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An Investigation of Evergreen Solar Inc. Bankruptcy by Considering Financial and Engineering Facets

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Abstract- In this paper, a company, Evergreen Solar Inc., located in Massachusetts, which was manufacturing solar panels for the photovoltaics industry is investigated. The company filed for bankruptcy on year 2011, closed its factory in Massachusetts and relocated manufacturing to China. In this paper, first, an introduction to solar energy will be provided. A history of the company then will be discussed. Finally, by considering the company's financial data, the market and industry involved as well as engineering aspects, the major reasons for the aforesaid bankruptcy will be examined.

Index Terms—Evergreen Solar Inc., solar panels, string ribbon technology, bankruptcy

I. INTRODUCTION

Solar energy is, simply, energy derived from the Sun's radiation. Indeed, sun is the most powerful source of energy which provides the Earth with as much energy every hour as human collectively uses in a year worldwide [1]. Table I shows the amount of solar energy reaching the surface of the planet versus human energy consumption [2-6].

In order to take advantage of this endless source of energy and produce electricity, some technologies are required to be employed, one of which is photovoltaic solar panel. Indeed, electricity could be produced directly from these panels which include a large number of solar cells containing semi-conductor materials, the most utilized of which is silicon. The procedure is that when the sun radiation hits these cells, it transfers its energy to the loose electrons knocking them clean of atoms. These electrons move haphazardly; therefore, it is necessary to make them flow in one similar direction. By utilizing two types of silicon which are "n" and "p" and organizing them in specific manner, it is possible to make those aforesaid electrons to create an electrical current [7]. The

obtained current then passes through a wire conduit leading to an inverter. This device inverts direct current to alternating which could be used for regular purposes such as lighting the lamps and so on and so forth [8]. Figure 1 shows the procedure in a simplistic manner.

Nowadays, wide assortments of people are willing to use solar panels in order to generate a portion of their electricity. Indeed, they list numerous reasons encouraging them to consider solar energy. They assert that it is clean, it does not produce greenhouse gases and any other pollutants in contrast with fossil fuels which create a massive amount of pollution [9]. Moreover, they argue that solar energy is free, it is infinite; however, the fossil fuels could be extremely costly and they are going to be depleted sometime in future [10]. However, it is a visceral judgment if it is said that solar energy does not have any disadvantages. Indeed, low efficiency, low reliability, limitations on installing location [11] and high price have been currently considered as the main shortcomings of this energy.

In addition to people willing to use this source of energy, solar energy has introduced a lot of opportunities to companies to invest and get involved in this newly emerged market. This market, on the other hand, introduced a lot of challenges that many companies could not survive it. In what follows, first, a company which was successful once upon a time in the solar industry, Evergreen Solar Inc., is introduced by considering its production and operating data. This company filed for bankruptcy on Aug. 2011. The most significant reasons leading company to bankruptcy will be carefully examined afterwards [34].

Evergreen solar which was founded in 1994 was a completely integrated producer of solar panels producing

solar wafers, cells and panels located in Marlborough, Massachusetts, USA. The market that Evergreen traded on until bankruptcy was NASDAQ stock market.

TABLE I. A COMPARISON BETWEEN YEARLY SOLAR FLUXES AND HUMAN ENERGY CONSUMPTION

Solar	3,850,000 (EJ)
Wind	2,250 (EJ)
Biomass Potential	200 (EJ)
Primary Energy Use (2010)	539 (EJ)
Electricity (2010)	67 (EJ)

NASDAQ is an American stock exchange which is the second-largest stock market in the U.S. and world by market capitalization and trading volume. This market which has a capacity of \$8.5 trillion [12] was founded on year 1971 and is located New York City. NASDAQ schedule is that it has a pre-market session from 4:00 am to 9:30 am Eastern, a normal trading session from 9:30 am to 4:00 pm, and finally a post-market session from 4:00 pm to 8:00 pm [13].

One of the most important technologies of the Solar Evergreen was string ribbon. The string ribbon technology is mechanism of producing multi-crystalline silicon strips which are used in photovoltaic industry [14]. This technology uses less silicon in comparison with the other solar wafer production methods. Indeed, more than 50% of the solar wafers manufacturing cost is due to the input silicon [15]. As the string ribbon uses less silicon, its manufacturing cost is less than the traditional methods. Moreover, the Evergreen claimed that its wafers created by string ribbon technology have nearly 30% less carbon foot print compared to other wafer panels [16]. However, the efficiency of the wafers produced by this method is around 13 % which is lower than the other typical wafers with efficiency of 15-16 % [16].

In their annual report of year 2010, Evergreen published its operating data for a period of almost five years. Table II shows some selected operating data for Evergreen Solar Company.

In year 2011, the company announced plans to close its main American factory and lay off the 800 workers of that site by March. Finally, on August 15, 2011, the company filed for chapter 11 reorganization with the intent of selling its assets.

II. EXAMINING THE REASONS OF BANKRUPTCY

As it was mentioned, the company filed for bankruptcy on August 2011. Since that time, a vast variety of reasons have been examined to explain the company's failure. In this paper the most essential justifications will be discussed. Fig. 2 categories the most important reasons which are going to be elaborated as follows.

A. Engineering Reasons

As far as engineering aspects of the company's collapse are concerned, two vital reasons could be discussed.

1. Off-size panels

As the company announced in its annual report, they historically were producing non-standard solar panels. Table III compares the dimensions of the panels produced by Evergreen solar and other well-established companies in the industry [17-22].

TABLE III. COMPARISON THE DIMENSIONS OF THE PANELS PRODUCED BY EVERGREEN SOLAR AND OTHER COMPANIES

Company	Length (mm)	Width (mm)	Diagonal (mm)
Evergreen Solar Inc.	2057.5	951.3	46
Mitsubishi	1625	1019	46
BP Solar	1667	1000	50
Sharp	1640	994	46
Kyocera	1662	990	46
Sun Power	1622	1002	54

It is seen from Table III, there is a huge difference between the length of panels produced by Evergreen solar and other companies. These off-size panels did not have market acceptance [23]. Indeed, one major problem with off-size panels could be that they cannot easily be replaced by standard size panels if the owner decides to change his panels.

Moreover, if the weight of the panels produced by Evergreen is considered, it will be understood that they are heavier in comparison with other panels. The weight data of panels produced by different companies are provided in Table IV [17-22].

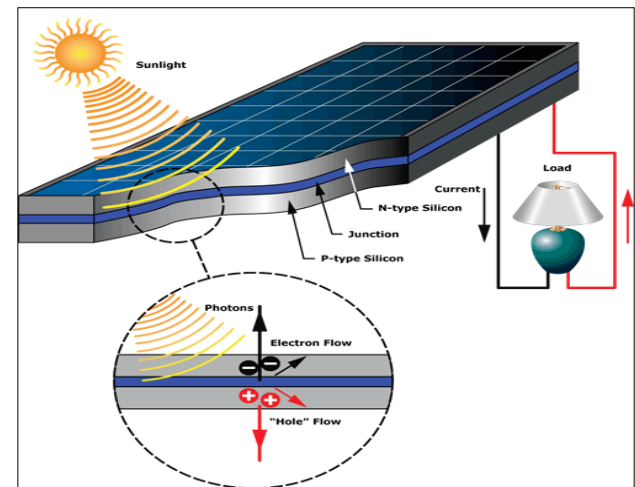


Figure 1. The procedure of the generating electricity from PV panels [33]

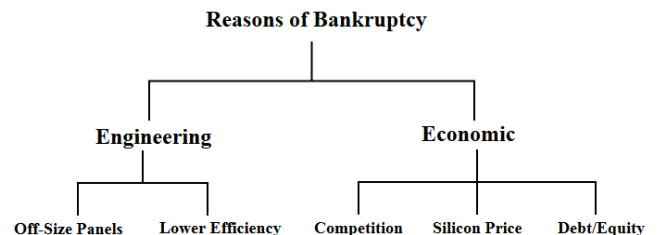


Figure 2. The most essential reasons for the bankruptcy

TABLE II. SOME SELECTED OPERATING DATA FOR EVERGREEN SOLAR COMPANY

Year/Operation data	Revenue(\$)	Operating expenses(\$)	Profit(\$)	Total Assets(\$)	Loss(\$)
2006	102,252	41,806	11,942	207,251	29,864
2007	69,866	42,606	17,028	553,255	25,578
2008	111,959	114,977	18,886	1,008,511	96,091
2009	271,848	116,255	18,364	827,633	97,891
2010	338,785	396,126	-55,188	424,470	451,314

TABLE IV. THE WEIGHT DATA OF PANELS PRODUCED BY DIFFERENT COMPANIES

Company	Weight (kg)
Evergreen Solar Inc.	23.4
Mitsubishi	20
BP Solar	19.4
Sharp	19.0
Kyocera	20.0
Sun Power	25.4

As it is understood from Table IV, Evergreen panels are approximately 3.5 kg heavier than the other panels. Indeed, one of the main concerns of homeowners who decide to use solar panels on their roof is whether or not the weight of these panels could damage the roof [24]. Consequently, the extra weight of Evergreen panels discourages users to install them on their roof specifically when it is necessary to install substantial number of these panels.

2. Lower Efficiency

As it was discussed, Evergreen was taking advantage of string ribbon technology to produce its solar panels. Typically, the panels which are produced by this method contains lower amount of silicon. However, their efficiency is less than the panels produced by traditional methods. Table V makes a comparison between panels' efficiency of different companies [17-22].

TABLE V. A COMPARISON BETWEEN PANELS' EFFICIENCY OF DIFFERENT COMPANIES

Company	Panels' Efficiency (percentage)
Evergreen Solar Inc.	13%
Mitsubishi	16.7%
BP Solar	13.5%
Sharp	15.3%
Kyocera	16%
Sun Power	20.1%

The efficiency matters when the output power of the panels is considered. Indeed, in order to get a specific amount of output power, it is required a specific number of panels to be installed. Therefore, when the efficiency of the panels which are used is low, it is necessary to install more panels to get that desired output power; hence, using low efficiency panels may lead to space problems specifically when the space availability is limited [25].

Moreover, although the overall cost of panels with higher efficiency is higher, their cost per watt is extremely lower. As a result, over time, panels with lower efficiency will produce less energy in comparison with the panels

with higher efficiency which translates into lower efficiency panels cost more per unit of energy [26].

B. Economic Reasons

Indeed, some of the most significant reasons of company's breakdown will fall into this category. In what follows these justifications will be separately discussed.

1. Competition

The most important rival of not just the Evergreen but the whole companies in the industry are Chinese companies [23]. Chinese companies have access to numerous advantages. According to Michel El-Hillow, chief executive officer of the company, Chinese companies will receive a considerable amount of government and financial support. Moreover, Chinese manufacturing cost is low. Consequently, these companies have become price leaders within the industry. In fact, they forced down the prices for panels by 60% in merely over two years [27]. As a result, according to supply and demand, the companies which offer a price more than market clearing price will go out of business. Evergreen which used string ribbon technology to produce its panels used to have the lowest price in U.S. because of less use of silicon in its production; however, its price was still extremely greater than price offered by Chinese companies. GTM Research analyst Brett Prior quotes "It costs \$1.10 per watt in China to make a solar panel. That same exact process costs \$1.80 here in the U.S. That's a 60 percent difference, and that's too big." Therefore, those who blame Chinese competition for Evergreen's bankruptcy seem to have cogent reason. Figure 3 shows that the average cost of solar panels production is dramatically decreasing in recent years in China [28].

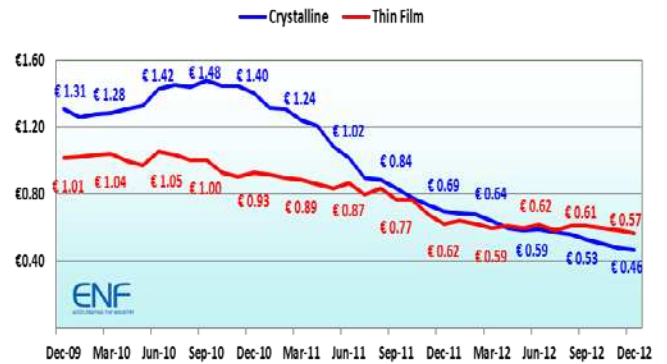


Figure 3. The average cost of solar panels production is dramatically decreasing in recent years

2. Silicon Price

One of the materials which is typically utilized to produce a solar panel is silicon. Consequently, the price of a solar panel is dependent on the price of silicon. Evergreen was proud of its string ribbon technology to produce panels as they were claiming that with this technology they use considerably less amount of silicon as input. Indeed, this technology was in favor of investors in years 2007 and 2008 as it used greatly less pricy raw materials [29]. However, as it could be seen in Fig. 4 [30], there is a continuous decrease in price of silicon in China and a decrease in year 2011 and then almost constant price for U.S.

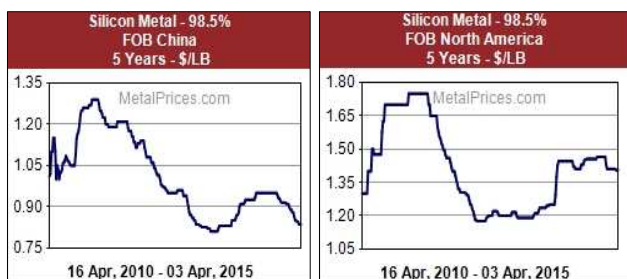


Figure 4. The trend of Silicon Metal's price in China and North America

Therefore, as silicon prices gradually retreated from their highs, using of string ribbon technology which uses less silicon would not be advantageous any more [29]. As a result, Evergreen technology was weakened.

3. Debt and Equity

The net loss of Evergreen Solar for 2010 was equal to \$465.4 million. In 2009, the loss of the business was \$266.2 million. In 2008, the net loss made by Evergreen happened to be \$228.6 million. In 2007, Evergreen's loss is \$16.5 million that happened to be a step up over the \$26.7 million that was lost during 2006. Obviously, the Evergreen did not like to be encountered with the profit inclinations and it simply did not make cash [23]. Table VI presents the net loss attributable to Evergreen Solar [31].

TABLE VI. THE NET LOSS ATTRIBUTABLE TO EVERGREEN SOLAR

Year	2006	2007	2008	2009	2010
Net loss	26,669	16,602	228,619	266,220	465,437
	dollar	dollar	dollar	dollar	dollar

As expected, Evergreen simply could not find a solution to pay its debt due to its expensive 13% Convertible Senior Secured Notes [32] which means exchanging debt for equity at the auction unless a large cash offer is received.

According to the court records, the company's listed assets were equal to \$424.5 million and debts of \$485.6 million [29]. Consequently, the value of Evergreen's assets were not sufficient to pay the company's debt. This

deficit (negative equity) means that the stock is fundamentally worthless and will likely not endure the bankruptcy process [31]. Table VII demonstrates the total stockholders' equity from 2006 to 2010.

TABLE VII. THE FOLLOWING TABLE DEMONSTRATES THE TOTAL STOCKHOLDERS' EQUITY FROM 2006 TO 2010

Year	2006	2007	2008	2009	2010
Total stockholders' equity (deficit)	92,847	393,293	587,638	399,186	(61,129)
	dollar	dollar	dollar	dollar	dollar

Evergreen will default on all its convertible notes as a result of the bankruptcy filing. Noteholders were working with Evergreen solar to reorganize the business reinforced by a closing of certain assets. After drastic decreasing in its workforce, Evergreen solar stated it will keep enough money to continue operating through the bankruptcy process. It seems likely that Evergreen Solar after the bankruptcy will successfully be a Chinese company operating from the Wuhan, China manufacturing facility, depending on the cooperation of Evergreen's Chinese investors [32].

VI. CONCLUSION

A lot of advantages introduced by solar energy have encouraged people to increase their usage of this source of energy as well as lots of companies to be involved into this industry. However, some companies may not be successful in this business. In this paper, after introducing solar energy, a company which was successful once upon a time in the solar industry, Evergreen Solar Inc., was introduced by considering its production and operating data. As it was discussed, the company went bankrupt on year 2011. The main reasons of the company's collapse which could be organized into two groups of Engineering and Economic then was examined in this paper. For the engineering aspect, off-size panels and lower efficiency in comparison with other companies were discussed. Competition, silicon price, debt and equity were studied in the economic section.

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