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SOLAR PARKING CANOPY AS A PART OF ENERGY EFFICIENT URBAN PLANNING

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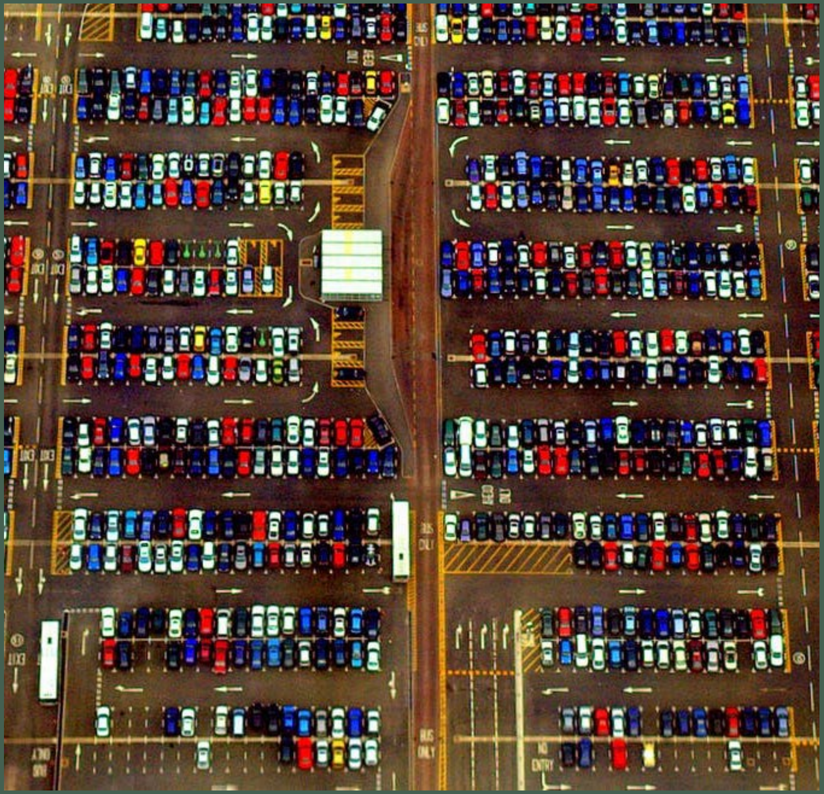
INTRODUCTION

- Population growth projections indicate that by 2050 over 70% of the global population will live and work in cities since urban development will continue its progression in the upcoming decades.
- The continuous temperature increase in the urban areas, affected by the rapid urbanization and undeniable climatic change, is escalating the energy problem of cities and intensifying the pollution problems.

INTRODUCTION

- Parking lots are large pavement surfaces that absorb the sun’s energy and retain heat thus contributing to the UHI effect.
- The number of spaces per vehicle is rising, as the adult population has become more dependent on cars, thus the large portion of the urban environment is dedicated to parking lots.



INTRODUCTION

- Installing a solar canopy over an existing parking lot is a more efficient use of the same square footage and could turn an open pavement surface into a significant electricity generator.
- Solar energy, as renewable energy, is seen as a necessary step toward sustainable energy development, reduction of fossil fuel usage and mitigation of climate change.

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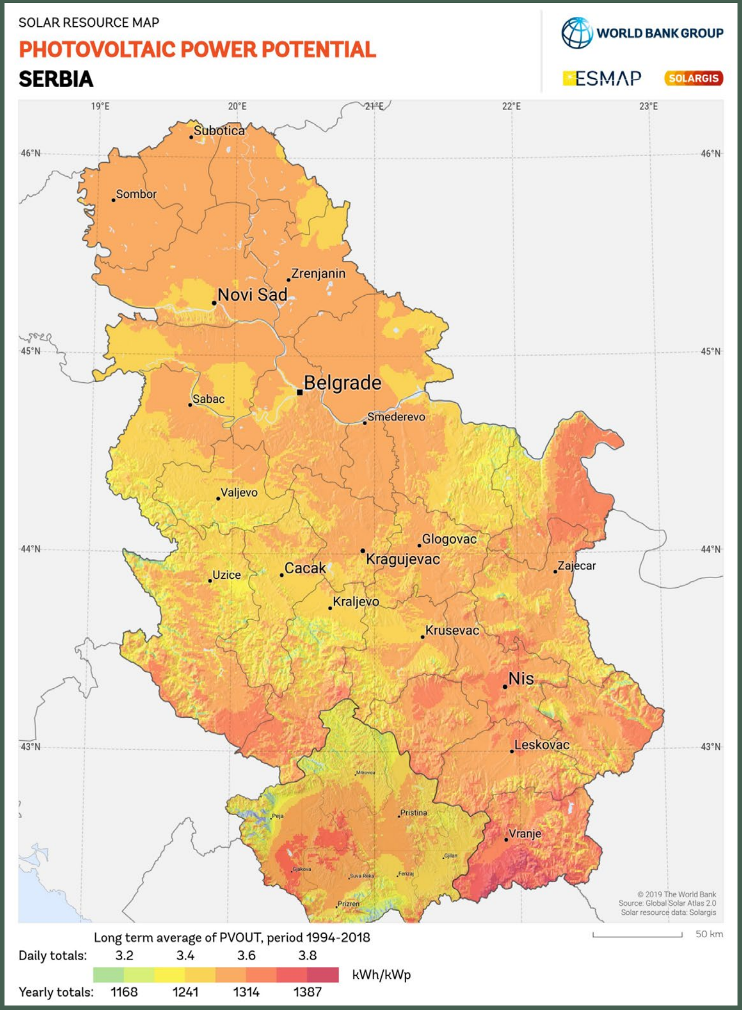
INTRODUCTION

- Annually, the average value of the overall sun radiation for the territory of the Republic of Serbia ranges from 1200 kWh/m^2 in northwest Serbia to 1550 kWh/m^2 in southeast Serbia, while in the middle part it is about 1400 kWh/m^2.
- The average solar radiation in Serbia is about 40% higher than the European average, nevertheless, the utilization of solar energy is nowhere near the practice in countries of the European Union.



BENEFITS

Solar canopies are an innovative way to maximize an existing space for multiple purposes and benefits.

- One of the obvious benefits is the shade provided by the solar panels covering the vehicles. Shade considerably reduces the vehicle temperature during the day, protecting it from sun damage, such as paintwork damaged or cracked and warped interiors during the hot summer period. Additionally, lower internal temperature provides more comfort for drivers entering the car after sun exposure and reduces their heatstroke risk.
- By installing the PV parking canopy, the University of Utah predicted production of electricity with close to zero emissions, meaning no CO2, NH4, or N2O produced.
- The research on the Paris metropolitan area showed a reduction in the Urban Heat Island (UHI) of 0.2 K by day and up to 0.3 K at night by deployment of solar panels.

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METHODOLOGY

- In this research, we will consider the Electrical Engineering High School Nikola Tesla Niš parking lot for solar parking canopy installation

METHODOLOGY

- Groundwork, reconstruction of the car access is suggested and the formation of 20 parking spaces. The 90° parking angle would provide the most parking spaces for a given area, two rows with 10 parking spaces each, divided by two-way traffic flow.
- In the north part of the lot, the pedestrian zone is designed making the straight line to the High School entrance plane.
- A truss canopy is proposed for a solar mounting canopy structure. Two, five columns, solar canopies are designed with a length of 24m and a width of 9m for ten cars in a row. The total of 432 m^2 space is at the solar canopy shade.

METHODOLOGY

- Array/system configuration and preliminary simulations were done in PVsyst software. Three cases C1, C2, and C3 were considered, with a unit nominal power of 220Wp, 340Wp and 540Wp respectively.
- The total nominal solar power for every case study was calculated for available space on a canopy at a 1° azimuth angle facing south and a 30° slope angle according to geographical location.

PV module	C1	C2	C3
Model	TP648M-220	TD6E72M-340-L	LR5-72 HIBD 540 M
Manufacturer	Talesun Solar	Talesun Solar	Longi Solar
Unit Nom. Power	220 Wp	340 Wp	540 Wp
nb. modules	322	210	169
Nominal (STC)	70.8 kWp	71.4 kWp	91.3 kWp
Module area	422 m^2	422 m^2	432 m^2

CASES ANALYSIS

Performed simulations were done searching for the maximum nominal solar energy generation for the given location, furthermore to be able to compare differences in results from C1 to C3.

- For C1 case the available produced energy is 82.21MWh/year with specific production of 1160kWh/kWp/year and a performance ratio of 81.21%
- For C2 case the available produced energy is 88.38MWh/year with specific production of 1238kWh/kWp/year and a performance ratio of 86.63%.
- For C3 case the available produced energy of 108.2MWh/year with specific production of 1186kWh/kWp/year and a performance ratio of 82.96%.

CANOPY ANALYSIS AND SYSTEM LOSES

- We took favorable case C3 and considered canopy characteristics, nearby building and tree shading effects.
- Two, five columns, solar canopies were proposed with a length of 24m and a width of 9m for ten cars in a row.
- The truss canopy has a single surface slope, with the tilt angle 10° of the rooftop. The total nominal solar power was calculated for 432m^2 of available space on a canopy at a -23° azimuth angle facing south.

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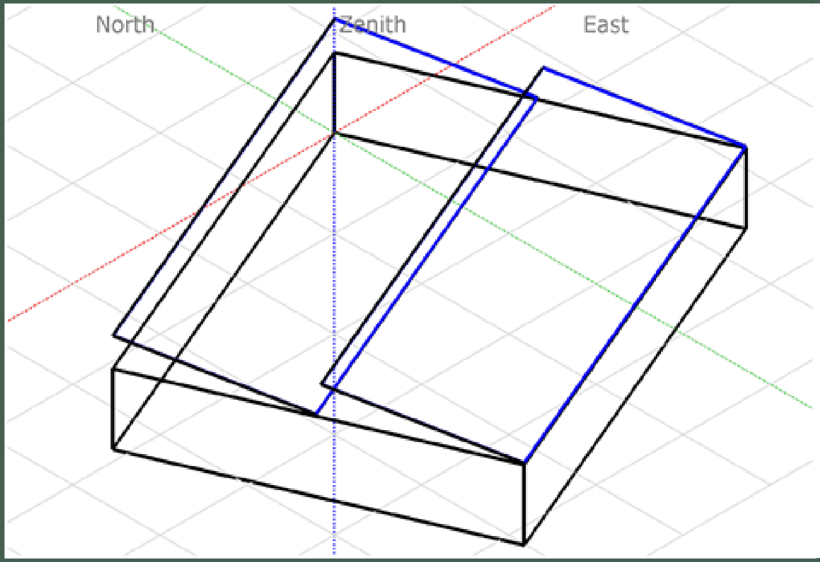
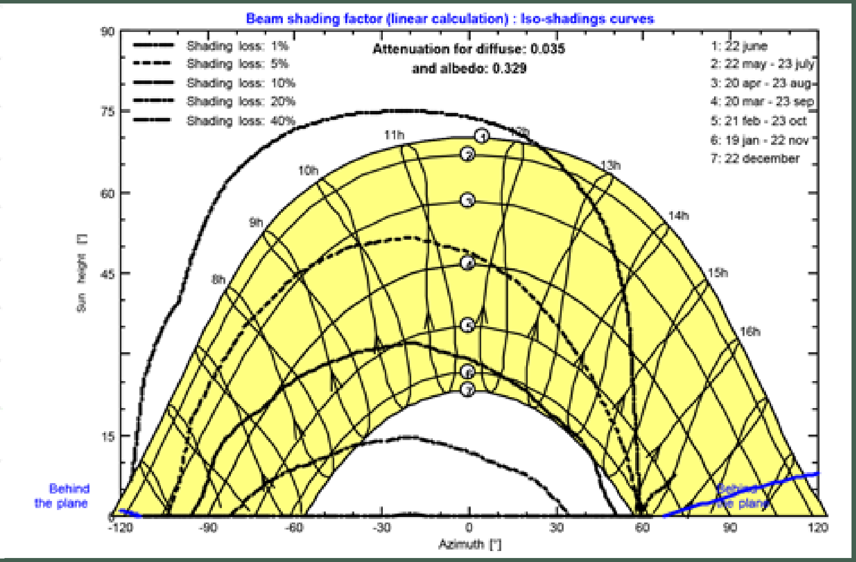
CASE STUDIES CONFIGURATION

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



CASE STUDIES CONFIGURATION

Still using 169 photovoltaic modules with a unit nominal power of 540Wp, but with canopy at a -23° azimuth angle facing south and a 10° slope angle, calculations showed

- available produced energy of 102.7MWh/year
- with specific production of 1125kWh/kWp/year and
- performance ratio of 83.54%.

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SIMULATION MAIN RESULTS

	Global hor. irradiation [kWh/m²]	C4				
		EArray [MWh]	E_User [MWh]	E_Solar [MWh]	E_Grid [MWh]	EFrGrid [ratio]
January	38.5	3.63	13.30	2.496	1.02	10.80
February	49.0	4.40	8.50	2.475	1.80	6.03
March	89.2	7.83	9.13	3.397	4.23	5.73
April	128.6	10.83	4.25	2.027	8.54	2.22
May	162.5	12.96	3.92	2.057	10.59	1.86
June	180.4	14.15	5.47	2.999	10.82	2.47
July	189.8	14.71	4.90	2.657	11.71	2.24
August	158.7	12.63	5.78	2.843	9.49	2.94
September	112.5	9.35	11.80	4.475	4.64	7.33
October	78.4	6.85	13.90	4.300	2.38	9.60
November	47.3	4.32	14.00	3.100	1.10	10.90
December	38.0	3.62	14.80	2.866	0.64	11.93
Year	1273.1	105.28	109.75	35.691	66.97	74.06

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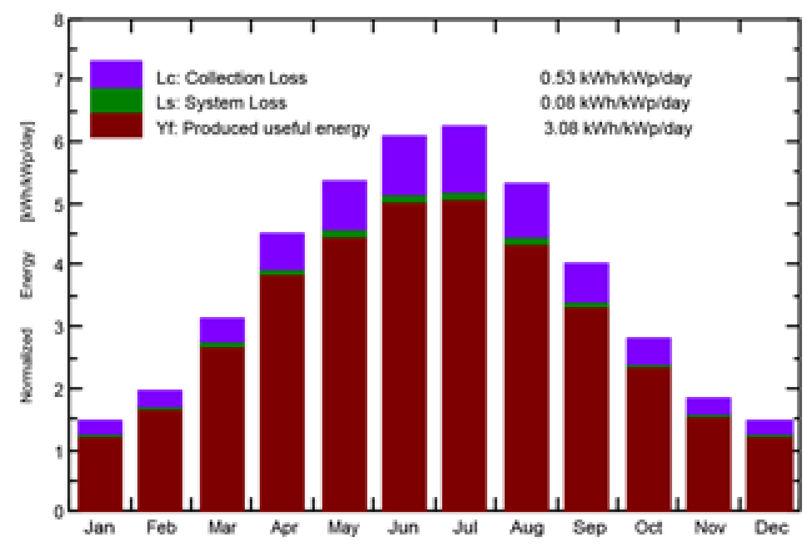
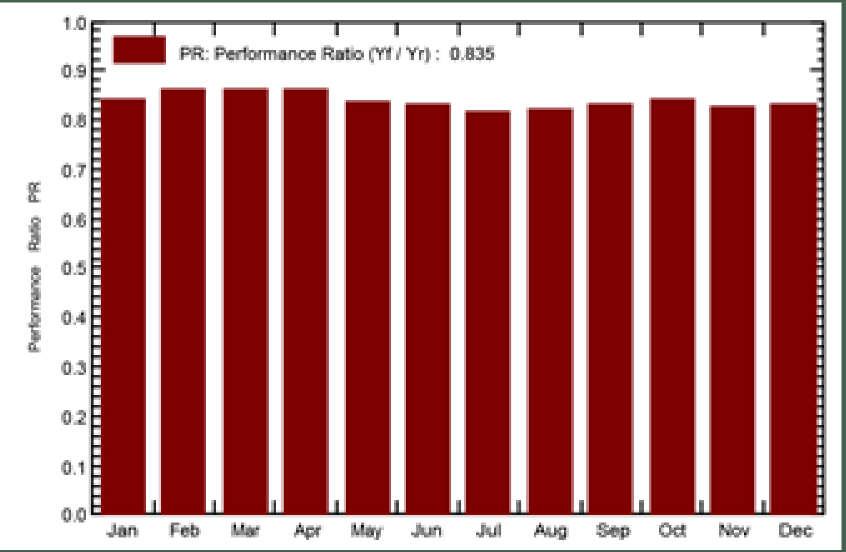
SIMULATION MAIN RESULTS

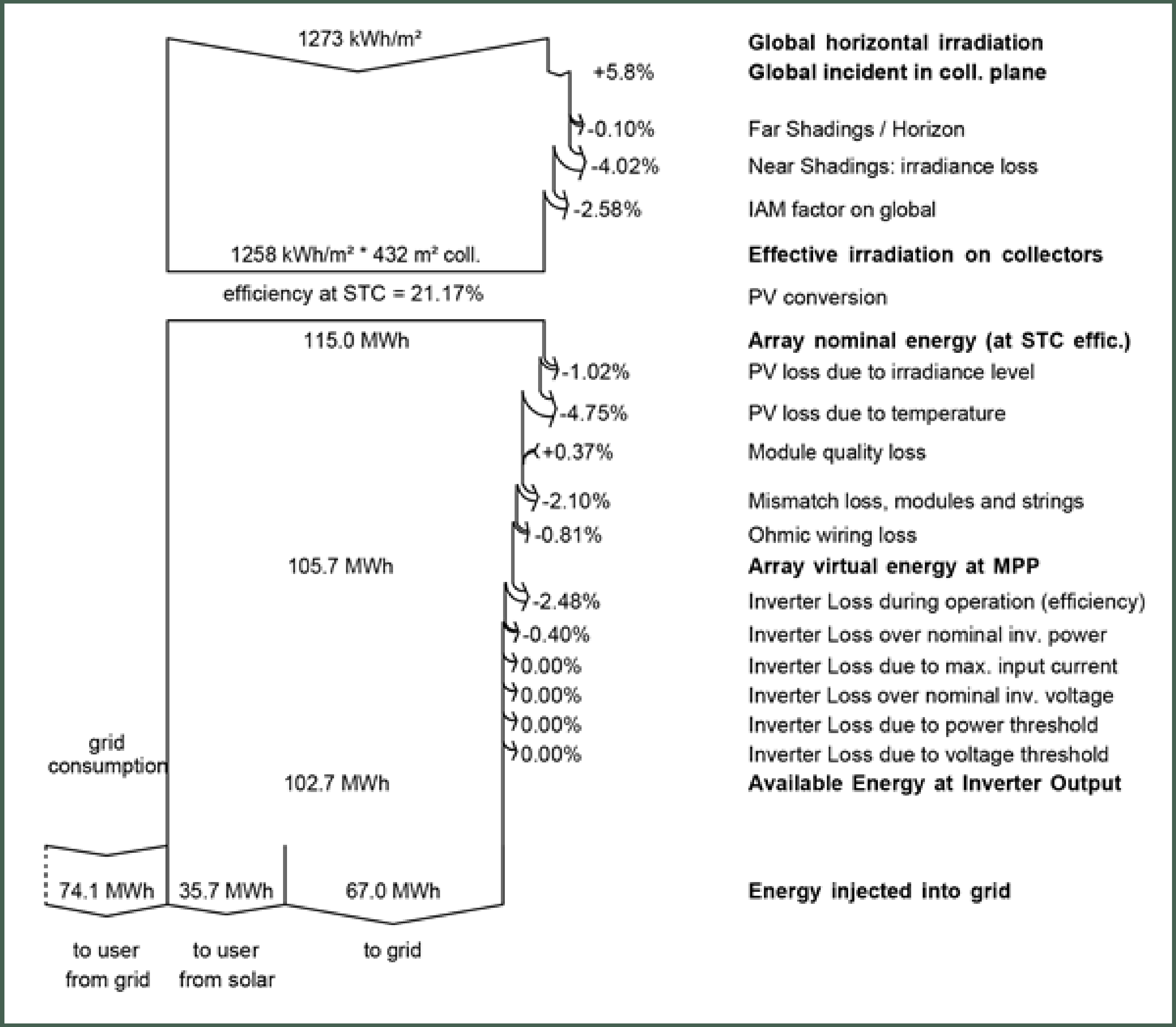
Normalized productions (per installed kWp): Nominal power 91.3kWp



Performance Ratio PR



LOSS DIAGRAM OVER THE WHOLE YEAR



DISCUSSION

- Over the whole year calculations showed that 74.1 MWh of the energy would be drawn from the grid for the internal consumption when PV is not sufficient, 35.7 MWh of the energy needs would be consumed by the user obtained from solar and 67.0 MWh of the excess energy would be injected into the grid obtained from solar as well.
- The installation of PV panels on the parking canopy would help to reduce the UHI effect by covering the parking lots, thus heat would be absorbed by the PV panels to create energy for Electrical Engineering High School Nikola Tesla Niš instead of being absorbed by the pavement to create higher temperatures.
- With solar parking canopy, the energy gained by the PV panels could be used throughout the power grid to power the lights, air conditioning, machines and electrical appliances in the main school building.

CONCLUSION

- A solar parking canopy could be built above pre-existing parking spaces, making it an innovative product that can turn a typical, non-productive parking lot into a cost-effective solar power plant.
- Using a solar canopy, the production of green energy could be realized and reduction in greenhouse emissions could be provided while adding aesthetic and accomplishing economic benefits.
- Parking lot solar canopy installations would be an excellent installation option not only for High Schools and University but for other public buildings and facilities with large parking areas, such as malls, airports, hospitals and others.
- Employees or customers would benefit from the shade as the lower internal temperature would provide more comfort for drivers and protect their vehicles. The shade of the canopy could also improve the fuel economy of cars that park underneath.