Differences in the effects of carbon prices and scale effects on carbon assets:Evidence from hydrogen power carbon trading in China

Xinao He [1, a]

[1] Economics and Management School , Wuhan University, China

[a] hxa2120@outlook.com

Abstract. Hydrogen energy has significant advantages in pursuing carbon neutrality goals. However, there is uncertainty about its economic value. In view of this problem, this paper discusses the hydrogen energy carbon asset valuation method, identifies the key influencing factors, analyzes their impact on carbon assets, and proposes a carbon asset valuation method based on the market method. We analyze the sensitivity of carbon asset value to hydrogen energy using Monte Carlo simulation, which compares the uncertain impact of various combinations of factors and incorporates time variation into the study factors. The results show that: (1) Hydrogen energy has a high carbon asset value; (2) Among the multiple factors considered, energy capacity has the most significant impact on hydrogen energy and carbon assets; (3) Carbon assets of hydrogen energy are determined by factors such as carbon emission reduction capacity, energy level and carbon price.

Keywords: Carbon assets, Hydrogen power energy, Sensitivity analysis, Market value approach.

1. Introduction

In recent years, developing countries have placed significant emphasis on hydrogen power due to its pivotal role in enhancing energy efficiency and reducing emissions. Hydrogen power not only fulfills local electricity demands but also mitigates losses in the transmission process, thereby decreasing transmission costs and losses. [1,2] Notably, China's hydrogen power market is the world's largest by valuation and has significant growth potential. [3,4,5]Although hydrogen's role in the environment is growing, its economic value in the context of carbon trading is less well understood. This paper analyzes the environmental economic value of hydrogen energy using market-based carbon asset valuation theory. The factors affecting the carbon assets of hydrogen energy are analyzed in depth and the underlying mechanisms are elucidated.

2. Theory and methodology

2.1 Carbon Asset Valuation for hydrogen power

Carbon neutrality is a crucial milestone indicating a dynamic equilibrium between carbon emissions and removals within an economy, signifying sustainable development for both the economy and society. Attaining carbon neutrality requires proactive and comprehensive strategies in response to climate change.

The market approach is both reasonable and widely accepted for valuing carbon rights assets, given these principles. By employing the market approach, we can quantify the incremental value of a company's carbon assets resulting from technological advancements. Based on this, we propose a time-scale model for the valuation of talking assets based on the market value approach.

$$V = Ho \cdot O \cdot A \quad (1)$$

ISSN:2790-1661 Volume-10-(2024)

In this equation, V represents the value of the enterprise's carbon assets. H_0 represents the carbon emissions reduced by the output of the firm after making technological improvements. By converting the power production of hydrogen power to the equivalent of 1 kg of standard coal and comparing it to the emissions of thermal power plants, the carbon reduction per unit of power production can be calculated as 0. 785 kg/kW h. O is the actual amount of electricity generated by the enterprise, and the average amount of hydrogen energy obtained by using hydrogen power curve and probability density function method is 912.75 TkW. A is the actual price of carbon .Based on the weighted average calculation of the sub-trading volume of each month based on the 2022 data of Tianjin Carbon Emission Exchange, the average carbon price is P=35.77 ￥/kg.

3. Empirical results and analysis

3.1 Carbon Asset Value of hydrogen power

The variables of the previous section are substituted into Equation (1), the carbon emission reduction of unit hydrogen power relative to thermal power energy $H1$=0.96kg/kWh. As opposed to using other integrated energy sources $H2$=0.81kg/kWh. hydrogen power energy capacity O=9136400kWh, actual price of carbon A=35.77yuan/kg. The results of carbon asset prices for V 1= 313 ,736,667 yuan and V 2= 264,715,313 yuan can be obtained. V 1 is the carbon asset of hydrogen power relative to thermal energy, and V 2 is the carbon asset of hydrogen power relative to integrated energy. The results mentioned above are obtained by averaging the variables H, O, and A. This approach represents a method for calculating the carbon asset of hydrogen power from a static perspective.

Then, we vary the variables O and A by ±10% of their respective variation ranges. When the variables are at the upper end of the range, the new values are O_1= 10,050,040 and A 1=39 .35 ,respectively. Conversely, when the variables are at the lower end of the range, the new values are O_2= 8,222 ,760 and A_2=32. 19. This process generates a total of eight combinations . By substituting the given variable values into equation (4) for each combination, we can determine the carbon asset of hydrogen power . The results demonstrate that changes in energy capacity have a greater impact on the carbon asset of hydrogen power compared to variations in unit carbon price and emission reduction levels. In fact, given the relatively stable carbon market price and the challenges associated with achieving significant advancements in emission reduction technology within a short time frame , expanding the power energy scale to attain economies of scale remains the optimal approach for enhancing the carbon asset. While the static point selection method is advantageous for explicitly calculating carbon valuation of hydrogen power , it is limited to assessing the value at a specific point in time and does not capture the relationship between carbon valuation of hydrogen power and various influencing factors.

Then, we vary the variables O and A by ±10% of their respective variation ranges. When the variables are at the upper end of the range, the new values are O_1= 10,050,040 and A 1=39 .35 ,respectively. Conversely, when the variables are at the lower end of the range, the new values are O_2= 8,222 ,760 and A_2=32. 19. This process generates a total of eight combinations . By substituting the given variable values into equation (1) for each combination, we can determine the carbon asset of hydrogen power . The results demonstrate that changes in energy capacity have a greater impact on the carbon asset of hydrogen power compared to variations in unit carbon price and emission reduction levels. In fact, given the relatively stable carbon market price and the challenges associated with achieving significant advancements in emission reduction technology within a short time frame, expanding the power energy scale to attain economies of scale remains the optimal approach for enhancing the carbon asset. While the static point selection method is advantageous for explicitly calculating carbon valuation of hydrogen power , it is limited to assessing the value at a specific point in time and does not capture the relationship between carbon valuation of hydrogen power and various influencing factors .

To comprehensively examine the factors that impact the value of carbon assets in hydrogen power energy , it is necessary to conduct a sensitivity analysis for each factor . This analysis should encompass the temporal variability that influences the value of carbon assets within a specific fluctuation range , while identifying the primary factors that drive the value of hydrogen power energy carbon assets .

3.2 Sensitivity analysis of influencing factors

To reflect the relationship between carbon valuation of hydrogen power and each influencing factor, we use Monte Carlo simulation with a random sample of energy capacity O and carbon price A fluctuating in a range of ±10% , the rate of change of which will form a normal distribution.

We assume that d = 0.011, c_0 = 0. 15 , σ_0 = 0. 15 , σ_A= 0.065 ,

μ_0 takes values between -0 . 1 ~ 0. 1 , μ_A takes values between 0.04 ~ 0.05. By analyzing the distribution of the variables of interest, the following hypotheses can be summarized:

$$c_t^{'}/c_t \sim N(0.011/(0.15+0.065\cdot t), 0.1)$$

$$O_t^{'}/O_t \sim N(\mu_0, 0.15)$$

$$E_t \sim N(\mu_E, 0.065)$$

Then, the effects of changes in $c_t^{'}/c_t$、 $O_t^{'}/O_t$、 E_t on $V_t^{'}/V_t$ are empirically simulated according to equation (9) , (10) , and (11) , and the effects of O and P on V are investigated.The results are shown in Figure 1, Figure 2, Figure 3, and Figure 4 .

Figure 1 demonstrates that the sensitivity of the carbon asset of hydrogen power to changes in carbon price increases, which represents the scenario where the energy capacity increases while the carbon price is stable . However, the sensitivity of the carbon asset of hydrogen power to changes in energy capacity remains relatively stable over time .

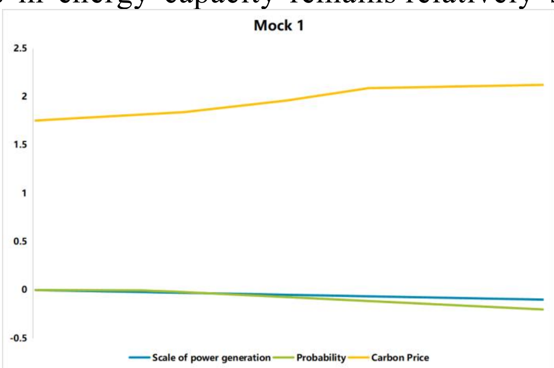

Figure 1: The horizontal axis represents time and the vertical axis is the sensitivity. When μ_A constant μ_0 and increasing by +10% , the value of V varies with t.

Figure 2 reveals that the sensitivity of carbon valuation of hydrogen power to changes in energy experiences a slight increase over time when μ_0= -0.15 , μ_A= 0.055, which denotes the scenario where energy decreases while the carbon price remains stable .

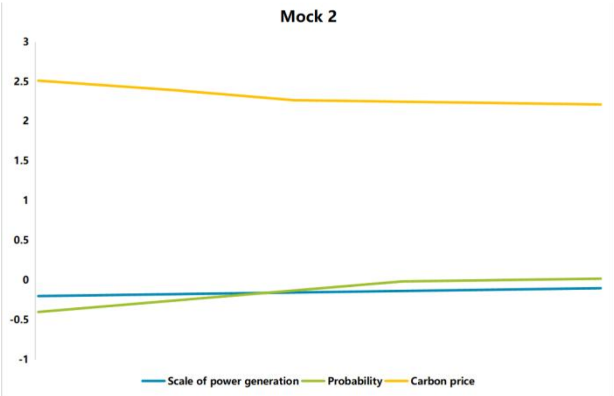

Figure 2: The horizontal axis represents time and the vertical axis is the sensitivity. When μ_A constant and μ_0 decreasing -10%, the value of V varies with t.

Figure 3 illustrates that the sensitivity of the carbon asset of hydrogen power to changes in carbon price remains relatively stable when $\mu_0 = 0$, $\mu_A = 0.06$, which represents the scenario where energy remains stable while carbon price increases. However, the sensitivity of the carbon asset of hydrogen power to changes in energy exhibits a significant decrease over time.

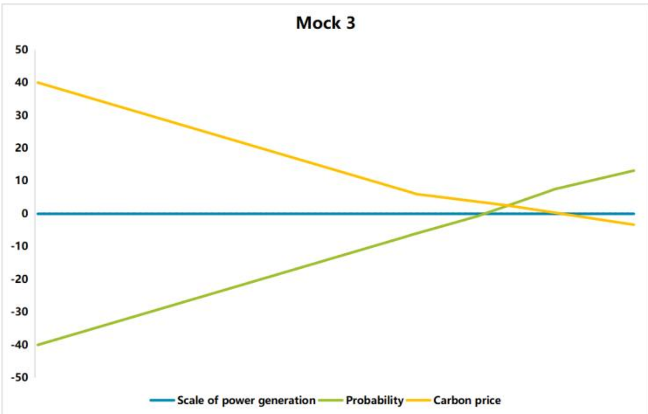

Figure 3: The horizontal axis represents time and the vertical axis is the sensitivity. When μ_A constant and μ_0 increasing by +10%, the value of V varies with t.

Figure 4 illustrates that the sensitivity of the carbon asset of hydrogen power to changes in carbon price remains relatively constant when $\mu_0 = 0$, $\mu_A = 0.03$, that is, when energy is stable and carbon price is decreasing. However, the sensitivity of the carbon asset of hydrogen power to changes in energy exhibits a significant increase over time.

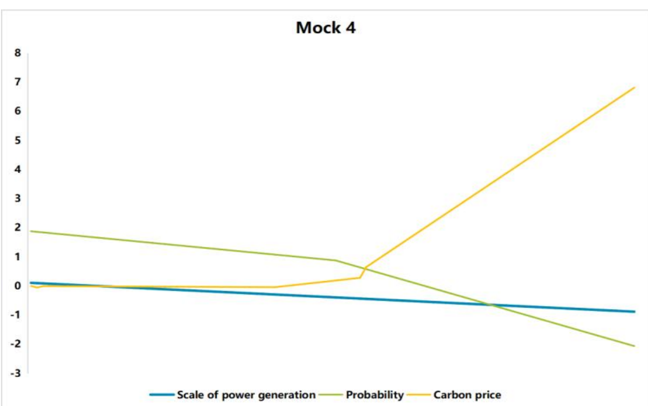

Figure 4: The horizontal axis represents time and the vertical axis is the sensitivity. When μ_0 is constant and μ_A increases by - 10%, the value of V varies with t.

The empirical analysis reveals that the carbon asset of hydrogen power is significantly influenced by both carbon price and the scale of power generation over time, with the scale of power generation having a greater impact than carbon price. Moreover, as time progresses, the impact of carbon price and abatement level on carbon assets tends to stabilize, unless the scale of power generation falls. These empirical findings underscore the importance of the hydrogen power industry and other energy-related industries to actively scale up economies of scale and take appropriate measures to manage the risks associated with carbon asset trading.

4. Conclusions and policy recommendations

This paper applies the concept of carbon assets in the context of hydrogen power energy and utilizes a market-based approach to evaluate their value. Furthermore, it examines the factors that influence the carbon value of hydrogen power energy and analyzes their sensitivities.

We also find that various influencing factors such as carbon reduction per unit of power energy, power energy price and carbon price show different sensitivities to hydrogen power carbon assets. It is observed that fluctuations in scale of power generation have a more significant impact on the value of carbon assets from hydrogen power energy compared to the price of carbon.

As an emerging renewable energy source, hydrogen power has garnered significant attention from the Chinese government. The government is particularly interested in understanding the role of hydrogen power in achieving carbon neutrality targets and its potential for driving economic development in wind-rich regions. To facilitate the government's plans of opening the carbon trading market for hydrogen power energy, it is essential to enhance the methods for valuing carbon assets in the hydrogen power sector. Given the exceptionally low carbon emissions associated with hydrogen power plants, their carbon value should surpass that of other energy sources, reflecting their contribution to both energy conservation and carbon reduction. By establishing carbon valuation of hydrogen power, companies and households heavily reliant on hydrogen power can expect to receive increased financial subsidies. In addition, this study provides theoretical support for enterprises to effectively balance costs and profits by using the wind-power carbon trading mechanism under the market-oriented carbon reduction system.

Declaration of Interest

No potential conflict of interest was reported by the authors.

References

[1] Hancevic , P.I., Nuñez , H.M., Rosellon, J., 2017. Distributed photovoltaic power generation: possibilities, benefits, and challenges for a widespread application in the Mexican residential sector. Energy Policy 110, 478–489.

[2] Ascui , F. , Lovell , H. , 2013. As frames collide: making sense of carbonaccounting.Account. Audit. Account. J. 24 (24), 978–999.

[3] Bebbington, J., Larrinaga-González, C., 2008. Carbon trading: accounting and report in issues. Eur. Account. Rev. 17 (4), 697–717.

[4] Nerini, F.F., Broad, O., Mentis, D., et al., 2016. A cost comparison of technology approaches for improving access to electricity services. Energy 95, 255–265.

[5] Anaya , K.L. , Pollitt , M.G., 2017. Going smarter in the connection of distributed generation. Energy Policy 105 , 608–617 .