# Decreasing of energy consumption in railway station

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***Abstract*—In the present paper a solution for reducing the electricity consumption in railway station is proposed. The considered object is small town Razgrad, located in North East Bulgaria. The article describes the necessary actions, which are taken to reduce electricity demands during the refurbishment and conversion of an existing railway station. Because global electricity generation accounts for more than 75 % of EU emissions. An overview of the current state of the electrical installations in the reception building of the railway station was made. By this analysis the lighting installation has been renovated, so that to increase energy efficiency of the studied building. The lighting control method is described in order to reduce electricity costs. The planned photovoltaic installation for own use is mounted on the roof of the building. It significantly reduces electricity costs – by 24 %.**

***Keywords—electricity costs, photovoltaic systems, photovoltaic plants, railway station.***

## I. INTRODUCTION

Rail transport is recognized as the safest method of transport in the world and is actively used in many parts of the world.

Rail transport occupies an important role in the transport system of any country. The development of industry and trade in a country largely depends on the development of railways.

Passengers, their turn demand increased comfort and better services.

To improve the quality of service it is necessary to retrofit old buildings.

On the other hand, there is an urgent need to reduce energy consumption and carbon emissions.

Climate change is a major threat to the world economy and causes a loss of over $1.2 trillion each year, equivalent to 1.6% of global gross domestic product (GDP). [1]

The shift to green buildings is particularly important as buildings consume one-third of the world's energy in both developed and developing societies. [3, 4, 5].

Compared to other large public buildings, train stations have certain characteristics that have a great impact on energy consumption.

Newly built railway stations worldwide (since 2003) consume 59.3% less energy than old railway stations. [1]

The structure of the proposed paper is organized as follows. In the next section, the current state of the electrical installation of the considered building is discussed. The measures and real activities made to reduce energy consumption in the renovated building are described in Section III. The paper finishes with conclusion remarks about the effect of the suggested new electrical installation supplied with energy produced by self-use photovoltaic system with respect to increasing the electrical demands in the building.

## II. CURRENT STATE OF THE INSTALLATIONS IN THE BUILDING

The subject building discussed in this paper is the railway station in Razgrad, a small town in North-East Bulgaria. It has a total floor area of 1 047 sq. m. and a floor area of 3 015.1 sq. m. Its current condition is shown in Fig. 1.

The reception building was commissioned in 1966. As a result of 55 years of operation, the engineering networks in the building are completely exhausted.

The electrical installations, in addition to being heavily amortized, do not meet the regulatory requirements in force on the territory of the Republic of Bulgaria in 2023.

For lighting of the railway station, luminaires are used. The condition of the luminaires is highly damped.

Fig. 1. Condition of the lighting installation in the railway station.

The light sources used in the building are E27 retrofit lamps and T8 fluorescent lamps.

In addition to having a high installed power, the luminaires do not provide the required standard illuminance according to EN 12464-1:2021 Light and Lighting. Workplace lighting. Part 1: Indoor workplaces.

There is a lack of external lighting on the car park side of the building, as well as façade lighting, which contributes to the discomfort of commuters using the station in the evening.

## III. MEASURES TO REDUCE ENERGY CONSUMPTION IN THE RECEPTION BUILDING

The design of the reception building provides for a new lighting installation, which includes 60/60 LED luminaires with a power of 29W.

This on the one hand increases the uniformity of lighting in the rooms and on the other hand, reduces the installed power.

It is envisaged to divide the lighting into series, so as to achieve a reduction in energy costs through adequate control by zones and hours.

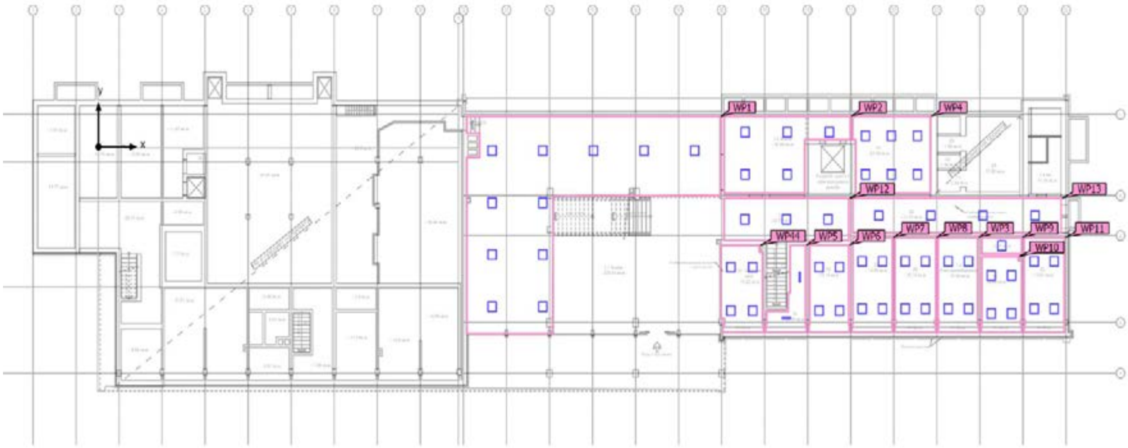


Fig. 2. Design solution of the lighting installation on the first floor.

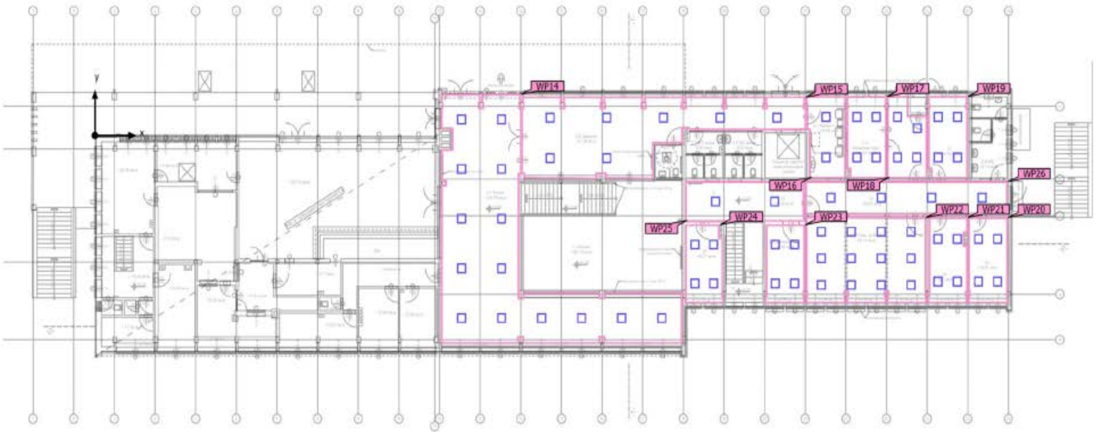


Fig. 3. Design solution of the lighting installation on the second floor.

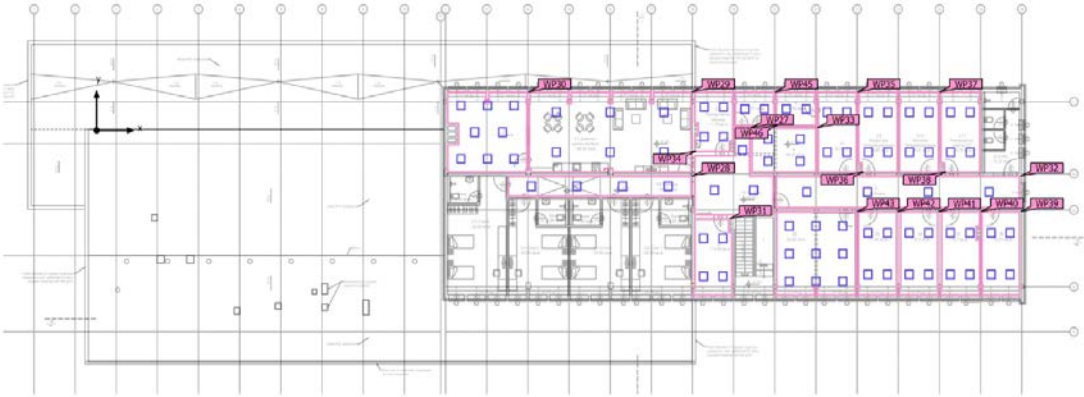


Fig. 4. Design solution of the lighting installation on the third floor.

The installed power for lighting in the station project is 8331W. The instantaneous installed power in the reception building for lighting is 34 684W. The principle electrical installations for each of floors 1, 2, and 3 of the railway station are visualized in Figs 1, 2, and 3 respectively. An effect of the implementation of this project is realized in a reduction of installed lighting power by more than four times. This is confirmed by the fact that the total installed power in the considered railway station building is 200kW.

Another technology that is envisaged in the reception building conversion project, in order to reduce the energy costs of the building, is the installation of a photovoltaic power plant for its own needs on the roof of the building. It is shown in Fig. 5. A similar construction is used in [2], where a photovoltaic system is installed on the roof of the VTU "Todor Kableshkov" for its own needs. Through this Laboratory, educational exercises are provided in order to teach the students about the functioning and benefits of green energy generated by photovoltaic cells.

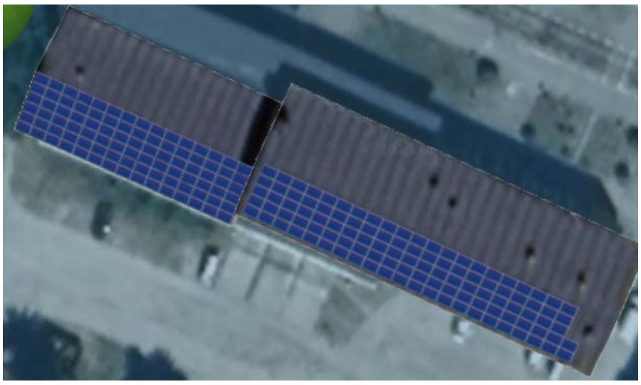


Fig. 5. Arrangement of photovoltaic panels on the roof of the building.

To achieve a total installed capacity of 78.80kWp, 197 photovoltaic modules will be installed generating constant voltage. The modules have a capacity of 400Wp.

The photovoltaic modules are connected in series in strings. The DC voltage obtained from them will be converted into AC voltage by 2 three-phase inverters with a capacity of 30kW and 50kW. The voltage will be transformed to 0.38/0.4kV AC and will be used for the needs of the electrical consumers in the building.

A Smart Meter will be connected to the system to monitor the electricity production from the photovoltaic installation and limit it when necessary to prevent the electricity being fed back to the grid, i.e. there will be no voltage return to the main source of electricity.

In case of insufficient electricity generation from the solar modules, the needs of the consumers will be supported by the grid supply.

To increase the overall efficiency of the power installation, the photovoltaic modules will be connected in series in 8 strings. The constant voltage current obtained from each string will be converted through the respective connected inverter into a 0.4kV AC current.

In turn, the AC output of each inverter will be connected to a switchboard "AC Panel" of the GRT FPP, equipped with the necessary switchgear and protection equipment.

The panel will power the electrical consumers supplied by GRT in the station building.

A Smart meter will be installed in the main switchboard on site to prevent the photovoltaic installation from returning electricity to the grid.

The connection to the electricity generated by the photovoltaic installation is to the internal electrical installation within the building, thus providing the ability to provide electricity to the consumers. The photovoltaic installation is not connected to the electricity grid and the connection to the internal electricity grid on site is downstream of the electricity distribution company's meter.

The connection of the individual modules to each other in a string is made by means of ready-made connections of the modules (the modules are factory equipped with cables and connectors). The extension of the end cables of the resulting individual strings is done by means of a special DC cable with UV protection and double insulation.

The individual strings are connected to the inverter via a 1x4 square mm solar cable.

The solar cables are laid on the supporting structure of the modules and are mechanically reinforced. As the photovoltaic power plant is outdoors (under the immediate influence of the weather), the reinforcement of the cables must provide sufficient mechanical strength. Cables, cable ducts, and pathways as well as all cable fasteners shall be weatherproof (dust, wind, high humidity, rain, snow, solar radiation).

Good European practice dictates that as much of the electricity consumed by all residential and industrial buildings as possible should be provided by local electricity generation from renewable sources [6, 7].

The consumption profile of the building is presented in Fig. 6 and it has the following form:

Fig. 6. Consumption profile of the building.

The total capacity of the implemented photovoltaic plant is shown in Fig. 7.

Annual Energy Production
102.85 MWh

CO2 Emission Saved (Annually)
48.34 t

Equivalent Trees Planted (Annually)
2,220

Fig. 7. Total capacity of the photovoltaic plant.

The performance of the developed photovoltaic plant by month in bar-graph form and in tabular forms are presented in Fig. 8 and 9, respectively. They show that the highest electricity production through the photovoltaic system is in the sunniest months of the year - from April to September.

The production and energy consumption of the photovoltaic plant in graphical and tabular forms are presented in Fig. 10 and 11, respectively. It is obvious, that during the period, mentioned above (from April to September) the photovoltaic plant supplies the building with the most energy compared to other months. But even during this period it only satisfies 1/3 of its needs for electricity.

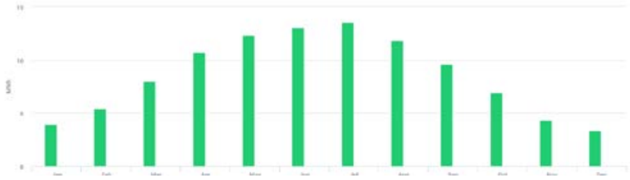
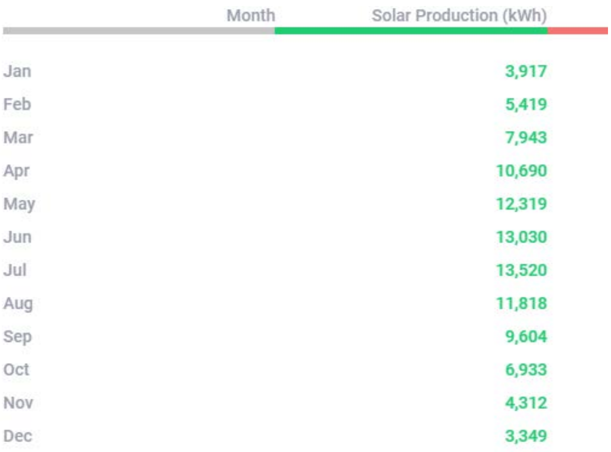


Fig. 8. Performance of the photovoltaic plant by month in graphical form.



| Month | Solar Production (kWh) |
|---|---|
| Jan | 3,917 |
| Feb | 5,419 |
| Mar | 7,943 |
| Apr | 10,690 |
| May | 12,319 |
| Jun | 13,030 |
| Jul | 13,520 |
| Aug | 11,818 |
| Sep | 9,604 |
| Oct | 6,933 |
| Nov | 4,312 |
| Dec | 3,349 |

Fig. 9. Plant performance by month in tabular form.

It can be seen from the graph below that 24% of the building's energy costs are covered by the photovoltaic plant installed on the roof.

Fig. 10. Photovoltaic production and energy consumption in graphical form.

| Month | Solar Production (kWh) | Consumption (kWh) | Self-consumption (kWh) |
|---|---|---|---|
| Jan | 3,917 | 37,858 | 3,917 |
| Feb | 5,419 | 29,821 | 5,415 |
| Mar | 7,943 | 37,858 | 7,943 |
| Apr | 10,690 | 32,803 | 10,633 |
| May | 12,319 | 37,858 | 12,280 |
| Jun | 13,030 | 34,933 | 12,967 |
| Jul | 13,520 | 37,858 | 13,302 |
| Aug | 11,818 | 40,059 | 11,794 |
| Sep | 9,604 | 32,803 | 9,597 |
| Oct | 6,933 | 34,776 | 6,933 |
| Nov | 4,312 | 36,637 | 4,312 |
| Dec | 3,349 | 38,738 | 3,349 |

Fig. 11. Photovoltaic production and energy consumption in tabular form.

## IV. CONCLUSIONS

It can be seen from the above that the measures to be taken after the reconstruction of the railway station building will result in an increase in lighting costs of at least four times. At the same time, thanks to the photovoltaic plant installed on the roof, electricity consumption will be reduced by 24 %.

With electricity generation accounting for over 75 % of EU emissions, it is imperative that more and more public buildings are re-designed to reduce carbon emissions.

## ACKNOWLEDGMENT

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