

# The Evaluation of the Situation in the Hydrogen Market

**Bachelor Thesis**

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## **BACHELOR'S THESIS**

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Appendices

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### **Abstract**

The thesis aims to evaluate the situation in the hydrogen market, focusing on companies that are only operating in the hydrogen sector. The main research question is supported by sub questions to present the reader with a more detailed result.

The methods used within the thesis is a financial analysis of Linde PLC, Royal Dutch Plc, Fuel Cell Energy Inc and Plug Power Inc. Hereby, the financial report of the companies from 2017- 2020 serves as a basis for the analyzation

As a result, it was found out that it is hard to detect an eventual bubble within the sector. It can be stated that there is an existence of a growth premium. Furthermore, the investor's behavior also indicates that the industry is overvalued.

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## 1 Introduction

An economy without greenhouse gases within the next 30 years - that is Europe's declared goal for halting climate change. Renewable energy can be used to offset fossil fuels like oil, coal, and gas. Hydrogen will play an essential long-term role in the transition of the energy supply. For clean mobility, the efficient electricity supply as a storage medium to compensate for fluctuating renewable energies, the gas will play an important role. Hydrogen is a very flexible energy carrier and can be used across sectors, providing excellent synergy. It is an essential building block for massively reducing emissions, especially those of the harmful greenhouse gas CO<sub>2</sub> emitted by the transportation and industrial sectors. Hydrogen will be a part of the future environmental protection policy. Simultaneously, the development of a cross-sector and, if possible, global Hydrogen economy opens up enormous opportunities for new technologies and business models. (Nüssler, 2019)

The annual global production of Hydrogen is currently around 600 to 700 billion cubic meters, which corresponds to a notional value of approximately 100 billion Euros. The annual growth rate is up to 10 percent. The most significant users are the chemical industry for fertilizer production, among other things, refineries for fuel desulfurization, and the steel industry, which together consume about 60 percent of production. Only a tiny proportion of no more than four percent of the global output is so-called "merchant hydrogen," which is freely traded, while the vast majority is not changed but produced and consumed in the same place. Used as automotive fuel, in turn, it accounts for only a tiny fraction of this traded volume market niche. Especially this niche has enormous growth potential ahead of it. For example, the entire amount of Hydrogen required for Germany's road traffic would be ten times Germany's current annual production of 22 billion cubic meters. However, even before the hydrogen age dawns for personal transportation, the world's increasing environmental pressures will be the main factor in the short term. Growing environmental regulations is an essential growth driver, as they bring an increasing need for Hydrogen.

Hydrogen is considered the new trend in the Financial World after Cryptocurrencies and Cannabis stocks. Hydrogen technology has been discussed for years, but the technology has never been able to catch on. A new trend wave has ignited on the stock market, bringing Hydrogen technology back into consideration. This trend is being fueled by the current climate protection goals and the rethinking of consumers. In line with the news situation on the subject of Hydrogen, the share prices of companies that are precisely at home in the Hydrogen sector have risen massively in recent years.

Large companies like Siemens and Bosch are investing in companies like Plug Power not to miss this revolutionary trend. Therefore, many small and medium-sized companies have entered the market to profit from the changed market environment.

## 1.1 Objective

The change in the market environment was the reason to analyze the current market. Hereby, the focus will be on growth and value stocks represented by four companies. The main aim of this research is to investigate the current financial situation of the Hydrogen sector. This is done by an evaluation of the value and growth of companies operating in the Hydrogen segment. After a sufficient analysis of the situation, the aim is to provide the reader with a detailed report.

Considering the purpose mentioned above and taking the initial topic into account, this thesis will concentrate on one key research question that a few sub-questions will support.

### Main research question

***What is the current situation of newcomers in the Hydrogen sector on the stock market?***

Hydrogen as an energy carrier raises the highest hopes, which accounts for both climate protectionists and investors. While the climate effect has been a long time coming, many investors have been very excited. High investment returns are possible, and companies like Plug Power, a representative of the growth stocks, are one of the investors' favorites. The aim hereby is to evaluate the situation of these companies by using financial factors as well as the investor's behavior and a historical comparison.

The sub-questions below are relevant to support the decision-making for the main question.

Firstly, to understand the background of the research, fundamental theories have to be taken into account. It will be supported by the question:

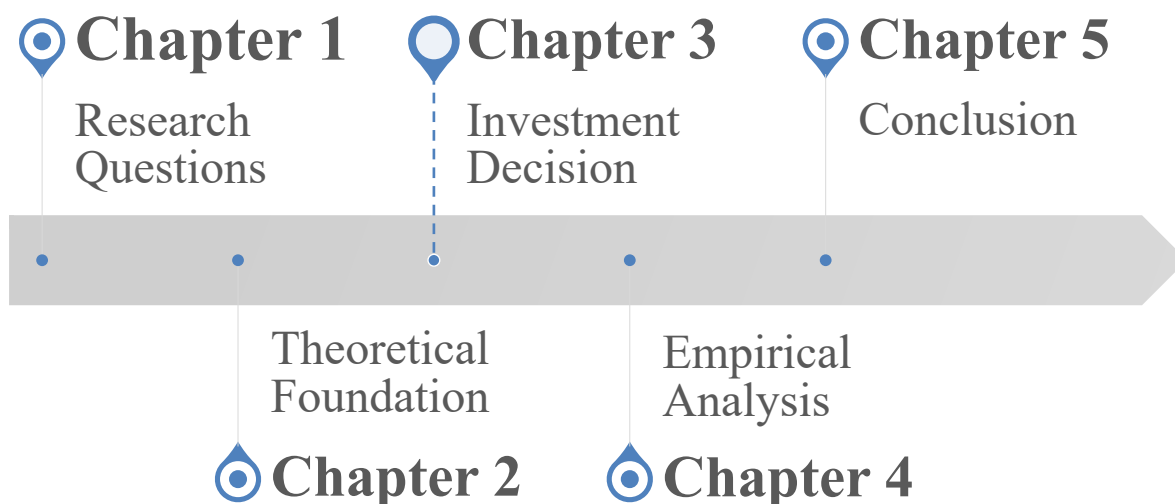
***1. What do financial theories say about investments into outperforming stocks?***

To support the research with financial data, fundamental financial ratios have been used.

***2. Which of the fundamental variables, Price/Earnings, Current Ratio, Debt/Equity, Market-to-Book Value, and EBITDA Margin, should be used as an indicator for risk analysis of a Hydrogen portfolio?***

## 1.2 Structure of the Thesis

To understand the composition of used financial theory, the background, and the analysis, the listing will be supported by this graph.



*Figure 1 Structure*

The first chapter represents the main research question alongside some sub-questions. It also includes the limitations and literature evaluation.

In the second chapter, the theoretical foundation for the thesis is stated. It presents financial theories, which can explain a value premium in the Hydrogen sector.

Within the third and fourth chapters, the companies for the empirical analysis are presented. Furthermore, the financial ratios are defined, which will support elaborating the situation of the sector.

The fifth chapter includes the presentation of the results. It also provides a detailed overview of the situation underlined by interpretations of the ratios.

### 1.3 Literature

The theoretical basis for this research is predominantly comprised of financial papers, journals, and books. The author of this paper claims that the literature used is of good quality and significance. This is related to the fact that the bulk of literature used is written by highly regarded and well-known financial experts. The majority of the papers have been reported in respected journals and subjected to peer review by other authors and journal editors over time. Since the Hydrogen sector's significant growth is relatively new, the thesis is also based on financial statements and reports of the used companies. There is always the risk that relevant literature has been missed due to the rapidly changing environment.

As the theoretical part of the thesis is heavily based on standard financial theories, a sufficient number of financial theories have been used. The Journal of Finance provides several researches on financial theory and is one of the most widely cited journals in economics. E. F. Farma provided valuable details about the CAPM within their research, which was the reason to base the thesis on this journal. Furthermore, the book "Principles of Corporate Finance" was a reasonable assistance to the specific theories and the investment chapter. The book was well written and provides a vast amount of financial theories and guidance to investment results.

Within the investment chapter, the representation of the companies is included. In order to deliver the reader the correct information, reports of each firm and the companies own documents have been used. All companies are operating along with the value change of Hydrogen. The process of hydrogen generation, storing, and transportation can be very complex. The book "Compendium of Hydrogen Energy" provided short explanations about the Hydrogen process, which will help to understand the four companies' business models better.

## 2 Theoretical Framework

Looking at the stock market's overall situation, the growth of hydrogen stocks has outperformed the market in previous years. Various discussions have been held about the over-average performance which has been occurred. The chapter aims to evaluate multiple financial theories that explain the existence or non-existence of a value premium in the Hydrogen sector. Various sources of reports and books will support the chapter as well as a historical check. In addition a short overview about the hydrogen production and possibilities will be provided.

### 2.1 Hydrogen Technology

Hydrogen is a gas and is abundant on Earth, but almost exclusively in chemical compounds (water, acids, hydrocarbons, etc.). Hydrogen is obtained by splitting water ( $H_2O$ ) into oxygen (O) and hydrogen ( $H_2$ ). However, it takes a lot of energy to split the molecule  $H_2$ . If this is done with the help of electric current, it is called electrolysis.

Electricity from renewable sources such as wind and sun can be used to produce hydrogen by electrolysis. This process for producing so-called "green hydrogen" is also known as power-to-gas and is one of the power-to-X technologies (PtX technologies) in which electricity is used to produce, for example, gases (power-to-gas), heat (power-to-heat) or liquid energy carriers (power-to-liquid). PtX technologies are seen as an important solution to meet climate targets and reduce greenhouse gas emissions

An important element in the hydrogen strategy is the so-called sector coupling. It serves to more closely dovetail and network electricity and heat, the transport sector and industry. Hydrogen plays a special role as a central coupling element between electricity and gas. Sector coupling offers several major advantages. It allows electricity from renewable energies to be used indirectly in many areas of industry that are difficult to electrify. In this way, it enables all sectors to reduce their CO<sub>2</sub> emissions with the help of renewable energies. (Bundesministerium für Wirtschaft und Energie , 2021)



## 2.2 Capital Asset Pricing Model (CAPM)

This section summarizes the Capital Asset Pricing Model (CAPM) and its drawbacks in estimating returns. The CAPM is a mathematical model that describes the relationship between systemic risk and expected return for assets, particularly stocks. In finance, the model is commonly used to price volatile securities and generate projected returns for assets based on their risk and cost of capital.

$$\begin{aligned} \text{Expected risk premium on stock} &= \text{beta} \times \text{expected risk premium on market} \\ r - r_f &= \beta(r_m - r_f) \end{aligned}$$

*Figure 2 - Capital Asset Pricing Model (Source: Richard A. Brealey, 2011, p. 193)*

*r = expected return of investment*  
*r<sub>f</sub> = risk-free rate*  
*beta = beta of the investment*  
*(r<sub>m</sub> - r<sub>f</sub>) = market risk premium*  
*r<sub>m</sub> = growth rate*

In order to calculate the expected return (r) of a security according to the CAPM, the following key figures must be known: the risk-free interest rate (r<sub>f</sub>), the systematic risk beta (β) and the expected return of the overall market. Once r has been determined, the value can be compared with the overall market.

There are, however, several observational variations from the CAPM. The beta of the formula appears to be an imperfect measurement of explaining returns (especially in recent periods), and CAPM is ineffective at explaining returns of stocks with unique character (stocks with a specific market capitalization). (E. F. Farma, 1992)

The CAPM's widespread acceptance and use by investors is ostensibly a concern because the model fails to clarify all risks associated with an investment.

The chance that unpredicted risk will cause a decrease in the performance of a particular investment is higher. As a result of CAPM's inability to clarify anomalies in risk and return trends, much research has been done in the financial sector.

Researchers have been searching for new ways to assess the risk-reward relationship more precisely. The premium associated with value stocks is one of these contradictions.

Since the higher expected return from investors punishes higher risk, a significant positive relationship between beta and the market to book value (MTBV) variable can be drawn.

As a result, beta could still be used as a variable when pricing an asset, and a higher return on a valuation stock could imply a higher level of risk. As a result, beta can be a variable being used to price assets, and the definition should not be overvalued. (R. S. Harris, 1994)

Growth stocks are expected to outperform value stocks during periods of positive stock returns (boom market). It is because investors want and extrapolate current trends to predict future growth based on past growth patterns. This phenomenon also appeared during critical times, such as the dot-com bubble in the year 2000, forecasting returns was widespread. (E. Ofek, 2002) It contradicts that the CAPM is unable to describe the phenomenon. If the CAPM is appropriate and higher risk describes the irregular returns of value stocks, a stock with a higher beta would outperform during a boom but underperform during a bust.

### **2.3 Efficient Market Hypothesis**

To understand why a value premium cannot exist, the thesis includes one of the most widely held financial theories in finance. The Efficient Market Hypothesis (EMH) will be applied to evaluate the ongoing situation in the Hydrogen sector within the investing chapter.

The EMH is one of the main theories and commonly applied approaches in the finance industry. According to (Kendall, 1953), the efficient market is “one in which stocks completely represent all available information.” In other words, market information indicating a potential change in the price of an asset can affect the values of that asset today. New data containing information about the asset’s future price could cause the price to change immediately. Therefore, the price of stock includes all relevant data.

The EMH is predicated on three claims or assumptions. These assumptions should not be confused with the three types of market efficiency: moderate, semi-solid, and strong market efficiency. A market can be described as efficient if historical data and information are included in the price of a stock. (Richard A. Brealey, 2011) A market can be described as very efficient if prices include all documented data and all information available. The EMH has three key arguments, which together concern the rationality of investors.

First, the EMH claims that the majority of capitalists are rational, which results in instinctive pricing of the market assets.

Furthermore, within the market, some irrational investors exist. At first glance, they might mess up the theory of efficient markets, but since these actions of investors are random, the activities will be offset in the long run.

Lastly, assuming a herd mentality for irrational investors would lead to arbitrage opportunities as the behavior is predictable. These phenomena might be possible, but the existence of rational investors acts contrary to the action. Due to the presence of these investor types, the balance stock investing will be equal again. In conclusion, even if the herd mentality might affect the market, the market can still be efficient. (Richard A. Brealey, 2011)

### **2.3.1 Theories resulting from the Efficient Market Hypothesis**

According to the efficient-market theory, arbitrage would quickly remove any profit opportunities and return market prices to fair value. While behavioral finance experts admit that there are no simple gains, they argue that arbitrage is expensive and often slow, so deviations from fair value will continue. Having the efficient market hypothesis in mind, some assumptions can be made.

The efficient-market hypothesis in its weakest form notes that the sequence of past price changes provides no details about future changes. When economists conclude that the market has no memory, they are expressing the same idea more succinctly. Financial managers often seem to behave as if this isn't the case. Managers, for example, tend to issue equity rather than debt following an unexpected market increase. (P. Asquith, 1986)

You can trust prices in an efficient market because they represent all specific data about the value of each security. It suggests that most investors would be unable to obtain consistently higher rates of return in a well-functioning economy.

## **2.4 Investors' Characteristics**

This section of the thesis aims to offer the reader a summary of irrational investor activity and its causes, which may clarify the presence of a market value premium.

The disposition effect states that investors tend to realize small gains and increase losses. In general, it can be said that the utility function runs differently for most investors in the profit and loss areas. In concrete terms, this means that the majority of investors perceive profits and losses psychologically differently. If an investor makes a profit on his investment, the initial profit provides the most significant benefit. Any further profit is still seen as positive but with an increasingly weakening tendency. The opposite is true for the negative development of an investment.

The first losses leave the most profound psychological mark on the investor. Gradually, however, a kind of habituation effect (many suffered price losses) occurs, and the subsequent losses are no longer perceived with the same intensity. In practice, the disposition effect leads to profits being often realized much too early and losses much too late. This behavior can be observed repeatedly, even among professionals, although there are golden stock market rules such as “let profits run and limit losses.” The disposition effect explains quite vividly the disaster on a financial bubble at that time. The initial losses still hurt, but the habituation effect kicked in and contributed to many investors suffering a total loss. Protection against the disposition effect can only be provided by consistently limiting losses by setting stop-loss prices. Even if the realization of losses is difficult, this avoids a possible total loss. (Schnichels, 2009)

#### **2.4.1 Overconfident Investors in an efficient market environment**

Usually, investors are confident about their investment decisions which affect the market environment. Individual investors' levels of confidence affect their investment decisions, as well as the global financial markets. As a result of this impact, the market as a whole experiences inefficient volatility. Reactions to new market details and weak fluctuations are usually a key component of how investors value information.

Understanding the underlying conditions of market confidence is also crucial for hedge funds or other investors to minimize these dysfunctional fluctuations. It can lead to an understanding of how to realize above-average returns using a different investment strategy approach. It would also be fundamental to consider the actions of individual stock managers or investors. (Odean, 1998)

According to (D. Hirshleifer, 1998) overconfident investors tend to overvalue information differently. This pattern is evident in many sectors and many decision-making processes, not only in the financial industry. In general, investors appear to be over-reacting to private information and under-reacting to public information. Also, investors tend to be optimistic about their abilities to make intelligent choices. Around the same time, they assume that all investors are worse off than themselves. It may sound insane, but it implies that the investor believes they are more intelligent than any other investor. This overconfidence tendency lets investors underestimate the uncertainty of the forecasts they produce and depend highly on their forecasts relative to additional possible forecasts. As the asset's actual value becomes evident to the consumer, they take credit for a successful result and accuse others.

Given this, there seems to be a clear evidence of unfounded investor trust. The unsustainable behavior creates even more fluctuations in the stock market, and thus the price diverges even further from the introductory price.

#### **2.4.2 The Bandwagon Effect and its consequence on investment decisions**

The Band Wagon Effect was initially used to describe a phenomenon resulting from the supply and demand role of the micro-economy. The hypothesis suggests that the more consumers starting to purchase a particular commodity, the more people will join, which results in increasing demand for this product. If this behavior occurs, the expression “get on the bandwagon” is used. (Harvey, 1950) It might seem to be the wrong decision to hop on the bandwagon, but as long as investors know when to hop off, it is entirely reasonable. The effect can be applied to different situations in economics; using it to the financial market might explain the reason for the existence of an economic bubble. The logic would be that as buyers start buying a particular stock, more and more would follow. This will continue until some people doubt the rationality of investing in this common stock and then start selling it before anyone else does.

If this occurs, a movement in the contrary direction will begin, and hence the price of the common stock will drop down. The hypothesis would explain why value stocks and growth stocks are moving towards their fundamental values.

Value stocks will initially be low-priced since no one is jumping on their bandwagon, while growth stocks would be heavily priced as buyers now want to be on the bandwagon. The majority of the buyers are following because the value share prices increase while growth shares are falling.

### **2.5 Past Events**

As the enormous growth of Hydrogen newcomers is happening, there might be a chance that some parallels can be drawn to past events. The focus of the thesis will be the new economy.

The dot-com bubble refers to the new Internet technology market’s speculative bubble in the early 2000s. Dotcom stands for the domain extension “.com” on the Internet. At the center of the dot-com bubble was the so-called new market or new economy. With the emergence of the New Economy from 1995 onwards, more and more young Internet companies appeared. Fast growth was the primary goal for the majority of Internet companies.

As a result, it was not uncommon for freshly founded companies to go public in order to raise growth capital. Characterized by high sales and profit expectations for the future, the prices of these technology stocks rose to heights never before reached. It quickly became apparent that the high expectations could not be fulfilled. As a result, share prices plummeted on the stock market in 2000. In particular, small investors and inexperienced stock market newcomers infected by the euphoria had to record significant losses. (Walther, 2009)

### **3 Investment Decisions**

Several companies have been chosen to guarantee a variety of business models and operating fields within the thesis. As a representative of businesses that are only focusing on hydrogen, Fuel Cell Energy and Plug Power are the best representatives for this category. In contrast, Royal Dutch Shell and Linde AG represent companies with substantial historical backgrounds and well-established business models. These companies have not to build up their business on Hydrogen, but they are now expanding their operating field towards this topic. The upcoming analysis and assumptions will be based on these four companies.

#### **3.1.1 Fuel Cell Energy Inc**

Fuel Cell Energy, Inc. provides fuel cell power solutions. The company engages in the design, manufacture, installation, operation, and maintenance of fuel cell power solutions. The company also provides turnkey power generation solutions to customers, including power plant installation, process, and maintenance. The company's division is the development and manufacturing of fuel cell power plants. It serves a variety of industries and businesses, including utilities, municipalities, colleges, government agencies, and a variety of manufacturing and commercial companies.

Hereby it markets its Direct Fuel Cell (DFC) plants, a third-generation distributed Hydrogen configuration that generates electricity, heat and Hydrogen for industrial and transportation purposes. However, the company is mainly producing fuel cells that are using natural gas for generating electricity. Having this in mind, it is hard to account them in the Hydrogen sector. As the ongoing transition moves forward and the availability of Hydrogen is rising, the fuel cells of Fuel Cell Energy can also produce electricity by using Hydrogen. Therefore, the company can still be described as a part of the sector.

### **3.1.2 Plug Power Inc.**

Another representative for a growth stock is Plug Power Inc., the leading manufacturer of comprehensive Hydrogen fuel cell turnkey solutions. Plug Power is advancing the Hydrogen economy. During an ongoing paradigm shift in the power, energy, and transportation industries, the company's revolutionary technology powers electric motors with Hydrogen fuel cells, addressing climate change and energy security while delivering performance gains and achieving sustainability goals. They developed the first commercially viable Hydrogen fuel cell industry. As a result, the company has constructed more fuel cell systems for e-mobility than anyone else globally. It has been the world's largest buyer of liquid Hydrogen, developing and running a Hydrogen highway across North America.

Plug Power was founded in 1997 as a joint venture between the utility DTE Energy and the instrumentation manufacturer Mechanical Technology Inc. Since 1999 the company is listed on the stock exchange.

In 2020, the company set a new high for gross billings, with \$96.3 million in the fourth quarter and \$337.4 million for the entire year. During the fourth quarter of 2020, the company deployed over 2,200 fuel cell units, with a total of over 9,800 for the year. The company completed the first-ever convertible green bond offering in the United States and the most extensive follow-on offering in the renewable energy market during the year. (Marsh, 2020)

### **3.1.3 Linde PLC**

Linde plc is a listed industrial group based in Dublin, Ireland. The company was formed in 2018 by merging the German Company Linde AG with its US competitor Praxair, which was initially founded by Carl von Linde and confiscated during World War. Linde's core business is still the process processing of technical industrial gases. (Metz, 2003)

As the leading gas specialist and one of the world's largest Hydrogen suppliers, Linde's expertise covers the entire value chain - from production and liquefaction to solutions for transport and storage to refueling hydrogen-powered vehicles. In recent years, they have made contributions to significant technological breakthroughs that increase efficiency and improve environmental performance in production, storage, and consumption.

Many innovations in building a practical, sustainable Hydrogen refueling infrastructure have been developed in collaboration with key industry players and funding from national governments such as the US, Japan, and Germany. These advances bring the vision of a sustainable economy, particularly in the expanding road transport/mobility sector, within reach.

The Linde Group sees enormous potential for Hydrogen in transport such as trucks, trains, buses, and ferries. The German-American Group, formed by Praxair and Linde PLC's merger, wants to be a big player in the H2 hype and investment projects over 100 Million USD. According to its figures, Linde already generates more than two billion dollars in sales from the production, sale, storage, and application of Hydrogen.

### **3.1.4 Royal Dutch Shell PLC**

Royal Dutch Shell (RDS) is one of the world's largest petroleum and natural gas companies and was the world's largest company by revenue in July 2012. The Group operates in more than 130 countries. Globally, Shell employs over 85,000 people. In 2016, the company had total sales of \$233 billion. About one million investors hold about eight billion shares. The company is registered as Royal Dutch Shell plc in the commercial register in London. The brand and Group of companies Royal Dutch Shell went back to the fusion with Koninklijke Nederlandse Petroleum Maatschappij in 1907. In July 2005, the two companies were merged to form Royal Dutch Shell PLC, a Public Limited Company under English law listed on the London, Amsterdam, and New York stock exchanges. In April 2015, Royal Dutch Shell agreed to acquire BG Group of the UK for £47 billion. RDS announced in February 2016 that the acquisition of BG Group had been fully completed. As a result, Royal Dutch Shell has become one of the largest commodity companies in the world.

The company focuses mainly on the production and distribution of fossil fuels. With the increasing demand for renewable energies and the decreasing availability of fossil energies, the company's focus on renewable energies has been strengthened. Together with the Dutch gas network operator Gasunie and the port of Groningen Seaports, the oil company Shell is planning the construction of the largest Hydrogen project in Europe to date.

Within ten years, a mega wind farm of a size between three and four gigawatts is planned. The energy will be used to produce green Hydrogen at the coast of North Holland. It will support Shell's mission to become one of the leaders in exporting renewable energy. (Shell, 2019)



## **3.2 Financial Ratios**

To evaluate the performance of the four different chosen companies, the most common ratios will be used.

The price-earnings ratio is by far the best-known ratio for analyzing stocks. It was one of the reasons to include the ratio within the thesis. In principle, the P/E ratio helps to assess whether a share is valued low or high. However, this share ratio alone is not significant. Therefore, it is necessary to consider other ratios. Involving the D/E ratio in the analyzation a more detailed evaluation can be provided.

### **3.2.1 Price-to-Earnings Ratio**

The price-to-earnings Ratio (P/E) is the ratio for the valuation of a stock that calculates its current share price along with its earnings per share (EPS). Investors and analysts use P/E ratios to calculate the relative value of the shares of the company. Therefore, it is a widely used indicator in the financial world to detect whether a stock is overpriced or underpriced concerning its earnings. A low P/E ratio means that the price is low relative to its generating ability. Simultaneously, a high P/E ratio implies that the stock is overpriced relative to its earning capacity. Since in most financial bubbles, the stocks were overvalued, the high P/E ratio can be an indicator of a potential bubble. (Wilkens, S. 2020)

### **3.2.2 Market-to-Book Value**

The market-to-book ratio (also known as the price-to-book ratio) is a financial accounting metric used to assess the overall market value compared to its book value. The market value is the actual share price of all outstanding shares (i.e., the market's price believes the company is worth). The book value is the sum that will remain if the corporation liquidated all of its assets and repaid all of its liabilities. The book value is proportional to the company's net assets, which fall from the balance sheet. In other words, the ratio is used to compare the net assets of a company that is available compared to the stock's selling price. A high ratio means that the selling price is much greater than the value of the book.

In contrast, a low ratio implies that the share is trade equal or under the company's book value. (Richard A. Brealey, 2011, S. 709-710)

### **3.2.3 Debt-to-Equity Ratio**

The ratio is used to measure the financial leverage of a business. The D/E ratio is a significant measure used in corporate finance. It is an indicator of the extent to which a corporation is funding its activities by debt versus equity funds. More precisely, it represents the potential of shareholder interest to pay all remaining obligations in the event of a slowdown in the industry. The debt-equity ratio is a significant indicator of the risk of an investment. A high ratio signals an increased risk.

On the other hand, companies with high debt ratios can often grow faster than those with low ratios. The ratio is especially interesting for Hydrogen companies which had enormous growth in the past years. It can provide significant information about the reasons for the development. (Richard A. Brealey, 2011, S. 716-720)

### **3.2.4 EBITDA Margin**

The acronym EBITDA is derived from the following formulation: “earnings before interest, tax, depreciation, and amortization. This figure, describes the company’s earnings, excluding interest, taxes, depreciation of property, plant, equipment, and amortization of intangible assets.

This indicator offers three advantages: First, it allows an isolated view of a company’s operating activities. The financial items that are excluded from EBITDA have no direct influence on the success of the business operations. Secondly, the different taxation of companies often makes international comparisons difficult. Therefore, if these influences are excluded, companies operating in different countries can be better compared with each other. Third, amortization is excluded in the margin. It describes the depreciation of intangible assets. These do not necessarily lose value over time and are not always replaced. Probably the best-known item for amortization, however, is goodwill in the event of an acquisition. Since the ratio should focus on the businesses' core operations, the EBITDA margin is more precise. To conclude, the EBITDA margin provides information on a company’s profitability in terms of its operations. (Wilkins, Deltavalue , 2020)

### **3.2.5 Current Ratio**

The Current Ratio measures a company's ability to service its current liabilities (due in less than one year). To calculate the third-degree liquidity, existing assets are divided by current liabilities. In principle, the value of the current ratio should be between 1 and 1.7. In practice, however, deviations are possible and not unusual.

A high value of this ratio, therefore, means excellent security for investors and the company. However, values that are too high should be avoided, as well as values of the current ratio that are too low (Richard A. Brealey, 2011, S. 719)

### **3.3 Company assets**

The analysis of the current situation of the Hydrogen sector represented by four companies will not only include financial ratios. It will also take intangible assets such as the competitive advantage, industry trend, future perspective, and the management into account.

For each company, competitive advantage is the key that leads to sustainable corporate success. In the long term, a company can only generate a profit surplus if it has a qualitative advantage over its competitors. In the case of supplier advantage, a company strives to provide a product or service that a competitor cannot provide in this form. In this way, an offer on the market always remains very narrow, and the company cannot be easily displaced by the competition. In recent years, companies have focused primarily on relying on tangible assets to create a competitive advantage. But more and more, intangible assets are now coming into focus. These can be assets such as employee knowledge, new technologies, innovative strength, or a strong brand. This growing interest in intangible assets is also reflected because more and more companies invest in intangibles. Since the Hydrogen branch is relatively new compared to established sectors such as the automotive, intangible competitive advantage is an extremely high value for these companies.

Another significant factor is the future of an industry. An essential part of a strategy or strategic planning in a company is how the future may look, how the competition, the market, the consumers will behave in the future, or which technologies will gain importance.

The effort to deal with the future is related to the fact that decisions have to be made in the present that also affect the future, and therefore information about the future is needed in the present. Decisions about a strategy cannot be made without incorporating ideas about the future into those decisions.

Thus, the future can be described as a significant uncertainty factor for a company. This uncertainty is further fueled by a corporate environment that has continuously gained momentum in the past and made increasingly tricky forecasts about the future. Therefore, it might be supportive of predicting a company's growth and value potential if they are operating in a future-tech sector. It also supports the investor's willingness to invest in such companies.

Furthermore, a significant intangible asset for the company's success in the stock market is the management. Good management is performance and results-based. Management is based on the requirements of the environment, the needs of customers, the demands of the markets, and the development needs of society as a whole. It defines these requirements in terms of tasks to be performed to produce results that meet the requirements. Every well-understood management thus aims for the best possible results for the customer environment; internal management is merely a means of achieving these goals. Good management releases forces bound up in the organization, just as it frees itself from unnecessary ballast. Good management is essential in a critical situation as it is the only option to maneuver a company into a better position. Those who deal with possible risks and their management in good times lay an essential foundation for efficient crisis preparation.

## **4 Empirical Analysis**

### **4.1 Used Data**

Within this chapter, a presentation and interpretation of results included. The sources of the data, its accuracy and reliability, special considerations for the data, and the data's shortcomings are all discussed here. The whole analysis is based on the financial statements of the companies. This segment aims to provide the reader with a summary of the data characteristics used in this article. Furthermore, it is not representative to look at a company at a particular time. Due to high volatility in share prices and the overall dynamic market environment, a time horizon of three years will provide more reliable results.

## 4.2 Results of the Ratio Analysis

*Table 1 P/E Ratio (Own representation based on Plug Power, 2021; Fuel Cell Energy, 2021)*

	One year average	Three-year average
Plug Power	-0,08	-0,096
Fuel Cell Energy	-1,88	-1,41

Visible are the results of the P/E analysis of the growth and values stocks companies.

First of all, the calculation of the ratio was not possible for growth stock companies. It only makes sense to determine the P/E ratio if a company is generating profits. In the case of Plug Power and Fuel Cell Energy, both companies could not generate profit. For example, the average earnings per share in 2019 of Plug Power were -0,35, which indicates that the company could not generate profit. Therefore, as stated above, the P/E ratio would be negative.

However, a ratio of 1 would already mean that a company develops its entire market capitalization in just one year, which is the ideal mathematical case. A negative P/E ratio would indicate an even better result. This conclusion would be wrong. Therefore, this ratio can only be used for companies with profits. For all other companies, the PE ratio is not meaningful. The only conclusion which can be drawn out of these numbers is that the companies are in a stage of development due to their short existence or their new market strategy, where profits usually cannot be generated. The ratio is not a good indicator of their performance.

In contrast, the results of the P/E analysis for value stocks differ a lot. The companies ,which have been chosen for the thesis ,are well established and have a long history. Therefore, they were able to turn their business model into a profitable one. Because of their positive output over the years, the challenge is at this moment to determine whether the company is overvalued or undervalued. The higher the value, the more “expensive” a company is. More expensive here means that the company has a high share price compared to its profits. Low PE ratios can be considered positive and suggest that a company is a “bargain.” If the company is overvalued, it can be the first indicator for a bubble, but the P/E ratio should always be considered a neutral instrument. Comparing Linde PLC with the other companies also becomes problematic when it comes to profit determination. After all, profit is not as straightforward as it seems to be.

Accounting policy measures and particular influences change the profit significantly. The relevant accounting framework already has an impact on the formation of the company's profit. While the German HGB applies the principle of prudence, the international IFRS requires a more realistic view. Due to various provisions and undervaluation, HGB profits tend to be constant but low. IFRS profits, on the other hand, reflect reality better. However, the reality is also that profits fluctuate. This means that PE ratios preferably fluctuate more on an IFRS basis.

The companies which have been used in the thesis are not all based on the IFRS. Linde is using the IFRS since their merger with Praxair. Therefore, there might be some differences.

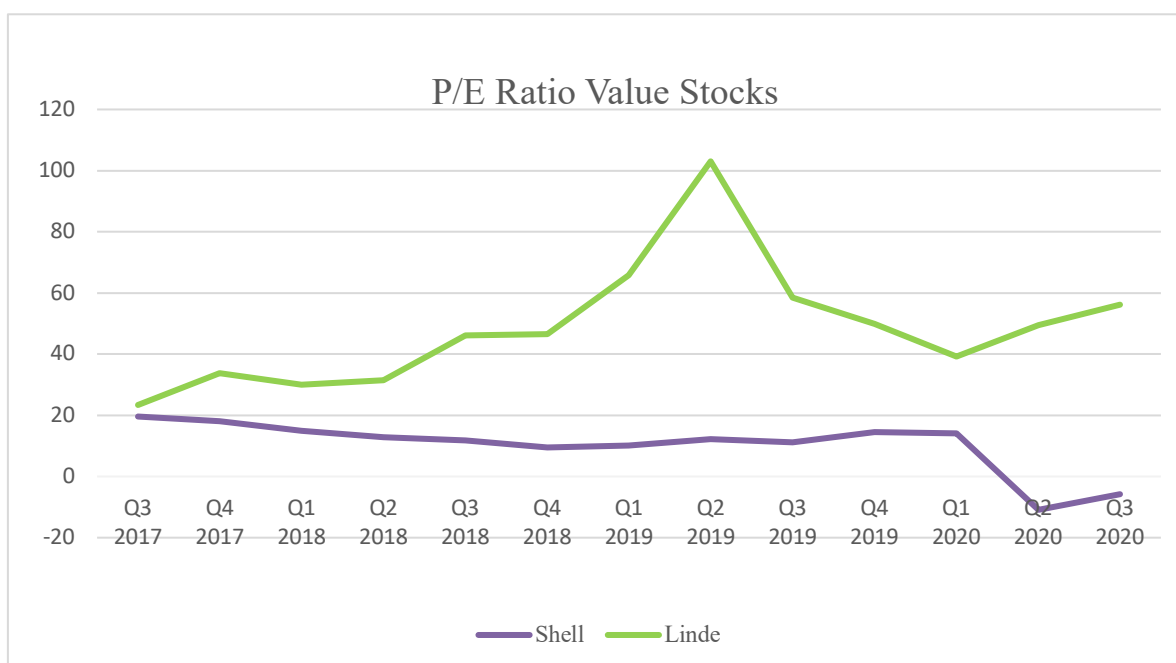


Figure 3 P/E Ratio (Own representation based on Shell, 2021; Linde, 2021)

Nevertheless, some conclusions can be drawn. Shell's P/E Ratio compared to Linde is relatively low. The company was able to increase its profit till mid-2019 continuously. It shows that Shell is working profitable, and combined with the P/E ratio, the company can be declared as undervalued. The Corona Virus affected most of the companies in this thesis, which can also be seen at the beginning of 2020, as there is a decrease. The most apparent difference is that the P/E Ratio of Linde PLC is higher compared to Shell. Linde managed to increase their net income as well, till the outbreak of the corona crisis. Compared to other companies in the sector, Linde has the highest P/E ratio. It could be the first signal that the company is overvalued. Nevertheless, it also gives a first sign about the investor's confidence and their trust in the company.

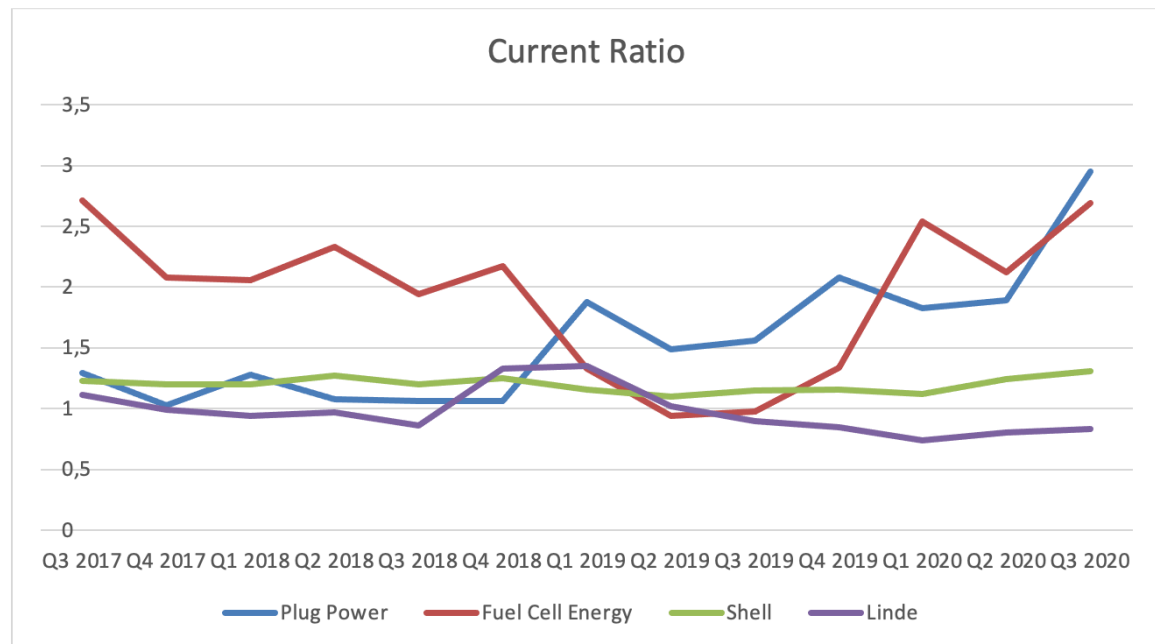


Figure 4 Current Ratio (Own representation based on Plug Power, 2021; Shell, 2021; Linde, 2021; Fuel Cell Energy, 2021)

The Current Ratio is a measure of a company's ability to service its current liabilities. To calculate the third-degree liquidity, existing assets are divided by current liabilities. In principle, the value of the current ratio should be between 1 and 1.7. In practice, however, deviations are possible and not unusual. A high value of this ratio, therefore, means excellent security for investors and the company. However, values that are too high should be avoided, as well as values of the current ratio that are too low. Based on the current ratio, it is comparatively easy to draw initial conclusions about the company's financial health. A value of less than one should always be avoided. This would mean that the company has more current liabilities than current assets. This circumstance is a warning signal.

Excessive liquidity, on the other hand, is just as damaging. Values of more than 1.7 can be assumed to mean that the assets are not being used efficiently.

The question now arises what conclusions can be drawn out of these numbers for the companies as a representative of the Hydrogen sector. First of all, the two value stock companies have to be evaluated. Compared to Plug Power and Fuel Cell Energy, Shell's Ratio is relatively constant, indicating a good sign. With an average of 1,2 in three years, the value was ideal as the company was constantly able to pay for its current liabilities. Shell was profitable using its capital for investments. There is no sign of an alarming condition. Linde's current ratio was more volatile, and they were not able to pay for their liabilities most of the time as the three years average was 0,98.

Linde invested in 2019 around 45 Million Euros in the Hydrogen Facility provider ITM. They are planning to produce the world's biggest Hydrogen electrolyzer (ITM Linde, 2019). The company is currently expanding its value chain, which comes along with huge investments. The relatively low current ratio is not something to be concerned about.

*Table 2 Current Ratio (Own representation based on Plug Power, 2021; Shell, 2021; Linde, 2021; Fuel Cell Energy, 2021)*

Current Ratio	One year average	Three years average
Plug Power	2,19	1,58
Fuel Cell Energy	2,17	1,94
Linde	0,81	0,98
Shell	1,2	1,2

In contrast, the situation for the growth stock companies differs a lot. Both firms have higher volatility. Since Q4 2019, both have incredibly high current ratios. If the current ratio is almost three, as in the Plug Powers case, the current assets service the current liabilities threefold. This interpretation has its limits because it is not as positive as it sounds. The working capital management is not well managed in both companies. The companies have increasingly expanded their inventory. This can be caused by a degree of sales. Especially for these highly fluctuate companies, it is essential to keep their current ratio down. The growth of these companies can only be guaranteed if they invest in their business model.

Furthermore, if the ratio continues as in the current situation, investors might lose their confidence in the company. This would provoke a decrease in stock prices and, therefore, the market value of the firm. The very high current ratio is something to worry about, and the firm has to reduce it.



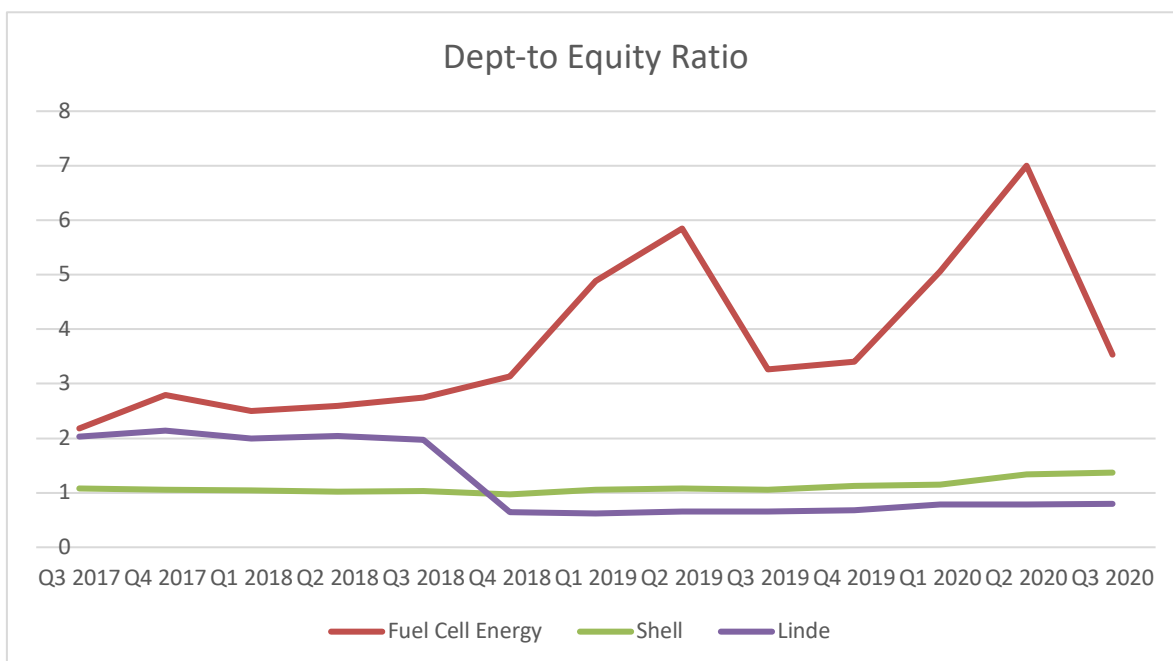


Figure 5 D/E Ratio (Own representation based on Plug Power, 2021; Shell, 2021; Linde, 2021; Fuel Cell Energy, 2021)

The debt-to-equity ratio, also known as the gearing ratio or D/E Ratio, is a static balance sheet ratio and is one of the best-known analytical tools. The comparison of liabilities and equity indicates how heavily indebted a company is.

Shell's Debt-to-Equity Ratio is very constant. The company has a range of values from 0,97 up to 1,37. The gearing of Shell was low compared to the growth stock companies. Financing the company by equity is less risky, as there is no repayment claim. If the company runs into difficulties, dividends can also be canceled. In 2021 Shell was able to raise its dividend by four percent. (Künfner, 2021) This indicates that the management is very optimistic about the future of their business model. Also, by raising the dividend, the firm has enough leeway to lower its dividend in case of trouble. As Shell and Linde have a long history, it is very typical that they have a D/E ratio which is low compared to newcomers like Plug Power and Fuel Cell Energy. Shell can be described as a low-risk investment in terms of debt to equity. At the end of 2018, Linde increased its shareholder's equity, which has changed its ratio. Since 2019 the company is financed predominantly by equity. Investors will most likely prefer the strategy of Linde because it indicates a lower risk. But on the flip side, a lower debt to equity ratio will also show the firm cannot take advantage of increased profits that financing leverage would bring. Linde misses the opportunity to increase its Return on Equity by using the leverage effect. When the interest rate is meager, Linde should consider financing its business more by dept.

In terms of financing by debt, the two newcomers have somewhat different numbers. Both companies have a highly fluctuating D/E ratio. As they both enter a relatively new market, they need to finance their business by debt. The volatility can be explained by volatile earnings, which they had to compensate with debt. As they are relatively new, they have not had the chance to build up enough equity to finance their business. The method of debt financing is widespread in this sector, it also provides advantages for the cooperation. Since the company has to pay interest on the borrowed capital provided, it can recognize this as an expense. This, in turn, reduces the tax burden that the company has to pay. In addition, lenders have no co-determination, which will make decision-making easier. Fuel Cell Energy is managing its ratio quite well, and there are no abnormalities in the ratio.

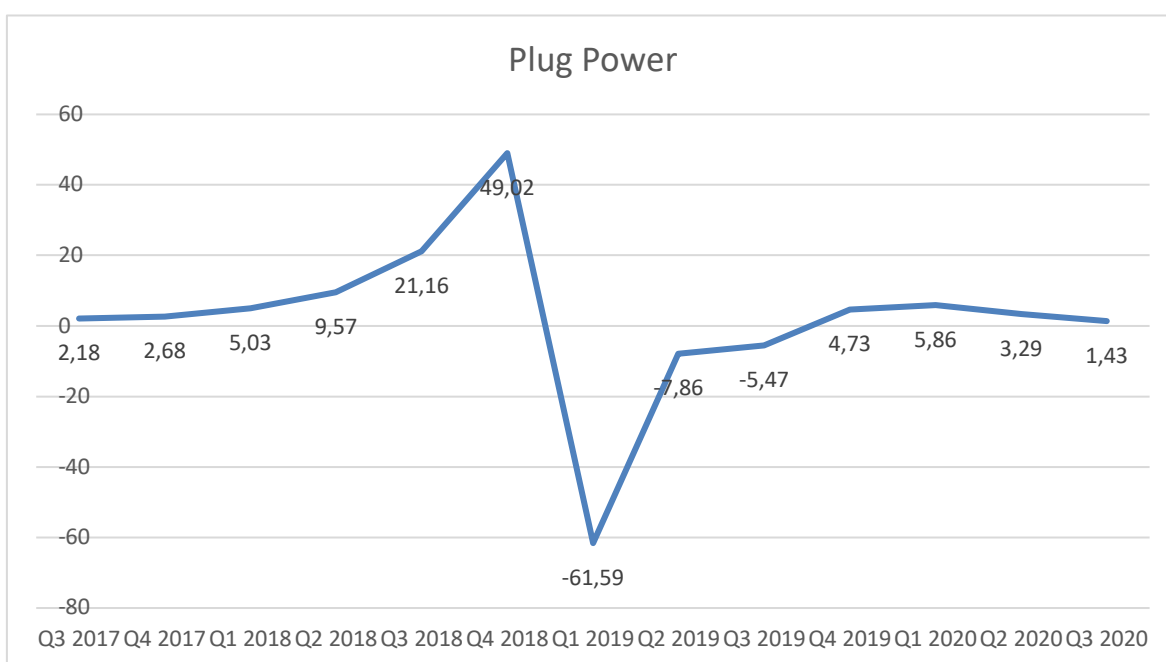


Figure 6 D/E Ratio Plug Power (Own representation based on Plug Power, 2021)

By having a closer look at the Ratio of Plug Power, abnormalities are obvious. First of all, it is visible that they have a negative D/E ratio. As the company is generating losses, the losses are transferred into retained earnings as a negative number. The company is not profitable for several periods, which entails an eat-up of their existing retained earnings and funds received from issuing stocks. Therefore, the shareholder's equity is negative, which results in a negative ratio. Debt recovery can be difficult for Plug Power. They must ensure that the company receives adequate revenue to cover the principal and interest payments frequently.

Furthermore, the company borrows from several sources, it must also pay interest and repay the principal to several lenders. If the management overestimates the firm's current financial condition, or if there is a slump in business for some reason, this can lead to payment bottlenecks, and the creditors can no longer be serviced. The result will be an over-indebtedness.

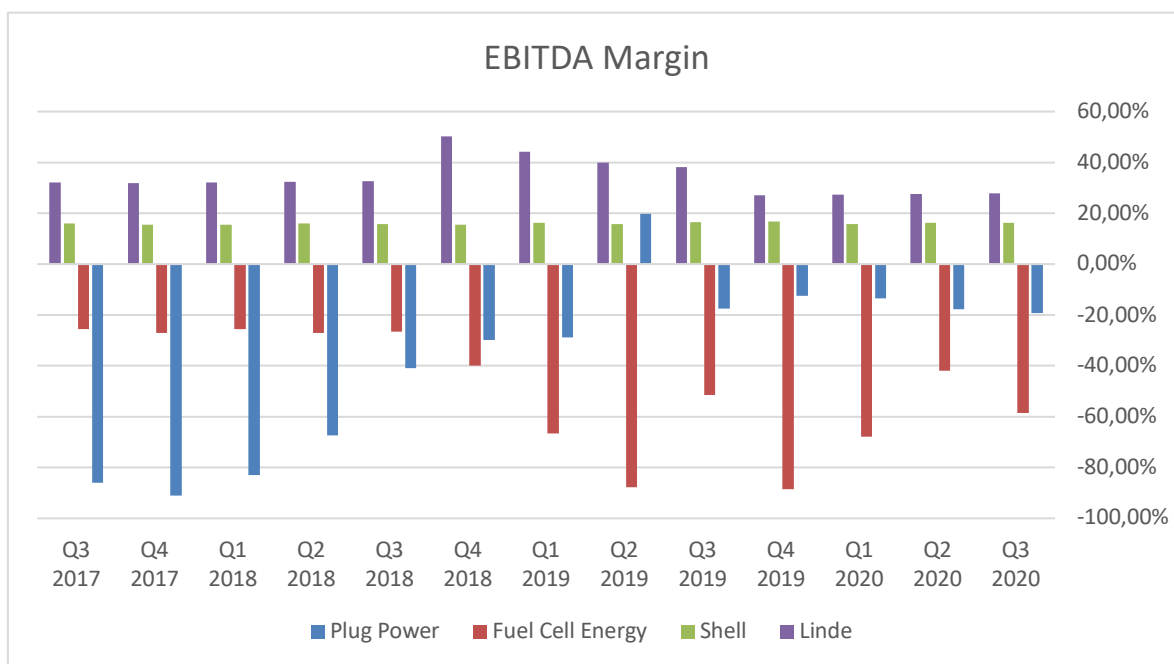


Figure 7 EBITDA Margin (Own representation based on Plug Power, 2021; Shell, 2021; Linde, 2021; Fuel Cell Energy, 2021)

EBITDA, also known as “earnings before interest, taxes, depreciation, and amortization, is one of the most important key figures measuring a company’s profitability. All over the world, companies measure their success by this key figure but are also compared with each other by banks and investors. Therefore, it was a good margin to compare the Hydrogen companies with each other. Since non-cash expenses or items that do not impact the core business are eliminated in the process, the focus is on the core business activities. It is essential to evaluate the profitability of the companies right.

The higher the value, the better the company has performed in its operating business. Linde and Shell outperformed the two other companies. The long-established ones have positive values, and especially Linde achieved a value over 50% for a short time.

As a company must be in a position to repay current and new loans, for acquiring new capital, a positive margin is significant. Both companies are in an excellent position to do so.

Even though the outbreak of the corona crisis affected the company's financial health, the EBITDA margin remained constant or had a slight decrease. It shows that the companies were operating and managing their business well as they could have positive output even in a critical situation.

In contrast, Plug Power and Fuel Cell Energy both have a negative margin. It means that a loss has been incurred in the operating business. This, in turn, means that the payment of interest, taxes including depreciation and amortization cannot be financed from the core business.

Therefore, those companies could only afford a negative EBITDA in the short term; in the medium term, only with correspondingly low debt and thus low-interest burden. If this is not the case, the companies will be bankrupt very soon. Plug Power is hereby in a better position. In the long term, they were able to reduce their negative EBITDA margin constantly. It implies that they are able to be more profitable. After acquiring business partners such as the consumer giant Walmart, they have a steadier distribution and could reduce their cost of operating. (Martorana, 2020). On the contrary, Fuel Cell Energy had an increase of their negative margin. If they are not able to lower their ratio, they will end up in bankruptcy.

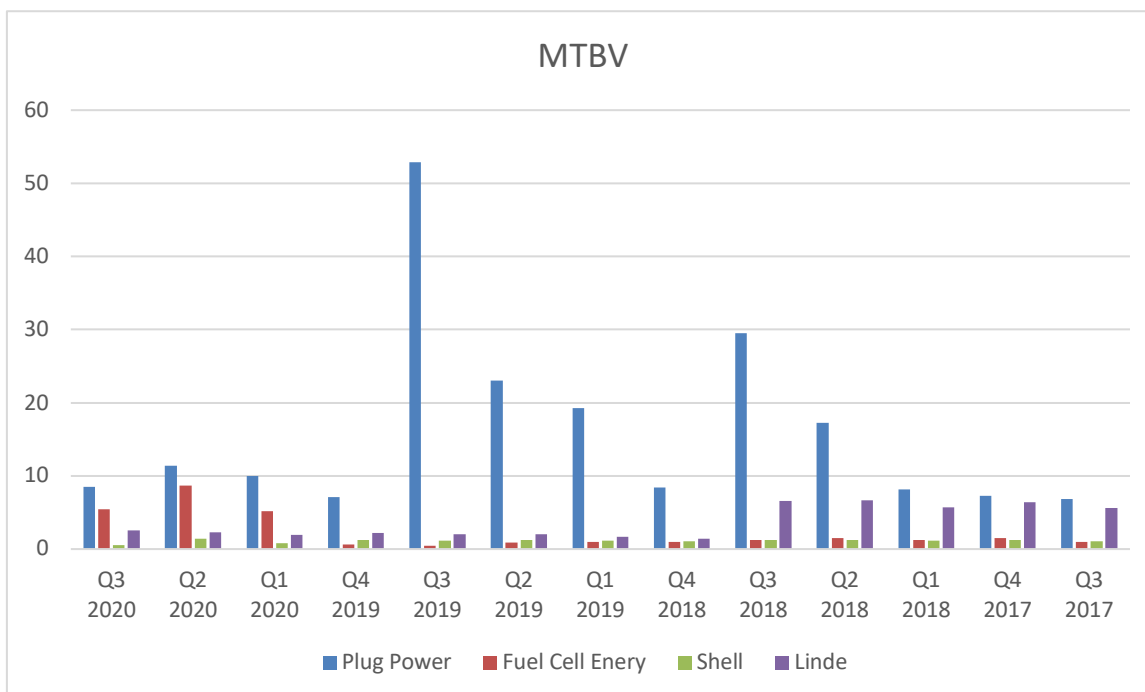


Figure 8 Market-to-Book Value (Own representation based on Plug Power, 2021; Shell, 2021; Linde, 2021; Fuel Cell Energy, 2021)

The Market-to-book Ratio is a valuation ratio designed to compare the market value of a company with its book value. The results for Linde and Shell are meager, which implies that these are undervalued. It means that a share of these companies is traded at a price that reflects almost the book value. One of the basic assumptions of investing is that, over the long term, stocks tend to trade at the price that corresponds to their true intrinsic or “fair” value. Furthermore, as both companies have recognized the trend of Hydrogen, their future orientation is given. They cannot be considered as value traps due their excellent possibilities in the future. Despite the fact of their promising future orientation, the comparison of the MTBV to the return on equity reveals another assessment. Linde, Shell and Fuel Cell Energy have had a decreasing ROE while an increasing MTBV (Stock Analysis on Net , 2020). A high MTBV combined with a low ROE should be interpreted with caution. This is because the MTBV suggests a company with growth potential whose book value is likely to increase shortly. The ROE, however, reveals that the return on equity is low, and thus, significant increases in the book value are unlikely.

Plug Power was very volatile compared to the other companies. The focus on the Plug Power stock started at the beginning of 2018. Investors are enthusiastic about the company’s future, causing share prices to rise faster than expected growth. High price-to-book ratios, on the other hand, are not always the product of an overpriced stock.

### **4.3 Result of the Theoretical Analysis**

The following will conclude the theoretical assumptions provided and will explain why it is hard to predict a financial bubble on a theoretical basis.

There are many possible sources of error in CAPM’s corporate finance applications. The simplified model could be a weak representation of the conduct of financial markets. In an attempt to enhance its realism, researchers have created several extensions of the model. Furthermore, betas are inconsistent over time. This causes problems as betas estimated from past evidence are used to measure the cost of equity in assessing potential cash flows. Betas can evolve as the fundamentals of society, and capital markets change. Also, betas calculated from historical data are susceptible to an error in statistical estimation. Therefore, the standard CAPM declines to consider the entire risk because it relies heavily on beta as a representative for the risk. Having these facts in mind, it might be hard to predict an eventual bubble.

As the Efficient Market Hypothesis is based on heavy assumptions, there might not be an efficient market. The Hydrogen market may not be completely effective because the point put forward by Efficient Market Hypothesis is based on solid assumptions.

Also, I would contend that markets cannot be competitive because it takes time and resources to check for data. If all the details would be included in the price, no one will bother wasting time and resources on searching for information. If nobody is looking for information, rates cannot contain data, and therefore markets are not successful.

Even though economies were competitive, the existence of a growth premium and a plausible financial bubble might still emerge because the efficiency of the growth stock would deteriorate due to increased competition, while the value stocks would have the potential to turn around their business in order to maximize growth.

Irrational investor behavior, such as extrapolation and multiple agency issues, may be a possible reason for the presence of a potential bubble. Extrapolation provides an incorrect hint of the potential success of stocks, and this is fixed after a while so that markets return towards their fundamental values. In comparison, buyers will be short-sighted and want a fast return, and invest heavily in growth stocks.

The disposition effect combined with overconfident investors can demonstrate why a financial bubble can exist. This is because professional stockholders want to create high profits if the stock market goes up, while professional stockholders tend not to generate a loss if the stock price goes down. In addition, the principle of investor overconfidence states that the momentum of the stock price gain is attributable to an initial rise in confidence. The effect of disposition revealed that investors sell their well-performing stocks too fast, which results in a reduction of momentum growth. Also, overconfidence is associated with the disposition effect as market prices decline, when buyers appear to hold too long to poor stock results as they expect the price to rise again.

In closing, the bandwagon phenomenon is also in line with the financial bubble because even logical investors seem to imitate the crowd's behavior. Once the majority believe the market is overpriced or underpriced, they would continue to change their trading trend and start purchasing value stocks and selling growth stocks, taking markets down to their fundamental values. The bandwagon effect nowadays is visible and is experiencing a new dynamic. The influence of social media announcements and the rising user numbers of neo brokers mutually drive the impact.

Usually, the users of these app brokers do not have a substantial stock trading background. They tend to overestimate news and follow a herd behavior (Damm, 2020). There is a possibility that Hydrogen stocks, , can be highly pushed by announcements of influential persons.

It would boost the whole sector, and the probability that the above-described effect will happen faster is something to consider.

#### **4.4 Results of the Historical Analysis**

Since the Corona crisis, Hydrogen companies are still finding brisk sales among investors. The Nasdaq has made up for the crash in February and March and is chasing records, while the other stock exchanges are still lagging. The background is the hope for transforming the entire energy sector into an environmentally friendly and sustainable industry.

There are parallels to the dot-com bubble: Stocks such as Plug Power doubled in value within a few weeks; the company is now valued at 21 billion dollars, almost twice as much as Siemens. (Onvista, 2021) And this even though the company has still not been able to generate a profit. Sometimes similar to the dot-com days, even a similarity in name is enough for success on the stock market. At the moment, investors are willing to invest in overpriced stocks of companies with something related to Hydrogen in their firm name.

Just as in the second half of the 1990s, share prices rose much faster than corporate profits. The real economy is not keeping pace with speculation on the stock market. This can be seen in the steadily increasing company and share valuations. Since 2019, stock prices on the Nasdaq, where most Hydrogen newcomers are traded, have doubled. In the same period, the profits of the companies listed there have only increased by just under ten percent. As a result, the price/earnings ratio (P/E) of Nasdaq stocks is valued at just over 30, well above the ten-year average of 19. (Sommer, 2020)

However, the euphoria surrounding Internet stocks two decades ago also shows this: The phase of highly and overvalued shares can last a very long time. As early as the end of 1996, then Federal Reserve Chairman Alan Greenspan warned against the irrational exuberance of the markets. At that time, the Dow Jones had risen to 6000 points.

The Dax was quoted at 2700 points. Greenspan was right in the long term, but not in the short term. The actual bull market and the vitality were only just beginning after his words of warning.

Three and a half years later, the Dow stood at 11,000 points and the Dax at 8,000. The slump came shortly after the turn of the millennium. It remained true: Those who got out too late were punished by life, but those who got out too early were also punished by subsequent developments. For experienced investors, this is also one of the lessons learned from the crash 20 years ago. (Sommer, 2020) There might be the chance that this could happen for the Hydrogen sector and its newcomers.

## **5 Conclusion**

### **5.1 Limitations**

This chapter will elaborate on the methods used in this analysis to provide the reader with a brief overview of the report's weaknesses, layout, format, and theories. Where appropriate, more details have been provided in the specific sections within the thesis. This research has some shortcomings, which will be discussed briefly below:

First, when looking at historical statistics, it is easy to extrapolate and conclude that the economy will continue to function similarly. Anyhow, since the past cannot forecast the future, doing so should be done with caution. All results provided in the thesis clearly state what has been, and during the review, there should keep in mind that markets' characteristics can change. Thus, a careful approach should be considered when attempting to forecast the future.

Second, the paper is limited to two companies that are fully operating in the Hydrogen sector. Shell and Linde are operating in the Hydrogen sector, but it is not their key business. They represent established companies and function as a comparison to the fully operating Hydrogen companies. Therefore, the limitation is hereby that the thesis does not fully reflect a branch. The results provide an assumption that is based on those four companies. They cannot be applied to every stock listed company which is dealing with Hydrogen.

Third, a fixed time horizon has been applied. Furthermore, no rebalancing has been involved within the empirical analysis due to changes in taxation, market capitalization, or other volatile factors. This would generate more precise and effective results, but it would also make company comparisons incredibly challenging.



Fourth, the usage of financial ratios. One of the main problems in analyzing ratios of shares is that these ratios are strongly oriented towards the past. Since they can only ever be based on the last balance sheet, current events and developments are not reflected upon. As a result, a false picture can result from the key figures.

## 5.2 Final results

1. *Which of the fundamental variables, Price/Earnings, Current Ratio, Debt/Equity, Market-to-Book Value, and EBITDA Margin, should be used as an indicator for risk analysis of a Hydrogen portfolio? Should intangible assets also be considered?*

Based on the empirical analysis of the thesis, the best response to the investigation would be that all ratios should be applied to evaluate the performance of a sector. It is essential not only to focus on one ratio. Therefore, a ratio system should be used, where several ratios are analyzed collectively. If a specific ratio should be included in the analysis, it should always be supported by another ratio.

A good example is the MTBV, which can be supported by the Return on Equity. The basic rule for this combination of indicators is that the ROE should also increase if the PB ratio increases. If the MTBV is high and the ROE is low, for example, caution is advised. This is because the MTBV suggests a growth company, whose book value is likely to increase in the near term. The ROE, however, reveals that the return on equity is low, and thus significant increases in book value are also unlikely.

Furthermore, the time horizon is an essential parameter for analyzing a market. During the thesis, there was always the focus on a time horizon of three years. It is possible to provide a better overview to interpret the ratios and balance short-time fluctuations with a long-term horizon. Especially in a highly dynamic market environment with many new companies entering the market, it is essential to have a greater time horizon. The Hydrogen sector has experienced enormous growth in the past years, as the focus on environmental protection was rising.

In some cases, it might be helpful to use existing time data to predict a future trend, so it is essential to use the ratio in combination with sufficient time. Hydrogen is trending, and newcomers are entering the market. Intangible assets such as the future orientation, the management, or existing cooperation should be considered.

Companies like Plug Power or Fuel Cell Energy have compared to established companies usually somewhat concerning numbers.

To reflect the whole environment a firm is operating in, all ratios should be considered. The benefit Plug Power is creating for their customer is higher as they are offering solutions to cover the complete Hydrogen value change. If a potential customer decides to use their products, there is a massive opportunity for aftermarket services for companies covering the entire value chain.

Furthermore, the board of a company, as experienced management guarantees the financial healthiness of a company. The importance of good leadership was visible within 2021. The Hydrogen specialist Plug Power had to correct several annual financial statements retrospectively. The auditors from KPMG have uncovered accounting errors. The Group's annual and quarterly financial reports for 2018, 2019, and 2020 reporting periods will have to be corrected due to accounting errors, mainly related to "several non-cash items." Among other things, this relates to the value of non-current assets and the amount of individual cost items. (Röder, 2021). The position management is, therefore a component in evaluating a portfolio that should not be missing.

***2. What do financial theories say about the existence of a value premium in the Hydrogen sector? What conclusions can be drawn?***

Normal financial theory can only justify a portion of the existence of a value premium in the Hydrogen market. Such a premium does not exist, according to the Efficient Market Hypothesis. However, markets may not be fully efficient because EMH's claim is based on assumptions. Furthermore, markets cannot be competitive since searching for knowledge takes time and resources. Nobody would bother wasting time and money searching for data if it was already included in the price. Prices cannot provide details if no one is looking for them, and therefore economies are inefficient.

Furthermore, even though markets were competitive, a value premium might also exist because the success of growth stocks would deteriorate due to increased competition. In contrast, value stocks would have the potential to turn around their business in order to maximize growth. Taking all of this into consideration, EMH does not preclude the presence of a value premium.

Also, the CAPM attempts to justify the excess returns of value shares with a more significant beta factor than the factor for growth shares.

This solution suits the model and seems plausible at first glance. Current research, however, indicates that the beta of value shares on average must not be higher than for growth shares. Since it depends entirely on beta as a surrogate for risk, the conventional CAPM struggles to account for the absolute risk. Additionally, the existence of a higher risk for value stocks compared to growth shares is present. As a result, CAPM does not always contradict a value premium.

Overall, traditional financial methods such as Efficient Market Hypothesis and Capital Asset Pricing Model seem incapable of explaining the presence of a High Minus Low in the Hydrogen sector. However, with the limitations of these hypotheses, there might be possible interpretations available. For the very least, the theories should not dispute the presence of the premium.

Having stated that a value premium is hard to explain, especially in the Hydrogen sector. The behavior of investors in the Hydrogen market defiantly differs from following a value investment strategy. The investor's behavior can be the first sign of a financial overestimation within the sector.

Irrational investor conduct, such as extrapolation and various agency issues, may be a possible reason for the presence of a blasphemous financial bubble in the Hydrogen market. The extrapolation provides an incorrect impression of the stock's potential results, which are later adjusted so that the prices return to their fundamental values. As investors hereby try to aim for maximum profit without having a long growth perspective in mind, they heavily focus on investing in growth stocks. Furthermore, investors may choose growth stocks over value stocks in order to satisfy the clients' expectations. This preference for growth stocks continues to lift their rates, resulting in an overvaluation of the market since most firms relying exclusively on Hydrogen are growth stocks. After a while, the market will return to its intrinsic value, just as it does in the case of extrapolation when buyers realize the price has deviated too much from the actual value.

Furthermore, the disposition effect combined with overconfident investors can explain why there is an overestimation. According to the principle of investor overconfidence, the traction of stock price changes due to an initial rise.

Furthermore, the disposition effect contends that buyers sell their high-performing shares too early, minimizing the growth in momentum. A correlation between overconfident investors and the disposition effect is existing.

When the share price falls, the owners choose to retain a poorly performing stock for too long as they expect it to rise again. As a result of investors' unreasonable behavior, a market correction tends to happen, regressing growth stocks back to their fundamental value.

Having the theory in mind, the bandwagon effect, visible for inexperienced investors, will act as a catalysator. The effect will accelerate the correction of the hydrogen market. When the majority of investors believe that a stock is overpriced or underpriced, they will all begin to reverse their trading trend. The result will be, buying value stocks and selling growth stocks, taking the prices closer to their initial values.

### ***3. What is the situation of growth companies in the Hydrogen sector on the stock market?***

The topic of Hydrogen and energy production has become an even greater focus of politics and business in the past years. It has created hype on the stock market, especially among German investors. Hydrogen shares were among the big winners within the last years.

There is no denying that the topic is hip. Especially because investments in green technologies of the future, such as Plug Power shares, have shown where share prices can go. For some investors, this could be seen as a kind of guarantee, regardless of the extent to which it is foreseeable which company will earn money in the end with the trendy topic of Hydrogen.

What is certain is that fuel cells and Hydrogen will be part of the future energy mix. However, from a long-term perspective, the current euphoria on the stock market should be viewed with neutrality, as it is well known that the hyped development of share prices to date provides no guarantee for the future. A fair amount of speculation drives the prices of Hydrogen companies. The prospect of new projects and orders is pushing the shares up.

Furthermore, by having a closer look at the companies' market environment and their financial data, caution is appropriate. Especially newcomers who do not have enough financial resources to survive volatile times. Hydrogen firms do not have enough economic substance, as the analysis has shown. They are dependent on the hype and their investors.

The past has shown that these phenomena are not new. In the 1990s where the “New Economy” has taken place, the stock market was utterly divorced from reality.

Analysts, board members, and investors infected by the stock market boom reflected a reality that did not represent the firms’ actual value. However, parallels can be drawn, as mention above, between the dot com bubble and the Hydrogen hype.

Nevertheless, the chance of an increase in Hydrogen demand is still apparent. Should the use of Hydrogen increase significantly in the coming years, the shares of companies in this sector should certainly benefit.

In closing, the evaluation of the current situation is complex in such a dynamic environment. If there is still the desire to invest in Hydrogen newcomer, the statement of Warren Buffet might be a piece of helpful advice.

*“Most people are interested in a stock when everyone else is. The right time to be interested in something is when no one else is interested. You can’t buy what’s popular right now and do well.” (Warren Buffet, 2008)*

## 6 Literature

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