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The Options Value of Blue Hydrogen in a Low Carbon Energy System

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An operator considering constructing and operating a Steam Methane Reformation (SMR) plant to produce hydrogen from natural gas for sale to the market faces the decision as to whether it is financially advantageous to incorporate a Carbon Capture and Storage (CCS) unit as part of the plant. Conventional Net Present Value (NVP) techniques could be used to estimate the plant's value with and without the CCS unit and inform the decision. Such estimates of the NPVs will, by their nature, be uncertain due to their reliance on uncertain future costs and prices.

By deciding on the fitting of the CCS plant at the start of construction, the operator will forgo the opportunity to take advantage of changes in costs and prices to maximise the value of the investment. In this work, the approach of Chyong and colleagues (Chyong et al., 2012) has been extended to enable an engineering flexibility / real options approach to value an ability to respond to changing circumstances. A structured approach has been used to identify possible engineering flexibilities that would increase the value of the plant. One case was identified for further consideration: a plant initially constructed without the CCS unit but with the necessary design adaptions to enable it to be retrofitted with a CCS unit ("CCS-ready plant")

A Real Options approach has been used to enable the value of this engineering flexibility to be calculated. If the circumstances are such that it appears likely that the retrofitting of the CCS unit will increase the value of the project, then the decision is made to retrofit the unit. This decision is made based on the consideration of historical data for the costs and income of the plant and whether retrofitting the CCS unit will increase the value of the SMR plant over its lifetime, assuming that costs and prices remain the same. These calculations consider learning effects on the capital and operation costs of the CCS unit.

Calculations were performed for various discount rates, energy prices, the costs of releasing CO_2 into the atmosphere, and learning rates. These calculations were performed by developing Monte-Carlo models. One model where the CCS unit is fitted at the time of construction, and one model incorporates the decision rule. These models follow the cash flows associated with the production and sale of hydrogen as costs and prices vary through the lifetime of the plant

To represent the range of possible costs and prices and the variable timing of the exercise of the option (if it is exercised), 100,000 iterations of the model were performed for each set of calculations.

This work shows that the availability of the flexibility to retrofit the CCS unit increases the NPV of the SMR plant when compared to the case where the CCS unit is incorporated at the time of construction, i.e., the option has a positive value. This result remains valid for different scenarios for the prices of gas and electricity and the costs associated with the release of CO_2 into the atmosphere. The results also hold for a range of different discount rates. There are also corresponding improvements in the Values at Risk and the Values at Gain.

The sensitivity of the option's value to the parameters used in the calculations has been investigated. This shows that the most sensitive parameter is the discount rate used. The prices of gas and electricity and the costs associated with releasing CO_2 to the atmosphere have a lesser effect. The magnitude of learning effects on the cost of retrofitting the CCS plant has a minimal effect.

Whilst in this work, the approach has been applied to the example of the decision of whether to fit a CSS unit to an SMR plant for the production of blue hydrogen it is believed that a similar approach can be applied to other situations thereby increasing the value of these projects.

Chyong et al (2012). *An Options Approach to Unblocking Investments in Clean Energy - Technical Annex*. https://www.cisl.cam.ac.uk/resources/sustainable-finance-publications/bei-options-approach-unlocking-investment-clean-energy

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