Solar PV leasing in Singapore: enhancing return on investments with options

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Abstract. Renewable energy is getting more important nowadays as an alternative to traditional energies. Solar energy, according to Energy Market Authority, is the most viable in the context of Singapore compared to other renewable energy sources due to land constraints. In light of the increasing adoption of solar power in Singapore, this paper focuses on solar PV leasing using a case study. This paper assesses the prospect for solar PV leasing companies in Singapore through the lens of embedded real options. The recent news that solar power is becoming the cheapest form of new electricity presents the leasing company an option to expand the scale of solar PV system. Taking into account this option, the Net Present Value (NPV) of the investment increased significantly compared to the case without real options. Technological developments result in a continuously changing environment with uncertainties. Thus, decision makers need to be aware of the inherent risk associated and identify options to maximize NPV. This upside potential is realized by exercising the managerial flexibility and exploiting the uncertainty. The paper enables solar energy planners to consider possible managerial flexibilities under uncertainties, showing how option thinking can be incorporated in the valuation of solar energy.

1. Introduction

One important pressing issue we are facing now is sustainable energy. Renewable energies such as wind, solar and nuclear have gained momentum in different countries and would replace traditional energies which are not sustainable in future. For Singapore particularly, land constraints and other considerations make solar energy the most viable renewable energy. Thus, the motivation behind this paper is to utilize real option analysis and decision analysis to study the economic value of solar PV leasing for manufacturers in Singapore.

2. Valuation methods

2.1. Risk-adjusted net present value

This method is based on discounted cash flow analysis; however, the discount rate is adjusted to reflect different types of risks. Discounted cash flow analysis discounts expected free cash flows using a discount rate and then sum them up.

\[
\text{NPV} = \sum \left( \frac{E(\text{free cash flow in year } t)}{(1 + \text{discount rate})^t} - I_0 \right), \text{where } I_0 \text{ is the present value of investment outlay for the project.}
\]

Total NPV = NPV (Revenue) – NPV (costs).

With option, the expanded NPV = Passive NPV + Value of Option to Expand.

Under this method, it is assumed that all future expected free cash flows are discounted using the same discount rate, which is not accurate especially for risky projects. It may underestimate the value of
projects and thus, lead to myopic decisions [1]. Furthermore, the result is subject to sensitive factors such as the discount factor and cash flows.

KP [2] pointed out there are generally two broad categories of risks, namely private risks and market risks. Private risks are company-specific or projects-related whereas market risks affect all similar companies. Thus, under the risk-adjusted NPV method, cash flows associated with private risks should be adjusted using risk-free rate since investors are unwilling to pay for a risk premium; in contrast, investors are willing to pay a risk premium for market risks. Using different discount rates for cash flows associated with different type of risks, the value of an investment or project can be more accurate.

2.2. Decision analysis with utility functions

Under the decision analysis approach, risk-preference is taken into account using a specific utility function. Table 1 below shows the utility function for risk averse, risk neutral and risk seeing cases.

| Risk Attitude     | Utility Function                                      |
|-------------------|-------------------------------------------------------|
| Risk averse       | \( u(w) = a - b \ e^{-w/\rho} \), \( a > 0 \)         |
| Risk neutral      | \( u(w) = a + bw \), \( a > 0 \)                      |
| Risk seeking      | \( u(w) = a + b \ e^{-w/\rho} \), \( a > 0 \)         |

In the equation, \( \rho \) represents risk tolerance. On a decision tree, each end-point represents an outcome depending on the preceding decisions. Compute NPV of each outcome and then the utilities of the NPVs. The decision tree is then rolled back using the utility of NPVs. Finally, the certainty present equivalent can be calculated from the utility function.

2.3. Risk-dependent utility

Compared to the decision analysis approach, the discounted cash flow method does not account for the risk preference. Instead of using a risk-free discount rate, a more comprehensive way would be using utility of NPVs for cash flows associated with private risks. The cash flows associated with market risks are still discounted using a risk-adjusted discount rate by adding a risk premium to the risk-free rate. This integrated method and detailed calculations will be illustrated in the next chapter.

3. Case study of solar PV leasing

Renewable energy is getting more important nowadays as an alternative to traditional energies. Solar energy, according to Energy Market Authority, is the most viable in the context of Singapore compared to other renewable energy sources such as wind and nuclear energies due to land constraints. It is clean, infinite, and free of charge.

3.1. Solar PV market landscape

In the U.S. and some European countries, roof-top solar PV has been a popular choice among residents. In a roof-top solar PV leasing arrangement, a solar PV leasing company negotiates with the owner of a residential or commercial building to lease the rooftop space at a predetermined cost over a period of time. The energy generated by solar PV is sold to the owner at a discount rate compared to the electricity tariff. If there is excess energy generated, it can be sold to the grid and profit will be given to the developer. Figure 1 below illustrates the model.

![Figure 1. Solar PV leasing model.](image-url)
PV stands for Photovoltaics and PV system can be made of arrays of polycrystalline silicon PV panels. The system connects to the grid and there is no battery storage. When exposed to sunlight, DC electricity is generated and the inverter, which is connected with PV arrays, converts DC to AC. In Singapore, there are a few solar PV leasing players in the market. Phoneix Solar, for example, has successfully implemented solar PV leasing projects in collaboration with SportsHub, Sheng Siong, Changi Airport Budget Terminal, INSEAD Business School, P&G, NUS-CREATE, JTC, City Square Mall, NUS High School of Math & Science, Singapore Polytechnic etc. Sunseap Leasing, another big player, has done solar PV leasing projects with Jurong Port, Housing Development Board (HDB), Marine Port Authority, Singapore American School etc. These successful projects illustrate the feasibility and future potential of solar PV leasing.

In October 2016, Mr. S Iswaran, Second Minister for Trade and Industry, announced the SolarNova Singapore programme. Being initiated by the Singapore Economic Development Board and in partnership with HDB, this plan aims to increase the adoption of solar power 350 MWp by 2020 according to the Ministry of Trade and Industry. This would lead to rising demand for solar deployment through solar leasing services. According to HDB, it has called a solar leasing tender to install solar panels across nine government organizations.

3.2. Case study: a solar PV leasing investment decision
Changi Airport (the “Host”) is considering entering an agreement with Solar Leasing, a solar PV leasing company, to install the PV system for its latest Terminal in order to save electricity. In this agreement, the duration is 20 years and the Host is granted electricity at a discount rate while Solar Leasing is paid for excess energy exported to the grid. Assume both parties are risk neutral. A preliminary cash flow model using traditional discounted cash flow analysis is shown in tables 2 and 3. Table 4 below illustrates the parameters used and NPV for both counterparties.

The recent news that solar power is becoming the cheapest form of new electricity shows that the price of solar is bound to fall [3]. One opportunity in this case is the decreasing cost of solar PV system due to technological development. In the next period, there is a high chance of lower costs, which leads to potential gain in profits. At present, only the probabilities are known. However, a year from now, it will be known if the costs are lower or remain constant. The decision makers can decide if they want to expand the system. In contrast to the assumptions of the discounted cash flow (DCF) approach, expected future cash flows are uncertain due to fluctuations in the costs. This will affect future decisions.

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 20 |
|------|---|---|---|---|---|---|---|----|
| Revenue | - | 52,403 | 51,355 | 50,328 | 49,321 | 48,335 | 47,368 | 35,699 |
| Costs | - | - | - | - | - | - | - | 375,000 |
| **NPV** | **18,358** | **112,243** |

Table 2. Cash flows for the solar PV leasing company.

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 20 |
|------|---|---|---|---|---|---|---|----|
| Revenue | 13,101 | 12,839 | 12,582 | 12,330 | 12,084 | 11,842 | 8,925 |
| **NPV** | **112,243** | **112,243** |

Table 3. Cash flows for the host.
Table 4. Parameters used for cash flow models.

| Solar Leasing Company                                      |
|----------------------------------------------------------|
| Number of kilowatt peak (kWp)                           | 250 |
| Cost / kilowatt peak (S$)                                | 1.5 |
| Electricity generated (kilowatt hours / year)           | 320,000 |
| Electricity tariff (S$)                                 | 0.2047 |
| Tariff annual growth                                    | -2% |
| Price discount factor                                   | 0.8 |
| Number of years                                         | 20 |
| Discount rate                                           | 10% |

One contingent decision we can identify in this case is the option to expand if cost is lower in the next period. The figure below illustrates the decision tree for this example.

Having learnt that the project is economically viable, the Host is offering Solar Leasing company the option to expand the project after one year if the cost of PV system is lower. Currently, the 250 kWp PV system can yield 320 MkWh out of 450 MkWh of energy required. Under the expansion plan, with additional information, it is assumed that there is a 70% probability of lower cost of PV system at S$1 per watt and 30% probability of S$1.5 per watt as before. If invests in another 250 kWp PV system, a total amount of 640 MkWh electricity can be generated; thus, 190 MkWh of electricity can be exported and sold to the grid. Using DPL software, we can represent the expansion scenario with a decision tree using a discount rate of 10% as shown in Figure 2 below.

![Figure 2. Decision tree.](image-url)

If cost is low next year, certainty equivalent = \( \max (0, 18,358, 150,368) = 150,368 \). Thus, the decision should be expanding the solar PV leasing system. A suitable valuation approach for the solar PV investment should account for uncertainty and the managerial flexibility (the option to expand in this case). To better understand the value of real options, a few scenarios are analyzed as illustrated in the scenarios shown in Table 5 below.
Table 5. Parameters used for cash flow models.

| Scenario | Decision | Year 0 | Decision | Year 1 | Cost | Year 1 |
|----------|----------|--------|----------|--------|------|--------|
| 1        | Invest   | Low    | Expand   |        |      |        |
| 2        | Invest   | Low    | Do not Expand |    |      |        |
| 3        | Invest   | High   | Expand   |        |      |        |
| 4        | Invest   | High   | Do not Expand |    |      |        |
| 5        | Do not Invest | N.A  | N.A     |        |      |        |
| 6        | Invest (no option) | N.A  | N.A     |        |      |        |

3.3. Risk-adjusted NPV

For the manufacturer, revenue is discounted using risk-free interest rate of 10% since it represents private risk. Costs are discounted using a risk-adjusted discount rate of 12% as it is subject to market conditions, and thus should be adjusted higher. The Certainty Equivalent obtained is higher than that using a universal discount rate.

After adjusting the model using risk-adjusted discount rate, the value of option to expand the project = Value of project with the option – Value of the project without real options = $134,581 - $18,358 = $116,223. This is a significant difference compared to the case without option, showing that options embedded in the capital investments can add value to them. Figure 3 shows the decision tree.

![Decision Tree](image)

Figure 3. Decision tree for risk-adjusted NPV.

3.4. Risk-dependent utility function

Assume the risk attitude here is risk averse. Using the utility function $u(x) = 1.1 - 1.1e^{-\frac{x}{57.625}}$, we can calculate Certainty Equivalent of revenues (private risks) by rolling back the decision tree. Since the costs reflect market risks, they are discounted using a higher risk premium.

If the risk attitude is risk seeking, a utility function $u(x) = x^{0.997}$ can be found. Integrating utility function and risk-adjusted NPV methods, the same option value can be derived.
4. Conclusion

From the author’s perspectives, carrying out research in this field has allowed the author to gain more knowledge about solar PV leasing especially with respect to the Singapore market.

The paper illustrates several important valuation methods through the case study of solar PV leasing. The decision analysis modelling involves the use of decision tree and risk-adjusted NPV as the primary modelling tool. By integrating theory and application on solar PV leasing, new insights are obtained. Such insights are critical for decision makers to assess the value of projects and options embedded accurately.

The results of the paper have several managerial implications. Firstly, it illustrates the importance of real option thinking especially when there is uncertainty. Real option thinking encompasses a valuation model as well as strategic management decisions. In certain sector such as energy sector which involves uncertainty and is susceptible to the market conditions, having the option thinking is critical. From a real option thinking perspective, this paper argues that a decision analysis approach could better capture the real options embedded in capital investments than other methods and shows how option thinking can be incorporated in the valuation of solar PV leasing. The results showed that with real options included in the analysis, the value of the project can increase significantly compared to the case without real options. Moreover, real options are valuable in electricity markets because of high uncertainties [4]. In future, decision makers will face more uncertainties when new technologies arise. For example, biomass and tidal energy are examples of renewable energy with embedded options. It is the author’s great hope that option thinking can be gradually adopted by more practitioners and this research can increase interest among the solar energy industry.

5. References

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