ENERGY EFFICIENCY IN OFFICE BUILDINGS THROUGH SOLAR APPLICATIONS
Euro Sun 2010

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Usage of modern technologies and innovations may easily decrease energy consumption in a building. But how profitable such a complicated system is for real? Complicating the equipment which aims efficiency increase leads to higher number of components in it, respectively higher probability of damage and the necessity of repairing it. The energy put and the CO_2 burnt in production of each component is another question. In most cases no matter how efficient a system is it cannot save the energy and CO_2 put into its production.
So, with this project I would like to demonstrate that an architect can create efficient office building by using mainly passive solar applications.
The following work is about: heating and cooling systems, air comfort, lighting, power supply, hot water supply, relaxation and recreation.

The building is situated in the center of Sofia (Fig.1). This is a region characterized by daily maximal direct sun lightening during winter time of 244 w/m² and summer time up to 700 w/m². Average sun heating for Sofia is 2100 hours or in other words – annual value of sun light is about 1400 kW [1].
The building is situated east – west. Both walls - the south and the north one are blind walls, which is preventing the cooling from the north facade, and overheating from the southern one. Maximum usage of sun radiation is reached by duplicating all the solar systems on both sides. One facade uses first half of the day, the other – second one. Thus the risk of overheating during sunny days is decreased.
All systems which are providing the building proper functioning are connected and controlled by autonomous server and specially developed software, called just “controller”.

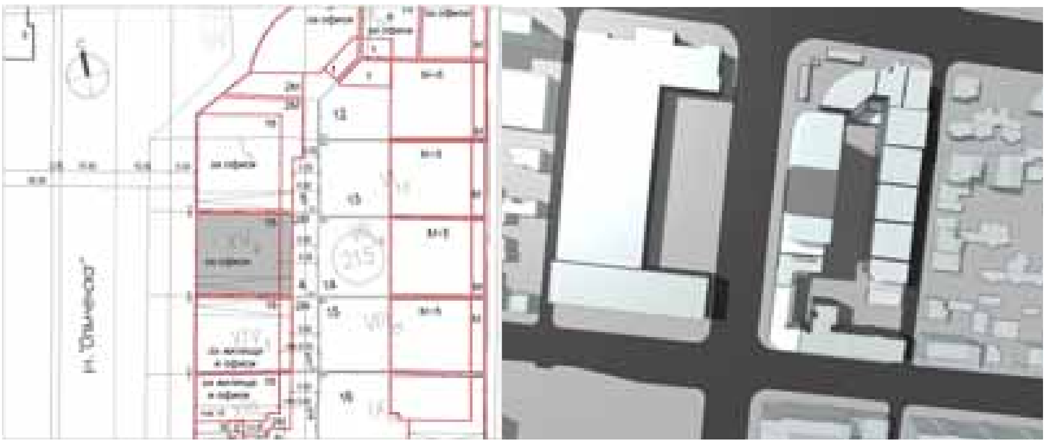

Fig. 1. Situation.

Due to its central situation and density of buildings around our building contains an automated underground parking. Its system works automatically. The cars enter the parking with engines turned off, which eliminates the necessity of ventilation to remove the exhausted air (Fig.2). This leads to decreasing total costs of building usage.

The passive method and the “solar chimney” principle are mainly used in the cooling and heating systems. Due to the building exposure the solar system is duplicated on both facades – east and west – thus a whole day work capacity is guaranteed. The chimneys are connected to air conductors via valves. The connections are in the floor and in the ceiling and depending on the operation mode one is sucking and the other- blasting the air.

As the parking is situated 10 meters under ground level the temperature in it is almost constant (9°-15° C depending on the season). The volume of the garage is been used as a “storage” for fresh air. In its upper part it is connected via suction filter to the system for fresh air supply. Air conductors connected to the chimneys are situated at the bottom of the parking.

There are two operation modes: summer mode and winter mode (Fig.2).

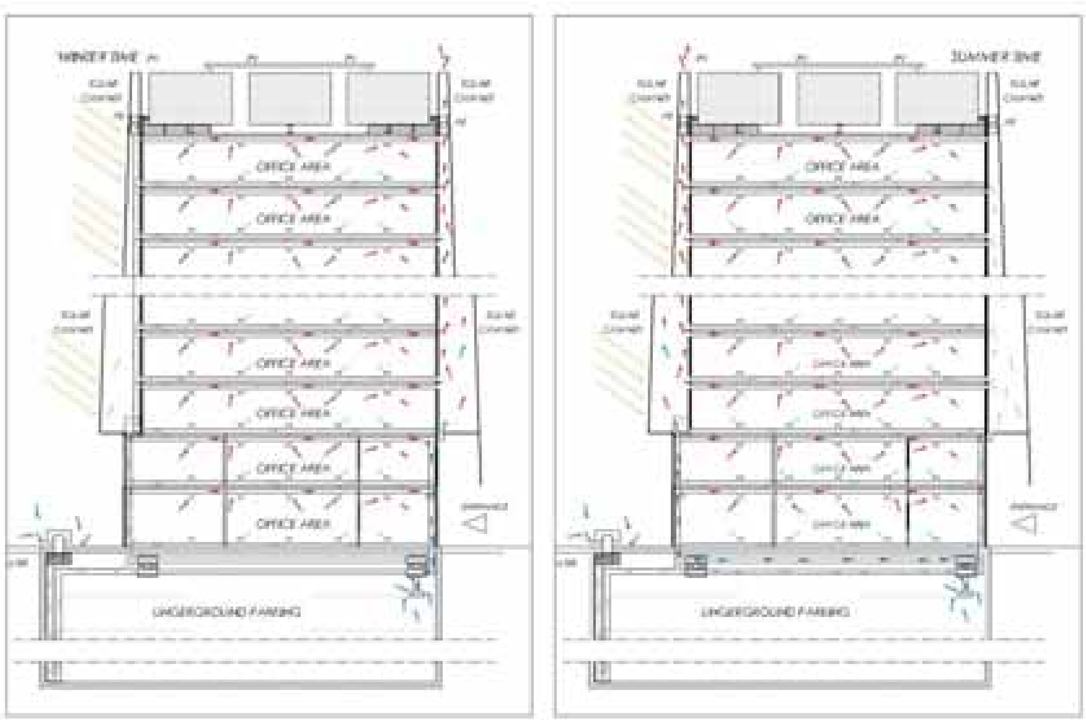

Fig. 2. Ventilation processes according to the season.

During summer time the air in the chimneys warms up by green house effect and due to the different temperature coming from the garages it goes up. The chimney’s horizontal section decreases in its higher part so the pressure increases which helps for the easier air suck from the working area. The doubled system on the other facade works as a fresh air supplier by blasting.

During winter mode the fresh filtered air from the garages warms up by the sun rays in the chimney. Whenever it reaches the necessary temperature it goes up along the air conductors leading to the working area. If the sun lightening is not enough a heat exchanger (HE) takes the heating function. There is one installed at the end of each chimney (Fig.2, 3).

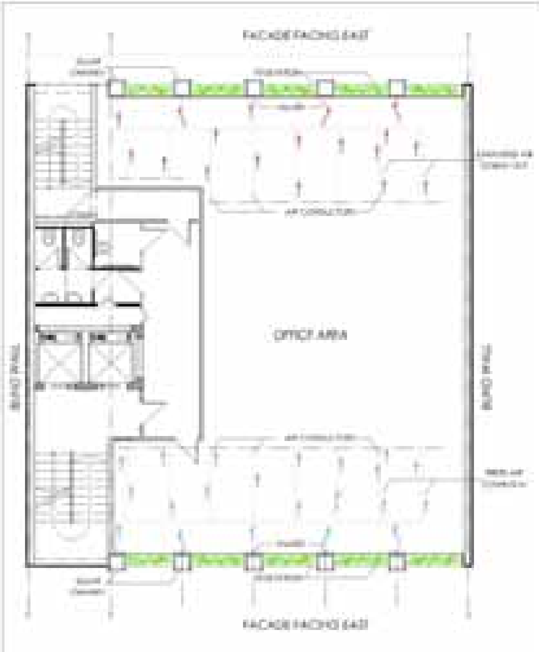

Fig. 3. Typical level with example of ventilation scheme.

Lightning in the building is achieved mainly by reflectors, which also give shadow and protect the rooms from overheating beneath the direct sun light. These systems are installed on both facades – east and west as even only one of them guarantee equal diffusive lighting of whole working space. East system produces light from the beginning of work day until noon and the west one – after noon till the end of the day. The method of studying the maximal efficiency of light comfort is represented by different methods. One of them is vector based mathematical approach (Fig.4, 5).

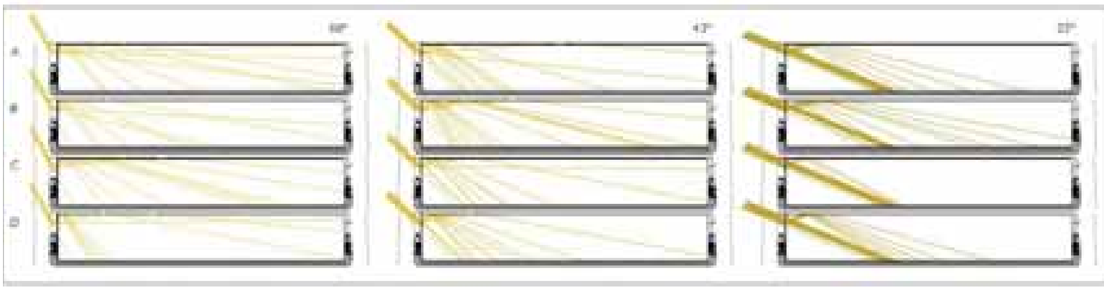

Fig. 4. Sunlight reflection research.

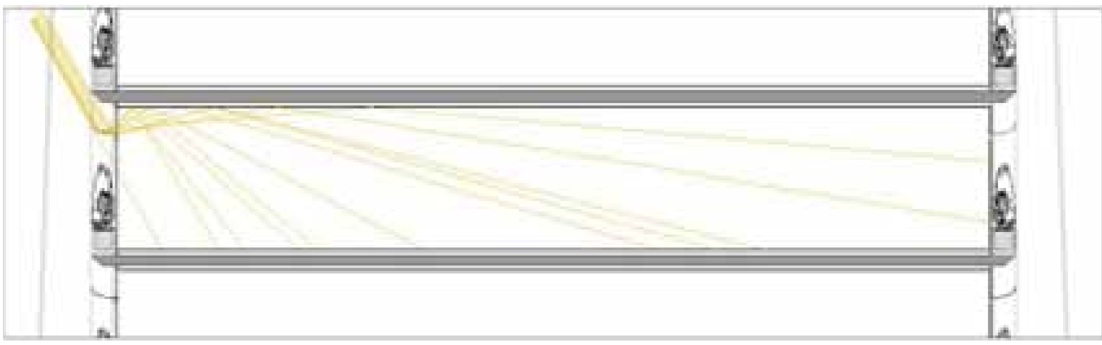

Fig. 5. Fragment from sunlight reflection research.

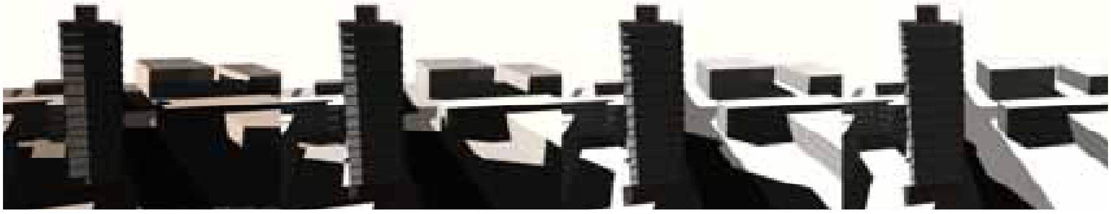

Fig. 6. Fragment from 3D sunlight reflection research.

Other technique which is used is creating a 3D simulation of sun lightening during different parts of the day in the four seasons (Fig.6). This is followed by developing an optimal reflector shape.
If the sun lightening is insufficient for the comfort needed, a 12 V diode lightening is turned on. It has up to 70% higher efficiency than the usual one. The lifetime of this installation is more than 100 000 hours which speaks for less maintenance.
The building controllers which include: from the whole valve system, to thermal and air quality sensors, are also working on 12 V. The energy needed for the alternative current supply is delivered directly from the system connected to PV farm installed on the roof. It is situated at an area of 200 m². The use of new generation PV installation with higher capacity of production is been provided. The system reaches power of 300 – 350 W/m², which is equal to 7MW for the entire building. Optimum amount of energy will be transformed into 220 V to prevent unnecessary loses in this process.
The PV installation is reaching 2000° C during working process, so the negative overheating is prevented by installing another system on its bottom, working as cooler it is also working as sun collectors for heating water. Another element with double function could be the heat exchanger at the end of the “solar chimney” absorbing the heat from the air released from inside, might be used for heating water for domestic needs if necessary.
A simple planting of a tree or just a plant is one of the main ways for compensating CO_2 emissions (Fig. 3, 5). With the purpose of reducing the CO_2 footprint during building life time, each level of the building is been planted. Each facade on one floor has 5 plant pots with average area of 0.9 m2. This equals 9 m² per level or 144m² for the height of the building. This leads to 2520 L worked CO_2 daily [2].
On other behalf plants on facades keep shadow and prevent overheating during hot summer days and during winter time their leaves fall and let the light penetrate into working spaces. Considering the height of the building plants are protected from the strong winds as being situated in bays. Water supplying is achieved via drop-irrigation with the water gathered after rains. Each lever has an external reservoir serving the lower level. This is made by means of preventing the usage of a pump for higher levels of the building. In case of higher water amounts than the capacity of the reservoir, water overflows down to the next one and thus to the garden area of the terrain.
Relaxation of inhabitants is an important part of the project – so staring at the branches’ play and the shadow shapes their eyes and senses easily rest.

A minimal usage of electricity is been provided as a whole in this project. No matter how big the necessity is, the building is capable of being energy independent.
Giving all the comfort and high quality of inhabiting, this building could be a good example of sun applications that might be used in projects of this type of buildings. The usage of recycled and base on natural products materials is recommended. Also reusing of some materials and local production, are also advisable.
All the systems used: PV, collectors, diodes are local Bulgarian production. This on one side stimulates the market and development of technologies in the field of renewable energy sources, and on the other decreases transport cost and CO_2 emissions.

[1] Dechko Dechev – Solar Collectors and Systems
[2] Stephen Fry – Institute of Cell and Molecular biology, Edinburgh University (adapted from submission to “The New Scientists” – The last Word).