August 2021

UNRAVELLING THE TRUE VALUE OF A CLEAN ENERGY INVESTMENT: THE REAL OPTIONS VALUE

Authors: Hettie Boonman, Matthew Halstead, Mirjam Groote Schaarsberg

To achieve a successful energy transition, it is important to accelerate and upscale investments in clean energy technologies (European Union (2018), Halstead and Donker (2020)). These investments typically involve many types of risk. The Real Options Value (ROV) approach is a method that has been specifically designed to assess the value of an investment in an uncertain environment. Contrary to the Net Present Value (NPV) method, the ROV approach takes into account that a firm's management is flexible in responding to an ever changing market situation. Using the ROV approach is arguably a more accurate way of valuing investments, and use of it could positively influence clean energy investment decisions. While the ROV calculation method can, in theory, take a variety of dimensions, the authors of this paper insist on selecting a practical ROV approach that is easily understood and easily applicable for real world investment projects.

Investment in clean energy technologies is an important condition to achieve a sustainable energy system. An estimated 19–90 trillion US dollars will be required worldwide to meet the Paris Agreement goals by 2050 (BloombergNEF (2020), IRENA (2020), Cozzi et al (2020)). Public investments alone will not cover the cost of achieving the Paris climate goals (Donker et al. (2020)), so investment from private sector sources is key for enabling a successful transition. But, clean energy projects tend to have relatively high up-front costs, low operating costs and higher risks compared to conventional technologies (Cattaneo (2019)), and these characteristics deter investors from investing in this market (Wuester et al. (2016)).

Investment risks arise due to uncertainty in energy and carbon prices, future demand and supply, technological risks, an ever-changing regulatory environment, and more (Egli (2020)). These uncertainties can make business cases for investments in some clean energy technologies less favourable. The ROV approach, which is based on financial pricing theory, is an investment tool that has been proposed specifically to deal with investment planning under uncertainty (Schachter (2016)).

THE STATUS QUO: THE TRADITIONAL NPV METHOD

The Net Present Value (NPV) is a simple, commonly used metric to assess project investment opportunities. The NPV is calculated by discounting all expected expenditures and revenues to the current time period. The summation of these two values minus the initial investment cost gives the Net Present Value (NPV). If the NPV is positive, this indicates that the investment is attractive, and if the NPV is negative, the investment is unattractive and should be withheld (Langley et al. (2020)).

The NPV approach to valuing investments has been heavily criticised in academic literature. Schachter (2016) points out that it is unsuitable for assessing clean investment opportunities because:

(1) NPV assumes that investments are reversible. However, when an investor decides to abandon the clean energy technology at a later stage, it involves very large sunk costs, making it in fact irreversible. Additionally, it thereby also neglects the risk of lock-in.

(2) NPV assumes that the future is known, while in practice there are a large amount of uncertainties that makes investment in clean energy technologies highly uncertain (Egli (2020)). These uncertainties are not taken into account when assessing a clean energy investment with a simple NPV.

(3) NPV assumes a now or never investment decision, and that operations have an uninterrupted constant stream of future revenues. While in practice, management has more flexibility than that. That is, it has the ability to postpone investment, make incremental investments, temporarily stop and later restart operations once invested. In case of a negative business case, the NPV only tells the stakeholder that ‘now’ is not a good time to invest. But the question remains: what is a suitable investment strategy after a few years when uncertainty has been partly reduced?

(4) NPV assumes a risk-free rate that takes into account all risk in the market. All types of risk are thereby equally important to the investment decision. In practice there are different types of risk that affect the investment decision and future revenue. We should distinguish between risks related to the company and the stand-alone project, and market or operational risk. Management has control over the first two types of risks. It will only invest when – as uncertainty unfolds – it is expected that the project will have a positive outcome. The company does not have control over market risk (e.g. price and demand uncertainty), and this type of risk should be accounted for higher compared to stand-alone or corporation risk in the assessment method.

THE ALTERNATIVE: REAL OPTIONS VALUE

A real option gives an investor the right, but not the obligation to invest in a product or technology. ‘Real’ means how tangible is the asset for which the decision is made. It is an actual product, service or technology (Saylor Academy (2012)). This is contrary to an option on financial products, which gives the investor the right but not the obligation to buy (call-option) or sell (put-option) a stock depending on the underlying stock price. Real options theory originates from literature about financial capital markets, which are typically highly uncertain markets. Uncertainty can be found in many other markets and situations, and has thus also been introduced for investments in (tangible) product markets.

> **“A REAL OPTION GIVES AN INVESTOR THE RIGHT, BUT NOT THE OBLIGATION TO INVEST IN A PRODUCT OR TECHNOLOGY.”**

BEI (2012) show case studies of projects in which both NPV and ROV have been calculated. One of the case studies analyses investment in an offshore wind farm in the UK’s North Sea. Two alternative options are considered. Option one commits the UK government to full construction of the offshore wind farm (similar to an NPV approach). With option two, the UK government commits to discrete investment of the windfarm, and performs an upfront study in which more data can be gathered (similar to an ROV approach). The study shows that the first option is likely to give a negative NPV. The second option shows that the possibility of gathering new knowledge on market conditions has a positive effect on the investment valuation. Similarly, Penizzotto et al. (2019) provide an example of investing in a rooftop solar PV project in a government building. The paper shows that by performing only a NPV calculation, a decision maker would not only decide not to invest in the rooftop PV, but also reject investment in the project in the future. Whilst a valuation using the ROV approach would postpone, but not dismiss, investment in rooftop PV.

Using real options theory to assess an investment opportunity acknowledges managerial flexibility in making investment decisions. Management is able to optimise and adjust choices depending on the situation in an ever changing world (Ceseña et al. (2013)). Typically, it is assumed that a firm can own the following types of options (Kozlova (2017)):

- The **option to deter** investment. In this situation it is desirable to wait until some of the uncertainty in the market is resolved.
- The **option to stage** investment, referring to the possibility to invest little by little. It allows a firm to gain information about the market. But also makes the investment reversible, contrary to a large lump sum investment.
- The **option to abandon** investment. This allows a firm to sell the project invested in.
- The **option to stop/restart** operations. After investment, it gives the firm the option to temporarily stop operations in case of an unfavorable market situation.
- The **option to grow**. After the first large investment has been made, it allows the firm to increase its production capacity.

A firm that calculates a NPV makes a now-or-never decision. The decision 'no' will not be reconsidered in the future. In contrast, the ROV method basically assumes a potentially infinite number of NPV analyses to be executed by the firm in the future. When it is not optimal to invest right away, it does not imply it will never invest. By allowing to delay the decision and keeping options open, the ROV method is more likely to eventually result in a positive investment decision compared to the NPV, especially when considering investment in a market that is expected to grow over time.

The ROV method assumes that all future *negative* NPVs will not result in investment and future *positive* NPVs will result in investment. Discounting all future expected NPVs (either zero or positive) to the moment where the ROV is calculated thereby results in a value that is likely to be larger than the NPV. Again, the importance of accelerating and upscaling investment in clean energy technologies to achieving a successful energy transition, emphasises the importance of using the ROV method for investment decisions.

"USING REAL OPTIONS THEORY, MANAGEMENT IS ABLE TO OPTIMISE AND ADJUST CHOICES DEPENDING ON THE SITUATION IN AN EVER CHANGING WORLD" (CESEÑA ET AL. (2013))."

There is an extensive stream of literature that use real options valuation for assessing investments in clean energy technologies. A large part of the literature uses a more theoretical framework (e.g. Dixit and Pyndyck (1992), Huberts et al. (2015), Boonman et al. (2015)), while other literature apply the method to an actual use case (e.g. Huisman et al. (2013), Finjord et al. (2018), Data et al (2007)). Schachter (2016) specifies which characteristics of these models should be used for practical assessment of investment in clean energy technologies.

The more theoretical ROV models assume a Geometric Brownian Motion[1] as underlying source of uncertainty. This approach is however criticised for being impractical for applying to real-world strategic investment decisions due to the unclear or unapplicable underlying assumptions (Copeland and Tufano (2004)). Also, it allows for only one source of uncertainty, while in practice clean energy investment decisions involve many types of uncertainty. Other models – based on monte Carlo approaches - have been criticised for being too computationally demanding for practical application.

Datar et al. (2007) developed a practical ROV model that takes the decision maker by hand through the underlying assumptions on future volatility and growth. This approach can incorporate multiple sources of uncertainty and assesses multiple type of investment options. TNO has applied this model for the case of investment in electrolyzers. Also, the model has been extended by TNO for analysis on non-financial KPIs, such as social or environmental indicators. There has been increasing attention on the social responsibility of organisations in the climate crisis (Wang et al (2016)), and TNO has attempted to capture this aspect of investment decision making by assessing the value of investment using a multi-value ROV approach (Langley et al. (2020)).

WHAT DOES THE FUTURE HOLD?

The authors of this paper strongly believe that, given external uncertainty and the existence of managerial flexibility, the ROV method is a more appropriate tool for valuing clean energy project investments compared to NPV. The fact that NPV is easily understood and applicable for real world strategic investment decisions does not compensate for the limitations of its underlying assumptions. Under the right modelling assumptions, the ROV valuation method is also understandable for decision-makers and easily applicable for a multitude of different investment situations. Moreover, it can help to boost investments in clean energy technologies, bringing us one step closer to a successful energy transition.

1 A Geometric Brownian Motion (GBM) is used to produce random pathways of a parameter for which its future trajectories are uncertain. More information on GBM is given by Lalley (2001).

REFERENCES

Ambiguity, R., & Bensoussan, I. A. (2013). Investment in High-tech Industries: an Example from the LCD Industry1. Real Options, Ambiguity, Risk and Insurance: World Class University Program in Financial Engineering, Ajou University, Volume Two, 5, 20.

Environment Initiative (BEI), 2012, An Options Approach to Unlocking Investment in Clean Energy

BloombergNEF (2020) “Solar, Wind, Batteries To Attract $10 Trillion to 2050, But Curbing Emissions Long-Term Will Require Other Technologies Too” https://about.bnef.com/blog/solar-wind-batteries-attract-10-trillion-2050-curbing-emissions-long-term-will-require-technologies/

Boonman, H. J., Hagspiel, V., & Kort, P. M. (2015). Dedicated vs product flexible production technology: Strategic capacity investment choice. European Journal of Operational Research, 244(1), 141-152.

Cattaneo, C. Internal and external barriers to energy efficiency: which role for policy interventions? Energy Efficiency 12, 1293–1311 (2019). https://doi.org/10.1007/s12053-019-09775-1

Ceseña, E. M., Mutale, J., & Rivas-Dávalos, F. (2013). Real options theory applied to electricity generation projects: A review. Renewable and Sustainable Energy Reviews, 19, 573-581. Dixit and Pyndyck (1992))

Copeland, T., and Tufano P. (2004) A Real-World Way to Manage Real Options. Harvard Business Review.

Cozzi, L., Gould, T., Bouckart, S., Crow, D., Kim, T. Y., Mcglade, C., ... & Wetzel, D. (2020). World Energy Outlook 2020. Paris: IEA.

Donker, J. Gavrilova, A., Halstead, M. (2020) “Financing the energy transition in the Netherlands, the important role of institutional investors” https://www.tno.nl/en/focus-areas/energy-transition/roadmaps/system-transition/the-social-aspects-of-the-energy-transition/financing-the-energy-transition/

Egli, F. (2020). Renewable energy investment risk: An investigation of changes over time and the underlying drivers. Energy Policy, 140, 111428.

European Union (2018). Energy and the MFF. Study prepared at the request of the European Parliament’s Committee on Industry, Research and Energy (ITRE).

Halstead and Donker (2020) Thinking Big: Narrowing the Investment Gap for Energy Efficiency in the EU. Perspectives paper

Huberts, N. F., Huisman, K. J., Kort, P. M., & Lavrutich, M. N. (2015). Capacity choice in (strategic) real options models: A survey. Dynamic Games and Applications, 5(4), 424-439.

IRENA (2020) “Global Renewables Outlook” https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Apr/IRENA_Global_Renewables_Outlook_2020.pdf

Kozlova, M. (2017). Real option valuation in renewable energy literature: Research focus, trends and design. Renewable and Sustainable Energy Reviews, 80, 180-196.

Lalley, S. (2001) “Lecture 6: The Ito Integral” Univesrity of Chicago. http://www.stat.uchicago.edu/~lalley/Courses/390/

Langley, D. Boonman, H. Wieclawska, S. (2020) “Multi-value Real Options Valuation”. TNO working paper.

Mathews, S., Datar, V., & Johnson, B. (2007). A practical method for valuing real options: The Boeing approach. Journal of Applied Corporate Finance, 19(2), 95-104.

Penizzotto, F., Pringles, R., & Olsina, F. (2019). Real options valuation of photovoltaic power investments in existing buildings. Renewable and Sustainable Energy Reviews, 114, 109308.

Saylor Academy (2012) “14.3 The role of Real Options in Investment decisions” https://saylordotorg.github.io/text_developing-new-products-and-services/s17-03-the-role-of-real-options-in-in.html

Schachter, J. A., & Mancarella, P. (2016). A critical review of Real Options thinking for valuing investment flexibility in Smart Grids and low carbon energy systems. Renewable and Sustainable Energy Reviews, 56, 261-271.

Wang, H.; Tong, L.; Takeuchi, R.; George, G. (2016). Corporate social responsibility: An overview and new research directions: Thematic issue on corporate social responsibility. Acad. Manag. J. 2016, 59(2), 534–544.

Wuester, H., Lee, J. J., Lumijarvi, A., Flannery, S., Veilleux, N., & Joubert, A. (2016). Unlocking renewable energy investment: the role of risk mitigation and structured finance. Int Renew Energy Agency IRENA.

21-12274 August 2021