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TechData Sheet

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Building Integrated Photovoltaic (BIPV) Roofs for Sustainability & Energy Efficiency

Technology Description

Rooftop photovoltaic (PV) systems have gained popularity partly due to the availability of unused roof space. However, the increased load can compromise roof integrity and void the roof warranty. One solution is to use a building integrated photovoltaic (BIPV) roof consisting of flexible, amorphous silicon (a-Si) PV modules adhered to a reflective polyvinyl-chloride (PVC) carrier sheet, which is then bonded to an Energy Star-rated PVC roof membrane. The BIPV system provides benefits of energy efficiency and renewable energy, can potentially cost less than a conventional roof and PV system and result in a shorter payback period.

DoD Environmental Security Technology Certification Program funded EXWC to demonstrate and validate how well BIPV roofs perform as both PV and roofing systems. The study evaluated an existing BIPV roof at Luke AFB and new systems at NAS Patuxent River and MCAS Yuma. Roof integrity, energy output, roof reflectivity and roof temperature data were collected and analyzed. Operations and maintenance requirements were qualitatively evaluated.

Before (left) and after (right) photos of the demonstration system at NAS Patuxent River, MD

Value to the Warfighter

Potentially reduces funding required to meet renewable energy and net zero goals, which allows for funding to be reallocated to other Dept. of Navy requirements.

Economics of the Technology: ROI or Payback

BIPV roof cost effectiveness is best compared to conventional roofs and rooftop PV systems. Roofing labor and material costs are relatively steady, but costs vary based on roofing type and quality, so a $5-$20 per square foot range was used in comparison scenarios. The *California Solar Statistics* website shows that the installed cost range of PV was roughly $7.5-$10 per Watt (W) in 2008 and $4-$7.5/W in 2012. The BIPV roof contract was awarded in 2008. The price reduction is significant due to the selling price of crystalline PV modules. Unfortunately, a-Si PV modules did not experience as significant a

price reduction. Savings-to-investment (SIR) ratios for sample cases and comparison to BIPV roof costs are shown in the following tables.

System Life	SIR with Avoided Re-roof at $5/sq.ft.	SIR with Avoided Re-roof at $20/sq.ft.	SIR with Avoided Re-roof at $5/sq.ft. & Rebates	SIR with Avoided Re-roof at $20/sq.ft. & Rebates	SIR with Avoided Re-roof at $5/sq.ft. & HVAC Savings	SIR with Avoided Re-roof at $20/sq.ft. & HVAC Savings	SIR with Avoided Re-roof at $5/sq.ft. & HVAC Savings & Rebate	SIR with Avoided Re-roof at $20/sq.ft. & HVAC Savings & Rebate
15-Year	0.10	0.30	0.13	0.84	0.14	0.44	0.18	1.22
20-Year	0.16	0.48	0.20	1.34	0.22	0.66	0.28	1.85

SIR values of various scenarios based on Arizona case study at electric rate of $0.073/kWh.

Location	BIPV Cost at time of Award	Conventional Roof @ $5/sq.ft. and PV @ $4/W	Conventional Roof @ $5/sq.ft. and PV @ $7.5/W	Conventional Roof @ $20/sq.ft. and PV @ $4/W	Conventional Roof @ $20/sq.ft. and PV @ $7.5/W
Site I (Luke AFB)	~$6M (2005)	$2.2M	$3.5M	$4.4M	$5.7M
Site II (Patuxent River)	$363K w/ roof repairs; $332K w/o	$188K	$282K	$428K	$522K
Site III (MCAS Yuma)	$254K w/o rebate	$129K	$201K	$268K	$340K

Actual BIPV roof costs compared to estimated 2012 capital costs for conventional roofs and PV systems

Technology Transition Documentation

BIPV roofs are still relatively new and evolving. The type studied is no longer available due to adhesion problems and better design practices. In some newer systems, thermoplastic-olefin (TPO) membranes have replaced PVC because some claim that TPO is more adhesive-compatible; flexible PV modules based on other materials have been used because of higher conversion efficiencies; conduit became surface-mounted to be more firefighter friendly.

UFC and UFGS documents were not created due to product changes and a lack of data on the new components. In addition, the Navy roofing subject matter expert does not recommend BIPV roofs at this time with a significant reason being the lack of long term performance data. Therefore this product is recorded under transition category 4.

Site Implementation

In spite of the improvements, the problems identified by this study may still occur with new adhered systems. The National Electric Code addresses some PV safety concerns, but fire and firefighter safety standards still need development, so consult with base safety personnel before and during the design phase. Improper water drainage can reduce roof longevity and may be remedied with a thorough review of the design by a roofing specialist, using a rigorous quality assurance/control plan, and

performing a BIPV roof assessment before the workmanship warranty expires. In the case of a retrofit, problems with the existing roof need to be remedied prior to BIPV roof installation. Mold growth can reduce roof reflectivity even if it does not reduce roof longevity so ensure that the manufacturer and installer warranties address this aspect. PV adhesives may still fail and improperly tested solutions may worsen the situation by making other remedies more difficult to implement. A comprehensive warranty may mitigate risk, but is ineffective if the warrantor goes out of business as was the case during this study. Third-party solutions may be available, but may void any remaining warranties. Various acquisition vehicles can mitigate the technical risks, but contracting complexity, costs, and risk must be balanced.

The concerns with BIPV roofs can be mitigated, so DoD personnel in charge of rooftop solar projects need to determine whether or not the cost and benefits outweigh those of conventional rooftop PV systems. It is recommended that DoD personnel interested in BIPV roofs be aware of the issues, consult with a roofing specialist and obtain training and/or consultation from experienced personnel prior to the design and construction phases.

Specific Applications

It is recommended that DoD maintain a list of adhered PV systems and their basic PV and roof components and survey a sample set every few years to identify performance/durability trends.

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