ABSTRACT

The Tesla solar roof is a building-integrated photovoltaic (BIPV) product that takes the functionality of solar panels and integrates it into roof shingles. A home with a Tesla shingles installed would have both a protective and complete roof and the capacity to generate solar energy, but without installing solar panels as well. Solar shingles like Tesla's product alleviate the common concern about aesthetics held by property owners. By installing the Tesla solar roof, you don't have to install solar panels to generate electricity, which some property owners find visually unappealing. The cost of a Tesla solar tile installation remains largely unknown.

Many solar industry stakeholders recognize that solar needs to be rebranded as an aesthetic and technical improvement that could be a part of a home renovation rather than a hefty module that is nailed onto your rooftop. That sentiment was emphasized in Elon Musk's October 2016 launch of Tesla's new roofing product. The company aims to bring solar further into the mainstream by removing any sort of aesthetic concerns that homeowners may have.

INTRODUCTION

The most recent news coming out surrounding the Tesla Solar Roof is much of the same, with a new glimmer of hope. According to a Bloomberg report, work at their Buffalo Gigafactory is accelerating with the implementation of 24/7 operating hours and about 80 employees per shift working solely on Solar Roof shingles. The company is currently working through about 11,000 orders for the Solar Roof that it has received up through May 2018. While not perfect news, those solar shoppers looking to finally install a Tesla Solar Roof can see light at the end of the tunnel. Tesla hasn't given any specific production numbers, but several reports say that they have worked out major manufacturing hiccups. The company's SVP of Energy Operations, Sanjay Shah, says Tesla is gearing up for the Solar Roof side of their business to see "tremendous growth in 2019". Musk himself tweeted recently that the first solar roof deployments will begin in summer 2019. Electric report, a full installation of the Tesla Solar Roof takes about 2 weeks.

Tesla started accepting deposits to reserve solar roof tiles in May 2017. In January 2018, the company announced that they are ramping up production of the solar shingle product at their Buffalo Gigafactory. Then in mid-March, they completed some of the first initial installations for customers at the top of their wait list in the California area approximately six months after their initial estimate.

Elon Musk revealed in August 2017 that he and another Tesla executive have installed the solar roof on their respective properties already. While the company stated that they have begun installations for their waitlist, it was unclear when Tesla will be installing the roof at a national, mass-market scale. In August 2018, it was reported that only 12 solar roofs had been installed in California, the country's leading solar market, by the end of May 2018. Tesla blamed the continued delays on an imperfect process at their Buffalo Gigafactory, and they planned to ramp up production toward the end of 2018.

To give prospective solar roof customers more information, Tesla has launched a calculator that provides estimates for its solar roof. The company has also released basic pricing information: customers can expect to pay around $21.85 per square foot for their solar roof.

HISTORY

Solar shingles became commercially available in 2005. In a 2009 interview with Reuters, a spokesperson for the Dow chemical company estimated that their entry into the solar shingle market would generate $5 billion in revenue by 2015 and $10 billion by 2020. Dow solar shingles, known as the powerhouse Solar System, first became available in Colorado, in October 2011. The powerhouse Solar System continues to live on in its 3rd generation iteration, and has exclusively been licensed to RGS Energy for commercialization. In October 2016, Tesla entered the solar shingle space in a joint venture with SolarCity.

Tesla started development in 2012, installing prototypes at selected industrial customers. In some cases, Power Packs have reduced the electrical bill by 20%.Tesla originally announced the Powerwall at the April 30, 2015 product launch with power output of 2 kW steady and 3.3 kW peak, but Musk said at the June 2015 Tesla shareholders meeting that this would be more than doubled to 5 kW steady with 7 kW peak, with no increase in price. He also announced that Powerwall deliveries would be prioritized to partners who minimize the cost to the end user, with a Powerwall installation price of US$500.

When originally announced in 2015, two models of Powerwall were planned: 10 kWh capacity for backup applications and 7 kWh capacity for daily cycle applications. By March 2016, however, Tesla had "quietly removed all references to its 10-kilowatt-hour residential battery from the Powerwall website, as well as the company's press kit. The company's smaller battery designed for daily cycling is all that remains." The 10 kWh battery as originally announced has a nickel-cobalt-aluminium cathode, like the Tesla Model S, which was projected to function as a backup/uninterruptible power supply, and had a projected cycle life of 1000–1500 cycles.

In October 2016, Tesla announced that nearly 300 MWh of Tesla batteries had been deployed in 18 countries. The Powerwall 2 was unveiled in October 2016 at Universal Studios' Colonial Street, Los Angeles, backlot street set and is designed to work with the solar panel roof tiles to be produced by SolarCity.

Chapter-1

1.1 About solar roofs:-

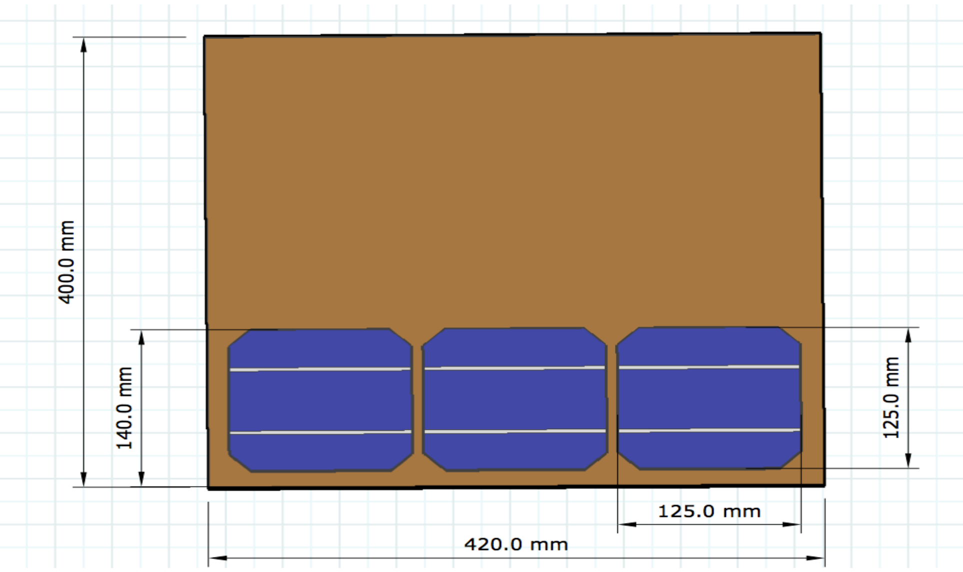
Solar tile is a fully integrated single piece solar photovoltaic (PV) roof tile that will install onto any building structure with a pitched roof. Solar electrical power is generated through the photovoltaic solar cells embedded within the integrated solar tile. The FreeSuns Solar tile is dimensioned to be a direct replacement for existing Eternit cement fibre roof tiles.

The FreeSuns SOLARIS™ solar tiles can utilise the existing wood batons installed for Eternit roof tiles. The design of the FreeSuns SOLARIS™ solar tile is unique in that it incorporates electrical safety circuit for each individual tile resulting in an unprecedented level of PV Fire Solar safety for roof tops.

The FreeSuns solar roof tile comes complete with all waterproof junction boxes, cabling and connectors. The design of the FreeSuns SOLARIS™ Solar tile permits the highest percentage of solar cell coverage on all roof types. Another unique aspect of the integrated design of the FreeSuns solar tiles is the strength of the double lamination tempered glass resulting in an ultra strong roof tile "triple the strength and quadruple the life" of a traditional roof tiles.

No extra planning: FreeSuns solar tiles are ideal for direct replacement for Eternit roof tiles.

Ease of installation: Fitted to standard wooden battens 48mmx24mm using traditional roofing installation techniques.



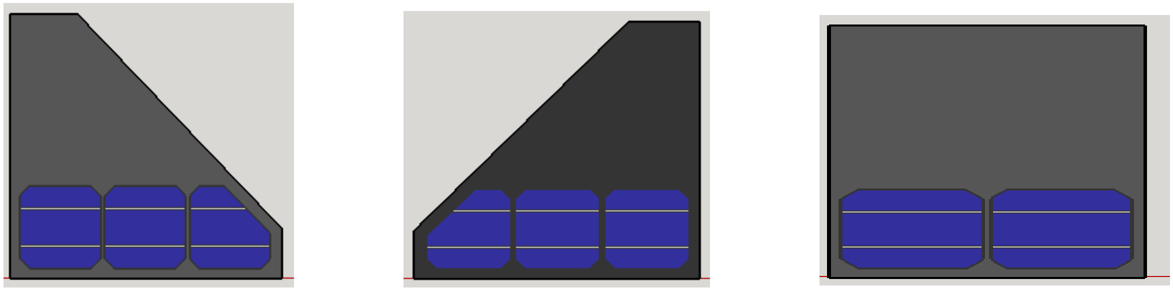


Fig-1: Freesuns SOLARIS™ Solar PV Integrated Roof Tile

1.2 PHYSICAL SPECIFICATION:-

TABLE-1

Width	420 mm
Height	400 mm
Thickness	7 mm
Roof Pitch Minimum	10 degrees
Roof Pitch Maximum	90 degrees
Nb Tiles / m2	16
Roof Surface PV Coverage	> 80%
Power per m2	128 Watts
Individual Tile Weight	2.95 kg
Installation weight	47.25 kg/m2
Minimum Batten Size	48mm x 24mm (standard)
Stainless Steel Mounting Hook	3mmx120mm
Impact resistance	Hail - 25 mm at 32.5 m / s

1.3 ELECTRICAL SPECIFICATIONS:-

TABLE-2

Rated Power	8.5 Watts
Power Tolerance	+3%
Voltage at Pmax	1.55 V
Current at Pmax	5.45 A
Open Circuit Voltage	1.87V
Short Circuit Current	5.80A
PV Cell Technology	Mono-Si
PV Cell Efficiency	18%
Safety diode per tile	10 A
Temperature Co-efficient at Pmax	-0.37%/degree above 25C +0.37%/degree below 25C
Connectors	MC4 type IP65 push click connectors
Cables	300mm each 4mm2 double insulated Class 1 solar cable rated -40C to +85C

1.4 MATERIAL SPECIFICATION:-

In solar roof tiles there are three kind of material used by the TESLA which have physical appearance as a normal tile. These tiles have three layers, which are as Color louver film, High efficiency solar cell, Tempered glass.

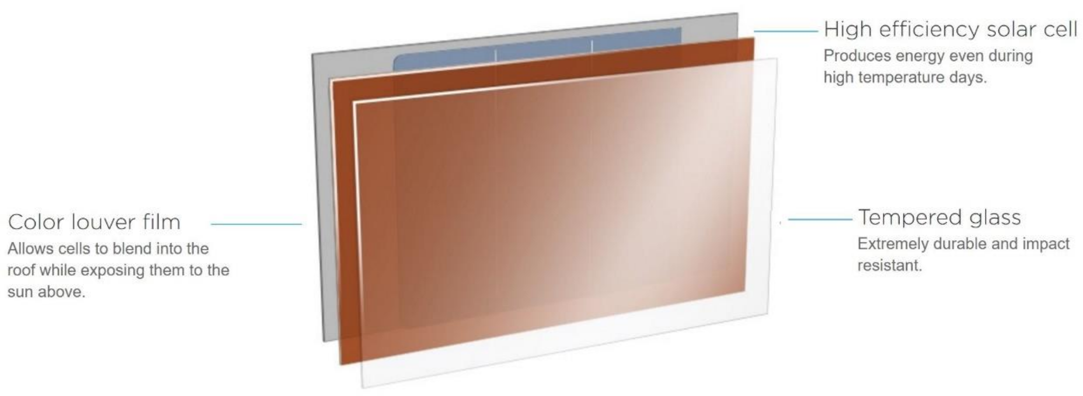


Fig-2: Layers of tesla solar tiles plate

1.5 TYPES OF TESLA SOLAR ROOF TILE:-

In this solar power system, according to the CEO Elon Musk of TESLA group there are four kinds of solar roof tiles have been patented which are different from BIPV and normal PV plates. These plates have physical appearances as a normal roof tile which strength is normally more than the Asphalt and Terracotta glass plates.

Tesla solar roof tiles have been launched in four different kind of tiles which are as fallows-

1. Tuscan Glass Tile
2. Smooth Glass Tile
3. Textured Glass Tile
4. Slate Glass Tile

Fig-3: Schematic view of solar roof tiles

Chapter-2

2.1 POWER SUPPLY SYSTEM:-

The Powerwall and Powerpack are rechargeable lithium-ion battery stationary energy storage products manufactured by Tesla. The Powerwall is intended to be used for home energy storage and stores electricity for solar self-consumption, time of use load shifting, backup power, and off-the-grid use. The larger Powerpack is intended for commercial or electric utility grid use and can be used for peak shaving, load shifting, backup power, demand response, microgrids, renewable power integration, frequency regulation, and voltage control.

Announced in 2015, with a pilot demonstration of 500 units built and installed during 2015, production of the product was initially at the Tesla Fremont factory before being moved to the under-construction Gigafactory 1 in Nevada. The second generation of both products was announced in October 2016.

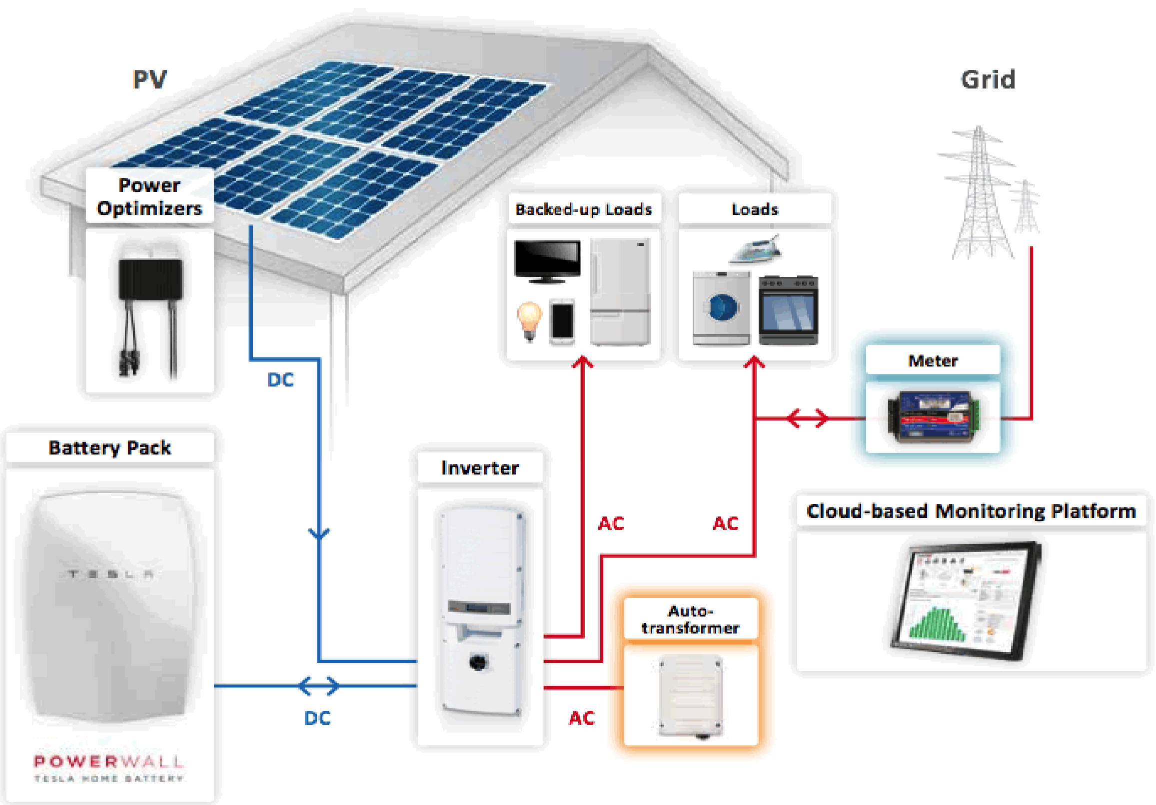


Fig-4: Layout of power Supply system

2.2 PV MODULE AND INVERTER SELECTION:-

The Solar World 245W Polycrystalline PV modules were selected for this work due to their high efficiency values and because they were highly evaluated in the 2013 PV+Test2.0. The PV module type is crystalline silicon and has a lifecycle between 25-30 years. The inverter and the Powerwall battery is expected to be replaced commonly every 10 years and therefore the replacement of these two components takes place in year 10 and in year 20. The 3KVA 2400W 24v 8 Multiples Eco solar 3-in-1 Hybrid Inverter was chosen to work together with the Powerwall Battery since it includes an inverter, a charger and a regulator with an efficiency rate of 93%. The energy flow between the two components starts with the injection of the solar energy into the household grid for self-consumption, and then the surplus energy is injected into the Powerwall battery without grid injection.

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2.3 PERFORMANCE RATIO (PV SYSTEM LOSSES):-

Losses generated in the inverter, batteries, wiring, and module soiling, affects the PV system performance ratio (PR) between 75-90% and therefore the default PR value is 0.75 according to and for this work the PR is assumed as 0.80 due to the type of PV modules that are used.

2.4 ECONOMICAL PARAMETERS: -

The economical methods (IRR, DPBP and PI) are calculated by considering the economic parameters that are mentioned below and respective values presented in Tables.

All cities and states differ in solar production values, PV System initial investments, hybrid inverter linked to Powerwall investment, electricity tariffs, interest rates, and the electricity evolution rate.

The common economic parameters in all cities and states include the same O&M cost rate, inverter replacement rate, Powerwall battery replacement rate, PV module degradation rate, Powerwall battery loss and hybrid inverter loss. The Powerwall battery replacement assumed in this paper takes place in year 10 and in year 20 where battery prices are expected to drop, therefore the Powerwall battery cost in year 10 would be 25% less (1904.68€) than the current price and in year 20 there would be a 50% drop (1269.79€). The electricity price for the next 25 years is predicted by calculating an average evolution rate of the electricity price for Portugal based on the past 25 years and the same was done for the United States from the past 20 years.

The same approach was used to predict the interest rate for the next 25 years in which an average is based on the past 16 years of the real interest rate for Portugal and an average over the past 25 years for the United States. In order for the investment costs to be realistic in this research, at least three quotes from different companies for Portugal and for the United States had to be received to then make an average investment value for each country. All quotes include turnkey solutions in which they include all the components of the PV system, the Powerwall battery, mounting structure, delivery, and installation.

2.5 OPERATING AND MAINTENANCE COST:-

The O&M made during the PV system's lifespan include inverter and Powerwall battery replacement, which adds extra costs estimated between 0.5-2.4% of the initial investment per year. The O&M cost rate as well as the inverter and Powerwall battery replacement costs are presented in Table 3.

TABLE-3

Common parameters of Portugal and the USA

Parameter Description	Value
Maintenance and operations rate	2%
Inverter Replacement cost rate	8%
Powerwall Battery Annual Charge/Discharge	2555kWh

Energy	
Powerwall Replacement Cost in year 10	1.904,68 €
Powerwall Replacement Cost in year 20	1.269,79 €
Powerwall Cost	2.539,58 €
Powerwall efficiency loss rate	8%
PV Degradation rate	0,70%
Project life time	25 years

The Powerwall grid charging solution without the PV system in California makes double the investment during the 25-year period with a 7 year payback time because of the savings made from the gap between the on-peak and super off-peak hourly tariffs. The payback takes place before the 10-year warranty of the Powerwall battery in scenarios 2 and 3, making the investment even more attractive.

The Powerwall solution is not viable in any scenario in Portugal due to the high investment cost and low difference between the daily tariffs. The Tesla Powerwall battery is a separate component that is connected to the PV system, adding extra costs to the initial investment since it does not have an incorporated AC/DC inverter. Some scenarios turned out to be viable investments even though the hybrid inverter and Powerwall battery replacement costs are also considered in year 10 and 20.

The attractiveness of these kinds of investments only improves if the PV system costs decrease and the electricity prices increase, which is predicted for the coming years. The PV system cost and electricity prices as well as the solar radiation values, play a big role on making double the investment during a 25-year period, as seen in the off-grid scenario that involves the State of Hawaii. The Tesla Powerwall battery solution is a viable investment in regions where the electricity tariff is over 0.25€/kWh just as seen for the State of Hawaii.

Chapter-3

3.1BUILDING INTEGRATED PHOTO VOLTAIC SOLAR CELL(BIPV):-

INTRODUCTION:- 1. Installations of solar photovoltaic (PV) technologies on building rooftops are common in some parts of the world. The vast majority of these systems are composed of modules that are mounted off the surfaces of roofs using different types of racking hardware. System designs are most influenced by PV performance considerations, and aesthetics are often secondary. But growing consumer interest in distributed PV technologies and industry competition to reduce installation costs are stimulating the development of multifunctional PV products that are integrated with building materials.

This emerging solar market segment, known as building-integrated PV (BIPV), continues to attract the attention of many stakeholders, as evidenced by the mention of a rooftop solar shingle product in the President's 2011 State of the Union Address (White House 2011). BIPV offers a number of potential benefits, and there have been efforts to develop cost-competitive products for more than 30 years. The deployment of BIPV systems, however, remains low compared to traditional PV systems. In this report, we examine the status of BIPV, with a focus on residential rooftop systems, and explore key opportunities and challenges in the marketplace.

2. Luma Resources' solar shingle product, honored in the 2011 State of the Union Address, is composed of a polycrystalline PV module adhered to a metal shingle 3 Feed- A continuum of PV system designs exists with various levels of integration with building materials and architectural features there is no consensus definition of BIPV. Many stakeholders describe BIPV as a multifunctional product one that acts as both a building material and a device that generates electricity (e.g., a solar shingle). Incentive programs and market reports, however, sometimes include partially integrated PV systems those that blend with the designs of building materials but are not multifunctional in their descriptions of BIPV. In Europe, for instance, the rules to qualify for BIPV-specific incentives are sometimes vague and include semi-integrated PV products (PV News 2010).

3. In many cases, semi-integrated products are a combination of PV products and traditional buildings materials (EPIA 2010). These combined products do not replace traditional building materials, and some stakeholders have described them as building-applied PV (BAPV).

Photon International describes BIPV modules as products that are "specifically constructed for building integration," and, in their recent survey of more than 5,000 commercially available modules, less than 5% were listed as BIPV.

4. Photon adds, however, that standard modules can also be integrated into buildings using certain mounting systems, implying that semi-integrated systems can also be described as BIPV (Photon International 2011). Regardless of the specific definitions of BIPV, it is clear that there is a continuum of integration with building materials among a class of PV products suited for rooftop and facade applications.

For this report, we consider BIPV to be a multifunctional product (not a combination of independent products) that generates electricity and replaces traditional building materials by serving as a significant weather barrier on residential building surfaces. Figures show examples of rack-mounted PV.

5. In other words, if the hypothetical BIPV cases we outline below were removed from rooftops, then repairs (e.g., waterproofing) would be required to ensure that buildings are protected from the environment. We call traditional, non-BIPV systems "rack-mounted PV"; these systems are intended to generate electricity only, are mounted on racks, and do not replace the function of building materials. The two photographs on the left in

Least integrated **(Open rack-mounted PV)**

More Integrated **(Closed roofrack mounted PV)**

Fully Integrated **(Direct mounted BIPV multifunctional)**

Fig-5: Different types of BIPV cells

The competitiveness of BIPV in the marketplace largely depends on its cost compared with PV. We examine this issue using a bottom-up analysis of installed PV and BIPV system prices for hypothetical rooftop cases and carry this forward to estimate levelized cost of energy (LCOE) values for each case. All cost values throughout this report are provided in 2010 U.S. dollars. We also examine less-quantifiable issues that affect the development and market adoption of BIPV products.

3.2 BIPV CHARACTERISTICS AND GROWTH OPPORTUNITIES:-

As with many solar products, the market price of BIPV systems is a key factor that affects the demand for systems and resulting levels of deployment. An analysis of two California incentive programs showed that BIPV rooftop systems have been sold at higher market prices than rack-mounted PV systems. BIPV on new homes sold for about 8% more than competing PV, on average, from 2007 to 2010 (Barbosa et al. 2011). However, the prices reported in incentive program databases do not necessarily reflect downward trends in system costs because they are subject to a range and the price disparity grew over the survey period, as illustrated in market dynamics. Higher BIPV system prices may result from supply chain issues for products and services or consumers' willingness to pay premiums. Incentives may also influence the price disparities between rack-mounted PV and BIPV.

BIPV may hold potential to increase PV suitable space on buildings. One study of PV supply curves found that building rooftops in the United States could host about 660 GW of installed capacity, assuming the installation of rack-mounted PV with a 13.5% conversion efficiency (Denholm and Margolis 2008). This assessment of PV-suitable rooftop areas accounted for shading, obstructions, and architectural designs that cannot accommodate traditional module form factors. Arguably, BIPV could increase these PV suitable areas on buildings if products are lightweight or designed for specific building features.

The International Energy Agency (IEA) estimated that incorporating BIPV on building façades could increase PV suitable surfaces by about 35% (IEA 2002). Yet, there is considerable uncertainty about these findings, including how PV suitable spaces are defined and how the lower energy generation potential of PV devices on vertical building surfaces reduces the economic viability of projects. rovides more information on these points.BIPV's aesthetic advantages over traditional PV could increase consumer appeal and provide growth opportunities. Additional considerations about BIPV market factors, such as industry interest and government support, are listed in Table 4.

TABLE-4. Potential Opportunities for BIPV Market Growth

Installation cost reductions	• Lower non-module costs – elimination of racking hardware, and greater use of traditional roofing labor and installation methods • Cost offsets for displacing traditional building materials • Lower supply chain costs – leverage more established channels to market
Improved aesthetics	• Consumer willingness to pay premiums in some markets. • Broader appeal for residential solar product designs
Higher technical potential	• Increased PV-suitable space on buildings
Solar industry interest	• Showcase applications • High growth potential • Technology differentiation may help suppliers distinguish themselves • Possible cost reductions and new channels to market
Government support	

	• Maintain historic/cultural building designs • BIPV-specific incentives in select international markets

3.3 HISTORY AND STATUS OF BIPV DEVELOPMENT AND DEPLOYMENT :-

In the late 1970s, the U.S. Department of Energy (DOE) began sponsoring projects to advance distributed PV systems, including collaborations with industry to integrate PV with building materials. By the 1980s, companies such as General Electric, Solarex, and Sanyo had developed PV shingle prototypes, but technical challenges and high costs slowed the commercialization of these products (SDA and NREL 1998). As PV technologies became increasingly efficient and reliable in the years that followed, more stakeholders pursued the blending of PV devices with building materials. In 1993, DOE initiated a program called Building Opportunities in the United States for PV (PV:BONUS), which was designed, in part, to help commercialize innovative BIPV products (Thomas and Pierce 2001). Similar programs were established by groups in Europe and Japan around the same time (Arthur D. Little 1995). Today, partnerships among PV manufacturers, architects, and building-materials suppliers intend to address barriers and bring new cost-competitive products to the market (Fraile et al. 2008).

Because BIPV has been known mostly for showcasing solar applications in sustainable building designs, it has been regarded as a nice product compared to rack-mounted PV products. One of the first U.S. homes with BIPV was built in 1980 (Arthur D. Little 1995), and systems were later incorporated on commercial structures such as the 4 Times Square Building in New York City in 2001, where about 15-kW of amorphous silicon (a-Si) BIPV was installed (DOE 2001).

Larger BIPV systems have been installed more recently, including a 6.5-MWp DC system on the Hongqiao Railway Station in China, completed prior to the 2010 Shanghai World Expo (IEA 2011). At the simplest level, BIPV systems are derivatives of common PV module designs and installation methods; early product designs were often highly customized for specific buildings and architectural features. Today, BIPV products have more standardized designs that are intended to integrate with many common building materials. Although the market prices for BIPV are still higher than for rack-mounted PV, new products offer lower costs and better performance than BIPV systems of the past.

Overall, the global deployment of BIPV is small in comparison with the deployment of rack-mounted PV. By some estimates, the cumulative installed capacity of BIPV (and related semi-integrated PV products) worldwide was 250–300 MW by the end of 2009 (EuPD Research 2009, Pike Research 2010). This was about 1% of the cumulative installed capacity of distributed PV systems at that time (Mints and Donnelly 2011). Part of this limited market share can be attributed to the price premium of BIPV relative to rack-mounted PV, as well as qualitative factors we discuss in the following sections.

3.4 TECHNOLOGY TRENDS AND THEIR INFLUENCE ON BIPV:-

3.4.1 SILICON WAFER BASED CRYSTALLINE CELLS (C-SI)

PV products based on C-Si technology are the most widespread and predominant on the market. Under ideal test conditions these inorganic semiconductors provide high module efficiencies of around 15% for multi-crystalline and up to 20% for mono-crystalline modules. Both offer a good cost-efficiency ratio and a certain variety in their visual appeal. Due to the specific material properties of the Si-solar cells, the modules available commercially are mostly rigid, opaque, and flat. Semi-transparent solutions can be obtained by a specific encapsulation, typically in

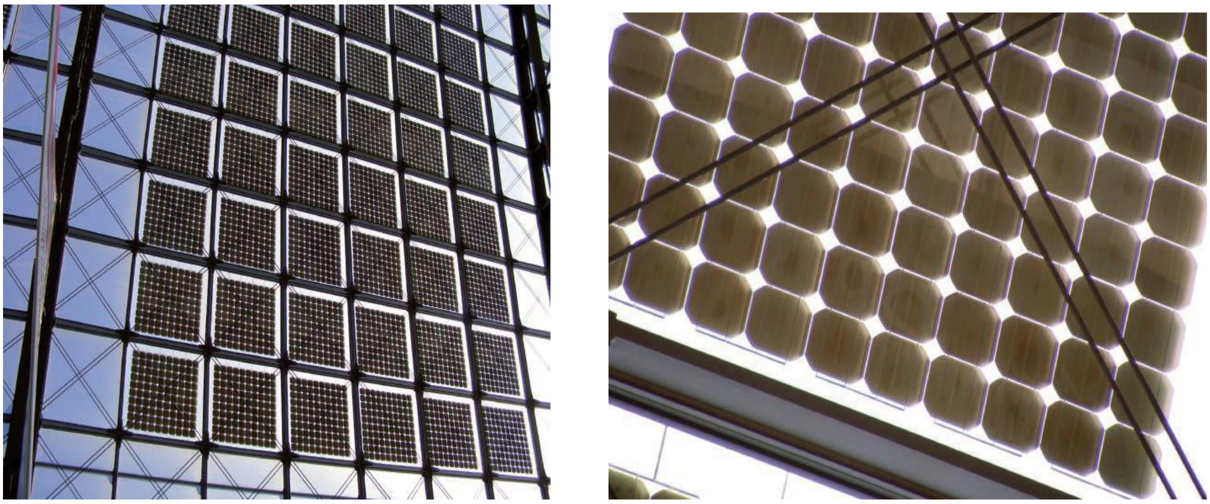

Fig-6: Hauptbahnhof, Berlin (Germany): Detail of the 1700 m2 curved roof surface covered with 780 semi-transparent c-Si panels, each customized, comprising 78’000 c-Si wafers overall (Energy output: 180 kWp, Architect: Meinhard von Gerkan; System provider: Optisol, 2003)

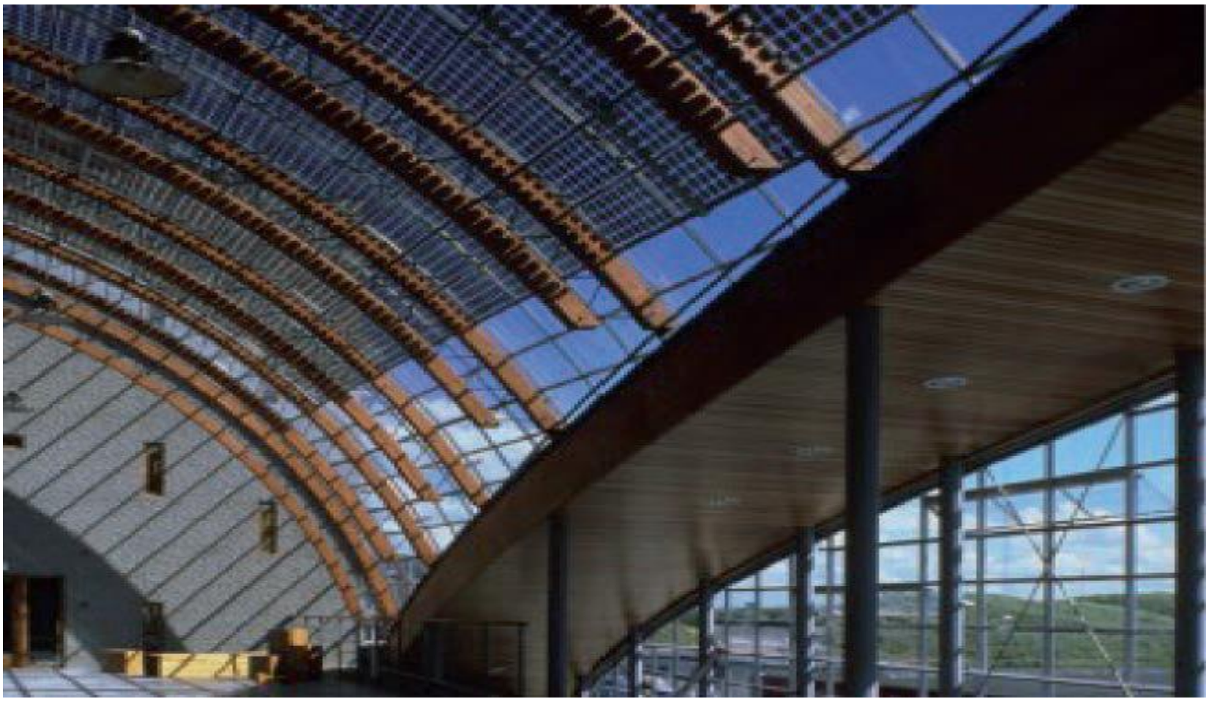

Fig-7: ECN, building 42 (Petten, The Netherlands): Semi-transparent and curved c-Si-skylight roof (Bear Architecten, 2001)

Fig-8: Albasolar Head Office, Alba (Italy): the exterior of the building consists of an amorphous photovoltaic ventilated façade (System
provider: Albasolar, 2012)

glass-glass laminates or by perforating the wafer. Transparency is produced by means of a particular distance set between the array of solar cells, which allows the transmission of light. There is also a range of coloured crystalline solar cells on the market. Homogeneity can be obtained by using a back sheet of a colour similar to the solar cell, as encapsulant, which makes the dominant solar cell structure more discrete. Back-contacted solar cells are often used for BIPV because of their hidden contact busbars.

C-Si modules are offered with aluminium frames or as a frameless device. Both have been used in BIPV since the start of the 1990s, with a preference for their use as in-roof solutions, opaque or semi-transparent facade elements, or as semi-transparent PV skylights. But despite their wide-ranging possibilities, the field of standard C-Si applications in the building envelop is limited by several technical constraints. One disadvantage of this technology is known to be the loss of performance as a consequence of high temperatures and of shading caused by the surrounding buildings, their chimneys, or other kinds of obstacles: even one single partly shaded C-Si module will thus lead to a significant loss of power, not only in that particular module, but in all the others connected in series within the same circuit.

They will all be affected and reduced to the same reduced power output as the one that is shaded, and as a consequence, the whole system could suffer a ‘cut-out’. This significant issue has to be taken into account when planning with C-Si technology. Here the recent emergence of microinverters associated to each individual modules can partially solve the problem and could provide a new impetus for integration of C-Si technologies. Another option of

Table-5: Market share of the various PV technologies in the BIPV market in 2009 (Source: Nanomarkets, EPIA analysis)

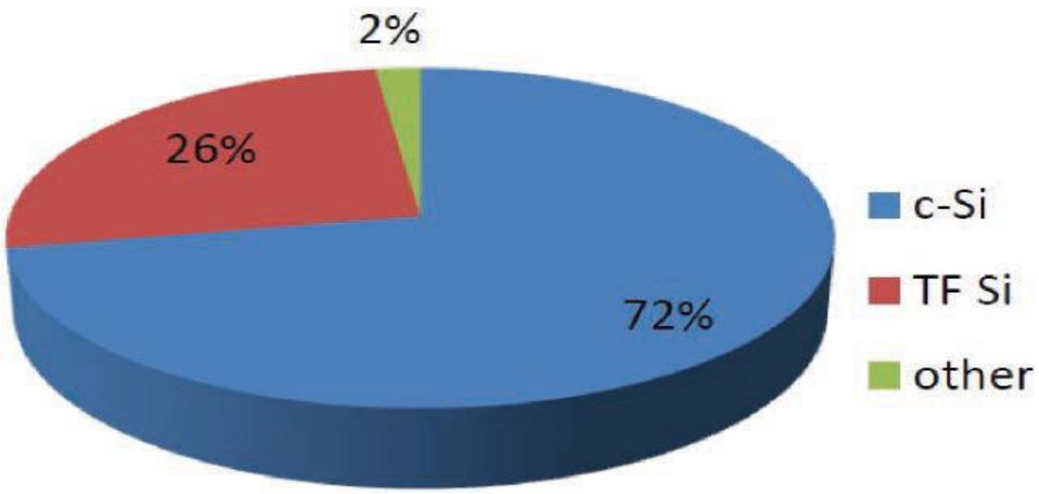

Table-6: Conversion efficiencies and temperature coefficients of Pmax of the various PV technologies

Technology	Module Efficiency [%]	Temperature Coefficient Pmax [%/°C] (+-0.03)
Mono-crystalline silicon (mono C-Si)	15–20	-0.45
Poly-crystalline silicon (poly C-Si)	11–15	-0.45
Copper Indium Gallium Selenide (CIGS)	10–13	-0.34
Cadmium Telluride (CdTe)	9–12	-0.25
Amorphous Silicon (a-Si)	5–7	-0.21
Micro morph Silicon (a-Si/mc-Si)	8–10	-0.30
Dye sensitized Cell (DSC)	2–5	-0.005
Organic Photovoltaics (OPV)	4–5	-0.43

choice is the use of modules made on the basis of thin-film technology which are usually less affected by partial shading. In Si-technology, irrespective of ever improving records for efficiency, there are no special new trends to identify that are about to lead to completely new BIPV features, despite the solar cells becoming increasingly thinner. Semi-transparent solar cells (with multiple openings rated directly in the cells) that were developed ten years ago failed to succeed on the market on account of their high levels of efficiency losses.

3.4.2 THIN-FILMS: AMORPHOUS (A-SI) AND MICROMORPH (MM-SI), CIGS, OPV, DSC:-

AMORPHOUS (A-SI) AND MICROMORPH (MM-SI):-

Despite all the positive prognoses that were seen as recently as 2010 and the anticipation of an expected increased market share for thin-film technologies, things have since fallen so far that some of these technologies have now even being declared 'dead' by the media and some competing industries. This is mainly due to the strong increase in production capacity (learning curve effect) and to the falling price of poly-silicon, the raw material that had previously made the competing wafer technology considerably more expensive than silicon based thin-film, where only very small quantities of abundant and non-toxic materials are used. Another factor that has displaced promising TF technologies even further toward the edge of the market is the overriding focus on cell-efficiencies, regarded as a fetish by most parts of the public: efficiencies of 6% for brownish amorphous and 10% for black micro morph PV modules –

with realistic options pushing towards 11–12% do not seem to be competitive figures at first sight, with c-Si and silicon heterojunction (HIT, see below) showing efficiencies up to 20%. This is both a clear misunderstanding and false conclusion for several reasons since official cell and module efficiency rates are exclusively assessed under ideal lab conditions and have no significance for the annual energy production under real weather conditions within a certain region. In other word the performance ratio (PR) of BIPV systems can be better for thin-films, thereby limiting the impact.

It does not take into account the lowest cost/m2 of thin-film technologies either, which is often a neglected factor in BIPV, as it can replace building elements which come in the same price range. We develop here below on some of these advantages of thin-film over wafer-based crystalline Si-technology. Firstly, compared with C-Si, the efficiency decrease in silicon thin-film cells is less affected by high temperatures and there are less significant losses of performance under conditions of indirect and hence lower sun irradiation caused by cloudy weather conditions and shading by trees, other buildings, or chimneys. The annual energy output of PV modules based on thin-films provides a demonstrably higher energy output than common standard screen printed C-Si technology.

It is clear that these facts have not been properly communicated to a wider public by the TF industry. On many facades in heavily built urban spaces, or on partially shaded roofs where the aspect of homogenous and uniform appearance plays a role, black micro morph Si-TF units are therefore still a product of choice with the promises of a higher annual energy harvesting. Secondly, when calculated per square meter, Si-TF modules, for example, still have a decisive price advantage over Si-wafer modules due to the drastic reduction of their semi-conductive layers and manufacturing process.

3.5 A SHORT OVERVIEW OF THE MAIN CATEGORIES FOR BIPV APPLICATIONS:-

ROOF SYSTEM :-

Roofs are so far considered to be the ideal field for BIPV applications since pitched roofs of a certain angle (i.e. within Central Europe: 30°) provide the best energy harvesting. Standard in-roof systems figure among the most common BIPV approaches: here the PV modules simply replace the tiles. A well-integrated system is characterized by an installation that is flush-mountable with the surrounding roof tiles, and a frameless module design. Water tightness has to be guaranteed, for instance, by means of a specific under construction of vertical rails, a horizontal module overlapping and an impermeable interlayer underneath. Framed modules are an alternative solution. Architects view them as less attractive, however, on account of the frame being used as an additional visible material. Besides in-roof installations that cover only a part of the roof, a full-roof covering of PV modules is regarded as a more economic and more elegant alternative choice: maximum surface area guarantees both maximum energy harvesting and a very appealing homogenous rendering, especially when an anti-glazing front glass is applied.

Fig. 9: Typical framed in-roof installation, Sumiswald (Switzerland): the installation achieves a homogeneous appeal through the fact that both, the frame and the modules, share the same colour.

Fig. 10: Frameless c-Si in-roof installation, Ins (Switzerland): 32 modules (Surface: 35 m2, Energy output: 5.12 kWp, System provider: 3-S Photovoltaics, Meyer & Burger Group, 2011; Courtesy: Derk Bätzner, Photo: P. Heinstein)

CONCLUSION

Tesla roof is a product that complements customers homes' architecture while turning sunlight into electricity. It is a brilliant idea from Tesla that aligns with its mission of accelerating the world's transition to sustainable energy. The benefits of installing this roof might be noticeable only for those who are green energy and technology enthusiasts. This is why this marketing plan target a customer profile for this kind of people.

The objective of this marketing plan is to position Tesla roof tile as the first choice for homeowners seeking aesthetics and green energy, gaining market share within three years. The marketing strategy will follow to create customer awareness regarding Tesla roof, develop Tesla's customer base, establish interaction with target markets, and work toward customer word-of-mouth and referral by building a network of accredited roof installers and customer satisfaction. This plan found that there is a potential for Tesla roof in the solar market of $3.92 Billion and its annual growth is 16%. However, 30% of this market represent the technology enthusiasts with $1.18 Billion. This %30 is the first target of Tesla roof.

It is suggested that Tesla targets the innovators and then the early adopters. The innovators are defined as the green energy adopter who care about footprint and they are also a technology enthusiasts. While the early adopters are the green energy adopters who care about prestige. To cross the Chasm, Bowling alley strategy should be applied to reduce the cost. This will allow Tesla to reach the early majority, which is defined as the economic green energy adopters who care more about cost and saving. A total budget of $170 million has been allocated for a three years marketing plan that focuses mainly on social media and public relations to reach the targeted consumers.

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