

Ecohomes and economical and ecological aspects of sustainable development of human settlements

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Abstract. This paper considers the economic and environmental issues related to the construction of eco-homes, one of the recent and acceptable projects meant to solve the sustainability issues, whose principles were presented at the Environmental Conference held in Rio in 1992. On that occasion, important traits of eco-homes were described, which can be synthesized in their efficiency and effectiveness in water use as well as radical wastewater and solid waste reduction, among other characteristics. In line with the intensively rising trend of projecting and experimental construction of such homes, their advantages are being emphasized, as well as the possibilities to momentarily start carrying out these projects in rural areas. However, in urban areas, the existing communal infrastructure and certain interest groups might obstruct the realization. This can be especially significant in the actual Serbia, characterized by the demographic abandonment of villages and small towns.

Key words: Eco-home, economy, ecology, environment, health, rural communities, communal branch, communal activities, Rio '92, Agenda 21

1. INTRODUCTION

Environmental issues came into the international focus at the beginning of the 8th decade of 20th century. Following the First United Nations Conference on the Human Environment, also known as Stockholm Conference, which was held in 1972 and by 133 countries, the United Nations founded the World Commission on Environment and Development (WCED) in 1983. The Commission's report "Our Common Future" (the so-called Brundtland Report) [25], published in 1987, expressed the need to seek for a new development model in order to avoid possible serious consequences and environmental degradation. This is when the term "sustainable development" was formulated to refer to a development model which allows the satisfaction of the necessities of the present generation without depriving the coming generations of the same opportunity. In 1989, preparations for the United Nations Conference on Environment and Development started, and the event took place in Rio de Janeiro in 1992, exactly 20 years after the First Conference. This was also 20 years after the publication of the Limits to Growth [12], famous but, according to Vaclav Klaus, also absurd book [8: 23], which became very influential, even though the

authors admitted to having deliberately deceived the public to raise their awareness on the topic [20: 49]. The Rio Conference gathered the leaders and high representatives of 179 countries, as well as a large number of local government, business, science, NGO and other levels' representatives. The Conference expanded on a sustainable development concept, pointing out two basic conditions: 1) every person has the basic right to a healthy environment, favorable for their health and general well-being and 2) the countries conserve and use the environment and natural resources according to the interest of the present and future generations. The Conference adopted a large number of documents, the most important of which is considered to be the Agenda 21.

Among numerous requirements, the Conference set ones concerning decent living conditions. According to the Agenda 21 [1], the main goals of the sustainable development of human settlements are:

- providing satisfactory living space, bearing in mind the population growth and the need to accommodate poor social groups in both rural and urban areas;
- A better human settlements management in order to improve the living conditions, in

developing countries in the first place, including special support to smaller town development;

- An adequate planning and use of available land to develop human settlements (creating an information system about land resources, improving the cadasters, tax deduction for effective protection and control of the use of land, as well as forming partnerships among public and private sector);
- An improvement in infrastructural systems' capacity, since they have a direct impact on the environmental conditions and settlements hygiene, water supply and wastewater disposal, sanitary services and managing liquid and solid wastes;
- An improvement of energy supply and transport systems in communities by using more energy-efficient technologies and alternative and renewable energy sources;
- Reducing the damage to communities and environment by prevention means and by rehabilitation and reconstruction of disaster-hit areas (areas affected by natural disasters or at risk of industrial accidents);
- Adopting policies and technologies that would contribute to construction and development of human settlements without having a negative impact on human health and biosphere, at the same time enabling greater employment opportunities in construction industry and improving the cooperation between state institutions and private enterprise;
- Strengthening human resource capital and institutions that deal with community development.

The whole concept of sustainable development, especially the concerning results of the Conference, including the dwelling issues, intertwine with economic and ecological aspects – neither can be thought of nor carried out without the others.

In 2008, Government of the Republic of Serbia adopted a National Sustainable Development Strategy for the period between 2008 and 2017 [15], which comprises, among other points: 1) a vision of a sustainable development of the country, 2) national priorities, 3) Strategy principles, 4) an analysis of the strong points and weaknesses of the environment and available natural resources, sustainability of a knowledge-based industry as well as present social

conditions and development perspectives, 5) an institutional framework, 6) the financial backing of the Strategy, 7) performance measurement indicators and 8) an action plan. One of the fragments of the chapter Socio-economic conditions and perspectives deals with dwelling issues and housing policies. Some of the strategic goals in this area emphasized in the Strategy are:

- 1) Providing appropriate housing to individuals/households who lack one and increasing the action potential of all the participants;
- 2) Prevention of decline of certain settlements, i.e. removal of the existing local "unhygienic settlements" and slums while avoiding their residents' relocation;
- 3) Increasing the housing security by putting an end to illegal construction and legalizing illegal constructions while avoiding any non-indispensable demolition, as well as introducing housing rent regulation measures;
- 4) Stopping a further decay of public housing fund and bringing the average housing conditions closer to the EU standards;
- 5) Eliminating the huge differences in housing quality among different settlements while conserving regional specificities;
- 6) Taking into consideration the special housing needs of marginalized groups, displaced persons and refugees;
- 7) Improvement in living conditions in rural areas.

The peculiarities of the current situation and of the present moment, including refugees, difficult situation of the Roma community and accumulated long-standing problems of illegal construction, have certainly contributed to the authentic economic and ecological housing-related issues being relatively neglected. However, Serbia did adopt the Agenda 21, whose Article 28 emphasizes the need to formulate a local sustainable development strategy, opening up the possibilities to give greater importance on local level to the sustainable development itself, as well as to the housing issues in general.

2. CONTEMPORARY HOUSING ISSUES

During the second half of 19th and in the 20th century, development of human settlements, especially of urban ones, has led to a large number of economic, ecological, cultural, health-related and other issues. Despite great effort and invested funds,

these issues are being solved slowly and with hardship, so much so that it can often be concluded that problems are arising faster than ideas and means to solve them. This especially refers to (huge) urban settlements, even though the city is considered to be “until now the most perfect solution in the evolutionary testing of the most convenient forms and kinds of human settlements” [14: 1]. Although the population density growth, that is, a larger number of urban settlements and their inhabitants¹, is considered to be normal and conditioned by the process of industrial and social development, urban sprawl and population and density growth in such areas² are the factors that have been causing numerous and, as it starts to show, unsolvable problems. Those problems are reflected in housing, that is in living conditions of people in urban settlements, as well as in greater and greater environment deterioration in settlements and their suburbs.

Unlike the past-era “pre-industrial” houses, contemporary multi-story “industrial” houses, which have been built for the last century and a half and have changed significantly the way of living, not only have brought problems to people who live in them but they are also very “vulnerable”. Since they depend on the communal facilities and networks, any discontinuation in the functioning of these facilities make these homes inadequate, and sometimes even impossible to live in. These facilities are numerous and diverse: water collection and treatment stations, water purification equipment, different kinds of thermo-electric power plants, boiler-room, pumping stations, compressing and transformation station, landfills, large water pipe networks and so forth; in a word, everything included in the communal infrastructure. On the other hand, the exploitation and maintenance of the multi-branch industry providing for these facilities consumes a great amount of resources, such as fuel, energy, chemical reagents, specific technologies and so forth. These houses are therefore not only vulnerable, but also very resource consuming. Besides that, they require significant workforce engagement, especially for physically hard and non-qualified work, as well as creating bureaucratic structures to manage it. Additional warehouses, energy sources and transportation companies and

equipment are also necessary. In order to obtain resources for “industrial” houses, it is necessary to engage companies working in various industries, such as mining, energy industry, metallurgy, mechanical engineering, chemical and non-metal industries, transportation, housing sector, communal services and others. The construction industry should also be noted, since it deals with the building of the houses, as well as their maintenance and reconstruction. This sums up to at least one third of the total industry capacity. Besides that, not only is it one third of the industrial capacity, but also a third that includes the technologically least advanced, work- and resource-intensive branches (both work- and resource-consuming), which imply a lot of waste and contamination.

The damage directly done to the environment by the contemporary housing construction is nonetheless only a tip of the iceberg, since it is necessary to keep in mind the production of consumables directly or indirectly connected to living and other aspects. All in all, analyses prove that per each resource unit consumed directly at home, tens of resource units are consumed in the systems providing for it. Similar conclusions are made when it comes to waste. According to Lapin [11], inadequate housing accounts for more than a third part of the total ecological damage done to the nature. If we also take into account the production of equally ecologically uneconomic consumables, whose structure and assortment are related to the housing type, the ecological damage produced by the housing sector can be estimated at more than 50% of total.

On the other hand, separation from nature and land has extremely negative consequences on human health, and not only on physical health. In addition, a general decay of urban environment leads to worse hygiene conditions in contemporary cities and city houses.

Until recently, all this was considered to be inevitable, and it was common to hear that the only alternative that the humans could be offered is to return to caves. Nowadays, however, it is evident that this point of view is outdated. All these consequences and dangers connected to life in big cities, especially in multi-story houses, have been known for a long time and projects have been started in order to reduce water consumption and waste production and to provide more healthy living conditions. This is how the eco-home idea came to exist. The modern technological advances have opened up the possibility to build homes that would provide a decent living on one hand, and to ensure a radical reduction of the

¹ It is estimated that in 2008 the number of people living in urban areas was the same as the number living in rural areas, having surpassed it by now.

² Large cities of more than a million inhabitants have the most problems, and it is the number of such settlements that is rising dramatically: by 1925, there were only 31, in 1965, their number rose to 138, while in 2000, there were 372. [7: 20]

environmental impact on the other hand. We would like to remind that the Rio Conference results emerged from growing claims to provide decent living conditions.

3. WHAT IS AN ECO-HOME?

According to Lapin [11], an eco-home is either a single-family home or a multi-dwelling unit with a corresponding piece of land, whose main features are: resource saving, little waste production, being healthy and well equipped, while non-aggressive towards the natural environment. These characteristics are mainly attained thanks to the use of autonomous or collective engineering systems meant to enable living based on rational home construction. It is especially important to emphasize that these characteristics are not only found in eco-homes, but also in the environment (or settlement) formed by such houses, as well as in engineering and production infrastructure providing for their functioning.

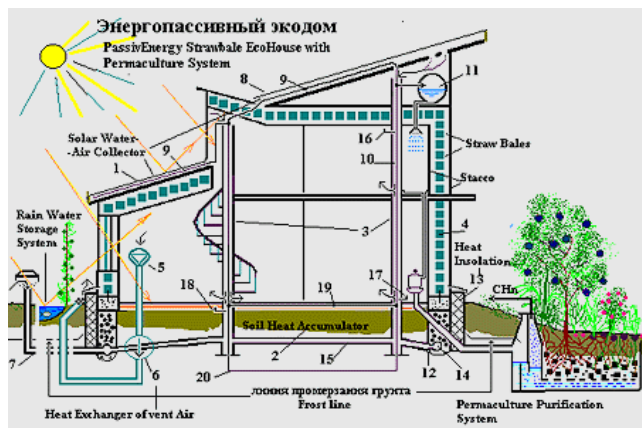


Figure 1. Energy-passive eco-home developed for the project “Eco-houses with “0” energy level, built of natural materials”, Minsk, 1998.

Eco-homes are sufficiently autonomous and do not require large engineering systems, networks and industries serving them, they are also nature- and human-friendly, and by being so, they sublime all the positive characteristics of the previous (“pre-industrial”) house types. Eco-homes vary depending on given physical-geographical and social conditions, but their previously specified traits are conserved in all cases (mainly the saving of resources, little waste production and sufficiently comfortable living conditions).

The eco-home will bring people back their independence and personal responsibility for organizing their lives in their own way, as well as for the state of the environment. It will require certain

habits, skills and knowledge, and through this, it will also play an educational role.

The figure 1 shows a scale model eco-home prototype developed for the project “Eco-houses with “0” energy level, built of natural materials” in Minsk in 1998, a project based on the majority of here cited principles and traits. The design has been developed with participation of Minskgrazhdanproekt and it comprised some extraordinary traits, which will be further detailed in this paper: a two-level wooden frame filled with straw bales, a cozy warm home, a winter garden, an artificial lake for rainwater harvesting, a south looking roof, a thermal collector and a thermal accumulator located in the house foundation, a ventilation system with an underground channel enabling heat recovery, a closed permaculture household sewage and a waste utilization system. The cost of one square meter of such living space only amounts to 150 USD, which is three to four times lower than in case of traditional dwelling, while the heating energy costs have been reduced to 0 (also indicated by the name of the project). On the other hand, regular buildings, even when brand-new, require energy consumption of between 200 and 400 kWh/m² per year. The eco-homes’ electrical panels allow them not to be forced to rely on the exterior communications and infrastructure.

Eco-home and energy

As underlined by Lapin [11], the contemporary ecological housing began with the energy-efficient houses, the authentic predecessors of the eco-homes.³ The energy-efficiency does not even come close to comprising all the eco-home’s characteristics, it is one of its most important traits. At the same time, successful energy-efficient home projects are a good basis for eco-home construction.

The significance of energy is well known and will therefore not be elaborated in this paper. We will merely call attention to some of its housing-related aspects. According to the World Energy Engineering

³ The close relationship between the energy efficiency and green housing is reaffirmed by the fact that some academic works regard them as two aspects of the same. For instance, see [13: 236]: “Nowadays, the green housing concept includes housing units with their own energy source and low energy consumption, which reduces its negative impact on the environment”. Such simplified opinion is not adequate, as it will be shown as follows.

Congress⁴, about one third of total energy in continental-climate countries is consumed for the purpose of heating. The harsher the climate, the higher is this percentage: in USA it amounts to 25%, in Finland it is 29%, while in Poland about 34-38% of total energy is consumed in residential sector, three thirds of it accounting for heating. However, homes also lose thermal energy through heat, air and humidity exchange to the outside. Thermal energy is lost through three main channels: through the solid constructions enclosing the house (walls, floor, attic), through the transparent parts, such as windows and through the air circulation (see figure 2 [10]). The losses through these channels are approximately the same in amount. In case one of the channels is closed, the energy loss will increase through the others. It is therefore necessary to prevent the energy escape through all the channels simultaneously. In the present high-priced energy situation, this proves to be extremely costly.

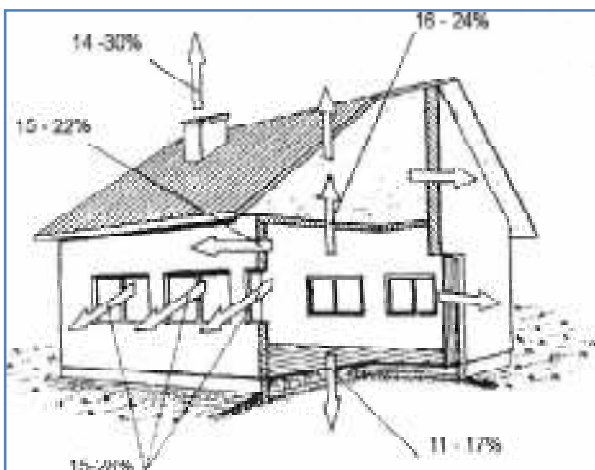


Figure 2. An approximate energy loss percentage in a regular home

Today's technologies cut down the heat loss to the point of sustaining homes without any heating whatsoever, even in the harshest climate conditions, such as for instance the ones in Eastern Europe, especially in Russia⁵. In order to achieve that, it is recommended that eco-homes apply certain standards, such as radiant heating, considered more

⁴ According to [23: 397].

⁵ Heat loss depends on the physical geographic conditions, that is on the harshness of the climate and it is proportional to temperature lowering as well as to longer periods of low temperatures. The harshness of a heating period is calculated as a product of an average temperature interval below 18°C and an average length of the heating period in days. This parameter in Russia ranges from 1,044 in Sochi and 12,045 in Oymyakon, while in Moscow region it equals to 5,025. This indicator in USA is on average 2,700, in Germany 3,160 and in Sweden it is 4,020. [23: 398]

economical and hygienic, correctly organized ventilation, an appropriate level of oxygen, which should be maintained not by the nowadays common passive ventilation, but through a series of other measures. In addition to a reducing reasonably the air escape, other measures should be taken to improve the ventilation system, such as a reduction of infiltration and internal air, the use of controlled ventilation while recovering the expelled heat, installing a correction system and an improvement of air quality.

Overall, energy is a sine qua non of an eco-home, and it should definitely be obtained from renewable sources. According to the UN classification, there belong the solar, wind, biomass and tide energy, as well as the water layer temperature differences, geothermal, hydraulic and a series of other energy sources. Hydro-power plants and biofuels could also be considered as renewable, but only under the condition that the dams are small and do not change significantly the hydro-system of the terrain and providing the biofuels are extracted from annual plants. However, the solar energy is the simplest one to use in addition to being plentiful enough in most parts of the planet to satisfy all the needs of the eco-home. Devices and equipment have been developed to convert solar energy into thermal, chemical or even electric energy with the help of infrared spectrum.

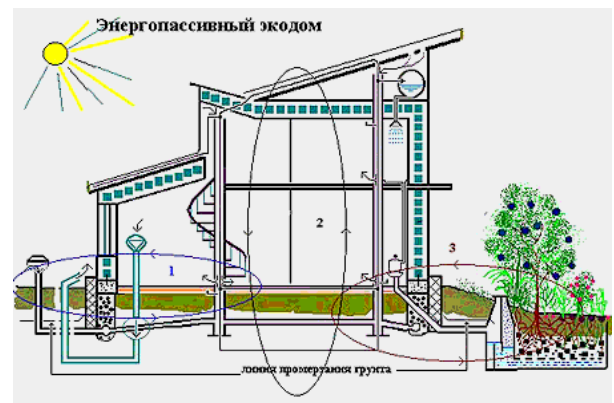


Figure 3. Circulation of matter and energy in an energy-passive eco-home: 1. Air, 2. Thermal energy, 3. Waste recycling

Figure 3 shows a diagram of matter, energy and waste circulation in the eco-home represented in figure 1.

Eco-home: water and waste

A regular house receives from the outside electrical energy, gas and other fuels, cold and hot water, air, consumables and information. By merely existing and functioning, a house and its by-products

cause certain issues. The most important of these by-products are wastewater and solid waste.

In big cities, an individual spends an average of a few hundreds liters of water per day, quantity that by far exceeds the actual necessity.⁶ Modern water supply systems deliver water at distances measured by hundreds of kilometers. These are huge, outspread technical systems, whose construction, maintenance and exploitation consumes large amounts of resources, thus harming the environment significantly. According to some estimates, about 30% of water is wasted within the system itself. The percentage could even be higher, depending on the system deterioration state and other factors. In addition to the water waste caused by the use of different home devices, its percentage could rise up to 50 or even higher. In countries where water delivered from the water supply systems is used for drinking as well as for other needs, such as in case of Serbia, the irrational consumption problem is aggravated by the loss of high-quality water.

Waters of different pollution grade and structure end up mixing in the sewage, which makes it difficult to purify them later on. The mixing of domestic and industrial wastewaters proves to cause even more trouble. The wastewater treatment process results in sewage sludge, which could be used as a fertilizer if it were not contaminated with heavy metals and other stable toxins. Therefore, it must be disposed of and this way, it continues being a secondary pollutant.

Besides the cited ones, another significant drawback of centralized water supply and sewage systems is their relatively low water economy, considering the fact that their maintenance accounts for the biggest part of the total expenses related to them. It is therefore estimated that water economy could only be improved by 15-20%.

On account of this, it can be concluded that the modern centralized water supply and sewage systems are technically, ecologically and economically deficient. This is the reason why more and more traditional houses are relying on individual water supply and treatment. When it comes to these aspects, the eco-home can take even more pride in its performance. The major differences in comparison with the traditional house lie in the division of waters according to their purification grade and purpose as well as in managing efficiency without compromising

the consumer standards. In order to achieve that, a larger number of water pipes need to be placed near the water source, and they should accordingly be as short as possible. The treatment process and technology will depend on the water composition at the source point. The appearance of the water filter announced the potential of the eco-home.

One of the possible water sources could be rainfall, which should not be used for purposes other than watering plants except in very exceptional cases. Unfortunately, in today's Serbia, the precious potable water is used for this purpose. Another aspect of using rainfall for watering is an approximation of local and natural water balance.

According to the results of investigations, flush toilets account for about one half of total domestic water consumption, bathrooms account for about a third, while the rest is consumed for the purposes of washing, cleaning, dishwashing and food preparation. This is the area where the eco-home offers vast possibilities for reaching greater water economy. The use of dry toilets is encouraged in eco-homes, which not only affects the direct water economy but also the wastewater quantity. Even though the modern cleaning tools are becoming more efficient and greener, their characteristics still leave much to be desired. We should expect the appearance of efficient non-reagent cleaning technologies based on the physical effects, such as ultrasound and cavitation. This will greatly facilitate the wastewater purification and reuse. The wastewater treatment systems in an eco-home must be separated structure- and function-wise in order to different sorts of purification to take place, depending on the wastewater contents. The sludge produced this way can be transferred to bio-toilets where it would merge with feces and organic waste to be transformed into fertilizer. It is surely possible to foresee an appearance of non-standard waste, which would require special treatment technology. The use of bio-toilets in eco-homes will have other effects, above all by reducing the soil erosion, which is currently turning from renewable into a non-renewable resource thanks to the use of the modern agriculture methods. Today, many bio-toilet constructions already exist. One of the most famous ones is the Clivus Multrum (KM)⁷ non-water composting toilet, which contains no mobile pieces and consumes no energy. It is made up of a several cubic meters room, located in the warm basement of

⁶ According to the Rio 92 Conference documents, by 2000 it was planned to provide every city resident with a minimum of 40 liters of high-quality drinking water per day.

⁷ See [2] for more details.

an eco-home. The room is divided into three parts, whose contents, affected by the gravity, move over the time down from a higher to a lower cell, where they are taken out from periodically (once per 1.5 to 2 years), transformed into fertilizer concentrate. The use of such fertilizer would solve the problem of degradation of the agricultural land, already faced by practically all the countries in the world. The safety of the whole installation and that of the product itself is guaranteed for by the Swedish Ministry of Health, after their years of experience using bio-toilets. Of course, it is necessary to ensure that certain kinds of waste such as plastic packaging are not disposed of, since they are practically non-degradable. Since a KM is planned to also receive food and bio-waste through a special opening, this product has all the features of an authentic bioreactor.

One of the most promising and most intensively developed ways to purify wastewater consist of transferring it to special bio-lakes and botanical surfaces where people could take advantage of the ability of sugarcane and other water plants to feed on organic compounds, pathogenic bacteria and other chemical pollutants.

Eco-home and waste issues

According to the projections of the UN, by the middle of this century, the world population will have risen up to 9 billion, most of the planet inhabitants living in cities. Urban areas already have more waste-related issues than rural areas. On the other hand, the better standard of living and city population rise will only exacerbate the problem. Nowadays, domestic solid waste amounts can already be compared to the industrial waste amounts. This is one of the reasons why the removal and disposal of waste is one of the most serious global issues, while the system dealing with the problem is a whole industry, comprising many different activities and requiring a large amount of funds, resources and non-qualified and physically hard work. Considering the fact that the contemporary society is dominated by the production and consumption of single use goods, based on the use-and-throw principle, all the domestic waste components are valuable secondary resources, at least until they are mixed. Landfill issues affect most cities. It should be noted that even legal and above all illegal landfills have negative side effects, reflected in additional soil, underground waters and air contamination. In this way, the main goals of sustainable development of human settlements find themselves even more hindered. Underestimation and

irresponsible behavior towards waste imply serious energy, resource and ecological losses.

Having in mind the future tendencies, the waste issue could be solved by accepting the following principles: 1) reduction instead of creating more waste, 2) reuse; 3) recycling.⁸ Moreover, the reuse and recycling of waste open up a new market, a waste market. According to the estimates of OECD, the yearly exchange of communal waste could reach the value of about 120 and in case of industrial waste even 147 billion USD. The issues related to the reuse of solid waste (solid material recycling), have been known for a long time, even though in Serbia they have not yet been systematically solved, as in other, more developed countries⁹. Today's developing countries are estimated to recycle less than 10% of city waste, while only its small part is treated respecting the corresponding regulations.¹⁰ However, the eco-home also offers significant advantages in this area. No later than in the eco-home planning phase, special spaces must be designated within the house for primary treatment of waste, its separate collection and safe storing. On the other hand, as in case of bio-toilets, plastic waste is a special problem requiring special measures. For instance, in some of the American States it is prohibited to use plastic packaging for food products.

The waste issues are multiplied by the fact that a significant part of solid communal waste is simply not managed, unlike some other kinds of waste, for instance: accumulators, batteries, pesticides in traits, photographic chemicals, household chemicals, solvents and paint. As one can conclude, the nature of some of these types of waste is dangerous, even toxic. In this group are also explosive substances, liquid gas, inflammable liquids, solid materials, as well as self-flammable substances, oxidized, contagious, radioactive, corrodible, and other similar kinds of waste.¹¹

⁸ WBCSD. *All About: Food and the environmental, Reduction should be target, Parliament votes in favor of waste recycling incineration.* (as in [9: 96].)

⁹ About 40% of total paper in the world is produced from mackle paper (53% in Sweden, 42% in Japan and 46% in Western Europe). Besides that, more than half of the waste in Japan is reused. [23: 419]

¹⁰ This is especially big of a problem in Serbia, where composting idea is only in its beginning. See [23].

¹¹ Collecting data on hazardous waste was only organized in Serbia a few years ago. It is estimated that there has been an average of another 8 million tons of hazardous materials per year in FR Yugoslavia since the embargo in the early 1990's. [17: 202] According to the data of the Ministry and Agency for Environmental Protection, the amount of hazardous waste in 2007 was 5.2, rising up to 5.7 million tons in 2008 [16: 129].

When it comes to eco-homes and their advantages, especially referring to the waste production, it is certainly to take into consideration its complete life cycle, including not only the exploitation phase, but also construction and utilization after its expiration date, while the utilization phase consists of nothing but applying the well-known recycling principles to all the physical products and goods. Since the existing construction technologies cannot be considered green¹², an eco-home construction must be based on the use of new technologies. The eco-home is a low-rise house, therefore its construction does not require the use of especially solid materials and qualified staff, which is the case in multi-story and complex buildings. On the other hand, its construction turns less energy-intensive. A major part of construction work can be performed by the future users themselves, by using local construction materials and mini-technologies developing recently. At last, providing for the functioning of an eco-home in the broadest sense requires less production force, so the engaged companies will mostly be high-technology companies producing little waste.

Other features and advantages of the eco-home

A low-rise eco-home with its auxiliary buildings can fit into the natural environment more easily and without harming the environment. Its possibilities to function this way are significantly higher than in case of an ordinary low-rise eco-home thanks to the modern resource-saving technology, which lowers the impact on the surrounding eco-systems. Regardless of their common basic principles, eco-homes will differ depending on the geographic environment.

In regards to the presence of plants in and around an eco-home, it is certainly very desirable and useful. Having plants at home can improve the hygiene, the aesthetic quality of life and after all, they could even provide fruits, a function that should not be underestimated. Plants can also play other roles, such as being used as interior decoration or as medicine, along with their important role in humidity regulation, oxygen production, destruction of harmful substances and micro-organisms and so forth.

Permaculture is a special concept related to the eco-home, meaning a long-term, stable kind of agriculture. The main idea of permaculture is that people should create their own eco-systems, which should include as many species useful for humans as

possible. Permaculture systems have all the features of natural eco-systems: biological diversity, stability, self-reproduction. Adopting permaculture principles can result in the relationship between invested and gained energy being 1:100, which is much more advantageous than 1:60 to 1:20, obtained in primitive agricultural production, and especially when compared to intensive production, such as the USA farming, where this ratio is 10:1.

Living in eco-homes will contribute to a gradual return to the traditional, community way of living, which has already been forgotten in many regions and countries around the world. Besides that, thanks to being based on green principles, the eco-home can have other positive effects on human life and health, as well as on the whole community.

4. ECONOMIC AND ECOLOGICAL ASPECTS OF THE ECO-HOME AND ECO-SETTLEMENTS

The eco-home features that have been described clearly show its multiple advantages compared to the standard home. Following is a review of some of its ecological and economic advantages in specific conditions rural and urban areas.

Eco-home and rural communities development

There are no formal limitations and obstacles to applying the eco-home as a development concept in both urban and rural areas. However, practical problems and obstacles do exist. Their essence is reflected in already over-sized and heavily built up cities with vast infrastructure systems burdening the environment and making the cities inflexible and unsuitable for the necessary changes. This is why it seems more probable that the eco-home project will start in the less populated and less built up rural areas, only later to spread to urban areas. The message is clear: rural areas should not be developed after the example of city development, since this is neither necessary nor affordable, and even if this path were taken and such effects were achieved, the experience proves that they would not be worth the effort and all the funds invested. It can therefore be concluded that the eco-development of rural areas is evidently a good path to take.

Eco-settlements made up of eco-homes could, be of different sizes and construction of bigger eco-settlements, for instance around large companies, is a possibility that could not be ruled out. In any case, however, they are not likely to reach the size of a megalopolis. The need to build large settlements,

¹² According to expert estimates, 5-7 tons of waste are produced during a house construction in the USA.

especially the size of a megalopolis, will disappear not only thanks to the conscious actions taken to prevent it, but also because of the eco-home and eco-settlement nature. Their construction will mean that the engineering and communal infrastructure will cease to be necessary, as well as some of the industrial and other activities, warehouses, landfills and so on. All this does not mean that there will be no cities, but their character and size will change significantly. Cities will start “getting closer” to small towns and differences between them will start disappearing, although even nowadays they seem to be quite relative in many aspects. However, the essence of this “approximation” is the exact opposite of today’s phenomenon of rural areas urbanization. This is just another proof to underline the notion that the rural settlements should not be developed so that they have all the same issues that cities already have.



Figure 4. Eco-village - 2000 Project, Minsk

Figure 4 shows a scale model of an eco-village developed as a part of the “Eco-Houses with “0”-Energy Level Built of Natural Materials” project, for the occasion of the Minsk International Conference, held in 2000.

Eco-home and development of urban communities¹³

For a long period of time, considered to have lasted several thousands of years, people lived in villages, which were obviously able to provide an acceptable level of services to satisfy people’s needs. Then, about five to six thousands of years ago, people started building cities. For a certain period of time, they also satisfied the needs of their inhabitants, a fact that, according to Doxiadis [5: 17], might need to be

¹³ In his first paper about the ecological living issues [3] the author did not deal with the aspects of urban communities, eco-homes and eco-settlements, but he expanded on those issues in his later work [4].

considered as surprising, having in mind the constant technological advances that quickly improve the living conditions in cities. On the other hand, living in cities has more and more negative consequences: more people are suffering traffic accidents, moving around a city consumes a lot of time and effort, social and racial issues are multiplying, crime rates are high and getting higher, sanitary situation is becoming more difficult to manage and maintain, and even more difficult to improve. It is becoming obvious that the human settlements, especially urban ones cannot provide for high-quality living conditions. The question is how to improve the living standard in cities, or put in other words, is it possible to integrate eco-homes into cities? Bearing in mind everything that has been said about the eco-home, this seems to be possible.

The clustering of eco-homes into eco-settlements creates a complete living environment, which can be a village or a distinct area within a bigger settlement, since settlements can be of different sizes, excluding megalopolis.

The described energy-efficient features of eco-homes enable them to be autonomous instead of relying on communal engineering networks. Since these networks are a fundamental feature of today’s cities, this new advantage could change the way we project cities. The minimized influence of this factor will modify and reshape the cities, changing their appearance and structure.

First efforts to transform cities were first taken in the second half of 19th century, as a consequence of the overly intensive city growth and of the industrialization process, as its direct cause. This process, known as an ecologization of cities, went through several phases, but none of them resulted in success. Some of these efforts even had adverse effects, as was the case with Le Corbusier’s idea and realization of his vertical city project, i.e. the building of tall buildings, which were supposed to leave more space for greenery.¹⁴

The newest tendencies are, however, taking the opposite approach: that of developing smaller settlements. The population density in eco-settlements will be lower, since the available land will be used more effectively – there will be fewer industrial and communal properties and warehouse facilities. It is recommended that auxiliary and industrial buildings, such as garages, agricultural

¹⁴ According to Le Corbusier’s urbanism principles, only two cities have been built in the world: Chandigarh, India, a city of 150,000 inhabitants and Brasilia (projected by his followers). According to the general expert opinion, both of these cities were disastrous failures.

equipment warehouses, be included into homes. Space for these facilities could be found either in the basement or in the second floor industrial compartment. The separation of these spaces should be avoided, since it can change the geological structure and harm the hydrological balance of the soil. Due to the safety issues related to them, the only exceptions may be seasonal food and energy-accumulator storages.

Today's vast asphalt- and concrete-covered surfaces will be turned into green spaces, which will significantly improve the microclimate and the hydrological balance and at the same time this will reduce the necessity for huge storm drain systems. On the other hand, road networks, pedestrian crossings, bicycle trails and passages in city microzones should be constructed above ground level, keeping the ground surfaces free.



Figure 5. St. Petersburg Sustainable Urban Community Development Project

Eco-settlements and green microzones will not need a centralized sewage system. However, in case of complex hydrological conditions storm drains will be necessary, although not as much as now.

Eco-settlements will not necessarily mean a full autonomy of all houses, since in some cases the merging of some engineering systems into collective networks could prove to be useful. Above all, this refers to energy systems. In this case, during the transformation of accumulated energy into electrical energy, thermal energy loss problems will arise (about 25% will be lost). These are some already frequent issues and solving them should not be too hard. The installation of accumulators near certain institutions could be a part of the solution. Also, using collective water supply systems and collective renewable energy sources could be acceptable in some cases.

Figure 5 shows a typical ecological multi-story building project, developed in 1966 in Sankt Petersburg. The vital principles of the project are recycling, energy saving and composting for the

purpose of rooftop gardening; techniques which have all already been presented, only adapted to a multi-story building.

In this way, an eco-settlement consisting of multiple eco-homes would differ from today's urban areas in many aspects and the state of its environment would improve significantly. Therefore, social psychological environment and life quality would change. It should be noted that in urban areas, not only residential, but also industrial, communal and other areas (administrative buildings, cultural and health care institutions) would still be relevant. Because of their specific nature, some of these would still be preferably multi-story buildings and regardless of the undoubtedly better quality of life, this would certainly make it impossible to reach the eco-home quality.

Multi-story buildings should be planned to be separate units with a corresponding local engineering network. At the same time, these neighborhoods would be the city areas where recycling would take place. This system would substitute today's system of waste disposal, which does not solve issues related to the environmental contamination.

5. CONCLUDING REMARKS

Considering the current state of human settlements and not only when it comes to different countries with different natural (comprising climate, hydrology and pedology), economic and social circumstances, but also when it comes to different settlements within the same country, it is clear that reaching a sustainable development of human settlements will not be linear and uniform and that it will differ depending on the place. However, the eco-home concept, as described in this text, is able to satisfy the basic economic, technological and especially ecological requirements and principles that are put before development in this century, exactly as defined in Agenda 21.

Many countries have already taken some measures to implement the eco-home concept. Therefore, their experiences could be invaluable once Serbia has started working on a certain project. The fact that they include some of the countries that are unjustly underestimated in Serbia should not be a reason to have doubts about these projects, on the contrary! It is their experiences that should be the starting point and a positive example of how, even with modest funding, ideas can be devised and carried out, which are ahead of their time. One of them is Belarus, a country that is forced to deal with energy

issues and other problems related to sustainable development in a serious and systematic way due to its natural and other circumstances. The experiences of Belarus [6] should certainly be taken into consideration.

The authors of this project, as well as other authors of such projects, state that it is and will continue being strongly opposed by big construction companies and the traditional construction materials industry. However, as the authors of another project [22] dealing with urban areas, claim, resistance can also be expected from local authorities, from bureaucratic structures when it comes to obtaining the necessary documentation and from the older and more conservative part of the population, typically opposing new ideas. Of course, other problems could also be added to this list; some can be expected and identified in the very beginning and others will inevitably arise once the project enters the implementation phase. However, these are expected reactions and in no way should they prevent projects like these to be carried out. In smaller towns and rural areas, such resistance should not be expected, at least not to the same extent.

As we can see in the advantages of the eco-home and eco-settlements described in this text, the cost-related issues, indispensable for the implementation of every project, would be minimized by their advantages in the aspects of energy, waste, water etc. The economic justification of this project is more than obvious. As emphasized in the introduction, the economic and ecological elements of human life and activity are inextricable, supporting and reaffirming each other. This is why there should not be doubt that, once they have begun, these projects will be brought to an end.

It is important to emphasize the role of civil engineering and especially of housing sector in helping the industry and even a whole country to get out of crisis. Construction participates in total gross value added with only less than 5.5% but the implementation of any investment project requires the participation of many other activities. This is especially the case with housing construction, which accounts for almost 19% of the total value of works done within construction. According to the criteria used in developed countries, in order to restore the primary market of dwelling, which is considered to be one of the main requirements for the recovery of the construction branch, as well as for the economy as a whole, the price of a square meter should not exceed a two-month average salary. In today's circumstances, it is hard to expect any and especially not a significant

salary increase in the near future. The solution should therefore be found in a housing costs reduction. One of the possible ways to manage that is by using the effective construction technologies that have either already been developed or are being currently developed and perfected as parts of the eco-home and eco-settlement projects. One of the interesting projects whose essence lies in the use of effective technology, based on straw-bale construction, was developed by the vicepresident of the International Academy of Ecology Evgeniy Shirokov [22]. Eco-homes construction started in Belarus in 1996, while the first energy autonomous home was made with straw bales in Belarus village of Beloruchye in 2008. Besides the described advantages, they are characterized by extremely fast and easy construction, as well as fire-resistance.

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