CASE STUDY OF BIFACIAL PV BASED NOISE BARRIERS IN LITHUANIA
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ABSTRACT: In this work, installed PV noise barrier (PVNB) projects by Solitek in Lithuania have been reviewed from technical and economical perspectives. Bifacial PV modules were integrated with aluminum frames and rubber gaskets to be replaced with standard sound barrier panels (perforated aluminum) where such mounting structures enable simple retrofitting option for noise barriers. Modules in series were connected to DC/AC Inverter and grid. Data from inverter, weather station and 3 pyranometers have been employed for performance evaluation of PVNB. In addition, electromagnetic properties of PVNB in cellular network band (900 - 2000 MHz) have been explored.
Energy generation pattern of PVNB corresponds to typical generation curve of vertical PV installations where two energy peaks are visible. Calculated and simulated performance ratio differs around ~0.15 which is explained due to shading structures above PV noise barriers which affects irradiance absorbance both from east and west sides. The different designs of PVNB with different distance between supporting pillars (2.5m and 4m) in the segment shows price difference from 8% to 16% comparing with standard noise barriers and by having fixed prices such of electricity 110 eur/MWh and 150 eur/MWh, the payback time for both designs range from 2-3 (when d = 2.5m) to 5-7 (when d = 4m) years accordingly. The findings after experiments of signal transmittance and reception of the electromagnetic radiation passing through PV module indicate the module similarities to metallic plate in terms of attenuation and signal strength properties for cellular network applications.

1 AIM AND APPROACH

The purpose of this work is to demonstrate economical and renewable energy benefits of retrofitting infrastructure objects with PV energy. In this work, PV project of 22kW have been installed in Lithuanian railways with bifacial PV modules. Panels have been integrated into segments where such objects contained 4 portrait-oriented PV modules, and the orientation azimuth of system was -77.9°. Frameless PV panels were integrated with aluminum frames with rubber gaskets and replaced with standard sound barrier panels (perforated aluminum) where such mounting structures enable simple retrofitting option for noise barriers. Modules were connected in series to AC/DC Inverter and grid. Daily and monthly energy generation values from inverter and climatic sensors (weather station and pyranometers) have been used for quantitative evaluation.

Figure 1. Picture of retrofitting procedure and finished work of PV noise barriers in Lithuania, Juodšiliai

2 SCIENTIFIC INNOVATION AND RELEVANCE

The usage of renewable energy, specifically PV energy, has become fast growing market where installation capacity increased worldwide from 240 GW (2022 year) to 407 GW (2023 year) [1]. Despite widely employed building-applied PV and building-integrated PV projects and installations, the market potential for infrastructure integrated PV (IIPV) is sizeable, considering the extensive availability to retrofit built and installed infrastructure objects along the road [2]. Yet, IIPV market is more relevant where land is sparse or very expensive which results in small amounts of available economical and technical data to evaluate the main benefits of decarbonizing existing infrastructure.
The study presents financial and technical evaluation (e.g., energy yield data, PR evaluation and other related parameters) of IIPV modules where such information gives the realistic view on possibilities of retrofitting already-built objects. In addition, for measuring solar panels' radio frequency scattering parameters, reflection and transmission coefficients of vertically arranged solar panels were performed in frequency range 500-2000 MHz Wide aperture antennas have been used to provide homogeneous illumination and low spillover of RF radiation besides solar panels. Both vertical and horizontal polarizations were considered.

3 RESULTS (OR PRELIMINARY RESULTS) AND CONCLUSIONS

Fig 2. presents energy generation pattern of PVNB (on 10th of July) which corresponds to typical generation curve of vertical PV installations where two energy peaks are visible. Although, the second power peak is reduced due to additional shadowing which is caused by the metal constructions above PV system which could be spotted in Figure 1 in the right picture.

Figure 2. Energy generation representation

In Fig 3, for additional evaluation, performance ratio has been calculated using irradiance data from pyranometers and monthly energy yield from DC/AC inverter. The higher values for November and January compared with e.g., September and August could be explained due to more diffusive irradiance which translates into less sharp shadowing and lesser contrast between affected and non-affected surfaces of PV module.

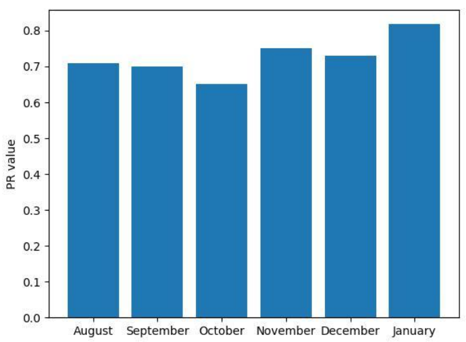
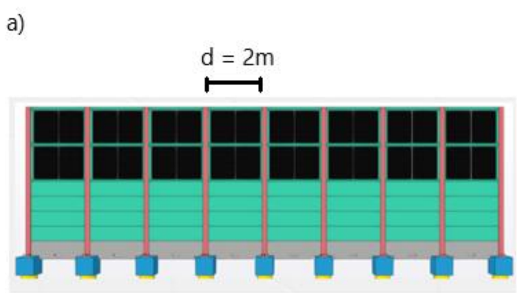


Figure 3. Calculated monthly PR of PV noise barrier system.

The different designs of PVNB with different distance between supporting pillars (2.5m and 4m) in the segment shows price difference from 8% to 16% comparing with standard noise barriers and by having fixed prices such of electricity 110 eur/MWh and 150 eur/MWh, the payback time for both designs range from 2-3 (when d = 2.5m) to 5-7 (when d = 4m) years accordingly.



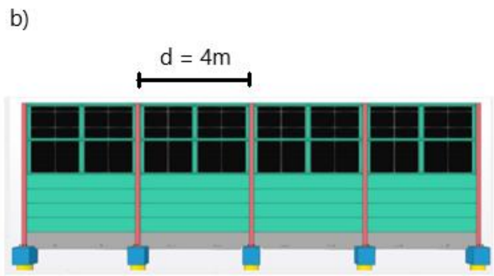


Figure 4. PV noise barrier segments with different distance between pillars.

The findings after experiments of signal transmittance and reception of the electromagnetic radiation passing through PV module indicate the module similarities to metallic plate in terms of attenuation and signal strength properties for cellular network applications.

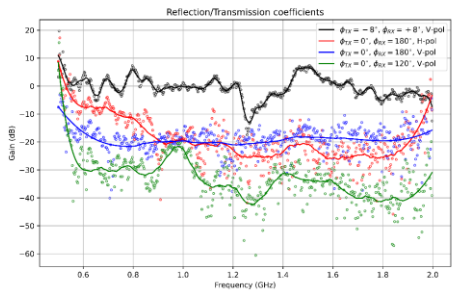


Figure 5. Reflection and Transmission coefficient gain dependance on frequency for different polarizations.

4 CONCLUDING NOTE – SUBSEQUENT DEVELOPMENT

Following the implementation of the two pilot projects in Lithuania, the experience gained was further consolidated through the realization of a first pilot project in Italy.
The project was implemented along a section of the E80 roadway, in proximity to the ANAS Smart Road Center, and involved photovoltaic integration within an existing noise barrier. The intervention included the installation of 45 segments composed of aluminum-framed solid bifacial photovoltaic modules rated at 435 W, resulting in a total installed capacity of approximately 19.5 kW, distributed over 100 m of noise barrier length.
The estimated annual energy production of the system amounts to 18,283 kWh/year, confirming the technical feasibility and energy performance of the infrastructure retrofitting approach previously observed in the Lithuanian case studies.
The project was carried out in collaboration with ANAS, acting as the road infrastructure authority, GSM Continental as the installation contractor, and SoliTek as the supplier of photovoltaic modules, integration structures, and technical know-how.
This installation represents a concrete step toward more sustainable, safe, and intelligent infrastructure, highlighting the strong potential for scalability and replication of photovoltaic noise barriers as an Infrastructure Integrated Photovoltaics (IIPV) solution within the European context.

5 REFERENCES

[1] S. Philipps and W. Warmuth, “Photovoltaics Report,” Jul. 2024. Accessed: Nov. 08, 2024. [Online]. Available: https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdfThis section should have the progressive number before the title, exactly as for the previous ones.
[2] J. Van Overstraeten, P. Mace, E. Bosch, C. Plaza, and M. de l’Epine, “D2.1 – IPV market analysis and identification of stakeholders’ needs,” 2024. Accessed: Nov. 08, 2024. [Online]. Available: https://www.seamlesspv.eu/wp-content/uploads/2024/05/SEAMLESS-PV_WP2_T2.1_D2.1_PU_DL_M10-BI-20240416-v1_submitted-1.pdfDo not add any unnecessary space between the listed numbers of your references.

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