

BUILDING INTEGRATED PV-SYSTEMS FOR THE UNITED STATES

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ABSTRACT: Known as one of the leading companies involved in building integrated Photovoltaic (PV) systems, Atlantis has fabricated, designed and installed a large number of impressive PV systems all over the world. In addition to the two existing manufacturing facilities in Europe (Härkingen (CH) and Gera (D)) a new Atlantis manufacturing facility was built in the United States in 1995 to supply the American market with solar electricity generating building materials. The facility is located in Exmore, VA near the Chesapeake Bay. To successfully enter the American PV market, the products had to pass hardest test conditions of Underwriters Laboratories (UL) and PVUSA. For selling Photovoltaic roofs, the different ways and codes of building houses in the USA compared to Europe have to be taken into account.

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1. DEFINITION OF BIPV

Taking into account that different companies use the term "BIPV" in different ways of understanding, we would like to express our point of view, which is a basic guideline for our companies philosophy.

BIPV definition: Building Integrated Photovoltaics (BIPV) is a building material that will produce electrical power from sunlight and is an integral part of the building envelope.

2. PV-MARKET IN THE USA

In the United States, the number of building BIPV applications is small. Large PV companies typically produce standard modules for rooftop applications or 'stand alone' off grid systems. Generally, BIPV is considered to be too expensive for a large-scale application. Also the situation to receive grants for solar energy is by far not as good in the US as it is in Europe.

Over the past two years the first ideas for building integrated PV systems were developed by different US PV companies, but no wide spread application has occurred to date. In fact many of these BIPV components were a form of 'add on PV' and not actual PV building components. Some companies offer standard size frameless modules in crystalline and amorphous cell technology, especially for facades. Some projects have been realized in this sector. Nevertheless, Architects design their facades not in accordance to available standard size modules but rather to standard curtain wall specifications or building specifications. In this sector, custom-made modules of flexible size are required.

The Atlantis Solar Systems team is specialized in integrated Photovoltaic building materials and systems. To enter the PV-market of North America, the Swiss Atlantis Group founded the subsidiary Atlantis Energy Inc. (AEI) in 1995. The southwestern part of the United States, with its

excellent annual solar irradiation is a most promising area in the US to produce solar electricity. In addition, the local electricity companies of Sacramento (SMUD) and Los Angeles (LADWP) funded programs to promote solar energy. Consequently, Atlantis decided to place the headquarters of AEI in Sacramento, California.



Fig. 1: Kit Carson School, Sacramento, 32.4 kW Sunslates

In addition to this, Atlantis built up a factory for the manufacturing of energy producing building materials. Taking the advantage of the Virginia Incentive Grant program, the company Solar Building Systems Inc. (SBS) was placed on the Eastern Shore Virginia near the Chesapeake Bay. All PV production equipment was designed and constructed by Atlantis Switzerland and shipped to the USA. With a production capacity of about 1MWp/year, Solar Building Systems Inc. produces custom PV products and large quantities of Sunslates[®] (SL), a PV-roof shingle system developed by Atlantis [1].

Atlantis Photovoltaic skylights, Photovoltaic roofing materials and the electrical balance of systems were designed and installed throughout the United States by the Atlantis team.

3. THE SUNSLATES[®] SYSTEM

3.1 The rooftile system

Atlantis Solar Systems developed the Sunslates[®]-system in 1997. Based on a standard Eternit rooftile, these PV building elements are easily mounted by roofers on standard wooden structures. The PV elements are connected to each other, using a specially designed junction box and corresponding cables. These electricity generating rooftiles can cover the whole roof area. Even shaded areas near chimneys or dormers can be covered by SL using dummy slates without electrical function. The full roof integration includes the perfect finishing of ridge and edges. This way, a very esthetical solution of PV roof integration can be presented.

Using the standard integrated ventilation system of Eternit roofs, the SL are kept dry on the backside and are cooled to reach higher Photovoltaic efficiencies. This allows the roof to stay in good condition and a long lifetime of energy production will be attained.



Fig. 2: Stand alone system in Montana, 12.4 kW Sunslates

3.2 Quality aspects

For the European market, the Sunslates[®] were certified according to Ispra 503 / IEC 1215. For the American market, this certification is not sufficient in the home or commercial sector.

To be easily accepted by engineers, architects, contractors, and building inspectors on the American market, the SL went through rigorous industrial qualification tests performed by Underwriters Laboratories, Chicago (IL). Additionally, wet high potential electrical testing was performed on entire roofing systems at PVUSA in Sacramento (CA). The system outdoor electrical performance tests are continually monitored by PVUSA at selected system sites throughout the USA.

For products sold on the US market, the UL certificate is almost mandatory. Completion of the Photovoltaic series of Underwriters Laboratories tests classified the Sunslates[®] under UL1703 qualifying it as Listed Photovoltaic Modules and Panels. Completion of the UL790 fire resistance tests classified the SL under UL790 and as a Prepared Roofing Material Shingle with a Class A degree of resistance to external fire and flammability limits.

Listing of the SL under the UL1703 involved careful selection of component materials, careful design and engineering of SL construction, system design, and extensive performance testing. UL1703 required the testing

of every SL material component, the individual SL and the SL-system as a whole. The tests included mechanical loading, arcing, hot-spot endurance, corrosive atmosphere, humidity, temperature cycling, accelerated aging, fire, mechanical impact, inverse current, dielectric voltage, and strain relief, not naming them all. Even our Sunslates Installation Manual is UL Listed.

Underwriter Laboratories fire ratings are extremely important to contractors, building owners and insurance agents. UL has three fire rating categories classified under UL790. These categories range from Class C, which is the lowest rating to a Class A rating. (Most home roofs in the US are required to have a Class A fire rating)

Sunslates[®] have a Class A fire rating under the UL790 test procedures. Three types of tests were involved: Burning brand, Intermittent Flame and Spread of Flame. The Burning Brand test uses a burning wood brand at temperatures of ~ 2000deg. F placed directly onto the SL. This is a test to determine if the brand will burn through the PV roofing material. The Intermittent Spread of Flame Test also is a test to determine if the roofing material (SL) will burn through to the sub-roof. In this test, flames are in direct contact with the SL-roof for 2 minutes, turned off for 2 minutes, etc. for a total time of one hour. The last test of the series is the Spread of Flame Test (Fig. 2). As the name implies this is a test to see if the SL roof will ignite and spread the flames. The SL roof is set at a 5/12 pitch with a steady flame forced onto the roof (directed by a 12mph wind behind the flame). The rigour of these tests maintains quality standards and guidelines, which the customer can rely upon knowing that the Sunslates are a reliable and safe product of best quality.



Fig. 3: Spread of flame test at UL, Chicago

4. BIPV PROJECTS IN THE US PV-MARKET

Atlantis Energy faces an exponentially growing BIPV market in the US and particularly for Sunslates[®] roofs. With innovative sales approaches, fast and "on-time" design/installation and the pleasing architectural appearance of the projects, an extraordinary confidence from builders, developers and distributors can be gained. The advantages of the PV roofing shingle system give an ideal opportunity to use the "on-site" roofers and electricians for construction. The product is advertised in building/roofing magazines and the actually realized projects received an excellent response from builders and

developers on PCBC (Biggest building show for the United States in San Francisco, 1999).

4.1 Building Integrated PV skylight projects

As its first building integrated PV project, Atlantis designed and fabricated a 40kW_p BIPV skylight system on Rikers Island near New York City in 1996 (Fig. 4). The system uses 198 semi-transparent laminates allowing 20% of sunlight to illuminate the building. This large system powers the composting system for the island.

The second BIPV skylight system was installed at Presidio Park at the base of the Golden Gate Bridge in San Francisco, CA. This beautiful but small BIPV system is a semi-transparent roofing system producing 1.5kW of power.



Fig. 4: Rikers Island, New Your City, 40kW_p skylight

Atlantis started partnerships with larger skylight glazing companies and facade suppliers. Promising large projects are going to be built within the coming years.

4.2 The SMUD contract

Atlantis is contracted to build several megawatts of building integrated PV-roofs in California. The contract with SMUD (Sacramento Municipal Utilities District) includes the use of Atlantis solar building materials [2] for a large number of houses in the Sacramento area. Within the SMUD project, Atlantis installed 150kW_p of Sunslates[®] on a multitude of dwellings ranging from homes through schools to churches (Fig. 1). Typical home installations range in size from 2.5kW_{DC} to 4.5kW_{DC} . This phase of the contract required the use of crystalline solar cells but the following will also require the use of thin film materials. The overwhelming response received in the Sacramento area reflects the great demand of BIPV products.

4.3 LADWP

Atlantis Energy has started to build up a distribution network in the Los Angeles region, including the biggest roofing material retail distributor in the LA, ALL Roofing Supply. The first sub-division of 13 homes at 2.5kW_p each have already been successfully installed. The region promises tens of megawatts for BIPV projects in near future. LADWP (Los Angeles Department of Water and Power) will provide a buy-down program for its customers

to reduce system costs, which will make integrated PV building materials financially more attractive and affordable for many homeowners.



Fig. 5: Regis Homes, Davis CA. 3.5kW_p systems on 3 homes

4.4 New Homes construction in sub-divisions (production homes)

Building in sub-divisions is another aspect of our success to sell BIPV products in large scale. In the US a large percentage of new homes is constructed by building in sub-divisions (10 to 100 units). AEI is closely working with some major builders like Prodigy Homes, Regise Homes, US Homes etc. in the country. The Sunslates[®] roofing system is sold as an option and in some cases as a standard item on these newly built homes. (Fig. 5)

The goal is to install the SL roofing systems as a standard item on the new homes by increasing the demand from new home owners and building up confidence into Atlantis PV products. In many regions, the financial incentives are clearly starting to make a difference, additionally many customers look at this value-added system as a wonderful re-sale option.

5. FINANCIAL ENGINEERING

Key to the rise of building integrated photovoltaics in many regions of the United States has been our ability to demonstrate that BIPV is economically feasible. Our new financial engineering approach combines all cost saving factors to demonstrate how cost effective BIPV can be in new Californian homes. This specially designed Atlantis software indicates cost reductions resulting for different regions to show whether the analysed Sunslates[®]-system has an attractive economic balance for this customer.

The projects are approached by considering the financial structure of the payment. In case the system is financed by a mortgage home loan, AEI performs a cost analysis of the home with a SL roof. The analysis includes the loan's mortgage rate, added costs and extra monthly payments, the home price, system location and produced kWh of electricity, local utility rates, tax savings and any additional opportunities for savings.

In most cases the total benefits are more then the extra mortgage payment, which makes the SL roof very attractive for new home buyers. The results of the program are used for sales purposes and presented to the customer

for their review and suggestions. The system design and economic analyses are performed in parallel for an optimum solution.

The following example reviews a recent project, realized in California by a local home builder :
 The mortgage interest rate was: 7.5% for 30 years; Roof Orientation: South; Roof tilt: 4/12 (18°); System size: 4.3 kW_p; Utility rates: \$0.098 / kWh; Figure 6 illustrates, that for the example described above a positive return on investment after taxes is achieved for installed system cost up to approximately \$5/W_p.

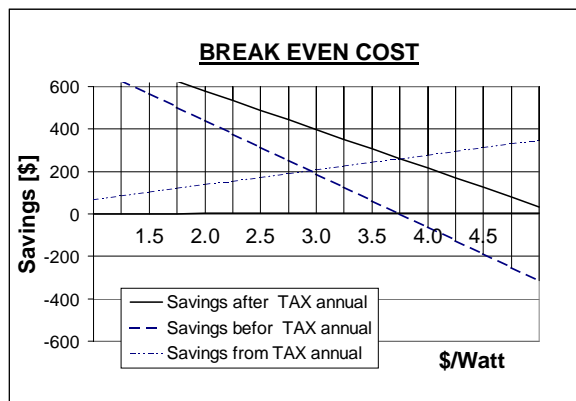


Fig. 6: Cost savings as a function of installed system costs.

For optimum solutions the software performs economic analyses of the region and calculates the break-even costs of a system (at what price the system can be sold for the optimum benefits of the customer).

6. CONCLUSION

Compared to the European market, the US-market is still more dominated by standard modules, but now a growing fraction of specially designed building integrated PV elements is entering the market. As one of the pioneers for building integration in the United States, Atlantis implemented numerous integrated PV installations, primarily using the Sunslates[®]-system.

The most important qualification steps have been taken, passing the strict UL and PV-USA tests. This opens the door for a wide spread installation of Sunslates[®] systems throughout the United States.

The increasing demand of esthetical solutions for PV roofs is a promising sign for the future. First larger programs to support solar energy have been introduced in the south western part of the USA.

Especially the opportunity to sell beautiful and perfectly integrated PV roofs to thousands of house owners opens a big market for BIPV in America.

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