Photovoltaic noise barriers

1. Background

The implementation of photovoltaics on noise barriers (PVNB) is an increasing occurrence across miles of motorways and railway tracks in Europe and worldwide. It is one of the most economical large scale PV grid-connection applications and has many additional benefits to protecting the surrounding area from the noise of the motorway or train routes. Since the first PVNB was installed along a kilometre of the A13 motorway in Switzerland, in 1989, there has been a growing interest in such applications and numerous PVNB structures have been established in Germany, Switzerland, Italy and The Netherlands. With the need to increase renewable energy technologies and meet worldwide CO_2 reduction targets, PVNB have significant potential to assist in reaching these targets in addition to supplying renewable electricity to thousands of homes and businesses and in some cases offering major financial investment.

2. Locations

Research has estimated that there are around 27 trialled and working PVNB across Europe, one PVNB is working in Australia and several trials and studies are being carried out in other countries, specifically Canada and the UK. The first PVNB installation, in 1989, has led to numerous successful PVNB grid connections and trials in different countries.

Figure 1, 1.7km PV noise barrier in Italy

Table 1 shows the location of the world's PVNB as of 2011. At present seven countries have at least one working PVNB and together total 7.3MW of installed capacity. Germany leads with a total of 13 PVNB which together total 4.8MW of capacity. Although Italy has only recently installed PV onto noise barriers, it currently has 1.5MW of PVNB along two motorways. Italy is also home to the longest PVNB in the world which stretches for 1.7km (1 mile). Following on from its first ever PVNB, Switzerland now has a total of seven PVNB installed across seven motorways and railway tracks which collectively make up 434.6kW of capacity. Australia, Austria, France and The Netherlands have all been slower on the uptake of PVNB but nonetheless they all have a least one working PVNB ranging from 24 to 216kW.

Location	Size (kWp)	Construction
Austrailia- Melbourne	24	2007
Austria- Gleisdorf	101	2001
Austria- Seewalchen	40	1992
France- Foquiere	63	1999
Italy- Oppeano (Verona)	833	2010
Italy- Marano d'Isera (Trento)	730	2009
Germany- Aschaffenburg	2065	2009
Germany- Tögin am Inn	1000	2007
Germany- Freising (Munich)	600	2003-2009
Germany- Freibury	365	2006
Germany- Bürstadt	283	2010
Germany-Vaterstetten	180	2004
Germany- Sausenheim	100	1999
Germany- Biessenhofen (Bayern)	90	2010
Germany- Saarbrücken	60	1995
Germany- Emden	53	2003
Germany- Ammersee	30	1997
Germany- Rellingen	30	1992
Germany- Großbettlingen	28	2006
Switzerland- Melide (Tessin)	123	2007
Switzerland- Domat/Ems	100	1989
Switzerland- Giebenaach	100	1995
Switzerland- Safenwil	80	2001
Switzerland- Münsingen	12	2008
Switzerland- Zurich (Aubrugg)	10	1997
Switzerland- Zurich (Walliselen)	9.6	1998
The Netherlands- Amstelveen	216	1998
The Netherlands- Utrecht	55	1995
Total	**7380.6**	

Table 1, Location of PVNB systems

Although the UK currently does not have any PVNB there have been a number of studies carried out in order to look at the benefits and offer some answers to questions often raised. A number of environmental groups and councils are also keen to see the potential of PV on noise barriers.

3. Energy Output

The energy output of any PV system is relative to area covered in PV panels, the azimuth of the panels (orientation), the angle relative to the horizontal plane (pitch) and the amount of solar radiation at the site of the installation. Table 2 is an example of a PVNB system based on a stretch of the M40 in the UK.

Length (m)	Height (m)	Area (m2)	Azimuth (°)	Pitch (°)	Number of Pv panels (max)	kWp	kWh per annum
730	3	2190	South	35	1719	310	252,500
				Total	**1719**	**310**	**252,500**

Table 2, an example of a PVNB system along the M40

4. Cost

The cost of installing PV onto noise barriers varies and will depend on a number of factors. First and foremost if the noise barrier is already in place then the costs incurred will only arise from mounting the actual PV system onto the barrier – of course not all barriers may be appropriate! A report produced by Parsons Brinckerhoff for DECC[1] outlined recent PV installation costs received from installers for different system sizes. Table 4, below, summaries the cost of large PV systems.

Band (kW)	Average Cost of installation
50	£92,300
75	£150,000
200	£260,000
1000	£1,200,000
5000	£6,200,000

Table 3, Summary of large PV system costs

The type of PV technology that is used will also vary the price of the PVNB. The trial carried out on the M27 used amorphous silicon due to the low manufacturing cost of this technology; however, amorphous silicon usually has a lower efficiency and life expectancy compared to poly-crystalline and mono-crystalline. Although poly-crystalline and mono-crystalline panels are slightly more expensive to produce they have much higher energy efficiency and it is therefore recommended that

[1] Parsons Brinckerhoff (January 2012) Solar PV cost update

either panel is used to obtain maximum energy output. Furthermore, the cost of installing PV onto noise barriers can also be offset by creating a community based Energy ESCo.

Figure 2, PV trial along M27

4.1 FIT and ROCs

In April 2010 the FIT was introduced as an incentive to encourage the production of renewable electricity. Since then, the Government has reduced the FIT several times with the latest reduction coming into effect on 1st April 2012. In addition, phase 2 of the comprehensive review indicates that the government is proposing a further reduction in July 2012 to enable control of cost and maintenance with an indirect link with returns. Table 3 illustrates the 3 possible options that the government are proposing for different sized systems.

Band (kW)	1st April tariff	Option A[2]	Option B[3]	Option C[4]
≤4 kW	21p	13.6p	15.7p	16.5p
> 4-10kW	16.8p	10.9p	12.6p	13.2p
>10-50kW	15.2p	9.9p	11.4p	11.9p
>50-150kW	12.9p	7.7p	9.7p	10.1p
>150-250kW	12.9p	5.8p	8p	10.1p
>250-5000kW	8.9p	4.7p	6.8p	7.1p
Stand alone	8.9p	4.7p	6.8p	7.1p

Table 4, FIT costs

The FIT tariff works alongside the Renewable Obligation (RO) which is the primary approach used for large scale renewable electricity installations. Table 5, below, shows the comparison in payments per annum received from both the FIT and the RO and makes the point that the RO is more beneficial than the FIT for larger scale applications.

[2] Option would be preference if deployment between 3 March and end- April 2012 exceeds 200 MW.
[3] Option would be preference if deployment during March and April 2012 is between 150 and 200 MW.
[4] Option would be preference if deployment during March and April 2012 is less than 150 MW

PV System size	Cost of installation (Average installer estimates)	FIT (p/kWh) 3/3/12	FIT per year	FIT (p/kWh) 1/7/12 (option A)	FIT per year	ROCs payment per year
50kW	£92,300	12.9	£5,263	7.7	£3,142	£6,283
75kW	£150,000	12.9	£8,582	7.7	£5,123	£10,245
200kW	£260,000	12.9	£22,886	5.8	£10,290	£20,579
1000kW	£1,200,000	8.9	£78,947	4.7	£41,691	£83,382
5000kW	£6,200,000	8.9	£394,733	4.7	£208,454	£416,909

N.B 1 ROC = 4.2p/kWp. Currently 2 ROCs are received for every MW. ROC price correct as of 31st March 2012.

Table 5 FIT vs. ROCs

5. Benefits

Noise barriers along motorways and railways tracks typically stretch for several miles and there is often the opportunity to install PV on these large structures. Mounting PV onto already existing noise barrier structures is similar in many respects to installing PV onto roofs of buildings and as such makes a positive use of an existing structure to accommodate the panels. This then avoids utilising additional land or creating a structure both of which may incur additional costs. The visual aesthetics of noise barriers can also be improved with the introduction of PV onto the often dull and monotonous looking structures. As with any PV system, there are economic benefits with payments from the Feed in Tariff (FIT) and the export tariff (at a rate of 3.2p/kWh), if any electricity not used is sold back to the grid. Furthermore, the PV on noise barriers can help increase the awareness of renewable energy.

Local communities and groups who are located near areas of high noise pollution are often keen to get noise barriers installed and to seek improvements. Such populations may well be able to make use of the potential electricity supply and benefit directly both from further noise reduction but also from cheaper electricity if a local scheme (e.g. through a social enterprise) is established. Currently, there are funding streams and market enabling measures to assist such innovative actions.

6. Common concerns with PVNB

6.1 Glint and glare

Solar PV panels are specifically designed to absorb light rather than reflect it, however, extensive and on-going PV 'glint and glare' research is being undertaken to improve the efficiency of PV panels still further. Reflected light is an important consideration when looking at PVNB as any increased reflection can be seen as deleterious. A number of studies have been carried out to observe whether there is a risk of glare and therefore a distraction to motorists. A PVNB trial took place in the UK[5] over a period of 3 years to investigate the performance, costs and driver behaviour in relation to a PVNB on the M27. Conclusions from the study found that 'no significant difference in braking was observed before and after the installation of the solar array'. It should be noted that the PV array in this study was set back from the motorway. In addition, a further study recently carried out in California, revealed that 'the flat-plate arrays [along motorways] would not create a significant hazard to motorists'[6]. When considering installing PV onto noise barriers it is important to carry out a thorough assessment and choose the right module type along with the optimal position in order to minimise any possible issues arising from the reflectivity of the panels, thus avoiding any possible potential distraction.

6.2 Noise reflection

Noise barriers are in place to protect properties situated behind them but questions have been raised concerning noise reflection to the opposite side of the road. PVNB studies carried out have revealed that there was a slight increase in noise on the opposite side of the road (to the PV installation), however, this was minimal and unlikely to be noticed by residents. Research indicates that careful positioning of the PV (including the angle of tilt) can further minimise and/or mitigate reflection issues. In addition, research on trees and shrubs and their effect on noise reduction have been carried out and have been used along motorways to aid noise amelioration from traffic. Planting trees or shrubs behind or opposite the noise barrier can help absorb the reflected noise from the PV panels and thus lessen the increase in noise on the opposite side of the road. Careful maintenance of such systems will be required to avoid shading given rapid growth and a reduction in the energy output.

The design of the noise barrier is an additional way to overcome noise reflection. Six different designs for installing PV onto noise barriers exist; top mounted, shingles, O-W vertical, N-S Vertical bifacial, horizontal zigzag and cassettes. Research has shown that zigzag, cassette and shingles configuration have better sound absorption properties than the top mounted and vertical designs[7]. A competition in 1996 in Austria and Germany revealed that the shingles configuration is an

[5] http://www.highways.gov.uk/knowledge_compendium/DA144AAA7CCD4D47984453C11EE7FE6D.aspx
[6] http://www.nwppa.org/web/presentations/2011_EandO/Solar_Highways.pdf
[7] http://sesci.ca/sites/default/files/pdfs/Remmer%20and%20Rocha%202005.pdf

economical technique to retrofitting existing barriers, particularly where noise reduction needs to be improved and this design shows high sound absorptive qualities.

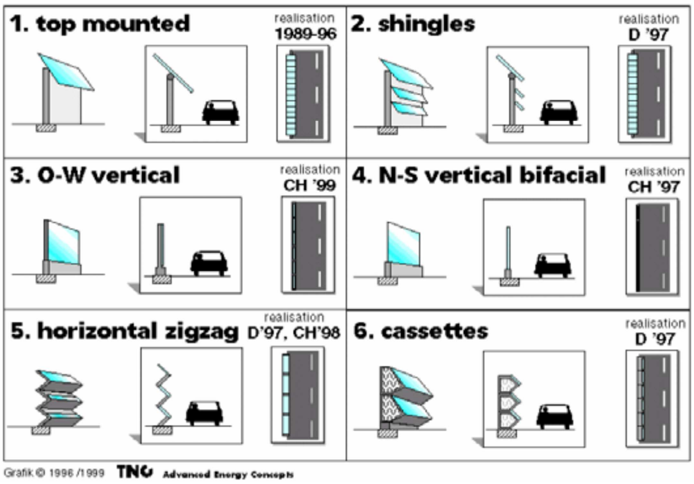

Figure 3, Types of PVNB

6.3 Theft and Vandalism

With the increasing number of PV panel installations worldwide the opportunity for panel theft and vandalism has also increased. Most panel thefts unsurprisingly are from unsecured locations or remote sites; however, prevention methods can be employed to reduce possible impacts. Basic security measures such as putting a fence around the structure, if ground mounted, or installing security cameras can act as a deterrent. In addition, due to the recent increase in this crime companies, such as Heliotex[8] and Bryce fastener[9] both based in the USA have begun to sell anti-theft products such as specially cut security bolts and fasteners which essentially lock the panels down more efficiently and make it difficult for thieves to remove. Insuring the PV array is also sensible and will protect against loss, damage or theft of the panels.

Figure 4, Security bolts for PV panels.

[8] http://www.solarpanelcleaningsystems.com/
[9] http://www.brycefastener.com/

7. Conclusions

The installation of PV onto noise barriers is increasing and is becoming a more familiar sight around the world. Noise barriers are principally installed to protect an area from noise pollution but can be given a double purpose of also generating renewable energy when facing west through south to east by adding PV panels.

Figure 5, Italy's longest PV Noise barrier

As with any large scale PV system the capital cost can be substantial but there are benefits and incentives to installing them. Furthermore, a community based ESCo can be an additional approach to draw in local support and to provide community benefits. Although there are concerns about PVNB, research carried out indicates that the benefits of using PV by far exceed any negative aspects for most applications.

Overall, by planning to integrate PV into noise barriers whenever an upgrade is due or future barriers are planned will enable the usage of such structures to be maximised and to increase the deployment of renewable energy technology in the UK.

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