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STRIVING FOR SUSTAINABLE ARCHITECTURE IN THE 21ST CENTURY – MAIN ISSUES IN THE DEVELOPMENT OF INNOVATIVE OFFICE SPACE CONCEPTS

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Abstract

The knowledge on office building in the past and present, how the workspace evolved to incorporate contemporary technological breakthroughs, was in this paper combined with goals of sustainable building in a "smart" office building design in Belgrade, Serbia, taking local factors into consideration to create a comfortable space for the employees in a dense urban matrix with a minimal environmental footprint, and considering the workflow of contemporary office spaces, it's multidirectional input and increasingly horizontal work hierarchy. Issues of proper inputs for building today in the 21st century are thoroughly considered in this paper and respective building's design features as shown here: how to deal with location, position and orientation of the building, organization of both formal and informal areas, natural ventilation, green glazed surfaces, solar energy, wind turbines, rainwater utilization measures, surrounding vegetation, lighting and appliances, and piezoelectric paving.

Keywords: **Location, position and orientation; Formal and informal areas; Natural ventilation; Green glazed surfaces; Solar energy; Wind turbines; Rainwater; Vegetation; Lighting and appliances; Piezoelectric paving.**

1. INTRODUCTION

Today's buildings, like the one shown in this paper in detail (JB Headquarters, Belgrade, Serbia by ArhiArhi. Belgrade, Serbia), designed in accordance with contemporary technologies, are increasingly energy-independent and less and less dependent on the long-established conventional power-consumer system. Sustainable architecture involves the integration of various energy production and conservation methods into the building itself, to provide a clean and inexpensive source of energy for permanent use [1]. Global concern for current condition in which our planet is, makes a challenge to all the professions, therefore many architects are trying to contribute to the solution of the problem.

Architects, whose job is to plan, draw designs and make great interventions in our environment, are trying to turn themselves to nature, its postulates, and base their designs on that. Only in this way they can enable their buildings to live in synergy with the environment. Appreciation of nature and its value in our lives, and that of future generations, is the most important element of sustainable design. The building should truly reflect the ongoing search for expressing our relationship with nature through its design and language.

1.1. Context and background

Taking this even further, a building's design can have a direct effect on how we assimilate, learn, and integrate with other people and how society integrate sustainability into our lives. A building has the potential to teach and convey new ways in which sustainable principles materialize. In this way architects are taking a role of some sort of educators. Their design is stimulating users to exploit space in the best possible way. This aspect of architecture as a profession comes to the limelight when we are discussing designs for office buildings as well. These are places where a substantial part of our society is at work. Nowadays architects are mostly willing to implement sustainable concept in office design and alternative energy resources. They respect the environment, and in that way, they are actively involved in shaping common awareness about global problems. Building design can demonstrate architect`s solutions to this growing problem.

After some initial major investments in various systems that are installed in the facilities, huge savings are made during their life cycle and the environment remains cleaner. This is exactly why and where architecture designers should strive for more emphasis to the role of the case studies like the one elaborated in this paper as frontrunners in architecture developments in the future. This also must emerge as the scope of future studies and designs' goals that shall surely show the use of more scientific methods to improve sustainable performances' levels against current situation and rating systems' thresholds.

1.2. Inputs

The idea of a self-sustaining private home, as an easily achievable goal for every individual, is increasingly prevalent. One of the latest inventions in this direction is roofing tiles made with integrated photo-voltaic cells at the beginning of 2000s, an invention more recently continued by Tesla, Inc. Of course, the biggest savings and profits are made in large consumer establishments, such as public and office buildings or industrial plants. These objects are supported by their sheer size. Their pillars have a large cross section, so they can install natural ventilation ducts, wind catchers, as well as rainwater drains through which the water is discharged into underground tanks, from which it can then be used for various purposes instead of otherwise going to the sewage system. Large buildings usually have a large roof area, which in contemporary buildings is usually flat and sometimes used as a terrace, which often remains completely empty, without any essential function, instead of being arranged and equipped to ensure the use of large potentials of solar energy.

Large facades are another point of great interest for architects in this regard. In addition to their usually large glass surfaces, there is always a part on the facades that covers the ceiling and the suspended ceiling. It is this zone on the facades that is the right place for green walls or, if exposed to the south, solar panels. This is particularly interesting in the domain of skyscrapers, where the façade envelope is at least ten times larger than the roof area [2].

1.3. Location

The property is located on South Boulevard, facing south, facing residential homes and buildings, and close to the Highway and Autokomanda, on the west side, and King Alexander Boulevard, on the north and east sides. The isolated position relative to the main roads partly separates it from the crowds and makes it easier for employees to access. There are also several legal and administrative facilities nearby, such as a court, police station, etc., with which companies located here could also do business.

The site currently houses a grove and old barracks of various warehouses. Such a building would increase the value of its entire surroundings, and with its low-rise character would not endanger nearby family houses and low buildings. The adjacent building, which serves as a storehouse in its outline, supports the design of the building itself and the access roads overlap. The underground garage of the facility, intended for the parking of only employees' vehicles, is reached down a ramp located on the east side of the site. After parking, employees can enter the ground floor of the building with internal vertical communications, or the main entrance on the ground floor, which is reached by steps located directly west of the ramp. Visitors to the building leave their vehicles in the parking lot in front of the entrance, at ground floor level.

2. PROJECT CONCEPT

2.1. About the project

Basic criteria for the sustainability of a building relate to electricity consumption and its sources, CO_2 footprint and drinking water consumption. These parameters are considered to get as close as possible to the maximum possible values, since sustainability cannot be observed on only one object, and its wider environment must also be kept in mind. That is why some of the procedures relevant primarily to administrative buildings are covered here [3].

Energy-saving measures relate to ventilation, cooling, and heating, as well as the use of lighting and operating devices, this means that new devices and lighting solution must consume energy more efficiently. These measures are complementary to local energy production, primarily in the form of solar and wind energy, but also of geothermal energy, which is largely present in the country, Serbia. Then there is the energy of falling water, when collecting rainwater, biofuels and, finally, an innovation from the world of physics, a very interesting idea concerning piezoelectric materials that respond to human movement and thus produce energy. Comfort measures are a natural consequence of measures for better energy consumption, but they are further enhanced using a green facade and roof, by letting light and air through atriums, by using rainwater for certain, usually cleaning purposes and the like. For most of these measures, saving money and time is the primary consideration, and comfort and sustainability are only secondary. But, in the end-product, these secondary ones are most striking, which are the enduring goal of such contemporary architecture.

2.2. Position and orientation

The building is freely erected on its plot and closed to the sides where there are other buildings. The front is fully open and overlooks the main street (South Boulevard). This position of the building leaves a lot of room for installations on its façade, as well as below or above it, without any disturbance to the surrounding buildings.

The building is designed in accordance with the rules of sustainable architecture, keeping in mind both its usual engineering components and its IT-related components. Only its front completely opens, as opening every other side would endanger the residents of the neighboring plots who live in low-rise houses with private yards. It is an office building, whose regular activity at an accelerated daily pace could upset the residents of the surrounding buildings, who certainly want to keep their own peace in their apartments and enjoy the slower pace of their private lives. Therefore, openings are provided only on the front and back of the building, which are open to the streets and cannot bother anyone.

The back of the building is oriented north, gets less sun exposure and has panels with moss-like plants, which love the shade and make the building more beautiful for views from the neighborhood. [4] The adjacent boulevard is used as a stream that channels airflow to, from and around the building. Instead of trees and people just swinging in the street when they go outside, this energy will be used to power a small part of the interior electrical appliances in the workspaces of the building. The shape of the building itself is such that its “chipped” sides cut the incoming air streams and channel it from all sides. Small wind turbines are planned on the top of the building, which convert that constant movement of air into energy [5].

2.3. Underground garage

Parking is always an important issue when designing buildings [6]. The human body, viewed from above, is approximated to a 60 x 60 cm square, while cars are about 230 x 500 cm. The space used for parking vehicles is certainly one of the important elements already at the beginning of designing a building, especially a building for commercial use where workers arrive from all parts of the city and wider. The construction grid selected for this facility is 8 x 8 m, which fully meets the required building standards, and allows for the rational placement of as many parking spaces as possible. One car spends 90% of its time stationary, in one place, and constantly occupies 12.5 m^2.

Emission of gases is an extremely important element in environmental sustainability [7]. In addition to having enough parking spaces, it also has space for bicycle storage for employees who prefer this type of transportation. The space for manipulating vehicles in the parking garage is 6 meters wide, which is ideal for parking at 90 degrees. The pillars, which share the directions of driving through the garage, by their very orientation, direct how to drive inside the parking lot and avoid a collision. They can also be used to place advertisements and similar panels, which should be visible. Below each parking spot is a smaller light sensor, which always senses whether the shadow of the vehicle falls on it, so a large digital board can display the information at the entrance to the building, which also shows the exact positions of vacancies.

2.4. Ground floor

The entrance to the ground floor of the building is located near the stairs and elevators. Next to the entrance area with a windshield is a reception desk with a smaller seating area, as well as coffee shops where client visitors can talk if needed.

The beveled edge of the building adds to the dynamism of its mass, and on one side there is a car entrance to the underground garage. A 30-degree angle of entry allows the cars at the inlet or outlet to not interfere at right angles, but at a much more favorable obtuse angle, which reduces the turning angle of the car and provides more usable space.

2.5. Floors

Inside the building, there is a large open space at all levels, suitable for social interaction among employees and for a good working atmosphere. In this way, the maximum utilization of natural light, which enters both longitudinal sides, is also ensured. The openness of the workspace allows ventilation of the interior through the vertical columns, which extend the entire height of the building, through all floors. The bathrooms and vertical communications are located along the edge of the building, where there is also an empty space for connection of installations, including the drainage of water from the roof to the underground tank.

The workspace is practically open space, where all employees work together. There is also a handy kitchen with desks where employees can rest while preparing a snack or just sit and take a breather, a site for impromptu conversations and rest. Kitchen appliances are powered by the solar panels and wind turbines located on the roof of the property, which can provide enough power for them, considering the buildings location. There are also large reclining chairs in the workspace, which have a board on which a laptop is placed. They are extremely important for casual use, at a time when employees can no longer sit hunched over at the computer, so they need to get a little better. In order not to abuse, and not to reduce the productivity of employees, such chairs are placed next to the office of the chief and his secretary.

3. PROJECT TECHNOLOGIES

3.1. Natural ventilation – Sections

The principle of the ancient Persian wind catchers applied all over this ancient country and especially in the city of Jazd. The catchers which could use the cold of the surrounding desert at night to make ice for food storage, is in itself very simple and still applicable today. Pipe openings in the roof of the building turn in the direction of the dominant wind, and with them sheltered lower openings are placed through which warm air leaves the building.

Within this project, three verticals are planned for the introduction of fresh air into the building, two along the pillars and one covering the entire staircase. [8] In addition to these, there are two more verticals that expel warm air, both of which target the roof greenhouse. In addition to heat, this air also contains a large amount of CO_2 and water vapor, as it comes from workplaces where people work all day in two shifts, and its natural destination is among plants. Plants process that air cooling into the garden through the vertical shared with the rainwater drain, and a small canal terminal that runs through the garden. Located by the cold-water drain, the air cools further and returns to the bottom of the vertical, where it flows below the floor and rises upwards [9].

3.2. Green glazed surfaces

Large, glazed surfaces as usually a substantial part of the building envelope in office buildings are good for lighting deep spaces and are desirable in office space. But the big disadvantage of these systems is that the glass also lets in infrared rays, thus warming the inside of the building. The role of insulation and transmission is of particular importance in providing necessary indoor environment and must be very carefully considered and calculated in advance, i.e., already in the design process.

The solution is to install ever more advanced systems of green vertical gardens. Considering the functionality of the interior, the layout of the windows and garden components on the façade has been designed, which also satisfies the conditions of light and thermal comfort.

Contemporary green facades are based on a similar principle – nanobiome, the basis of which is the overlapping of functional schemes of plants and patterns of sunlight intensity on the entire façade area to maximize the amount of green cover, but there is always sufficient space for plant development, so that a large area remains clear to light the interior [10]. Plants are stunted due to unequal living conditions for everyone on the panel. The watering system uses water vapor and capillary movement of water through vapor permeable pots, which greatly facilitates the construction of the panel itself and the entire facade, as there are no water pipes, and there is no risk of freezing and bursting of pipes in winter.

The green façade lowers the temperature by 2–3°C near the building, regulates the humidity of the entire environment as well as inside the building and, of course, greatly increases the comfort level indoor for its employees. A similar principle was applied throughout the facade. In addition to the functional benefits, the application of this procedure has led to an interesting rhythm on the facade, which further contributes to the aesthetics.

3.3. Solar energy

By measuring radiation on the surface of the panel, it came to light that, at one square meter of any surface at noon, the energy of light reaches 1 kW per hour.

By measuring the amount of light energy that falls on a single panel, considering that it falls with 100% of its power during the daytime hours, and decreases relatively before and after, we have come to an average of 3.5 hours of full sunshine over a total of 24 hours in the day.

The contemporary quality of solar panels, which have an effect of 22–24% and therefore a capacity of 250–350 Wh per standard panel, of 2m^2 (2x1) or 1.5m^2 (1.6 x 0.9), has been considered. We calculate that 10 m^2 of solar panels gives an average contribution of 1200–1500 Wh (10 m^2 = 5 meters tract).

On the flat roof of the building, with a 72 m long solar front, about 30 panels in a row, or 60 m^2 of panels, 0.6 m in height can be placed. The next row must be at least 1.2 x heights from the roof, which is 1 m. Therefore, 5 rows or 300 m^2 of panels can be placed on a roof 16 meters deep.

If we multiply 300 m^2 by 1200 Wh, which is the lowest possible number, we get 36000 Wh. Daily, this is 144 kWh of electricity, and annually 56520 KWh. The office average by US standard is 126 KWh/m^2 average, and the 1152 m^2 floor consumes 122112 KWh annually.

From the calculation we can see that 300 m^2 of panels on the roof completely covers the needs of 1152 m^2 of office space, which in the case of a 3-storey building means that it covers 15% of the needs of the entire building. Of course, we take the smallest possible contribution of the panel and the highest possible consumption throughout the calculation. Panels integrated into the vertical garden would further increase the figure but did not enter the budget.

By investing in panels, the sustainability of the building increases significantly, while saving on electricity, which otherwise partially disappears in transmission. The emission from non-renewable energy sources is significantly reduced, as is the electricity bill.

The use of solar energy is a growing trend worldwide. Initially, solar panels were very expensive and still not sufficiently efficient. Over the next 25 years, this has changed significantly during their use around the world. In the early 1950s, technology embedded in solar panels ensured that only 6% of the captured sunlight was converted into efficient electricity, and today that figure goes beyond 25% [4]. The cost-effectiveness of this energy has increased significantly over time, reducing its cost, and making panels much more affordable today. One watt of non-renewable electricity costs about 50 cents, while today the same one watt obtained from solar energy costs only about $ 1.5.

3.4. Wind turbines

Wind turbines in cities and on top of buildings in theory seem like a good idea. It is usually stated that with the height the wind speed increases and that it can be used. Most cities are in geographically low areas, in a valley, where it is usually not too windy – that is why they are favorable places to live. The efficiency of wind turbines on the roofs of buildings, where due to the different shapes and heights of buildings of constant turbulence, is much lower than in open fields, where the wind flow is laminar, uniform. In such locations, solar panels are far more cost effective [11].

Northern Serbia with Belgrade is a zone where heavy northeastern wind blows for several months a year, and northern wind in winter. It is much different from typical cities in river valleys. Even the greater part of Belgrade is at the top of the hills exposed to the wind, especially from the east and southeast. Horizontal axis generators would be more advantageous here, as they generate more current and make better use of strong winds such as would be found in the surrounding environment.

The facility has 3–5 windmills with a capacity of 2 to 5 kW/h, which are driven by an average wind of 4.5 to 6 m/s. During the day, each windmill would generate 40 kW–150 kW, and the facility has a total of five such windmills, covering an area equivalent to 10 m^2 of solar panels. A high figure, but nowhere near as large as it would be for solar panels.

The real significance of this system is that it should be complementary to other systems, on days when the weather is stormy and cloudy, and the sun is almost gone. Then the panels do not contribute much to the production of energy, but windmills in such conditions have a greater contribution and compensate for their disadvantages. In synergy with ventilation ducts, vertical shaft generators can be installed that maximize the use of turbulent rising air.

3.5. Rainwater utilization measures

The use of water collected from the roof of the building has its roots in ancient civilizations, but it is largely neglected in the contemporary city [12]. This water is treated as unclean and directly discharged into the sewage system, causing major problems during periods of heavy rainfall. And in fact, this water is ideal for use in sanitary blocks, for irrigating green installations and for car washing [13]. Precisely these utilitarian functions use 85% of the water in buildings. The average person needs 2l of water a day, one toilet drains up to 400 ml of water each time, and it also requires a certain amount of water to provide pressure in the pipes. The same is true for watering plants, which can be aeroponic with advanced systems, through water vapor and small capillary tubes. Responsible, sustainable use of water is not expensive, it saves a lot and is very efficient. But this is precisely why it is not well advertised, because it does not bring profit to the manufacturer and supplier of the system, as energy solutions do. This simple installation saves a lot of money, is easy to maintain and control, but its main contribution is environmentally friendly and therefore should be applied as an integral solution for buildings, especially for administrative buildings that have a large surface of their sheath.

Belgrade has about 660 mm of atmospheric water fall per year, 75% of which is rainfall, i.e. 480 mm. It is possible to efficiently collect 70 to 90% of the precipitation that falls on the roof. This building has a roof area of 1152 m^2. 443 m^3 of water can be taken in as useful rainwater instead of simply going to the sewer. This water is routed through a rig through the middle of the roof and side drains, and then vertically channeled into underground tanks, where it passes through the filter system and becomes usable for hygiene, and perhaps even for drinking. The average household uses 11 m^3 of water, so the facility collects enough water per year for 44 households. Drains also runs through the roof garden, where part of the water is used for irrigation.

In addition to this large-scale installation, small modifications to the water consumption method and the use of two taps (for two types of water – beverage and utilitarian) would further increase the sustainability of the facility [14].

3.6. Surrounding vegetation

Gardening around significant administrative objects, as well as objects whose owners or users wish to emphasize their importance, has always been above all an indicator of power and harmony, but of human dominance over nature as well. It was an expression of the wealth of the owners and the skill applied in maintaining the gardens that would not have survived without a person's regular care. This is how parks, castles and palaces, alleys and boulevards were once decorated. The contemporary trend of sustainability brings us back to the principles of the design of old home gardens, which optimally use the land as the most valuable resource, to beautify a person's life and source of nutrition, and at the very threshold of his home [15].

This project around the facility envisages a garden with many easily viable and self-sustaining plants, primarily locally grown species. These are all plant species that will work and develop in synergy. Zoning was done primarily according to position and orientation, to isolate the object from its surroundings or to approach it. Particular attention was paid to the area of the building that is along the street, as the car is still a favorite means of transportation for employees. Air pollution in the parking area and access to the garage is always high. That is why a very special grass, the so-called Fountain Grass that uses the C4 photosynthesis system was selected for the area. This system involves the uptake of 3 to 4 times more carbon dioxide from the atmosphere. In addition, this plant, much more than others, binds heavy metals from the surrounding air, such as lead. Most of the C4 photosynthesis plant species are grasses and desert plants, so native shrubs; birch, elder shrubs, and spruce are selected as shrubs and tall plants. These plants have long been known for their healing effects on the surrounding air and their leaves or flowers are still used today for medicinal purposes. They can grow even in some lower quality soil areas and are very resilient and durable. In the shady parts of the site, conifers such as yew and juniper are located on the north side, enclosing the object from the street to the rear. Ordinary dandelion was chosen for the flowers, as was the sunflower along the main, southern façade. Both dandelion and sunflower are beautiful plants, very useful, easy to grow and maintain, although they are sometimes mistaken for weeds.

Another important feature is that deep root systems make the soil loose, which conserves water in it, and raises the level of nitrates and useful salts from the depth of the earth to plants with shallower roots. Vertical gardens grow flowering species that have a shallow root and tolerate moist air, such as various species of ivy and creeper, as well as tropical small-leaved plants. Successful planning of the surroundings of the building achieves both good aesthetics and a healthy impact on man and his surroundings, as well as great savings in irrigation water used for lawn maintenance [16]. A sustainable, responsible garden saves more than 70% of the water that otherwise goes to irrigate a classic representative garden, and looks equally good, if not much better.

3.7. Lighting and appliances

A major problem with most administrative buildings is the depth of their tract, which often does not allow optimal lighting in all spaces. This is somewhat addressed by high ceilings and open-space principle in the organization of workspaces, but the problem of lighting remains quite large even then. Lighting always brings with it a few problems. First, these are energy consumption and unnecessary space heating, followed by aesthetics, light comfort and temperature, as well as light color, which can negatively affect workers. This project envisages panel lights that fit perfectly with the ceiling structure, and which diffuse light with a diffuser to less disturb space. The LGP diode and diffuser board emits 35% less heat than conventional lights. Light is a milder, more moderate color, and helps make computer readability easier to read. Energy savings are achieved in the field of electricity (30%) and in the field of air-conditioning, because when the lights are not on, the climate and regulation do not have to work (40%), and the biggest reward is a much better productivity of workers, as a consequence improved and much more comfortable working environments, which directly increases firm's benefit and profit [17].

Here are devices without which every administrative facility is unthinkable, although large energy consumers are usually neglected in the design process, and in relation to the later life cycle of the building, as a factor of sustainability, although they are highly influenced. Immediately after the optimization of lighting, it is precisely the various appliances in the building that become the main consumer of electricity and heat emitter, and often with their continuous operation raise the temperature of the interior raises by 2 or 3 degrees Celsius, especially if the computers consist of two parts – the case and the monitor. The use of the latest and most efficient devices should be imperative in designing every new one and in remodeling every existing one so that it can be considered sustainable. This also implies the improvement of existing devices when possible, and regular maintenance.

A large problem in the interior is regularly caused by dust accumulating and clogging the cooling system, which is most seen with appliances located closer to the floor, below desks. Many cleaners are scared to clean the electronics so as not to spoil and damage it, but with this practice, the life span of the device is significantly reduced, and the work of employees is endangered.

The solution is to introduce computers that have an integrated monitor and chassis that stand on the desk and are ventilated directly by the air circulation in the workspace. Workers do not raise dust to their height with their movement and it is easy to train staff to clean them with synthetic cloths [18].

With the advancement of the technology of fuels synthesized from organic matter, gasoline or oil that do not contain heavy metals and additives that are harmful or even destructive to the environment can be produced from vegetable matter, whether nutritious or waste. Today, in many countries, corn and other cereals are being converted into biofuels, primarily ethanol, which is then used as fuel for cars. This is a waste of an extremely valuable resource that can, and should, be used on a far better way – to feed the population. It is possible to produce fuel of this kind from residues, from non-edible parts, because they contain complex compounds that are insoluble or even toxic. This method of maximum utilization of the produced has been applied in the past in the production of fertilizers and compost. It is certainly not a proper preference to give to a vehicle, not to the person using the vehicle. Using the whole plant in the process produces only 3 times more biofuel than when using only residues. In doing so, the food itself can be used or sold further for profit.

As this facility already has several wind turbines on it, which despite being lean, must have an extended base around them, as well as many solar panels that directly convert light into electricity, the space for the roof garden itself would cover 30–40% of the roof area. Although a glass garden may seem unnatural and close the space, it offers a higher level of climate control and increases horticultural success.

3.8. Piezoelectric paving

When all the above measures are considered in energy production and saving, most of them refer to the capture of energy from nature, which is currently being "dumped", because the technology for its use is more expensive, more difficult to install and requires maintenance. But it should be borne in mind that the energies from all these sources – light, chemical, and kinetic energy of wind, water, and the like – are all used to produce electricity and kinetic energy. Apart from all others, there is another source of energy that is present everywhere where humans are and has not been used at all – our movement, the kinetic energy of human steps [19].

The discovery of silicon as a micro conductor and its electrical properties contributed to the emergence of solar panels and efficient methods of transmitting electricity [20, 21, 22]. One of the interesting properties of silicon, i.e., of its crystals, as well as of certain barium and bismuth crystals, is also piezoelectricity – the translation of pressure energy into electricity. Recently, this property of the materials has also been used in the production of paving, and one of the successful examples is the installation under one football pitch in Brazil, which after a few hours of a football game gathered enough energy to keep the lights on for about 10 hours, or all night. Within the project, an analysis of workers' movements was carried out, which was very common in administrative facilities (paper transfer, communication between tables, serving, etc.). Certain zones and directions in the building show a higher frequency of movement, while others are significantly quieter. In places where the movement of employees is more frequent, instead of standard floor treatment, modular panels would be installed, generating several wattages per step. In addition to the landing boards, there are pavement lanes that can be successfully applied on the street and in the parking lot around the building.

The average number of steps of an office worker at work is about 7000, and the open-space principle in space organization further increases this number to about 8000. Of those 8000 steps, a third refers to the usual same route, from and to the entry zones, the main hallway, space with coffee maker and similar service, toilet, and stairs. This then means that it is about 2500 steps per person per day. The floor of this facility employs 70 employees, which then gives 175,000 steps as a minimum permanent number. One step per piezoelectric panel generates about 7–10 watts of electricity, which is then equal to a total of 1,225 megawatts per day for just one panel, which in turn is sufficient for ten hours of the whole floor! The only disadvantage of this system is the market purchase price, which is at least 200 E for a 50 x 50 cm board, which is, of course, a very high price per square meter of surface, but still quite cost effective over time.

Robots of this type are extremely useful and have long been in use in places where they need to work all day and all night to get some work done on time. They have emerged as a compulsory tool for the transfer of cargoes from intercontinental ships. Since ships of this size must be loaded and unloaded quickly, it takes several days, provided that they are operated 24 hours a day. That is why the work introduced small robots with strong motors, which have a certain path and pattern in their movement. Since then, they have also been widely used for office buildings, as they are an ideal cleaner. They move very fast, like mice, at about 10–20 km/h, and clean the floors and floors of the building during that time. They are interspersed with cameras inside the facility, which read the hygienic condition of the facility and create new routes that the robots then cross to clean further. Robots like these are increasingly being used for various gatherings, where they serve guests instead of real waiters while also cleaning the floor.

The robots have a built-in mechanism that reads the cards of all employees, which employees normally carry with them, thus avoiding getting close to the signal of the card at less than 1 m. This prevents the robot from colliding with employees. The robots are fully supported by the electrical current produced internally.

4. CONCLUSION

The challenge of designing a contemporary office building comes from two very different aspects. It comprises the social and economic aspect of the new workspace mentality, the shift towards more creative interpretations of the space, and incorporations of new areas for both work and leisure of the employees. Secondly the myriad of innovations towards an environmentally friendly building, which adapts to its surroundings and climate to leave a minimal footprint on the environment and save money on increasingly expensive non-renewable energy sources via the implementation of passive systems. These factors must all be held in mind to design even a simple office building where both the environment and the workers will be appreciated and able to work towards a creative, sustainable future.

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