BUILDING THE WORLD'S LARGEST BIFACIAL SOLAR NOISE BARRIER

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ABSTRACT: In the Solar Highways project, knowledge institutes ECN and SEAC, and the executive body of the Dutch Ministry of Infrastructure and the Environment (Rijkswaterstaat) teamed up to build a bifacial fully integrated solar noise barrier. Not only is it the largest solar noise barrier in the Netherlands to date, it will also be the largest bifacial noise barrier in the world. The solar noise barrier will be 400 m long and 5 meters high and will be facing east and west. To achieve the objectives of maximum solar energy output and minimum operation and maintenance costs, we designed and published a procurement based on the principles of 'Most Economically Advantageous Tender' (MEAT), enabling the weighing of monetary alongside non-monetary aspects in the same procurement. Six system designs were submitted by contractors. After assessment of all submitted offers in the MEAT framework, the assignment was granted to Heijmans Infra. By submitting a design that enables a high cell coverage ratio together with minimized construction shading, the output is maximized. Smart design features ensure minimum operation and maintenance effort. After commissioning of the installation in December 2018, we will carefully monitor it with respect to energy output and maintenance costs.

Keywords: Infrastructure Integrated PV, BIPV, Bifacial, PV Noise Barrier, PVNB

Figure 1: An impression of the bifacial solar noise barrier design by Heijmans

1 BIFACIAL SOLAR NOISE BARRIERS

The advantage of *bifacial* solar noise barriers is that they can be used alongside any road, regardless of its direction [1]. More general, solar noise barriers generate renewable energy using existing infrastructure, saving otherwise wasted space. Rijkswaterstaat (RWS) will build a new noise barrier along the A50 highway in Uden, the Netherlands. At this location, the road runs north-south. Therefore the noise barrier sides will face east and west. Using conventional monofacial solar cells would mean a suboptimal electricity output. By using bifacial cells, the output will be increased by capturing light in the morning from the east side, and capturing light in the afternoon using the other side of the barrier.

Combining solar energy systems and noise barriers is an idea that was first executed in the 1980's. In the Netherlands, two systems were built in the 1990's. After these projects no follow-ups were initiated for two decades. This could be attributed to, among other things, the high price of PV, theft, vandalism and the lack of urgency for generating renewable energy. Recently the subject has regained interest in the Netherlands. Several Dutch construction companies have designed and built prototypes of solar noise barriers. In these designs some of the aforementioned problems are addressed. Mostly in Germany and Switzerland, a number of solar noise barriers were built in recent years, including a number of bifacial noise barriers in Zürich along a Highway bridge and in Münsingen along a railway line [2]. The bifacial

Figure 2: A prototype based on the ECN reference design for a bifacial solar noise barrier.

solar noise barrier in Uden will be the largest bifacial solar noise barrier to date.

2 THE PROCUREMENT PROCEDURE

To overcome the problems with theft, the Uden solar noise barrier will have fully integrated solar modules. To tackle problems with vandalism and high maintenance costs, the procurement of the Uden solar noise barrier was set up based on the principles of 'Most Economically Advantageous Tender' (MEAT). In this type of procurement, value is added to aspects other than cost price. In the case of the Uden solar noise barrier procurement, the MEAT tender aimed for maximum electrical output, together with measures to minimize the efforts and cost for maintenance. Six consortia of companies responded to the public tendering procedure, and all submitted a proposal. As guidance for how to maximize energy output, the procurement was accompanied by a reference design made by ECN [3]. The purpose of this design was to minimize the negative effect of self-shading or construction shading of the structural noise barrier components on the solar modules. For this the cell placement over the module was adjusted and a smart stringing and bypass-diode layout was designed. More information on the reference design can be found in the aforementioned reference. A prototype of this design was built and monitored. Figure 2 shows an image of this prototype. The tendering contenders were challenged to come up with a proposal that improves upon the ECN reference design, with regard to the energy output. Furthermore, they were asked to optimize their design to minimize maintenance effort and cost.

3 THE WINNING DESIGN

After assessment of the six designs on total cost, expected energy output and ease of maintenance, the bid by Heijmans Infra came out as the winning design. For the design and construction, Heijmans formed a consortium with Scheuten, Van Campen Bayards and Libra Energy. Heijmans and their partners gained knowledge and experience in the design and building of (bifacial) solar noise barriers in the previously executed SONOB project [4], leading to a very innovative design. A crucial improvement in the design of the PV module is the choice of modules with a height of 2 m instead of the regular height of 1 m, which is the standard height of noise barrier modules in the Netherlands, according to the Modular Noise Barrier (MGS) standards. In this way half the horizontal construction bars are avoided. Therefore the relative effect of construction shading by the horizontal parts of the frames is halved. In addition to that the effects of construction shading [5,6] are mitigated by dividing the active area into two areas. The top part, which suffers most from construction shading in summer, when the sun position is high, has a horizontal string layout, such that when this part is shaded, the output of the main area is not negatively affected. The main part of the module has a vertical string layout, to mitigate the effects of self-shading from the vertical support structure. Using this string layout enables using a very high cell density, without losing much output due to construction shading and thereby maximizing the energy output.

The system is fully equipped with module level power management system by using power optimizers. The main reason for this is safety. In the event of a vehicle crashing into the barrier, the optimizers will return to a safe working voltage, minimizing risk not only for the people in the vehicle, but also for the emergency services. As a bonus less-performing modules, caused by (external) shading, soiling, graffiti or defects, will not influence the rest of the system.

To build a vandalism-proof system, all electronics and cables are integrated into the carrying structure, and are not reachable from outside without specialized tools. For safety reasons it is important that all maintenance can be performed from the safe side of the noise barrier, away from the traffic. This means that cleaning or maintenance can be performed without disturbing traffic. All noise barrier elements are identical. This modular structure means that when a module is irreparably damaged, the modules can be replaced. Four spare modules will be kept in stock by Heijmans Infra.

Preparatory actions for the construction were started in March 2018. In the summer months an old concrete

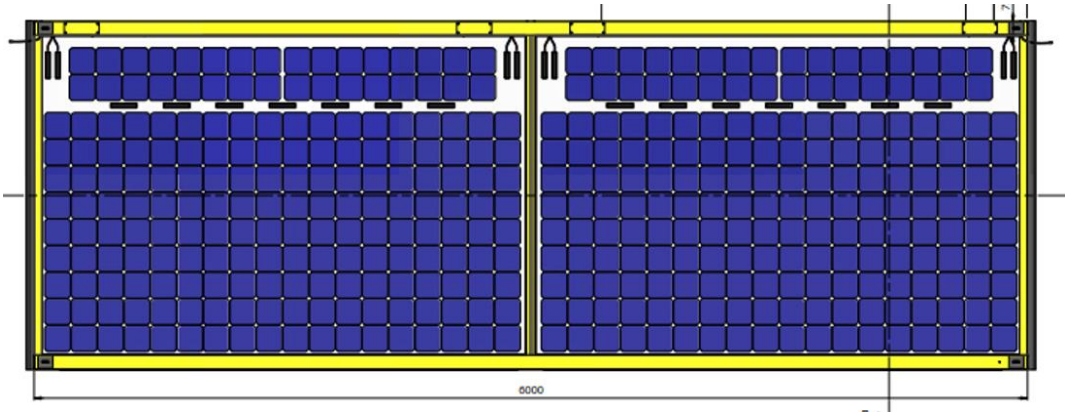

Figure 3: The Heijmans modular solar noise barrier panel design. By using a horizontal string on the top part of the modules and vertical strings in the main part, the effects of self-shading are mitigated.

noise barrier was removed and the foundations for the new solar noise barrier was placed. In September and October the bifacial solar noise blocking elements are placed. Commissioning of the system is planned for December 2018.

4 MONITORING

After finalizing the bifacial solar noise barrier in the last months of 2018, SEAC will carefully monitor the total solar energy output of the installation for 18 months. We will not only monitor the energy output of the bifacial solar noise barrier, also the efforts and costs needed for maintenance will be assessed. To analyze the business case for building and exploiting solar noise barriers, information about the costs of operation and maintenance is crucial. The most important missing information in this respect is the cost of cleaning the installation. A more frequent cleaning regime will enhance the energy output, but will add costs to the maintenance. To find out what is the optimal cleaning frequency with the business case in mind, a part of the installation will function as an O&M research section. This installation is split into 5 identical experimental sections. Each section will have a different cleaning regime, ranging from cleaning of both sides of the barrier every 6 months, cleaning only of the safe side (away from the road) to not cleaning the barrier at all. By assessing differences in energy output and relating them to the cost of cleaning, we can design the optimal maintenance scheme with the business case in mind.

LARGE SCALE ROLLOUT

The Uden bifacial solar noise barrier will be the largest of its kind in the world. Nevertheless we foresee a large and growing market for solar noise barriers in the near future, not only in the Netherlands, but also in the rest of the world. By setting up this project not as a one-time pilot, but through a tendering procedure for a permanent fixture, the procurement of the installation can be copied for future projects. In this way, future projects will be much easier to set up and execute. In this project we show that the technical hurdles for building a vandalism proof bifacial solar noise barrier can be taken. Crucial input for business case calculations is gathered in the monitoring phase, taking away the last barriers regarding the business case towards large scale rollout of building solar noise barriers.

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