rational distribution of spaces, large exposure objects, or adaptation of the

roof slope to the needs of biologically active partitions. But most importantly, all certification systems are constantly changing, according to technological and economic development.

## 8. Conclusions

To sum up, environmentally-friendly solutions in the construction industry, are not isolated projects or technologies, but a combination of factors that cooperate in a proper configuration capable of achieving a higher standard of living and a positive energy balance. The benefits for man and environment are still relatively low, especially in economic terms. However, we cannot abandon ecological thinking, as with further development of the currently promoted solutions, it will be possible to improve the performance of individual systems, which over time can make our buildings (not only residential ones) self-sufficient. How serious the matter is can be seen at every step, with subsequent climate changes and the images of degraded natural environments. To protect our future, we should start with small solutions, because they are what make sublime projects possible.

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