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A Risk Management Decision Model for Energy Service Companies by Using Real Options

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Abstract

Energy efficiency improvement is an important objective of energy policy and strategy in all developed countries. Energy service companies (ESCOs) are usually described as important change agents that can restrain energy demand and attenuate climate change by increasing efficiency. They are the firms that deliver energy services and/or other energy efficiency improvement measures in a user's facility or premises, with a certain degree of financial risk. Payment for the services delivered is based on the achievement of energy efficiency improvements defined by an agreed performance criteria. As a result by the concept of performance-based contracting, ESCOs primarily differ from consulting engineering firms specializing in identifying and offering efficiency improvements, which are typically paid for their advice and undertake no risk that their recommendations will yield results. Therefore when an ESCO undertakes the contract, it goes under both financial and performance risks. The energy price volatility lies in the center of the risk and traditional capital budgeting techniques like net present value (NPV) analysis may not cope with the complex, dynamic and uncertain nature of energy markets. The study introduces a real option decision model for energy service companies to enter an energy service contract considering the risks under uncertainty and dynamism. An illustrative case study that employs energy price fluctuations in Turkey demonstrates the applicability of the proposed model. A sensitivity analysis is also realized by examining the effect of volatility of the energy prices in the market.

Keywords: Energy Service Companies, Energy Service Contracts, Real Options

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1. Introduction

Energy efficiency is a key issue for the nations to reduce the dependence to fossil fuels or energy imports and helps in increasing the security of energy supply. It provides two main advantages; reducing greenhouse gas emissions and increasing industrial competitiveness by saving energy costs. Energy efficiency is defined as reaching the same quality and level of some end use of energy (e.g. heating, cooling, lighting and distributed electricity) with a lower level of energy input (Gunn, 1997). The standard approach in energy efficiency evaluation views the measure as an investment (Thompson, 1997) and examines the trade-off within admitting higher initial capital/installation costs in return for lower future electricity bills during the lifetime of the energy efficiency measure (Croucher, 2011). Thus the consumer wishes to decrease to minimize the cost of the energy, on the other hand to implement energy efficiency practices need a big amount of capital of investment so that even though energy efficiency projects provide more in energy savings than they cost, consumer firms refuse to invest energy efficiency projects. This issue is known as "efficiency gap".

Energy service companies (ESCOs) usually described as important change agents that can restrain energy demand and weaken climate change by increasing efficiency can transform the "efficiency gap" into a viable business (Soroye & Nilsson, 2010). They are the companies that operate in developing, installing and financing comprehensive, performance-based projects designed to improve energy efficiency or reduce maintenance costs for energy-consuming facilities over a certain time period (Lee et. al., 2003; Vine, 2005). ESCOs function under an energy performance contracting arrangement which is a complex contractual arrangement between the beneficiary and the provider (normally an ESCO) of an energy efficiency improvement measure, where investments in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement (European Commission Directive, 2006/32/EC). Therefore, by the concept of performance-based contracting, ESCOs are primarily different from the consulting engineering firms which are specialized in identifying and offering efficiency improvements, typically paid for their advice and undertake no risk that their recommendations will yield results (Okay, et. al. 2008; Lee et. al., 2003).

Risk is defined as the effect of uncertainty on objectives (ISO 31000, 2009). When ESCO undertakes the contract, it goes under both financial and performance risks. The study focuses on the performance risk where the energy price volatility lies in the centre. Volatility can be defined as a measure for the magnitude of percentage changes in prices over time (Lintner, 1965). Traditional capital budgeting techniques like net present value (NPV) analysis may not cope with the complex, dynamic and uncertain nature of energy markets due to the fluctuations in the future prices of energy whereas the ESCO has the income from the share of the cost savings. The study proposes a risk decision model based on Black-Scholes real option valuation method for energy service companies (ESCOs) to enter an energy service contract considering the investment risks under uncertainty.

The rest of the paper is organized as the following. In the following section, conventional capital budgeting methods for the evaluation of ESCO investments are described. Real option concept is explained in the next section. Subsequently proposed model employing Black-Scholes option valuation method is stated with explaining the model parameters. In the next section a numerical example is given by using historical data of energy prices of Turkey and sensitivity analysis is realized to examine the process under different values of price volatilities. Paper is concluded in the last section.

2. Economic Analysis of ESCO Investments

The benefit of the energy efficiency investments is the savings in energy bill of the energy consumers. ESCOs operate under energy performance contracts and have their revenues (R) from the share (α) of savings in energy bill (S). The revenues of ESCOs can be viewed as shown in the following equation where α is the percentage value corresponding to the share of savings that comprise revenues of the ESCO and it takes a value between 0 and 1.

$$R = \alpha S ; \qquad (0 < \alpha < 1) \tag{1}$$

2.1 Traditional Capital Budgeting Methods

The discounted cash flow (DCF) method pioneered by Fisher (1907, 1930) and based on building expected future cash for each future period, is widely adopted in the evaluation of investments and real asset investment decisions (Lee & Shih, 2010). In DCF analysis each expected cash flow is discounted back to the present value (PV) and when initial investment costs are subtracted from PV, the net present value (NPV) is yielded. If NPV is greater than zero, the investment is economic and decision-makers should proceed, on the contrary the investment is uneconomic and needs to be abandoned.

Traditional capital budgeting investment decisions can accept the investment profitable when the discounted sum of revenues (R) is greater than the investment cost (I) (NPV>0). This NPV which provides an estimate of the net financial benefit when this investment is made is calculated as shown in equation 2.

$$NPV = \sum_{t=1}^{T} \frac{R}{(1+i)^t} - I \tag{2}$$

where i refers to the interest rate known as time of money and t is the time completion of the project.

Alternatively NPV can be set to zero and when the equation is solved for I, the internal rate of return (IRR) is determine provided by an investment, I, that provides shared savings or revenues of R (Jackson, 2010). When the value of IRR is greater than the cost of capital that means the investment will be profitable.

Furthermore expected values of investment costs and benefits can be specified when uncertainty is considered as expressed in equation 3. In addition equipment life times can be expressed with a risk factor, *r*, the value of which is difficult for most financial decision makers to determine when considering energy efficiency investments (Jackson, 2010).

$$\mathrm{E}[NPV] = \sum_{t=1}^{\mathrm{E}[T]} \frac{\mathrm{E}[R]}{(1+i+r)^t} - \mathrm{E}[I] \quad (3)$$

In addition payback (PB) analysis is a practical decision method where investment cost is divided by annual revenues to find the number of years needed to pay investment's itself. The relationship between PB and IRR can be determined by setting NPV equal to zero in equation 1 and solving for I/R as described in equation 4.

$$PB = I/R = \sum_{t=1}^{T} \frac{1}{(1+r)^t} \quad (4)$$

However, Ansar & Sparks (2009) who have examined several studies conclude that consumers and producers who make energy-saving investment decisions based on standard computations of NPV, have to be using extraordinarily high discount rates for valuing the future savings in energy costs.

2.2 Risk Management Approach

The investment decision making process when considering energy prices involve complexity and dynamism. High and low energy price cases and savings are occasionally provided in investment risk assessment (Jackson, 2010). Therefore price volatility which is hardly to be modeled and predominated is at the heart of risk (Sadeghi & Shavvalpour, 2006). This issue can be viewed from the calculation of the discounted sum of savings in energy bill (S) and revenues of ESCO (R) shown in the following equations.

$$S = P_t(F_C - F_N) \quad (5)$$

$$R = \alpha\, P_t(F_C - F_N) \quad (6)$$

where P_t is the price of energy in period t, F_C is the amount of energy used before applying the energy efficiency practices, F_N is the new amount of energy used after the energy efficiency project implementation. In this model since the future prices of energy P_t involves uncertainty; risk associated with the degree of uncertainty occurs (Thompson, 1997). The measure of uncertainty is volatility described by the percentage changes in prices over time.

Discounted cash flow techniques are not capable enough for evaluating investments with significant managerial flexibility, and therefore decision analysis or the option pricing approach is mostly chosen when evaluating these kinds of investments (Myers, 1984). One of the advantages of the real options analysis is its description of dynamic complexity much better than the classic NPV analysis emphasizing on detail complexity (Smith, 1999). Lin & Huang (2010) state that real options analysis is more conservative than the NPV method in supporting decisions in the face of uncertainty for both entry and exit projects. Furthermore Myers (1977) argued that profits which are made by cash flow created from an investment are consisted of the use of currently owned assets and an option for future investment opportunities. The value of the real option can be determined by using traditional NPV and option value as expressed in equation 7 (Smit & Trigeorgis, 2004).

$$\text{Real NPV} = \text{Conventional NPV} + \text{Option value} \tag{7}$$

3. Proposed Risk Management Decision Model for ESCOs

Real options which has superiority over the traditional capital budgeting methods especially coping with uncertainty, have found a large amount of application areas in energy investment studies. In the energy investments three important characteristics exist; irreversibility, uncertainty and flexibility and conventional project investment evaluation methodologies can hardly incorporate with these characteristics (Uçal & Kahraman, 2009). Therefore employing real options for the risk management in the investment decision process would be relevant considering the future volatilities in the energy prices.

3.1 Review of Real Options

An option is the right, but not the obligation, to take an action in the future (Amram & Kulatilaka 1999). Real options theory has been based on the financial options theory which is developed for the value assessment of the options on uncertain financial assets. A financial option is defined as the derivative security whose value is derived from the worth and characteristics of another financial security or so-called underlying asset (Reuer & Tong, 2007).

Basically two types of financial options are defined; call option and put option. A call option on an asset gives the right, with no obligation, to acquire the underlying asset by paying a pre-specified price (exercise price) on or before a given maturity while put option similarly gives the right to sell or exchange the underlying asset and receive the exercise price (Trigeorgis, 1996). In addition, a European option gives the right to exercise the option on the expiration date. On the other hand, an American option gives the right to exercise the option on or before the expiration date. European options normally trade over the counter, while American options usually trade on standardized exchanges. A buyer of an European option that does not want to wait for maturity to exercise it can sell the option to close the position. On the contrary, an investor holding an American-style option and seeking optimal value will only exercise it before maturity under certain circumstances.

The real options concept was developed from the seminal idea of Myers (1977) that one can view the flexible investment opportunities of as a call option on real assets like a financial call option offers decision rights on financial assets (Reuer & Tong, 2007). Therefore the financial option valuation models can also be employed as valuing real assets. As a formal definition, real options are the investments in real physical assets, as opposed to financial assets, which give the firm the right, but not the obligation, to take on the certain future actions (Reuer & Tong, 2007). Real options provides a systematic approach and integrated solution using financial theory, economic analysis, management science, decision science, statistics and economic modelling in applying options theory in valuing real physical assets in a dynamic and uncertain business environment. The options to delay the investment, to expand or contract a project, to abandon it or to switch the modes of production are considered when real option values are assessed (Roemer, 2004). The irreversibility nature of investments is also worthwhile in the real options analysis. Dixit & Pindyck (1994) suggest 'investment expenditures are sunk costs when they are firm or industry specific … and cannot be recovered'. The real options theory is a dynamic approach that takes into consideration the changes in the future and supports the adaptations of the firm to the changes and uncertainties (Foss & Roemer, 2010).

The characteristics of financial options can be transferred to real investment issues so that different financial option pricing methods (Black & Scholes, 1973; Merton, 1973; Myers, 1977) have been used as to assess the value of real investment projects under uncertainty (Foss & Roemer, 2010). Black and Scholes (1973) develop a closed form solution for valuing a European option with one variable for continuous time. Merton (1973) extends the option valuation method of Black and Scholes (1973) considering the stocks with decreasing values due to dividend outflows to represent the option value of a product opportunity. He defines a parameter that shows a rate of asset value erosion during the time. In addition the binomial lattice approach of Cox, Ross, and Rubinstein (CRR) (1979) is a flexible and easier numerical procedure for valuing options for discrete time in the case of one variable. Boyle (1988) develops an extension of the CRR procedure for option valuation in the case of two state variables by using simulation technique. In this paper Black-Scholes formula with Merton's extension is considered for valuing the investments of ESCO projects.

3.2 Black and Scholes Real Option Valuation Model

Black and Scholes (1973) value financial options by calculating the expectation as a function of a Brownian Motion and derive a differential equation that must be satisfied by the price of any derivative dependent on a non-dividend-paying stock. The model (Black & Scholes, 1973) is based on the assumption that the stock price S_t follows the dynamics given by the stochastic differential equation (Nembhard et al., 2003)

$$\mathrm{d}S_t = \mu S_t\,\mathrm{d}t + \sigma S_t\,\mathrm{d}Z_t \qquad (8)$$

where, Z_t is a random variable that follows the Wiener process and has the following properties: $\mathrm{d}Z_t = \varepsilon \mathrm{d}t$ and $\varepsilon \sim N(0,1)$ and $\mathrm{d}Z_{ti}$ and $\mathrm{d}Z_{tj}$, $i \neq j$ are independent from each other. This is the same as the change of the Wiener process $Z_t(\mathrm{d}Z_t)$ that follows regular distribution and the mean is 0, and the variance is dt (Lee & Lee, 2011).

The variances of $\mathrm{d}Z_t \sim N(0, \mathrm{d}t)$ are dt means that uncertainty is in proportion to the length of time. All derivative products or services can find value in a partially differential equation under a certain boundary condition, which is the price of the derivative products or services. The option formula of Black–

Scholes is the finding of the European call option and put option, respectively under the boundary condition of $Max[S_t - X, 0]$ or $Max[X - S_t, 0]$ (Lee & Lee, 2011). The price formula of the European call option is as follows:

$$C_0 = S_0 N(d_1) - Xe^{-rT} N(d_2) \tag{9}$$

$$d_1 = \frac{\ln(S_0/X) + (r + \sigma^2/2)T}{\sigma\sqrt{T}} \tag{10}$$

$$d_2 = d_1 - \sigma\sqrt{T} \tag{11}$$

and

S_0 = the price of the underlying stock

X = the strike (exercise) price

r = the continuously compounded risk free interest rate

T = the time in years until the expiration of the option

σ = the implied volatility for the underlying stock

$N(.)$ = the standard normal cumulative distribution function

$N(d_1)$= the probability that a random draw from a standard normal distribution will be less than d_1

$N(d_2)$= the probability that a random draw from a standard normal distribution will be less than d_2

In the above model, C_0 is the current value of call option S_0, the current value of foundation assets X, exercise price, σ^2, the instantaneous variance of the earning rate of foundation assets, r, the earning rate of risk-free interest, and T, the remaining period until the expiration date of option.

Merton (1973) expanded the formula that decides option price and takes the dividend for stock into account as follows:

$$C_0 = S_0 e^{-qT} N(d_1) - Xe^{-rT} N(d_2) \tag{12}$$

where

$$d_1 = \frac{\ln(S_0/X) + (r - q + \sigma^2/2)T}{\sigma\sqrt{T}} \tag{13}$$

$$d_2 = d_1 - \sigma\sqrt{T} \tag{14}$$

and

q = the continuously compounded annual dividend yield.

3.3 Explanation of the Model Parameters for the ESCO Case

The Black-Scholes model can be utilized to value the energy efficiency investments of an ESCO. Some of the parameters used in NPV analysis can also exist in real options valuation model. The investment costs including financing costs of any replacement conversion, distribution and control equipment, the staff and material costs for operation and maintenance refers to strike or exercise price (X) in the options model and holds a call option. If the expected discounted sum of revenues (S_0) which is the shared savings in the energy bill is greater than the investment costs, the option should be exercised. The main difference from the NPV analysis is the real options approach considers the uncertain future values of the revenues which depend on the changes in the energy prices. The option value (C_0) is calculated referring to equation 9.

Future volatility is undoubtedly the most critical parameter among all the input parameters in option pricing models (Costa Lima & Suslick, 2006). The volatility of expected cash flows is a function of the uncertainty of expected cash flows and the management's ability for responding to the resolution of this uncertainty (Piesse & Van de Putte, 2004). Luehrman (1998) states three approaches for estimating σ.

1. Taking a guess
2. Gathering some data
3. Simulation of σ

In the proposed model the σ parameter shows the volatility of the energy prices. Its calculation is based on the changes in the electricity prices over the years. The historical data of the prices can be used to estimate σ.

The parameter *r* is the continuously compounded risk free interest rate in other words the time of money. It varies according to the economic conditions of the countries. Time until the expiration of the option (*T*) is referred to the contract duration. It shows the time in years until the deadline of the energy efficiency project undertaken by the ESCO. The parameter *q* is the rate of asset value erosion for a new investment. The brief explanations of the parameters in the Black and Scholes model are given in Table 1.

Table 1. The description of the parameters used in ESCO investment risk model

Parameter	Description
C_0	Value of the option for ESCO investments
S_0	Discounted sum of ESCO revenues
X	Initial investment including financing costs of any replacement conversion, distribution and control equipment, the staff and material costs for operation and maintenance
r	Inflation rate (Continuously compounded risk free interest rate)
T	Time in years until the expiration of the contract
σ	Volatility of the energy prices
q	Rate of asset value erosion

4. Numerical Example

The numerical example is based on an ESCO project implemented in Turkey. The model uses the data of monthly electricity energy price changes in Turkey for the years 2008 and 2010. In order to reach more realistic results, the energy prices in Turkish Liras (TL) are converted to United States (US) dollars/cents and European euro/cents since the equipment is not usually produced in the domestic market rather imported from international markets. There have been fluctuations in the Turkish electricity prices because of the economic conditions in Turkey and international context as conversion rates are not often stable. Turkish electricity price is shown in Figure 1 with US cents and Figure 2 with Euro cents.

Figure 1. Monthly electricity US cent/kwh prices in 2008–2010 in Turkey (TEDAŞ- Turkish Electrical Distribution Company, 2012)

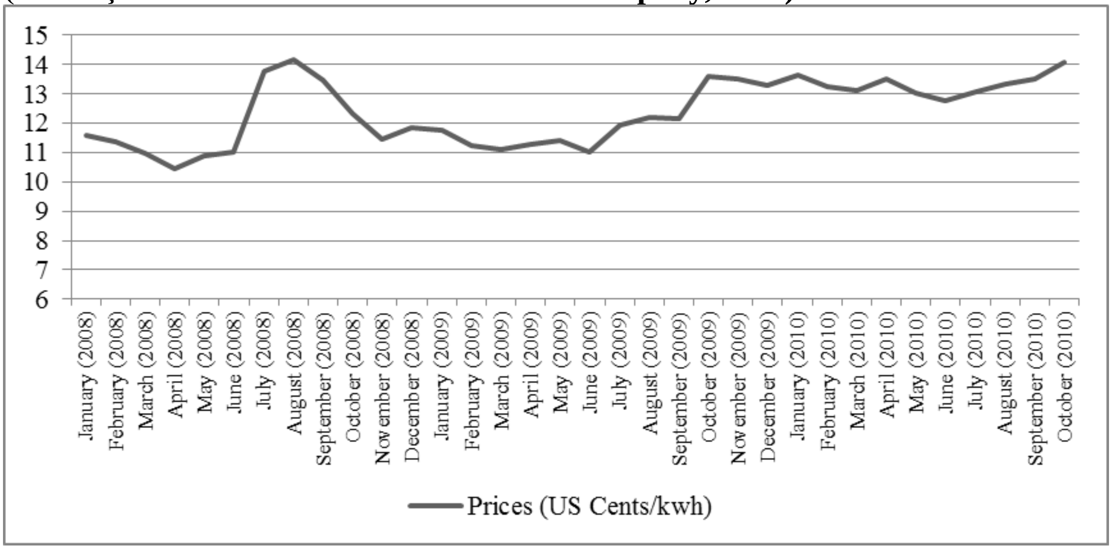
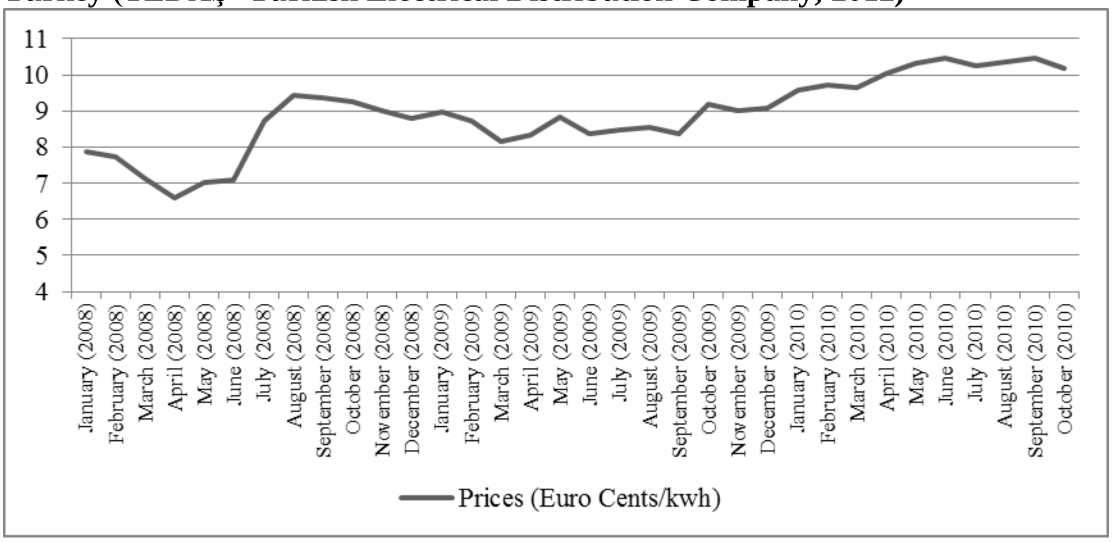


Figure 2. Monthly electricity Euro cent/kwh prices in 2008–2010 in Turkey (TEDAŞ- Turkish Electrical Distribution Company, 2012)



The annual volatility is calculated as 19.3% for US dollar/cent prices and 18.4% for Euro/cent prices. The model uses US cent prices since the revenues and costs are determined in US dollars. The inflation rate in Turkey may be reflected as the time of money (*r*) as 9%. The duration of the contract is 1 year and the rate of asset value erosion is accepted 3%.

The ESCO project involves the energy efficiency practices in a plant of an industrial consumer. After the examination of the facility of the client, energy performance contract is agreed to cover only the replacement of the industrial electrical motors with energy efficient ones. The revenue of ESCO from the shared savings in the energy bill is expected to be $300000 at the end of the contract duration of 1 year.

The investment of the ESCO is consisted of labor costs and financing costs in the design of the project, procurement, installation, commissioning, operating, maintenance and control of the energy efficient motors the and after the project training costs for the client's technical staff. The investment costs are calculated as $290000.

4.1 Analysis and Results

When DCF analysis is applied, the discounted revenues is equal to $275229 with the inflation rate (*r*) of 9%. Referring to equation 2, NPV is calculated as the following:

NPV = 275229 – 290000 = – 14770

Since NPV is negative, DCF analysis conclude that the investing the project is not profitable. On the other hand, real options approach views the project consisting of both the owned assets and an option for future investment opportunities. The option value (C_0) is calculated using equation 12 and it is equal to $21498. Then the real NPV is calculated according to the equation 7 as the following:

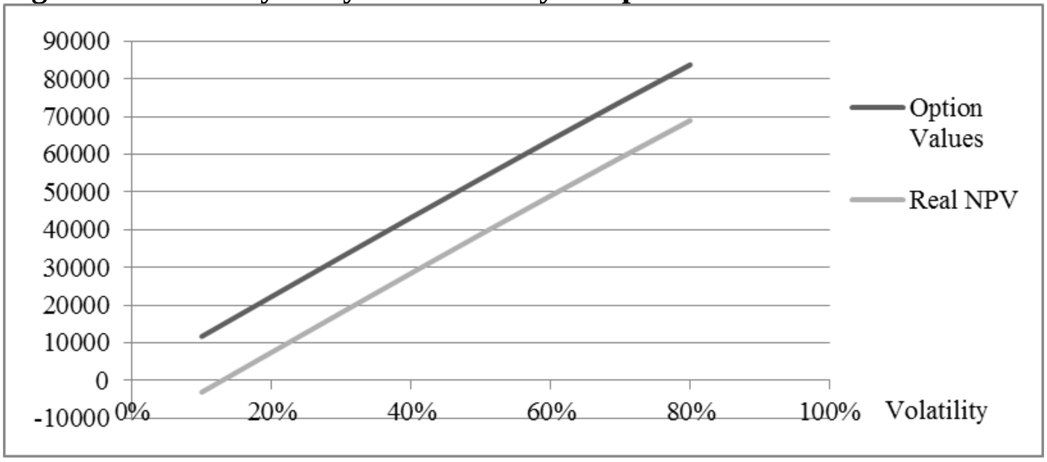
Real NPV = – 14770 + 21498 = 6782

The result demonstrates that ESCO should make the investment.

4.2 Sensitivity Analysis on Volatility

In the example, annual volatility is calculated as 19.3%. However the future volatility may be different due to economic, political and technological instabilities and energy prices are very vulnerable to these changes. Therefore the changes in the option value and the real NPV is observed by increasing the volatility (σ) values and keeping other parameters stable. Figure 3 illustrates the changes and it can clearly be seen that the option value regularly and linearly increases when the volatility of the energy prices increases. Options theory suggests that if the level of uncertainty increases, the option value increases so that as seen from figure 3, the investment may be made when the volatility has the any higher value than 13%.

Figure 3. Sensitivity analysis of volatility on option values and real NPV



Conclusion

Energy service companies deliver comprehensive energy services and/or other energy efficiency improvement measures to customers that own or operate facilities such as factories and buildings with a certain degree of financial risk. Their payments for the services delivered are based on the achievement of energy efficiency improvements defined by an agreed performance criteria. ESCO which undertakes an energy performance contract has undergone a risk because of the uncertainties in the future energy prices which are extremely effective on its income.

Traditional capital budgeting techniques are not beneficial in the assessment of energy investments because they are static and not able to cope with the dynamic and uncertain structure of the energy markets. The energy price volatility creates risk and uncertainty for the estimation of future incomes of ESCO. Real options analysis is a dynamic approach that considers the changes in the future and uncertainties. In real option approach, both the value of the real assets and the option value of the future opportunities based on the uncertainty are taken into consideration.

The paper proposes a risk management decision model for energy service companies who plan to enter an energy performance contract and make investments to implement energy efficiency projects for industrial or residential energy consumers. The model employs Black-Scholes real option valuation model that uses energy price volatility to calculate the option value of the investments. The case study demonstrates the application and comparison of the model with the traditional NPV approach. From a managerial point of view, real options analysis would be beneficiary for risk assessment of the investment decisions under dynamism and uncertainty. For the future studies, the results of the study can be compared with the other real options models in the literature and uncertainty modelling could be extended by considering economic and technological aspects.

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