P2X & Green Hydrogen as the Fuel of the Future

A Road Map for Innovation Adaptation and Energy Transition in Sustainable Energy Technology and Heating. Case: Oilon

Lappeenranta–Lahti University of Technology LUT

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Examiner(s): Professor, D.Sc. (Tech.), Jukka Hallikas,

Associate Professor, PhD, Mikko Pynnönen

ABSTRACT

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Climate change and the troubles it brings within have been widely discussed. At the heart of this conversation is the ideology of decarbonization as a key towards a more sustainable future.

Fossil fuels cause 90% of carbon dioxide emissions and account for 75% of greenhouse gases globally. They are created by the everyday things all around us from transportation to manufacturing and heating. This is where Power-to-X technology and green hydrogen step into play as the more environmentally friendly fuel solutions to produce energy and a potential replacement for grey- and blue scale varieties.

Power-to-X, also known as P2X allows a sustainable production of hydrogen via a process called electrolysis which utilizes renewable energy sources instead of the fossil ones. This combined with a decreased demand and interest of fossil fuels and the acceleration of the green energy transition due to the volatile global energy market, creates an opportunity for innovation and technology adaptation which are the key elements of this thesis.

A sustainable energy company from Finland called Oilon wanted to find a roadmap and a preliminary implementation plan for adapting P2X technology to their product catalogue via hydrogen burners and clean combustion.

Thus, their current markets and specifically requested potential markets were researched based on competition, hydrogen related economy, continental resources, related risks, and governmental initiatives to understand which markets to enter and in what order from theoretical perspective. Also, the opportunities revolving around international trade were considered for a more tailored approach.

The heating industry is considered to have massive potential in CO_2 emission reduction. This combined with the research that placed Oilon in the P2X and green hydrogen value chain as an infrastructural pillar advancing the energy transition in their own field of work as well as a service provider offering a demand tool for technology utilization and adaptation gives the company a central role in the ecosystem. All this considered the thesis concluded that the hydrogen burners have a niche, marketability, and scalability opportunities within them.

The thesis found that the continents possessed potential in various ways and risks levels. Instead of providing one indefinite solution, three alternatives were presented based on the analysis made on the markets and Oilon's strengths, weaknesses and external opportunities and threats. Each alternative approaches the adaptation differently considering separate elements within their strategies. The approaches vary from the least risky to the riskiest and can be adopted individually or collectively. The author however suggests starting from the mature market approach with proximity to minimize new technology related hazards and scaling up from there to the riskier and more infantile markets.

The author suggests that instead of focusing on P2X technology adaptation on a power scale basis as proposed by previous literature to be the adaptation path, the case company should focus on their experience and expertise to lead the way in capacity arrangements. Meaning, starting from the capacities they have the most experience in when it comes to hydrogen combustion and developing the rest of the innovation technology around that. The suggestion follows the ideologies of the institutional theory alongside other strategic- and market related concepts. Additionally, based on primary data findings the author further emphasizes the importance of modularity in product catalogue as well as considering hydrogen mixes as a pathway and steppingstone prior to commercializing pure hydrogen combustion. This would lower the threshold of innovation adaptation and allow the development of learning curve and customer awareness accordingly.

TIIVISTELMÄ

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Kauppatieteet

Noora Nuuttila

P2X ja vihreä vety tulevaisuuden polttoaineena

Tiekartta innovaatioadaptaatioon ja vihreään siirtymään energiateknologiassa ja lämmityksessä. Case: Oilon

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Avainsanat: Vihreäsiirtymä, Vihreä Vety, Power-to-X, Kestäväkehitys, Innovaatio

Ilmastonmuutos ja sen mukaan tuomat ongelmat ovat kuumia puheenaiheita. Keskustelun keskiössä on vahvasti läsnä puheet hiilidioksidipäästöjen eliminoinnista avaimena kestävän kehityksen mukaiseen tulevaisuuteen.

Fossiiliset polttoaineet ovat syy 90 % hiilidioksidipäästöistä ja aiheuttavat 75 % globaaleista kasvihuonepäästöistä. Nämä syntyvät jokapäiväisitä toimistamme logistiikasta, teollisuuteen ja lämmitykseen. Tässä kohtaa P2X teknologia ja vihreä vety tarjoavat oivan mahdollisuuden näiden päästöjen pienentämiseen sekä avaa ovia ympäristöystävälliselle energia teknologialle.

Power-to-X eli P2X teknologia sallii vihreän vedyn tuottamisen ekologisesti elektrolyysin avulla hyödyntäen uusiutuvaa energiaa kuten tuuli- tai aurinkovoimaa fossiilisten lähteiden sijaan.

Laskenut mielenkiinto fossiilisia polttoaineita kohtaan yllä mainituista syistä johtuen sekä viimeaikojen maailmantapahtumien, kuten sodan, johdosta, luovat houkuttelevia mahdollisuuksia energiateknologian alalla innovaatioiden kautta, joten innovaatio adaptaatio on keskeinen osa tätä tutkimusta.

Oilon Oy, kestävän kehityksen energiateknologia yritys Suomesta halusi selvittää millainen potentiaali on vihreällä P2X vedyllä ja sen markkinoilla ekologisen polttoteknologian näkökulmasta. He halusivat selvittää paikkansa tässä arvoketjussa sekä ymmärtää mitkä markkinat olisivat heidän kannaltaan potentiaalisimmat.

Markkinatutkimus toteutettiin tutkimalla yrityksen nykyisiä- ja heille kiinnostavia markkinoita arvioimalla muu muassa markkinoiden vedyn tuotantoa, käyttöä, taloutta, riskejä sekä näihin liittyviä resursseja, selvittääkseen markkinoiden kypsyyden.

Tutkimus osoitti, että lämmitysalalla on suuri rooli hiilidioksidipäästöjen alentamisessa. Oilonilla on vihreässä siirtymässä keskeinen rooli, sillä heidän tuotteensa ovat infrastruktuurillinen tukipilari, joiden avulla eri asiakasryhmät voivat omalla osallaan vaikuttaa päästöjen alenemiseen. Vedyn polttamisella ja vetypolttimilla on siis teoreettista potentiaalia markkinoilla.

Markkinoita voi lähestyä usealla eri tavalla, jotka työn kirjoittaja esittelee työssään. Alternatiiveihin vaikuttavat markkinoiden riskit, haettava hyöty sekä markkinoiden kypsyysaste. Yritys voi käyttää joko yhtä esitetyistä vaihtoehdoista tai käyttää kaikkia kolmea vaihtoehtoa polkuna heille parhaaksi näkemällään tavalla. Kirjoittaja kuitenkin suosittelee adaptaation aloittamista tuoteryhmistä, joissa Oilonilla on eniten kokemusta vedyn polttamisesta sekä kotimarkkinoita lähinnä olevista markkinoista.

Tutkitun datan perusteella kirjoittaja suosittelee vahvasti myös sekoitetun vedyn käyttämistä ponnahduslautana ennen puhtaaseen vetyyn siirtymistä taatakseen kilpailukykyisemmän hinnan sekä saatavuuden fossiilisiin polttoaineisiin verrattuna. Oilonin polttimien tapauksessa vetyä voidaan sekoittaa esimerkiksi maakaasuun ja täten hyödyntää ainakin väliaikaisesti maakaasulle tarkoitettua infrastruktuuria osana kuljetusta ja varastointia. Näin pyritään eliminoimaan innovaatioteknologiaan sekä infrastruktuuriin liittyvät riskit ja kulut, sekä vahvistamaan oppimiskäyrää ennen haastavimmille markkinoille siirtymistä.

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SYMBOLS AND ABBREVIATIONS

Symbols

CO_2	*Carbon Dioxide*
GW	*Gigawatt*
H_2	*Hydrogen*
kW	*Kilowatt*
Mmt	*Million Metric Tons*
MW	*Megawatt*
NOx	*Nitrogen Dioxide*

Abbreviations

EMEA	Geographic region consisting of Europe, Africa and the Middle East
KPI	Key Performance Indicator
MEA	EMEA with Europe excluded.
NDA	Nondisclosure agreement
NPS	Net Promotor Score
P2X	Power-to-X
R&D	Research and development

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1 Introduction

This section will introduce the foundation of the thesis from the research objectives to the related gaps, the limitations as well as the thesis structure. In addition, this section discusses the theoretical framework used for the thesis.

1.1 Research Objectives and Methodology

Extinction of species, rising temperatures, hunger, poverty, drought, and dreadful natural disasters. Climate warming is the cause of this if not acted upon. The precautions are interconnected, one causing another and influencing multiple. For example, the loss of jobs via loss of crops and livestock due to weather being too volatile connects us to poverty and hunger. All of which is caused by emissions warming up the globe and slowly making it unlivable by altering the conditions. (United Nations. 2023)

Fossil fuels cause 90% of carbon dioxide emissions and account for 75% of greenhouse gases globally. They are created by everything around us and within our daily habits; manufacturing goods and produce, transportation systems, generating power and consuming it as electricity or in heating or cooling. These emissions cause the temperatures to increase drastically leading to increased risk of severe storms, rise of ocean levels and loss of species. With natural disasters, lack of animals and imbalance of places with drought or extreme wet conditions comes difficulty to grow food or livestock leading to hunger and health risks worldwide with the introduction of new diseases and losses of especially outdoor jobs. Already 13 million people lose their lives per annum in the hands of mother nature and if climate warming does not stop this number will continue to increase. (United Nations. 2023) Now a Finnish burner manufacturer, Oilon wants to tackle this challenge head on with green hydrogen combustion technology, as they see it is the key to tackle fossil fuel produced CO_2 emissions.

Previous studies have found that the green energy transition has been accelerated by recent world events. The demand for fossil fuels has significantly decreased as green energy has paved its way to the minds of people.

P2X technologies allow the production of clean and ecofriendly energy thus corresponding to current megatrends of sustainability and planet conservation. (Rahman Daiyan, Iain MacGill, Rose Ama. 2020.)

P2X for example allows the environmental production of hydrogen which potential has for long been acknowledged as a source of clean combustion, energy creation and storing making it important to the globe but especially to the commissioning company as their field is heating. Emission free combustion is a key factor in Oilon's operations (Pitkänen. M. 2022) which ties together the company and the topic, enforcing the objective for the research.

This thesis focuses on creating a road map for a sustainable energy technology company from Finland called Oilon. This is done by researching the following questions: how the hydrogen ecosystem looks now and, in the future, is there a market for hydrogen burners, meaning will hydrogen be used as is or as a derivate, and where does Oilon fit in the hydrogen value chain. The research is both qualitative and quantitative and focuses on finding the best action plan for the company that accounts for their existing strategy and their interest in P2X technology adaptation for green hydrogen combustion. The roadmap considers different market potentials, threats and possibilities based on customer- and resource allocation among other related factors and aims to offer an efficient implementation plan for technology adaptation. The data researched varies from theories, books and academic articles to company interviews, government websites and internal documents. The thesis offers a more theoretical application viewpoint as for a practical implementation more details on the engineering technology and field testing would be required to understand the full scope of capabilities and marketability.

The empirical data in this thesis collected via primary and secondary sources. The secondary sources such as previous studies, hydrogen statistics and governmental sites work as a foundation for this research and their purpose is to give an idea of the general market situation, competition and the hydrogen economy and ecosystem. The primary sources consists of a survey, expert interviews, and intercompany documents to see if these align with the general market outlook or if there are differences to account for. With all of this together, a roadmap can be formed, and accurate suggestions can be created so that both are considered: the general market perspective alongside the intercompany experience and position.

1.2 Limitations and the Research Gap

The literature on P2X technology is new and fresh; it is rather limited, especially in the field of sustainable energy technology, combustion, and heating. There are articles of adaptation of the technology in other fields, but the niche sustainable technology industry of burners is lacking. Being that the industry is really a niche with strict regulations and safety protocols as fire is included, all adaptations require special attention. Thus, this does create limitations to the empirical research as there are little to no directly comparable practical examples of previous cases. However, this is noted, and more emphasis has been put to the case company's previous experience with technology adaptation alongside studying market patterns to paint a conclusive picture.

This does increase the relevance of the thesis as it explores the yet rather untouched sector to find a roadmap for the company to in theory adapt this technology efficiently and within the company vision. This allows us to draw a line connecting emission free combustion, hydrogen and P2X technology.

The thesis aims to bring together alternatives which detail what markets Oilon should target with P2X fuels, in what order and with what products by analyzing the operating environments and researching the opportunities and threats connecting the two, the markets and products to the technology. The thesis is conducted as a master's thesis for a business degree thus limiting the engineering angle of it.

1.3 Theoretical Framework

Theoretical frameworks include theories on internationalization such as the gravity model, as well as other business-related theories like Porter's Five Forces, Triple Bottom Line, Life Cycle Analysis and SWOT analysis that help the case company to understand their own advantages, disadvantages, and the potentials of their current and future operating environments. All theories are better detailed as they are applied but the following is the explanation as of why they were chosen for consideration and application.

Triple Bottom Line underlines the core values of the company, highlighting people, planet and profit categories. This helps to understand the foundation of the organization and helps connect the theory to the topic and the case company by tying together environmentalism, profitability, and societal aspects.

All of which are connected to green hydrogen as it has a potential positive impact to all this over time. This is as emissions decrease, the globe revives, new opportunities arise alongside new technologies allowing innovativeness of the people to bloom and turn into profits. This combined with a standard SWOT, strengths, weaknesses, opportunities, and threats paints a clear picture of the company's status and position. Life Cycle Analysis on the other hand allows us to understand the lifespan and environmental aspects of the products. Allowing to understand the ecosystem around it and reflecting how investing in sustainability could advance them. The Gravity Model and Porter's Five Forces are both connected to markets and operating environments. Gravity Model theorizes the intensity of trade and seeing if the trend with Oilon markets corresponds to its suggestions it will help choosing the markets to which take H_2 fueled burners.

Porter's theory considers a wider scale of factors affecting the operating environment which is ideal when analyzing market potential, threats, opportunities, and infrastructure. When it comes to a fuel economy which is very much connected to governmental structures and resource allocation using such theories allows a deep understanding of the true potential of each market without overlooking continental characteristics or company specs by disregarding one or the other. These frameworks create a thorough basis for market - and risks analysis as well as continental evaluations and possible country specific up picks.

Adaptation and implementation of roadmap utilizes more industrial engineering viewpoints by exploring innovation adaptation theories such as institutional theory, Mintzberg 5Ps of Strategy and the model of core competencies by Prahalad and Hamel.

Institutional theory is used in strategic management to underline the societal, political, and economic factors that create the operating environment for the company, to which it must adapt to succeed and thrive. Core competencies model by Prahalad and Hamel (1990) is used to understand the competitiveness of Oilon and thus their advantages in the field of innovative solution technology.

The model underlines the importance of finding it hard to imitate proficiencies in competitive markets so its use in this thesis is eminent to evaluating market positioning and related opportunities.

While this is a more traditional theoretical approach, a more modern perspective is brought on by the dynamic capabilities model by Teece, Pisano and Shauen (1997) focusing on rapid integration in fast paced markets.

While the energy transition is a whole process the related technological development and legislation are unpredictable opening the possibility and need of abrupt reconfiguration that needs to be accounted for in the thesis. Since the adaptation is tied to strategy the Mintzberg 5Ps (Strategy Safari. 1998) will help to elaborate the focal factors of strategic planning. The theory will discuss adaptation through plan, pattern, position, perspective, and ploy and with all considered conclude into a visual road map presentation tying together secondary and primary data.

1.4 Thesis structure

The thesis will first introduce Power-to-X technology as a concept as well as the case company to demonstrate why these two are linked and what is the current state of the company, working also as the literature review for the thesis. Afterwards a more detailed introduction to the objectives and requirements of the case company is provided followed by a set of analyses and research on the best markets for Oilon and the optimal P2X solutions based on product selection and previously presented requests. This is presented as the empirical part with interviews, surveys, tables, and statistics to support conclusions. The product and discussion will be a strategy-bound roadmap with alternatives for technology adaptation and summary of the study findings.

The structure is chronologically organized, helping the reader to understand first the two key players, P2X and the case company, then the progress and forecasts for the hydrogen and burner markets and lastly see the conclusions drawn to make an action and implementation plan. This way the thesis can be aimed at a wider audience. The case company is the priority to the thesis and the research has been tailored to their wishes and requirements.

However, the detailed explanations should open the doors also for readers more inexperienced in the topic who may be interested in P2X hydrogen technology adaptation to heating or wishes to know more about only one of these topics in relation to the said operating environments.

2 Literature Review

This chapter will more thoroughly explain the power-to-x technology linking it to previous literature and introduce the commissioning company in detail alongside their requirements for the thesis focus points. The chapter will detail what connects the topics to each other and analyse the green hydrogen potential for Oilon in specific.

2.1 Connecting Point for the Energy Transition

In the first subchapter the thesis will dive into the connecting factors for the industry, Power-to-Heat and green hydrogen to create an understanding of what unites the two and why it is important.

The previous studies suggest that many countries especially in Europe experienced a rapid increase in demand for replacing fossil fuels after the start of the Ukrainian-Russian war, putting the world in a position of a fast-paced energy transition. While this has been a sustainability question even before due to global warming, yet this event exposed the volatility of the fossil fuel market and opened a discussion of what shall be used in the future not only for the sake of being green but to be innovative and less dependent. (Kattelus. J. 2022) Yet this is not the first time that war has been described as the driver of innovation. Harvard Business Review's article on sustainability imperative also suggests that this has happened before, for example during the cold war. Likewise stating that often when it comes to natural resources and the environment, it adds a geopolitical factor to sustainability and related innovation technologies. For a company to thrive, grow and achieve stability they must correspond timely and efficiently to one or more of these megatrends. (David A. Lubin, Daniel C. Esty. 2010) Additionally, the literature supports eco-efficiency, sustainability and

renewables being one of the biggest megatrends of today and suggests it will keep its top position for a long time (David A. Lubin, Daniel C. Esty. 2010) as can be witnessed since it has remained so for over a decade now.

Knowing this, to thrive and grow, the commissioning company naturally must adapt to the megatrends and customer expectations of consumers which brings us to the central idea of this thesis. Oilon is a Finnish founded sustainable energy technology company focused on burner- and heat pump production with over 60 years of experience. Both product categories expand from residential use to industrial, making the products versatile and the capacity range diverse. The company has factories in Finland, China and United States, sales offices in the previously mentioned plus Germany and Brazil and retailers in over 70 countries worldwide making it an international enterprise. (Oilon. 2023) The company values are evident from their strategy putting an emphasis on the environmental wellbeing and sustainability of their actions. The shift towards greener fuels has started and the company is on top of it, pioneering in low emission combusting technologies globally. (Oilon. 2023) This thesis will focus on the burner side of the product range as P2X technology is linked to fuels and combustion.

With all this in mind P2X offers a more sustainable solution and an alternative to traditional fossil fuels. How it works is by utilizing the abundant molecules of renewable power and converting them into different reusables like hydrogen, ammonia, synthetic hydrocarbon, or hydrogen peroxide with primary conversion electrolyzer. This can also be taken a step further with secondary conversion production methods, for example hydrogen can be turned into ammonia with Haber-Bosch method or hydrocarbon with Fischer-Tropsch. Also, methane is an option through methanation process in which hydrogen reacts with CO_2. The evident benefits include decentralized production making the supply chain less dependent and volatile, decarbonization accounting the environmental aspect and it allows advanced energy storing (Rahman Daiyan, Iain MacGill, Rose Ama. 2020.) P2X hydrogen has the advantage of being versatile. It can work as a substance or a fuel, but it is also known for its incredible ability to work as an energy carrier. (Ramboll. 2023) This naturally offers massive new potential to international hydrogen trade by decreasing environmental risks.

Transportation and storage safety is much debated topic when it comes to hydrogen. The evaluation of its safety in green version has been by Natural Resources Defense Council by comparing it to other, traditional fossil fuels.

They start their article by explaining that hydrogen is nontoxic and in case of a leak will not contaminate the surrounding area nor cause harm to the environment or wildlife.

Hydrogen is also approximately fourteen times lighter than air and while this can require extra consideration in transportation design, it also means despite it being flammable the risk at the ground level is lesser than in the case of gasoline or propane for example. Meaning while the quick vaporization may cause a headache in the logistics planning process, in the transportation itself it possesses a smaller risk for people and building infrastructure. Likewise, while hydrogen is easily flammable, in any situation where oxygen is present, even gasoline possesses a higher risk of explosion than hydrogen given that many fossil fuels require a lower oxygen concentration for this to happen in comparison to the green H_2. Also, was a fire to happen the radiant heat produced by H_2 is lower than that of gasoline, emphasizing environmental safety once more. (Tae, C. 2021)

Unlike most fuels, when burning hydrogen, it does not create CO_2 emissions but instead the reaction produces water and thus it does not have a negative impact on the climate (Gencer. E. 2021). This is an important thing to keep in mind since the commissioning company, Oilon, is interested in the use of pure hydrogen and its market potential rather than its secondary conversion versions so even if the production starts with creation of hydrogen the markets may consume it in another processed format. As they claim themselves as pioneers is emission abundant combusting, constant innovation is needed to maintain and advance this forerunner position.

The market for hydrogen produced in a green way is growing rapidly. The rate measured is compound annual growth rate, CAGR of 54,98% within the next ten years from 2022 until 2032 and its current valuation is at over four billion US dollars, or three point seven billion Euros as of 2022. (Presedence Research. 2023). Additionally, the estimation of P2X market potential in a bit over ten years is grandiose. Electrolysis has been forecasted to withhold the potential of 1,411 billion Euros on a global level. Other very potential markets in both sustainable development scenario and net zero emission scenario are fuel cell engines, heavy- and light road and hydrogen transport by pipelines and in net zero scenario also the potential of cargo transport of H_2 rises to a notable level of over 100 billion Euros. Ammonia, ammonia engines, methanol engines and marine fuel cell engines possess the least forecasted potential in both scenarios. (Ramboll. 2023)

Thus, the company has studied their markets and future aspects on hydrogen as a fuel and sees it as one of the most potent for the future alongside other gaseous ones such as biogas and synthetic methane, liquids such as methanol and biodiesel and solids such as raw biomasses and biochar. The goal that the research presents is to eliminate or at least minimize emissions such as NOx and burning related particles as well as avoid the global supply chain vulnerabilities the last years have demonstrated with the COVID pandemic and the war. The prediction is that the role of combustion will maintain its position as it has been suggested at times being the best solution for, for example high temperature processes, remote areas, and high-capacity systems. In addition, such technologies as P2X, so power-to-heat has been suggested to make it even more sustainable than it already is, making it an efficient solution in the future. (Kattelus. J. 2022)

The interest in green fuels is nothing new. Dr. Walter Peschka, a German professor noted already in the 80s that hydrogen was more environmentally friendly to produce in comparison to pure fossil fuels and combusting it creates a near pollution free results without releasing excess CO_2 to the atmosphere like fossil fuel combustion would. (Peschka.W. et al. 1-2. 1992) Without using the now common term power-to-x he expresses that hydrogen has a potential of being the “fuel of the future” especially if drawn from primary energy via electrolysis (Peschka.W. et al. 1-2. 1992) which is much like in common day power-to-x technology. This prediction was if higher costs to the consumer are accepted in exchange for lower costs to the environment by the economies as this kind of fuel has always been pricier than fossil ones (Peschka.W. et al. 242. 1992).

As the interest in fossil fuel use decreases, the need for new technologies is evident. P2X has been linked to positive outcomes when it comes to circular economy, meaning using and storing excess of renewables. The electricity sector has been researched to produce over 30% of carbon emissions. Power to X has been studied to be a capital intensive yet fast route for decarbonization. This has been noted globally as nations such as Japan, South Korea, Australia, and the whole of European Union have been addressing new policies in hopes of advancing the adaptation of renewable hydrogen as they present it as a key for a greener tomorrow. In the EU, Germany and Iceland are notable producers of P2X tech, yet they are also known for further converting it to synthetic methane and synthetic methanol respectfully. (Rahman Daiyan, Iain MacGill, Rose Ama. 2020.)

As mentioned above, utilizing P2X technologies comes costly. Power-to-x produced hydrogen aka Power-to-H_2, price point starts on average twice as high as a standard version of the chemical. This is as not only the creation process is complex but global clean water scarcities affect the availability of the technology which happens to be the best alternative in producing hydrogen. While gray water has been used before it still does not quite compare to the best alternative and using salt water would add an additional, costly, and unsure step to the process called electrolysis alongside a procedure titled osmosis water purification. (Rahman Daiyan, Iain MacGill, Rose Ama. 2020.) On the positive side, technology learning rate suggests the more familiarity and experience in technology is gained the cheaper its utilization becomes. The International Energy Agency suggests a cost reduction of 4% annually, reaching a 66% reduction by 2050. Likewise, the cost of solar and wind energy, offshore and on shore are projected to keep the steady decline in price that they have had going on for a while now. The cost reductions for the previously mentioned are estimated to vary from 29% up to 82%. These factors combined allow P2X scalability, profitability, and expansion potential. (Ramboll. 2023)

This is something Oilon must take into consideration if wanting to proceed with utilizing and implementing this technology, not only from the customer side but also the consumer side. Especially during the early days before technology learning rate does its trick on the pricing. While R&D product wise will produce extra costs for the company like any new product innovation the customer is the one who would be combusting the fuel so price and availability questions must be accounted. With Oilon, given that little academic research exists online on P2X and direct use in burner, their early adopter position may require more trial, research and resources than being in a latter position of the technological adaptation curve. The curve is also known as the diffusion of innovation theory categorizes product users, in this case P2X users by pace of adoption in comparison to each other (E.M. Rogers. 1962). To use this theory in this context, Oilon must be initially placed in the role of P2X consumer instead of supplier, to act as an entity consuming this technology as a part of their operations by modulating products and only then does it become a supplier of combustion supporting P2X. Since hydrogen as a fuel is existent and the technology is otherwise already in use, putting Oilon to an innovator category in this sense could be controversial. Regardless, an early adaptor position appears to be the most suitable considering the previously mentioned conditions and knowing there are use of P2X hydrogen already just not quite like this.

The literature suggests that the transition towards Power-to-X technologies and green hydrogen will take place in three main steps. The first comes the smaller kW scale powered sources on a consumer level, known as the household application. This is followed by MW scale working its way up to industrial use either as direct hydrogen or as a secondary conversion to methanol, methane, or diesel for example. This step is described as a utility application. Finally, the last step is the economy grade integration aka GW scale, transforming P2X hydrogen production into a large-scale national export. A forerunner in this field is Australia, set to create a 15GW energy hub for green hydrogen conversion. While the potential is evident so is the geopolitical imbalance uneven resource division presents, making it much more efficient for some countries than others to adapt and produce. (Rahman Daiyan, Iain MacGill, Rose Ama. 2020.) Based on a previously introduced company product catalogue, Oilon products are mainly focused on the first two steps, residential and utility applications by residential, industrial and powerplant scale burners.

However, this theory is highly questionable since later we shall learn that industries are the leading users of hydrogen currently and the future forecasts support this trend to continue. Likewise, Oilon Chief Technology Officer, in a meeting on the 25th of August 2023 argues larger scale heating will initiate the transition and the sustainable residential heating will follow on the scale that it is not overtaken by heat pumps. Emphasizing, that the most potential the technology would offer to applications otherwise difficult to decarbonize by electric solutions.

Heating is a key part of many operations globally and its green shift shall not be overlooked or neglected. The problem Oilon and the thesis wishes to address is that if energy transition towards renewables is not taking place throughout industries and in different fields it negatively affects the planet.

This brings us to the current challenge. Studies on the circular economy demonstrate the challenge with fossil fuels and the currently most used production methods of hydrogen are linked to long-term sustainability and environmental safety. Waste management is a reoccurring problem as well as questions on transportation and storage, accumulating extra costs and causing extensive worries to those dealing with the matter. (Christina L. M. Et al. 2022)

While on the topic of hydrogen production specifically, currently most of the hydrogen produced is either grey hydrogen or blue hydrogen. 90% of hydrogen globally is on the grey scale meaning it's drawn from steam reforming with natural gas, generating massive amounts of CO_2 emissions. Blue scale is the same but uses carbon capture and storage-, also known as CCS technology for getting rid of the emissions by storing and disposing of it either underground or below the seabed. (Riello. 2023) While the latter sounds like improvement it is rather a "away from sight, away from mind" – kind of solution. To combat emissions, green hydrogen has been introduced and it's created from renewable energy (Riello. 2023).

The special focus on P2X water electrolysis is as it has been studied to carry the massive potential for future green hydrogen production. It has been proven that it can even be paired with other sustainable sources of energy such as wind or photovoltaic to enhance variation formation. It has been said that due to its configuration possibilities in combining it with the other sources, its varied production opportunities allow the producer to be flexible and experiment with different variations and cost efficiency. It is estimated that the use and demand of this for global projects will increase as this renewable becomes more popular and better known. (Ursúa et al. 2012)

This said the green, electrolysis technology utilizing hydrogen production does not go without critics and concerns. The most consistent concern throughout research of existing literature was water consumption the process requires. Awaking questions like will there be problems in resource availability in the future. Stoichiometry demonstrates that 1kg of hydrogen requires 9kg of water including the process of electrolyzing. Water used in the process can rarely be repurposed for consumption afterwards even if it could be saved. Resourcing electricity used in the hydrogen creation process from solar or wind power sources, known to be renewable, the freshwater savings could be as much as 10 billion cubic meters annually consumed otherwise by fossil fuel energy sources. This shows hydrogen use as a replacement for fossil fuels will save water and not vice versa. Supporting this is data showing that agriculture is the biggest consumer of freshwater with numbers over fifty times bigger than that of future hydrogen economy estimates.

Likewise, a bigger cut of water use goes to fossil fuel energy production and power generation once more demonstrating that hydrogen does not impose a risk to freshwater reserves. Especially since desalination of salt water can be done to convert salty water into a feedstock for the electrolysis process. Desalination is estimated to only increase the water price by maximum $1,50 per cubic meter and add only $0,01- $0,02 to the cost of kilogram of hydrogen depending on the method. 2014 analytics show that 20.5 billion m3 of water was used for hydrogen production which was still around a third less than in the creation of fossil fuel-based energy. Most of the critics come from journalism yet the negative marketing can have a deeming effect on the consumers ideas of the fuel. Science has debunked these concerns by the above given numbers and data to try to counteract the negative speculations (Rebecca. R. et al. 2014) Naturally once must consider that technological advancements, learning curve, energy prices and inflation can affect these numbers. Other critics argue also for the current price inefficiency hydrogen based heating faces, supporting heat pumps and electrification of the industry instead. However, research suggests a short-term solution of mixing hydrogen with natural gas to cut down prices and lower the threshold. (Dodds. E. P. et al. 2015) This is something already done by Oilon.

For a long-term pure hydrogen approach innovation and resilience is needed, starting from the infrastructural elements, and focusing on financially well-off markets. Combustion wise the customer will not face any practical changes in the heating process besides changing the fuel in the switch from natural gas to hydrogen. While this may lower the threshold in practise the question remains if the sustainability initiative alone is tempting enough to make up for the cost increase. While initial efficiency is debated it is concluded that this is a potent alternative to natural gas and other fossil fuel solutions in heating (Dodds. E. P. et al. 2015)

Previous research has dug deep into forecasting the future of green hydrogen and P2X specialized markets. Business Finland has researched this topic as a Delphi study with the help of 300 experts in a collaborative manner. The experts were from the private sector, public sector, the government, NGO’s, Research Think tank and Academia to create a wide scale study on the topic. This study presented the researchers with different questions and predictions in which the experts had to argue their own picks. (Kruse. M. 2020)

Currently the main hydrogen demand consists of oil refining, ammonia production and methanol production. However, experts forecast that P2X will have an increasing role in the future in this study as well. In 2040 industries with the greatest impact will be feedstock, transportation, and heating, at least in a hydrogen blended format. By that time around 6-10% of global energy consumption is predicted to be of green hydrogen, some even say the number to be 16% or more. They emphasize that to see a word wide impact sufficient investment needs to be provided or this will not happen. Some experts argue that taxation will be necessary in helping the transitions while others argue that political opposition will be too strong for that. The research panel views ammonia and other carriers to be of great importance in transporting hydrogen and reducing the transport costs. (Kruse. M. 2020)

However, the key challenge of adapting green hydrogen was not listed to be transport related but instead the access to ample supply of low-cost renewable energy. In this comparison factors like storage and gas grid access, water access and skill base were left far behind. Scalability wise investment, governmental support and -awareness as well as international- and national partnerships are deemed crucial. (Kruse. M. 2020) As hydrogen is questionable to transport due to it being highly flammable the focus can mostly be seen being local. Though the study by Business Finland (Kruse. M. 2020) was divided on hydrogen combustion we can see that pure hydrogen market is estimated to be larger than its derivates and although the derivates are argued to be easier to transport they still aren't seeing as much movement as hydrogen in its pure format as will be explained in the empirical section in more detail.

Experts forecast that hydrogen will see parity in comparison to other similar options by 2040. However, what is interesting is that heating as an industry is a big question mark. Other experts see great potential in it while the rest say hydrogen should not be burned. Also, there is a big question mark if hydrogen combustion will ever be pure or always blended. While some say parity will never be reached in the blended hydrogen for building heating sector, majority still argues that it will be reached at around late 2030s. High grade industrial heating will however experience the same in the early 2030s. Researchers also predict more positively its parity by fewer of them predicting it will never take place.

Heating has also gotten the minority share of global hydrogen demand drivers while highly ranking sectors are industries like steel and refining, chemicals, transport, and power generation. However heating rank is high enough to be considered as one of the primary industries of this economy.

Nonetheless, one must be critical to understand that while heat pumps are energy efficient, they are not the solution for every site. While this might be the ideal situation for some residential- and industrial buildings the reality for other sites, especially the larger the scale gets might be different. As Oilon is advancing their strategies with growing in the field of heat pumps having a competitive alternative internally could be an advantage when aiming for sustainability but not being able to adapt heat pumps. And going beyond, the green H2 potential for industrial high temperature heat, meaning over 400 degrees Celsius was forecasted to be 5-15% of all high-grade scale heating applications by 2040, some estimate this number to be 15% and above (Kruse. M. 2020).

The fact, whether green hydrogen can be adopted straight on or require blue hydrogen as a steppingstone to lower the threshold is so harshly debated the thesis will not investigate it any further than an acknowledgement. According to Business Finland panel 29% agreed with this statement while 27% disagreed and the rest fell in between, leaning towards neutral standpoint. (Kruse. M. 2020) The approach of this thesis is application possibilities and find the potential for Oilon as the Green H2 is rising in popularity to ensure Oilon can keep up with the changes in the markets. Other possible stepping stones for Oilon could be larger scale adaptation of hydrogen mix combustion, something that they have already some experience in.

2.2 PX2 Hydrogen Potential for Oilon

This subchapter will specify where in the technology the potential for Oilon lies and what are the company's environmental interests and strategies that link them to the targets of becoming more sustainable than ever before. This subchapter also discusses the general guidelines of industry standards and guidelines that dictate the manufacturing of burners to generate an idea of how the field functions.

A brief description of a burner is a device mixing fuel, gaseous or liquid, with oxygen to create a flame. This flame can be controlled and monitored to create heat for whatever purpose its meant in that moment. Burners are used in residential houses, industries, maritime, and powerplants to name a handful of examples.

Oilon has already renewed its strategy to be more sustainable than ever. The vocal points are the long-term sustainability of their operations alongside emission-free combustion to create a cleaner and greener future. The company has signed a Science Based Targets initiative to combat the climate crisis by agreeing to work towards lowering the global temperature increase. Not only this but the company has stated to lower emissions coming from their operations by nearly 50% from that of their 2019 statistics. (Oilon. 2022) Naturally not only the company sets their own environmental targets but also sets up to correspond to those set by nation or region they operate in or trade with. Such affecting regulations are emission standards, safety standards, product certification, labelling and packaging, export and import regulations as well as in some cases energy efficiency requirements.

Oilon burners are no exception. Globally there are different governing parties setting regulations and so are in the home market. In the EU, the burners are subject to non-road mobile machinery aka NRMM emission restrictions designed to protect the people and environment as well as restrict low-cost and less sustainable competition. (European Commission. 2023.) Oilon credits itself by advertising meeting even the world's strictest emission regulations and even exceeding them by their variable solutions (Oilon. 2023b) Europe has set NOx and CO2 emission regulations set based on five different scales or categories to accommodate and account for different industries, the heating industry included (European Commission. 2023). All this considered, green hydrogen could potentially rise up Oilon's sustainability even further though the job the company is already doing is notable and important due to its positive impact to the environment.

Emissions aside, another external consideration topic for the company are the set safety and quality standards to which Oilon has corresponded by manufacturing and designing according to ISO 9001 and ISO 14001 certifications. (Oilon. 2023c) The first one of the two is a guideline for quality management and the latter is one for environmental management. Together they help managing and monitoring related procedures, documentations, trainings, internal auditing and forecasts with a systematic approach to the topics (Integrated Standards. 2023). Author's years of experience working in the company ensures that oily parts receive special attention at packing stations at Oilon for nature conservation and the labelling of Oilon products always includes the product name and type, serial number, capacity and manufacturer info to make products easy to monitor, export, import and maintain. Maintenance helps prolong product life cycle which is an important part of sustainability as the product is of use for longer and reduces waste. Being durable, sustainable and reliable is at the heart of Oilon's product catalogue and this works as a foundation to their customer promise.

The TBL principles, also known as the triple bottom line, are thus strongly present in Oilon's line of work. The three key elements of TBL are people, planet, and prosperity, and the theory was created in the mid-90s by John Elkington (UW Extended Campus.v 2022). These three together measure a company's contributions throughout the stakeholder axis and the theory was designed to extend the perspective from the previously used financial bottom line to include more important factors of business operations (UW Extended Campus.v 2022).

From Oilon's strategy, it is clear, that the company is determined to improve its environmental aspects as an ongoing project, thus putting an emphasis on the planet aspect. Below is a visual (figure 1) that is a simplified version of the company strategy in the triple bottom line format drawn from the internal company strategy documents by Pitkänen from Oilon's marketing department (2022). The focus of the demonstration and strategical pinpoints chosen was on the strategical burner targets and efforts, excluding from the scope other operations such as heat pumps. Those were the following:

1. Socially, Oilon wishes to be a meaningful workplace by making employees feel heard and cared for. Additionally, they believe in when you sell something you can stand behind the rest comes naturally, hence the social aspects of environmentalism are an important part of the company's social strategy. Global warming naturally touches everyone and by putting in all this work the company wants to be a responsible and accountable partner showing transparency and having a committed set of employees who can be proud of what they are a part of.
2. Sustainability wise on the burner sector, the company has already invested in R&D and finding the cleanest combustion methods possible. Making modular products that can be adjusted as the megatrends morph, the company wishes to also encourage their customers to the green shift by making it as easy as possible. This is why Oilon has a keen interest in P2X technologies and more specifically hydrogen production. The benefits of P2X hydrogen are explained in the introduction and this is to draw a concrete connection between them and Oilon's strategy.
3. Prosperity is essential for any company to thrive and Oilon looks for profitability in creating clean combustion (e.g., via hydrogen use) and generally aiming for low-emission solutions as this is according to them and studies researched for this thesis the path of future growth aligning with the needs of the planet and the more conscious consumer behaviour.

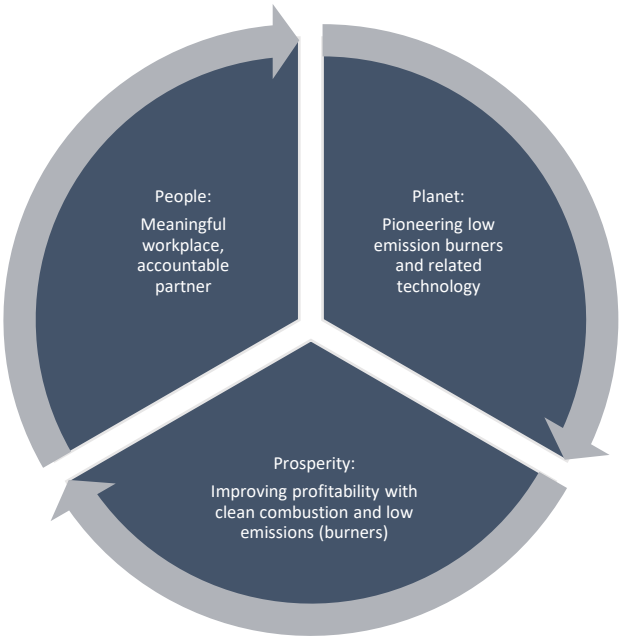

Figure 1: *Oilon's burner strategy visualized in TBL format.*

Not only do P2X technologies work alongside Oilon's strategic goals and targets but also there is a potential connection between P2X and improving the Life Cycle Assessment, LCA, of their products. LCA is a tool to assess the products or service's environmental impact throughout its lifespan and can help identify gaps within it (Finnveden. et al. 2014) If creating the products to be modular so, that with small component changes the burner can alternate combusting fuels, it could extend the usage period of the burner. Hence making it adaptable and the consumer would not have to result in extra consumption if wanted to change to a more environmental fuel as sites and technologies develop. Even without modular possibilities, burners with modern fuel combustion technologies and the openness to adapt P2X fuels the improvement could be possible in the user sector of LCA. If envisioning not only the life cycle of the burner from Oilon's perspective but also from the users, then also the raw material, and distribution sectors could experience sustainable advances as P2X fuels would be cleaner to combust and more environmentally efficient to store and transport. Packing advances would only be seen as less oily parts would need to be transported, decreasing the risk for the environment. Longer use allows disposal later in the lifespan of the product.

To truly understand what Oilon needs and how to tie it together with the rest of the thesis an Ansoff Matrix has been created and it is visualized as figure 2. The matrix helps to position strategical innovations into categories that will then assist in finding suitable action plans for said innovations. Since burners and markets for them are already specified the discussion in this case is on product development strategy. Hydrogen burner would be a product innovation, in this case modifying something existing to create something new.

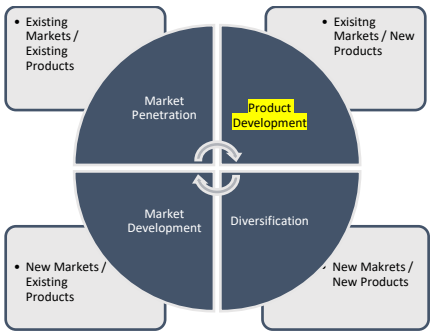

Figure 2: *Ansoff matrix for strategic approach evaluation*

When studying the expert insights on power-to-heat, it raises the question if heating is overlooked because by standard it would have other alternatives. As one states hydrogen "*should be directed to hard-to-decarbonize sectors*". (Kruse. M. 2020) Statements like this make the statistic sound more like an opinion rather than a research-oriented solution seeking. So, while these opinions exist upon discussions around P2X and heating, they should not be taken at face value since part of it appears to be reasoned by having other alternatives and not so much about lack of actual potential. The suggestion of heat pumps was one of the debated alternatives for the heating sector (Kruse. M. 2020). The possibility this technology offers for Oilon should be researched fairly based on the opportunities and threats solely over whether someone else may benefit from the technology more.

Additionally, some sources do contradict this stating that hydrogen possesses an important opportunity for the heating industry too, in the path of decarbonization, though a lot of work will be needed to be done. This is as despite the current high price of electrolysis, in the future, if scaled correctly can offer a cost-effective solution with less centralization and volatility than other heat source alternatives. (N.P. Brandon, Z. Kurban. 2017)

3 Market Research

In this section, a detailed market analysis will follow. The section will include a breakdown of current markets alongside an analysis of the markets Oilon has addressed their interest in the future.

The evaluation has been done by using different marketing analytic tools such as SWOT and PESTLE and will also include a risk analysis. The data assessed in this empirical section is both qualitative and quantitative, as some of the data is more focused on characteristics of market areas and hydrogen potential while the other is numeral detailing supply, demand and competition stand points. The research is broad and focuses initially on the continental potential while highlighting individual countries and regions deemed the most potential. Thus, this is not a study on specific customers or customer profiles.

3.1 The Analysis of Current Markets

This first subchapter will introduce the current markets of Oilon, dissecting each of them on a continental level to understand the competition and governmental maturity of them.

The current markets on Oilon are well spread and introduced in the very first section of this thesis. But for the sake of recap, the firm has factories in Finland, China, and the US, and in addition sales offices in Brazil and a small unit in Germany. To make the thesis easier to digest the markets will be assessed as Europe, North America, and Asia. This is also as the requested research for future markets will be done in the same manner adding Africa and the Middle East to the digest, eventually lifting the most potential markets from within the otherwise more continental overview.

In the market evaluation, we shall look at things like competitiveness, openness to new technologies, and hydrogen production and consumption now and in the future as any other region-specific notes that arise within the research. At the end of the section, a visual representation will follow. From all markets, the notable, generally known competitors based on size, competitiveness and product catalogue are evaluated to understand Oilon’s current position and market opportunities.

For comparative and comparable results, the competitors were purposefully chosen to have similar products which is quite given considering how niche the market already is.

3.1.1 Europe

To kick off let us look at the European market. When researching the biggest burner manufacturers in Europe, the following three came up on the top: Italian Riello Group, German Weishaupt, another Italian manufacturer called Baltur and Limpsfield from the United Kingdom. Looking into their catalogues it is evident that also what they combust seems to match up with Oilon varying from light- and heavy oils to hybrid bio solutions and dual fuel options. Size-wise, e.g., employee count, Riello (Riello. 2023) and Weishaupt (Weishaupt. 2023.) are bigger than Oilon and have a longer history, Baltur being an exception not stating their employee count on their site and their history is approximately the same as Oilon's (Baltur. 2023). But due to all these similarities and proximity these three were chosen to represent competition in Europe. The European market leaders also are European which follows the gravity model theory by economist Adam Smith (1776) suggesting trade is more intense with less geographical distance between the parties.

While there was little direct discussion on P2X fuels connected to these top companies, terminology-wise, offering different bio solutions do hint toward an interest in renewables and becoming greener. Most prominently, Riello is on a similar journey to Oilon in emission reduction, only it is slightly more ambitious with 10% higher targets on emission reduction. The Italian burner manufacturer has written about hydrogen being a part of the emission-free future of combusting (Riello. 2023). Additionally, they openly advertise water electrolysis-produced green hydrogen as their future choice once the cost competitiveness increases (Riello. 2023). This brings credibility to Oilon's ambition towards P2X hydrogen but does demonstrate that the competition is on the same path. Additionally, what we can learn from research is that Europe is offering a public investment initiative called Multiannual Financial Framework 2021-27 (MFF) for a post-pandemic economic boost and offering nearly two billion euros to innovation. Riello has started seeing this as an opportunity for boosting green hydrogen production in Europe and time for related technology adaptation. (Riello. 2023)

Researching Weishaupt sites they had not commented on hydrogen or P2X technologies, yet their product portfolio is impressive, and the ideology of environmental aspects is shared with Oilon, but they do not give up much on their future outlooks like Riello (Weishaupt. 2023). Baltur also seems to be a little more closed off on their future, but they do on their website state they wish to invest in sustainable technologies and believe their approach will make them a global industry leader. Their experience in the industry is 10 years more than in the case of Oilon and they have official offices in 60 countries, making them a confident player in the industry. (Baltur. 2023)

Finally, there is Limpsfield Combustion Engineering Ltd is from the United Kingdom. They offer hydrogen burners and address on their site being experienced in hydrogen combustion, emphasising that their expertise in this span beyond two decades. While the employee count is unknown the years of experience are less than half of Oilon's and the degree of internationalization is smaller, creating a less of a threat position from their behalf (Limpsfield. 2023) Beyond that, they seem to leave this to the customer to find the most sustainable fuels for their use and focus on being a manufacturer of burners rather than an upright innovator, hoping just stating that they are experienced in H_2 is enough to spark interest in them.

Bentone is a globally reputable brand who used to have presence in Finland as well until it later withdrew its brand from the market, allowing Oilon to take over its market share and customers. Nowadays in Finland Oilon caters spares for Bentone burners. While domestically their presence has been overcome, in other parts of Europe they are a notable competitor. As with all competitors the product range is the same and focus on the green transition is not so prevalent as one might expect. Their website as clauses on environment and sustainability such as ISO-14001, but nothing of their own environmental targets or lowering of emissions. They do sell biogas burners yet there is no emphasis on hydrogen as is, non the less a mention for green P2X variation of it. (Bentone. 2023) For Oilon this is good news as Bentone is not aggressively addressing interest in the same sustainable solution as Oilon nor are they as openly working towards the same mission as the rest on the competition.

A table demonstrating Oilon's position in comparison can be found below (table 1). Internationalization in the table means countries in which they have established their presence with either offices, factories or representatives, country signifies where the company is from, employees naturally is the employee count and years of experience mean how many years the company has been in the heating industry. The numbers are from the respective company websites and a similar table can be found after each market analysis section. Though in all markets some competitors are missing the number of employees it does not critically alter the credibility. The years of experience and internationalization weight more in this scenario, and employees were added to bring another perspective to company size.

Company / Specs	*Country*	*Employees*	*Year of Experience*	*Countries with presence (internationalization)*
Oilon	Finland	400+	62	70
Baltur	Italy	No Information	70	60
Riello	Italy	1800+	101	120
Weishaupt	Germany	4100	71	120+
Limpsfield	United Kingdom	No Information	28	30
Bentone	Sweden	No Information	69	90

Table 1: *Company specs based on each company's website's 2023 data. European market area*

Europe as a market for hydrogen-related technologies is promising and a massive thanks is to EU acceleration programmes. According to European Commission, hydrogen is still a small actor in Europe's energy consumption market, accounting only for a couple of per cent of the area's energy use. And the small 2% is still almost fully grey or blue hydrogen. Therefore, the European Commission wishes to start mass production of green hydrogen in Europe by manufacturing 10 million tonnes of it within the next seven years and importing the same amount within the same time frame. This new intensive strategy framework is called REPoweeEU. As a part of this, the commission is committed to creating investment and infrastructure for the hydrogen market and coordinating research and international cooperation around it. Not only is it green and aims to help to recover from last years' economic distress but also reduces the dependency of EU on Russian energy production

(European Commission. 2023 A) This strategic output is a potential gold mine considering Oilon's existing markets and future aspirations of hydrogen adaptations, considering especially that the cost efficiency still needs investment and work for which the commission can be of help with this framework by advancing production and demand of markets. Not only are the investments marginal for certain groups but the initiative has been said to be helping operators throughout the value chain (European Commission. 2023 A).

Out of over 40 projects all over the EU have been started. The states are Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Italy, the Netherlands, Poland, Portugal, Slovakia, and Spain. Most notably Estonia is focusing on new electrolyser technology, the Netherlands on fuel cell technologies, the French have chosen to study the logistics of hydrogen, and multiple nations are involved in bettering end-user applications in practice. According to the plan, this is only the beginning, and many more project accelerators are to follow as the framework undertaking progresses. (European Commission B. 2022) As of mid-2023, Europe holds the vast majority of global hydrogen projects and is considered the early adapter of such green technologies focusing on low proximity production and consumption combo to marginalize costs. Yet the Americans have accelerated their advances toward green hydrogen projects, dropping Europe's global share from 63% to 56% within the last half a year. Research predicts while green projects will go on in Europe, in scale North America will take over in the majority position. Nonetheless demand for hydrogen is expected to increase in Europe drastically, forecasting 60% increase by 2030. Prices on the other hand are expected to fall by over a third per kilogram for green hydrogen. (Horner. W. 2023) To place Oilon in this, arguably its place would be in the last of the set of the commission's examples, meaning focusing on end-user applications such as how to combust green hydrogen and with what technology as well as leaving the company to take on the marketing the European Commission has started by promoting low-carbon fuels and decarbonization.

Accounting for all this, Europe has massive growth potential. The competition gets rougher the southern we go, yet through interest has been expressed by the competitors, Oilon is not lagging. With the programmes and initiatives of the European Commission in mind, Oilon has taken interest in the right technology at the right time seeing how many projects and investments are within that field now and in the future.

3.1.2 North America

Now as we proceed to the North American markets, the competition gets rough. Though the geographical distance increases so does the advanced approach on P2X and green hydrogen which appears as the American giants are a step ahead of Europeans technology, and R&D wise. Exact specs of each competitor chosen will be presented in table 2 (table 2) below for North American market just like they were in the European section.

On the top of the North American game is Honeywell International Inc from the USA. Once more all competitors introduced in this section offer similar burners with the same fuel variations to combust, aligning them nearly equal to that of the European ones. However, to get back to Honeywell they have announced a new technology to produce hydrogen that they have developed deeming it as sustainable and more cost-efficient. Such ambitious inventions align with their elaborate climate goals which target the same issues as Oilon's such as carbon footprint. In addition, they operate in other fields of technology as well such as aerospace and construction and invest in tech companies which all together grants them quite an impressive portfolio (Honeywell. 2022) With their new catalyst-coat membrane technology they have been able to reduce the cost of electrolysers by a quarter (Honeywell. 2022) giving them a massive advance in contrast to the competition as their knowledge in renewable hydrogen is top-notch and their scope of information extends directly from their laboratories to their goods. Size wise they are way larger than Oilon, operating on a variety of industries (Honeywell Global. 2023) which must be accounted when looking at the company stats. This naturally grants them an excellent advantage in competition as they gain a wider scale of knowledge and have more resources. In comparison Oilon is tiny with a lot less experience and knowledge making Honeywell a big competitor in the US technology and R&D wise regardless of their burner selection being smaller than Oilon's.

Following Honeywell, is U.S. founded Selas Heat Technology Company and they fall on the same category as the previous one, not publicly showing much interest in being a green hydrogen forerunner but still offering Low NOx hydrogen burners. Thus, there is not much to analyse with Selas. Despite their years of experience, they never experienced a rapid internationalization of representatives, but they do cater service globally from the States office (Selas Heat Technology Company. 2023)

Based on this Oilon has used its years of existence wisely growing and expanding, with official local representatives on a global level bringing them some competitive edge in comparison.

Company / Specs	*Country*	*Employees*	*Year of Experience*	*Countries with presence (internationalization)*
Oilon	Finland	400+	62	70
Honeywell	USA	110 000	117 (heating)	80
SelasHeat Technology	USA	No Information	120	Local reps ~15, US rep offers global support

Table 2: *Company specs based on each company's website's 2023 data. North American market area*

To break down North America as a market, one must look at not only the competition but the production and use of green hydrogen as well alongside assessing its market potential in the future. As mentioned in the European section, North America is on the rise through extensive investments on green hydrogen technologies. One example of such investment schemes being Biden Administration's $369 billion towards sustainable energy programmes and R&D and another one being granting tax credits to the producers together making it the largest green energy investment in the US history. This is threating to Europe and the continent has been reported concerned over decreased competitiveness and possible project relocations from EU to the USA. However not all is competition and foreign collaboration initiatives have been accepted with special focus on electrolyzer technologies. (Horner. W. 2023) Aside from the States, Mexico increased their emission goals from 22% reduction to 35% for the next eight years (MIT Technology Review. 2023). This does demonstrate a progressive approach and encourages the use renewables and developing new, more efficient technologies. Not just from the industry perspective but on a governmental level, most ambitiously in the United States but also throughout the continent.

Canada has informed aiming to be emission free by 2050 by enforcing supporting policies and regulations, investing in green energy and – technology as well as work with carbon pricing to work in their favour in this journey towards renewables. The government is also focused on educating the public and private sector on green policy adaptation demonstrating in depth consideration of implementation. (Conigrave. B. 2023) This shows long-term thinking also on a societal and humanitarian level where initiatives are not only financial but show social responsibility.

3.1.3 Asia

The research on Asia turned out with the most unexpected results. While in other markets, domestic manufacturers have the ball, in Asia the market is dominated by European burner companies based on search engine optimization and search results of Google. After studying sites as in market presence, product ranges and industry reputation from company sites the notable ones were the previously introduced Baltur, Weishaupt and Riello. In this section the competition is quite even with equal internationalization and experience in years as can be seen in the detailed specs in the table (table 3) below.

While Asia is dominated by European brands, the Chinese innovation technology is rising globally, and identical counterfeit products are available on different websites like burnercontrolbox.com by Jinzihao. While not yet imposing a direct threat due to lack of experience and international brand recognition in this field, due to China's potential as a green energy producer and consumer further discussed in the next section, their assets and innovations need to be acknowledged to forecast competition and markets.

Company / Specs	*Country*	*Employees*	*Year of Experience*	*Countries with presence (internationalization)*
Oilon	Finland	400+	62	70
Baltur	Italy	No Information	70	60
Weishaupt	Germany	4100	71	120+
Riello	Italy	1800+	101	120

Table 3: Company specs based on each company's website's 2023 data. Asian market area

Project and funding wise Asia have also made advancements like its western counterparts. Most prominently South Korea enacted a carbon neutrality act and started a climate fund valued at nearly 2 billion USD in 2022. They also increased their spending on emission reduction by 50%, totalling to a bit over 9 billion USD. Hong Kong nonetheless invested in sustainable finance leadership the same year and the bonds are now worth over 10 billion USD. Thailand's green performance has decreased over the years but regardless of this they have launched a collaboration with the Saudi Arabia to receive technology for green hydrogen production. The production estimation is as high as 225 000 tons per year. China being the giant of Asia has been showing their efforts. While they aim to a 33% cut of all consumption coming from renewables by 2025, they are currently already reached a point in which over a quarter of their energy consumption is coming from renewable sources. Japan on the other hand invested 892 million USD on low emission fuel R&D via a government owned agency called NEDO. (MIT Technology Review. 2023) From this plenty of the notable achievements and advancements are in South-East Asia which is an important note when evaluating Asia as a market for Oilon. The local governments have acted and continue to do so to keep up with the rest of the world. Considering nearly half of the world's emissions are due to Asia being the home to the globe's top 10 emitters, this is great progression and a much-needed advancement in environmentalist consideration (Chhabria. P. 2023).

3.2 The Analysis of Hydrogen Markets for Future Potential

This chapter takes a dive into the outlook of the markets by understanding the cumulative production capacity forecasts of green hydrogen as well as the future trade outlooks of it. This section adds in new markets that Oilon wished to be analysed for market potential that cannot yet be considered the present-day key regions unlike the previously examined continents. To elaborate, the company hoped to see a dissection of regions increasing in hydrogen production and a breakdown of the market potential of the following areas: Europe, EMEA, and North America, thus adding Africa and the Middle East to the mix.

Globally practical use of P2X hydrogen is still marginal. However, studies show that the growth is evident in North America in the US and Canada, in Europe in Finland, Norway, the UK, Germany, Italy, and Spain, and in the Asian markets Japan has expressed the most openness towards this form of hydrogen production and use, especially through water electrolysis. (Ursúa et al. 2012) As mentioned before, also Australia has shown interest in the technology on a grand scale.

This data is supported by a study on the top 10 countries on hydrogen production that lists Australia, US and Spain as the biggest green hydrogen producers by 2030 based on different projects and related targets. From Americas Chile and Brazil have been listed as having massive potential, from Africa the number one spot goes to Egypt and then Morocco and Asia is represented by India as otherwise potential China was wiped out due to lack of competitive production targets. Also, Japan despite their keen interest did not make the cut. Yet when this is re-evaluated by the Chinese government their position is expected to rise among their targets as they are known to be ambitious and prosperous in renewables such as solar energy. When it comes to Europe Spain and Germany are estimated to hold the biggest producing possibilities. The visualisation of above is presented in the line graph (figure 3) illustrating cumulative capacity expectations of each country of the study quantitively. (Klevstrand. A. 2023)

Usage wise in Europe Norway has taken their sustainability as far as collaborating with Germany to create a transportation pipeline to support the logistics of blue hydrogen and advance the production and logistics of green hydrogen in Germany to support its related infrastructure and value chain. Together they hope to support Europe's competitiveness on the markets and ease the green transition. (Collins. L., Radowitz. B. 2023) Despite this, arguably due to India's success and China's massive potential and far-reaching resources studies also predict Asia-Pacific will arise and show its claws to the rest of the world as producers (Presedence Research. 2023).

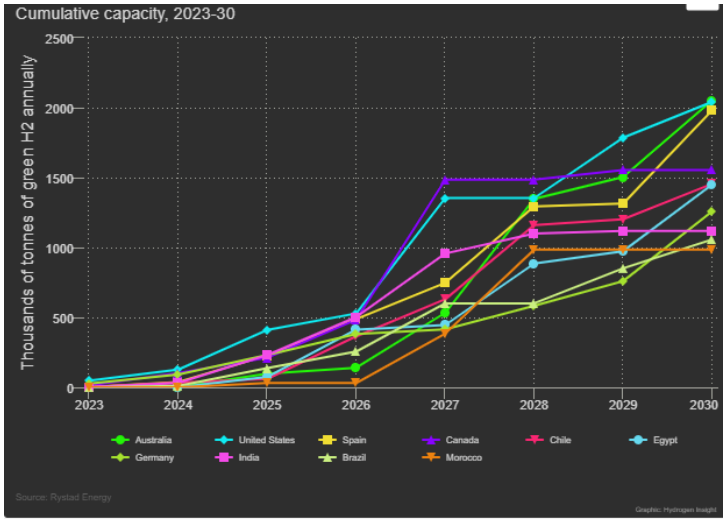

Figure 3: *Countries cumulatively by green hydrogen production, years 2023-2030. (Klevstrand. A. 2023)*

Now it is known who the future power holders of green hydrogen production are, so the next thing to do is to evaluate consumption trends. As of 2020 the top consumers have been China, the US and India followed by Russia and the European Union. China's number one position is far ahead of the followers, consuming 23.9 million metric tons while the second largest consumer only consumed 11.3 million metric tons. Out of the producers also Canada and Egypt made their way to the top consumers, consuming 2.5 million metric tons and 1.4 metric tons of hydrogen in general. The exact statistic is presented as a graph (figure 4) listing the top consumers alongside their numbers. These accounts all types of hydrogen from grey to green and blue in between. (Sönnichen.N. 2020)

Forecasting hydrogen demand shows the markets will remain approximately the same. China's demand will grow initially by 2030 to 40 million metric tons to 200 Mmt by 2050 further demonstrating the country's immense potential as a market. Europe will experience a growth from 2030 estimation of 20 million metric tons to 95 Mmt by 2050, North America in the same forecast will increase from 25 to 95 million metric tons within the same time span and the rest of the world will go from 50 Mmt to 235 Mmt confirming an increase globally. Once more this 2021 forecast oversees the consumption of all types of hydrogen. (Aizarani. J. 2023) Australia aside we see consumption trends are liked to production, re-enforcing trend has been and continuous to have a big focus on locality. Yet this can be prone to change as storage and transportation methods ease through the increased positive environmental impact.

Pure green hydrogen aside and all variations into consideration, 65% of overall consumption are focused on Europe, North America and Eastern Asia (McKinsey & Company. 2022).

This data however demonstrates that Oilon's interest is on the right course. Tackling technological challenges to adapt to green hydrogen use imposes massive growth potential and positive branding opportunities as the sustainable forerunner. Though the above data is for the use of hydrogen in general it confirms its strong position in the future. This together with the reinforced and governmentally accelerated global green energy transition it can be predicted that pioneering P2X hydrogen burners in the correct markets will be the right move for Oilon and support its strategical goals. Publicly available reports do not seem to detail the division of regional hydrogen consumption by pure hydrogen and processed variations of it e.g., methane that the commissioning company originally requested.

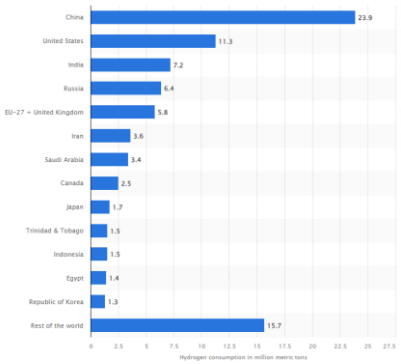

Figure 4: *Hydrogen consumption globally in 2020. (Sönnichen.N. 2020)*

With the previous key factors of supply and demand in mind, it is important to know that there is an imbalance in costs of production of hydrogen in general which can vary to be up to two point five times higher in more expensive regions in contrast to the cheapest. (McKinsey & Company. 2022). From the below figure (figure 5) it can be seen which producers are the cheapest and which the priciest. The same photo also paints the US, Central Europe and East Asia, especially China as demand centres in 2050 forecasts. The developing nations hold the place as the cheapest areas varying all the way from South America to Africa and Southern Asia, Australia being an exception as a developed nation. Some parts of Asia in production are not competitive considering import pricing. However, to some degree, outside of Japan and South Korea they do have competitiveness, especially in China locally and globally.

China does offer the most diversity where there are more expensive regions to produce that are not competitive, but they also have the largest cut of globally competitive production. In Europe pipeline hydrogen has plenty of potential continentally but imports and exports are not beneficial for the region. The US has production capacity to proximate markets as well as to correspond local demand but much like South America and India they will be importing most of the hydrogen derivatives. Research also shows that most of these market areas are in the middle when comparing whether it is more profitable to produce locally or to import when it comes to hydrogen as it is.

Most producers outside of Japan and perhaps South Korea do still fall into production locally being more cost efficient for them. However, when it comes to derivates like ammonia and methanol, almost all except some parts of the USA would experience imports to be more profitable according to 2050 estimates. (McKinsey & Company. 2022). As green hydrogen adaptation rate and global interest grows, so does the prediction on international trade. On this basis the author sees P2X technology as an obligatory energy carrier in the field. Therefore, the author links these two and estimates that in order to be efficient in trade the popularity of P2X as a carrier and a combustible fuel must rise alongside.

Nevertheless, the demand centres themselves already align with Oilon markets which is great considering the big production centres are also in these regions, supporting locality but also keeping a door open for exports. This data also suggests that there are big markets for pure hydrogen which have local and trade potential spreading the good across market areas and ensuring availability throughout chosen areas, opting there is also a niche for hydrogen fuelled burners. To keep in mind that where the local supply is minimal regardless of increased profitability of importation, the price will also most likely experience increases. Thus, from the customer perspective its crucial to consider if at the beginning of stage of adaptation there is financial readiness to invest in hydrogen burner use if prices are high. Shall it be so that prices drop as the technology becomes more mass produced and popular, the potential of these markets should not be overlooked meanwhile they should not be the primary focus initially. Instead, the initial focus would be on the mature, economically well-off nations with at least some local or proximate production to keep prices low and infrastructure supported. Such initial markets for hydrogen burners could be Central Europe, the USA and China. Followed then by non-central demand centres but still potential like rest of Europe, North America and rest of East Asia.

Experts see taxation and related regulation to be a big question on whether trade will surpass locality. Many experts do not see derivative driven trade being attractive in the markets. According to additional sources, so far it does look like the local focus is a key element of the hydrogen economy as it seems to avoid many of the transportation and trade related issues that also seem to be the biggest concerns of the whole thing. Alignment with previous research suggests that pipelines hold possible distribution potential for hydrogen.

This survey result was primarily positive in Europe while non-European participants were against it. (Kruse. M. 2020) As access to ample supply of low-cost renewable energy is seen as one key to adaptation, this calls for an advanced infrastructure and partnership network. Immature markets cannot compete with more developed ones without a good and well-managed organization. Business Finland panel chose Europe as the withholder of the most potential in green hydrogen by 2040, followed by China. Other notable mentions related to Oilon were Japan, North America, and the Middle East. The results may be biased according to Business Finland (Kruse. M. 2020) but the group stability enforces the results and they do align with the other sources used in this thesis. More on market selection, alternatives and evaluation criteria will follow in the next subsection of this thesis.

Likewise, literature once more emphasizes the importance of infrastructure not just resource wise but also logistics wise in an article by N.P. Brandon and Z. Kurban (2017) in which the authors debate the importance of hydrogen specific pipelines, suitable for this traditionally difficult fuel to transport. Once more increasing the importance of investment in this sector on a national and international level.

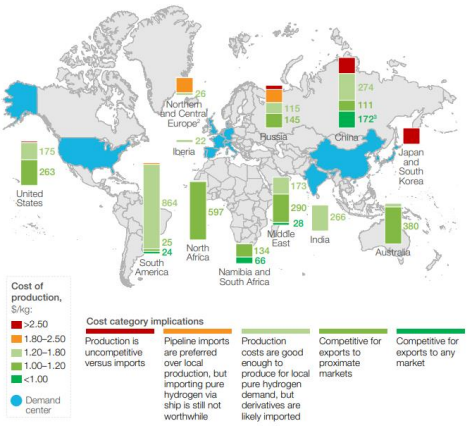

Figure 5: *Country specific calculation on hydrogen production competitiveness by 2050, numbers in million tons per annum (McKinsey & Company. 2022).*

As the supply and demand are explored, the next important thing from Oilon's perspective to understand is the use. In the photo presented as figure six there is a graph that shows for what clean hydrogen can do to the emissions of each industry. On the horizontal axis there are years from 2020 to 2050 and on the vertical, there are gigatons of cumulative CO_2 decrease by 2050 as a quantitative measurement. From the picture (figure 6) building and industry heat can experience huge positive changes from hydrogen utilization. It shows that the potential gigaton savings by 2050 for the heating industry could cumulatively be at around 50 gigatons. Though there is no quantitative report on ammonia or refining of hydrogen per country since savings in that can be up to 80GT. However, the estimation is that by 2050 half of clean hydrogen is transported overseas and 75% of its derivates will experience the same faith in that time frame giving some idea how the market divides. (McKinsey & Company. 2022) It must be seen as a big industry as well and something Oilon had addressed being curious about as refining could impact the need for hydrogen combustion in its pure form

An important note by Mr Kattelus, Oilon CTO is that they would not see themselves fit only to heating but to all the figure 6 categories besides transportation. And even in transportation they do operate in maritime but marginally compared to the other sectors.

Therefore, though the highlight is on heating the industry impact Oilon could possibly make expands beyond those limits. But this does show that environmentally Oilon's contributions can provide massive returns for the environment CO_2 emission wise.

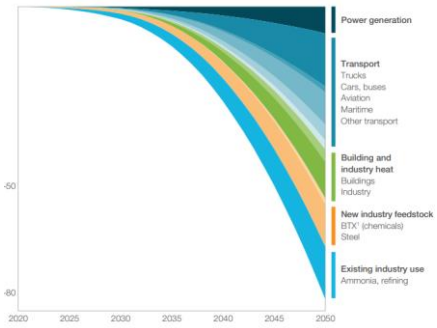

Figure 6: *Heating Industry's potential to reduce CO_2 emissions, years 2020-2050 on the horizontal axis, gigatons on the vertical axis (McKinsey & Company. 2022).*

Not only is it crucial to understand what the key regions of the hydrogen economy and its forecasts are, and what are the environmental savings but when it comes to a new technology and its adaptation also the innovativeness of the region, or in this case continent, should be looked at. The way it is done is by looking at the top-ranking countries of each continent and comparing them to each other to see which continent is the most innovative, R&D driven and shows the most openness in technology adaptation and initiatives. The measurement tool is Global Innovation Index, GII, rankings from 2022 in which the previous aspects were measured based by comparing the country's innovative inputs and outputs and accounting everything from the affecting institutions and infrastructure to markets, knowledge and business sophistication (WIPO. 2016). These pillars as they are called reflect how well the environment supports innovations and businesses. Institutions measure governmental support and protection, infrastructure is more general but considers e.g., sustainability and energy aspects, human capital and research measures things like research and education, markets overlook growth potential, investments and competitiveness and market sophistication kind of evaluates how this all comes together in business practises. Knowledge and creativity outputs evaluate their effect on innovations and out-of-the-box thinking. (WIPO. 2016) The highest-ranking countries with their global rank in the parenthesis for North America were the US (2), Canada (15) and Mexico (58), for Europe Switzerland (1), Sweden (3) and the UK (4), for Asia China (10), Singapore (7) and South Korea (6) and for the Middle East Israel (16), UAE (31) and Iran (53), and for Africa South Africa (61), Botswana (86) and Kenya (88) (Geneva. 2022). From this data it is evident that the epicentre for innovation is Europe and North America, having the highest-ranking countries. Also, Asia withholds a lot of potential while the Middle East and Africa rank visibly lower. This is something to note when making suggestions for Oilon market wise as technology is a big part of innovation and vice versa and with the high score a better and more rapid adaptation could be predicted. Ranking well overall in these categories would mean an efficient support system both micro- and macroeconomically by the government and by applied professionalism as explained by the pillars of evaluation categories.

Another index worth evaluating is the green future index which ranks countries based on sustainability. It measures the carbon emissions, energy transition, societal aspects, clean innovations and climate policies of 76 different countries globally. The results are based on efforts towards becoming clean via enforcing policies, investments in renewables and innovation. Thus, in this case this could be considered as the extension of the previous index.

The numbers are that of 2023. Once more the ranks are dominated by Europe, making 90% of the top 10 list of the overall greenest nations. The other 10% is represented by Asia and South Korea placing 8th in the ranks. Top 20 is enough to include the US and Canada representing North America. Top three nations by overall ratings are Iceland, Finland and Norway respectfully, maintaining a good position in all the above-mentioned categories.

To break down the five separate pillars individually for reducing carbon emissions, in addition to Europe, Africa had made notable ranks with Angola placing second in improvement on climate action. Hong Kong represented Asia on the fourth spot. (MIT Technology Review. 2023) Also, Latin America had done notable job in this section but as this is not Oilon's current or future interest, it is recognized but not analysed further. Energy transition pillar offered a top 10 place for all continents having Iceland as 1st UAE as 2nd, Norway as 3rd and Sweden 4th followed by Kuwait as the 5th. Saudi Arabia placed 8th while South Korea holds the 10th spot (MIT Technology Review. 2023).

As for green society assessing societal promotion of green practices the top 10 were rather divided between Europe and Asia. Positions 1,3,5,8,9, and 10 were held by European countries and 2,4, and 7 by Asia. This is the most equal division between Europe and another continent so far though it is still not close to 50/50. Number 6 was taken by the US. Clean innovation pillar measuring green patents and related investments demonstrated a similar trend. From the top 10, three were Asian countries and the rest European, illustrating these two being very progressive in sustainability across the board. Something interesting for Oilon has got to be that Finland ranked first in this one due to passing legislations requiring lowering carbon emissions in construction. Climate policy wise the top 10 countries consist almost fully of European nations with the only exception being Canada at number six. To see fellow North American nation, one will have to look at position 14 where the US is located, and the first Asian correspondent South Korea can be found three ranks down at the 17th position. (MIT Technology Review. 2023)

As a part of this thesis, Oilon wanted to know the potential for production and consumption of green hydrogen in relation with their products in the following markets: EMEA, North America and Asia, more specifically China. Quite frankly these have also been the countries most discussed by market potential so let us draw content from those and go a bit deeper into it.

EMEA stands for Europe, the Middle East and Africa. Based on previous data and analytics the latter two are not in the strong when it comes to market capabilities and the future outlook. While Europe will be discussed in a minute on the basis of the data already presented, the dissection can be started with the Middle East and Africa. Neither of the two made a strong entrance in the introduction of the hydrogen markets. From Africa only Egypt and Morocco were presented to have the comparable ranking for production and shine in this field, yet their numbers were marginal in comparison to other in the same listing (Klevstrand. A. 2023). Consumption wise currently Iran, Saudi Arabia and Egypt hold their place in the set of top consumers (Sönnichen.N. 2020), yet future forecasts have dropped them as individuals and categorized them as "the rest of the world" (Aizarani. J. 2023), suggesting Africa and the Middle East do not yet have measurable potential worth noting as its own. However, to bring prospect and objectify their positioning, these markets were separately researched as they were not present enough in global studies to make credible assumptions.

The lack of reports despite being a resource enriched country renewable energy wise, could be due to uncertainty. While production- and export costs in these areas have been deemed cheap, especially from Europe's perspective, financial instability and investment risks overshadow the potential (Wettengel. J. 2022). This said, the cost efficiency that could be achieved over time would need a massive amount of funding, investment, and innovation in these regions to achieve the needed development socio-economically. This meaning increased sustainability, better infrastructure, reliability, and advances in technology. The area also requires local policy advancements and legislations to become optimal for producing P2X hydrogen. So, while the potential is there, the lack of infrastructure makes these two not quite as mature as the other options and increases production, sustainability, and distribution related risks by not having sufficient framework or surveillance. (Samaties. P. 2022)

Though this already shows the risks in these markets are high but to support it further research in the competition was conducted to make fair comparison to the other markets dissected above as current markets. The market is rather focused on retail rather than their own brands.

The African self-proclaimed market leader for in burner retail is called Combustion Technology from South Africa with 35 years of experience retailing e.g., Limpsfield and Riello burners, enforcing their presence in the market (Combustion Technology. 2023). In the Middle East is the US company Zeeco has a big presence with over 49 years of experience offering similar burners to Oilon's (Zeeko. 2023). And to the Author's positive surprise this was the first market area in which Google search results picked up Oilon, but it was not found on any retailer site from the search engine optimization generated top picks list.

However, what is important to note it is only the local governments investing into green energy in Africa. China for the longest time has addressed their interest in helping Africa in related projects in exchange to mutually benefitting from the trade financially. The continent is the country's biggest trading partner and since China is a world leader in solar and wind power, they have a lot to offer in these markets. Their investments in the continent continue to increase varying from consulting and servicing to solar- and wind farms allowing China to access the rich resources enriching them in the process.

While the U.S. has potential to do the same, they are not so keen to the markets as they are offered less governmental funding from the States side, unlike China whose investments are very much government driven, giving them a financial advantage in the markets. Research does suggest partnerships will be crucial to reach success in sustainable energy sector globally. (Bartlett. K. 2023) This is important for Oilon to keep in mind that focusing some markets to Asia, to China specifically will evidently utilise African resources as well. This allows skipping the African local socio-political and infrastructure related risks as China will take on them through their initiatives and projects. Through that it has the chance to enhance the flow of renewable energy and fuels to their own home markets, increasing popularity and decreasing prices throughout the ecosystem as the technology becomes wider accessed.

Due to the contrast in true potential focusing both short-term and long-term MEA, the Middle East and Africa will be analysed separately from Europe.

4 Discussions

The discussion will follow in this chapter, meaning that the findings of previous research are being analysed and examined. First the key is to understand the extended market potential beyond the current markets by understanding the company profile a bit better. Once the complete company profile is being drawn the next thing to understand is the markets themselves and their potential accounting the company strengths and weaknesses alongside external opportunities and threats. The markets are evaluated by various factors affecting the push and pull effects of each and every market will receive a fair risk analysis to complete the picture. In addition to the secondary data this section will also introduce the collected primary data that is drawn from a survey and multiple interviews with experts.

After a thorough analysis the road map and implementation alternative suggestions are presented in a visual and descriptive format.

4.1 Understanding Extended Market Potential

Now that the markets have been scouted and dissected let us move on to market selection via an analysis of Oilon's strengths, weaknesses, threats and opportunities alongside diving deeper into the previously collected data. In addition to the previous markets, the MEA area will be digested like the existing markets. This section will evaluate the alternatives by strengths and risks and contrast them to Oilon's assets in the field.

4.1.1 Oilon's Company Profile

As insinuated the first part of this section is an analysis of Oilon's strengths, weaknesses, opportunities and threats which allow us to understand the company's position now as well as forecast its future potential to some degree. This SWOT was specifically made with hydrogen potential in mind, so it is more focused on those aspects rather than the company in general.

Undoubtably 60 years of history has guaranteed the company plenty of experience. As sustainability has advanced so has the technology, progressing from heavy oils and fossil fuels to lighter and bio-options. All the changes have required a lot of R&D to adapt to different fuels. All evidence presented in this thesis so far do opt for P2X hydrogen as a potential green fuel for Oilon's array of burners. Different fuels burn in different colours meaning flame detectors must be carefully selected and different combustion also requires a different burner head to control factors such as emissions. Such expertise has allowed Oilon to meet and exceed their emission targets as components and alterations play a crucial role in adjusting all emissions. Having this experience supports Oilon with combusting hydrogen, knowing what the standard changes are and how to implement them. Lucky for Oilon this is not a trial round on hydrogen combustion as they already have experience it, yet it is mostly coming from mixing hydrogen with another fuel such as natural gas with 70% and 30% ratios respectfully. While having such experience is great, but 100% combustion adaptation is needed more to become efficient and strong market player with this technology.

Based on a meeting on the matter on 25th of August 2023, such green transition to P2X is in the company viewed important opportunity for positive employer branding and strategy application according to Chief Technology Officer Joonas Kattelus. Not having much of such is a weakness that can be turned upside down by trial, prototyping and field testing. Also, trainings will be necessary since technical support is still inexperienced to commission and maintain these types of burners. Likewise, if the future was to be modular and hydrogen combustion was to take off trainings on fuel type changes would come in necessary for both intercompany and clients. Luckily, staff and clientele are experienced and adaptable based on prior industry progression and their existing knowledge will ease the load of training needs.

However, it is not only the willingness of adaptation but also the efficiency and resources. Prices can be portrayed as a risk if technology advancements cannot bring them down enough to be comparable to other fuels that possess the same capabilities performance wise. As noted before the competition has already gotten a whiff of this and worked on lowering production costs, however the author would argue as this type of hydrogen becomes more popular such solutions are researched by national institutions as well, taking off some of that competitive edge and contributing towards the good of the end customer.

This said, this would place Oilon in the value chain as a channel that offers a product and a way for the energy transition and in this way accelerates it throughout the three steps of adaptation, residential, industrial and infrastructural from kW scale to GW scale. (Rahman Daiyan, Iain MacGill, Rose Ama. 2020.). They are an infrastructural pillar advancing the creation of the sustainable energy ecosystem but also, they are a service provider who offers a demand product and a tool for the technology consumption. This place the company in a central key role in this circular hydrogen economy. This also puts the company in threat of innovation theft in case they do find new pioneering solutions optimizing hydrogen combustion. Of this topic there will be more information in the detailed market risk analysis in the market evaluation section. Such central position offers Oilon the chance to enhance the brand and even enter new markets if desired. The new markets do not have to be new physical locations but perhaps new clientele that comes with hydrogen combustion. Such could be expected from industrial sites not adequate for heat pumps as those are the best suited for the tech according literature review estimations.

This brings us to the last notable weakness beyond the obvious size comparison to competition which is the recent investment in digitalization. While this is a step to the right direction optimizing competitive digital resources will take time. Had this been done before there is a chance such product changes, component demands and overall operation optimization from R&D, manufacturing and warehousing to marketing and reaching the clientele could have been enhanced as information flows smoothly, transparently, and timely alongside up to date documentation. As one cannot know the competitor's software and systems they can only be expected to be used as an easy unfair advantage and thus will need special focus on Oilon's behalf as well to keep up. The conclusive visualization of the SWOT is presented below (Figure 7).

Figure 7: *Oilon SWOT analysis for the hydrogen markets*

In addition to the SWOT as the analysis on the company's profile also a comprehensive customer profile was assessed. Based on a survey from 2022, interviewing 104 customers the company was able to profile what mattered the most to the customer. The basis of this evaluation was a KPI called, NPS, net promotor score that ranks customers to categories: promotor, passive and critics. The promotors naturally promote the company, the passive exists as customers but do not engage in such active promotion as the first group and lastly the critics usually have some criticism to share and help the company to develop. (Danelon. M. 2022)

In the case of Oilon over 60% of customers gave the company an excellent grade. The scale of NPS evaluation is -100 to 100, 100 being a perfect score. It is calculated by subtracting the per centage of critics from the per centage of promotors. Oilon score was 49 NPS falling into the category of great but not excellent. However, what most supports the topic of the thesis was that the best score out of all categories Oilon reached in being sustainable. This means the green transition and sustainability in the company operations has not gone unnoticed and is even praised among the consumers. (Danelon. M. 2022) This indicates awareness and potential willingness to invest in innovative sustainable energy technology.

Other successful points for Oilon were contact personnel availability, respect for customer relationships, expertise and being customer oriented. Critics the company received over being understaffed in the department of technical support and at times lacking in communications (Danelon. M. 2022).

This emphasis is on the importance of value and message. Being environmental, being responsible, and communicative weigh over other more materialistic regards, which can be helpful in adapting such environmental technology which initially may increase costs on both sides of the supply chain. However, the critics must be taken seriously as new technologies will likely increase the demand for customer service and technical support during the initiation processes and adaptation phase.

The idea of the SWOT and studying the NPS customer analysis was to derive the company's core competencies and strategic capabilities from it. Core competencies include the learned skillsets of individuals and groups across the organization. If they are hard for the competitors to imitate the company can find their competitive advantage from within these skillsets. (Prahalad and Hamel. 1990)

One could argue that in Oilon's case the clearest advantage they have is their extensive experience alongside customer satisfaction in their sustainability strategy evident from the company background and NPS survey. This gives Oilon a strong basis to innovate new combustion solutions as personnel have obtained expertise and knowledge throughout the development process of said technology and the customers show alignment with the sustainability objective. When it comes to Oilon's dynamic capabilities they lie in the company's opportunity to seize the opportunity. Dynamic capabilities are a model designed to recognize the company's ability to reform in the era of fast paced market changes (Teece, Pisano and Shauen 1997) Due to the expertise and having its own on-site laboratories at Lahti factory, Oilon can operate independently, at its own pace and by doing minimize innovation and intellectual property theft in the process. Own laboratories also risk less dependency and allow fast movements not reliant on anyone else if needed. Customer willingness to become more environmentally friendly improves the adoption rate by decreasing the external risk of a high threshold.

4.1.2 Internal and External Market Interviews

Oilon interviews were started early September 2023 to acquire primary qualitative data on the topic from internal sales personnel and internal and external professionals.

The interviews were conducted as surveys as well as in a form on online meetings and emails. The internal survey included one set of questions and the in person and email interviews had one of their own. The internal questions were designed to be more specific to address the insight of internal sales personnel while the other set of questions was broader in hopes of sparking conversation through a wider set of experts from different fields. Both sets of questions can be found as the appendices with adequate descriptions. For the sake of ethics, all respondents were informed on the purpose of the study and the permission to use their answers was requested and granted.

The goal of the interviews was to understand weather primary data collection would confirm or oppose the findings of secondary data collection and if they could add value and perspective to the research. The results will first be revealed on the internal survey level after which there is the insight from the expert interviews.

The internal survey was conducted via Survey pal for which 38 invitations throughout the company's sales departments were sent. The response rate at the end of the survey period was 44.74%. The survey consisted of multiple-choice questions and open text fields for more in depth responses. The exact questions for the survey can be found presented as the Appendix 1 at the end of this thesis.

For the first question, the replies were divided strongly into two. Most responders saw hydrogen having potential as its own while the rest viewed its potential being at its best when mixed with other fuels like natural gas. The division was 65% and 35% for pure and mixed respectively.

Most respondents reported having an increased number of hydrogen burner inquiries in recent times while a small percentage reported the number of inquiries staying the same or slightly decreased. Only 6% of respondents reported not having any queries for these burners.

The regions in which the inquiries have come from include Brazil, Chile, Mainland China, Italy, Spain, Georgia, Russia, Argentina, Ukraine, Kazakhstan, India, Germany, Poland, The USA, and Belgium. These statistics support the initial demand center allocation of Europe, focus on central and southern regions, Asia focus on China and the Americas, North and surprisingly also South.

When surveyed about the drivers of customers when choosing a burner and a fuel the key was reported to be price with 13 respondents choosing this. The follow up is sustainability at 8 respondents which aligns with the NPS survey results previously conducted to analyze customer profile and satisfaction. Four respondents who had chosen "other" as an alternative had specified emissions being a massive factor, falling also in the category of sustainability. Not far behind comes availability and services, which therefore are much appreciated by our customers and must be focused on in the adaptation process. One respondent who had chosen "other" as an alternative had reported this varying from region to another on the main basis of availability.

Analyzing the results, what stood out was the importance of services. As there is an innovation in the making, pre-launching Oilon must ensure staff has received adequate training to correspond to servicing, commissioning, and other service-related demands of customers such as technical support.

Additionally, as availability and price have been brought up so strongly the focus should indeed be initially localized to demand centers and production areas, which have been research to be corresponding areas to each other and the adaptation should be gradual to account for early phase availability challenges.

On the topic of challenges, the next question concerned whether the respondents had any concerns about hydrogen combustion. This question had a rather fractioned response. Some elaborated being concerned about the costs and transportation related issues due to flammability. Especially in China their concerns were related to logistics. Some addressed their worry on burner technology not being developed enough to combust hydrogen without component wear and tear alongside addressing unease over their own lack of expertise in this field. Out of 17 respondents, however, nearly a quarter said they had no concerns whatsoever. The rest who did not respond out of the total number of respondents, can be added to this category as the question in the first hand was addressed to those who do have.

Previous research shows that infrastructure for transportation and storage is seeing investments and is of interest of government agendas alongside product and service innovations. Once those projects and initiatives kick off and start seeing results one can see the logistical methods and – pricing evolving to be more attainable and improved, causing a decrease in prices and lead times. Also, this should address availability concerns in the mid- and long-term thinking. Likewise, electrolysis and other technologies linked to P2X, and green hydrogen are predicted to be subject to learning curve, dropping prices on an annual basis as reported previously in the literature review. In conclusion, these concerns are topical but are also already being worked on even on an international level to be resolved. Thus, with time and progression these worries should naturally fade as technology becomes more popular.

The next question concerned Oilon’s position in comparison to the competition. The responses were divided into three categories. Most of the respondents said Oilon is behind the competition in hydrogen combustion technology. One respondent elaborated believing Oilon is ahead of the Chinese market but lagging in the others, emphasizing the successes of Honeywell in this field. Another important note was that even if the technology did exist in theory the concrete application has been too slow in comparison.

Nearly half did see Oilon being ahead or aligned with other burner manufacturers, claiming Oilon's good field experience was to thank for this. The third and the smallest fraction of this segment was those who addressed that Oilon is keeping up and saying H_2 burners should be standardized. However, Oilon should not be too keen on the statements of being ahead but note that a big part of their own sales personnel believed the company to be behind or barely keeping up. These opinions are important to shed light on the true and concrete nature of the situation, being in comes from the customer frontline and is the timeliest information one may acquire.

Coming back to learning curve and adaptation, the second to last question was on timeframe estimation. For the transition, most estimated on average 10 years. A small group of respondents had answers between four to eight years while the rest predicted 10 or even 15 years. One respondent even predicted the transition acceleration in the field starting to take place in six to eight months stating it is vital for decarbonization. On the other hand, one responded did state that they do not believe in a transition but instead see hydrogen standing alongside natural- and biogas.

While there is some uncertainty visible in the fragmentation of answers still as a median and average plus minus 10 years is seen as the optimal transition period. These statements are supported by the thesis' market research showing acceleration already within four years and increasing as we get closer to 10 years. This shows Oilon is recommended to start putting emphasis on this technology as there is still time for trial and error without ultimately falling behind.

The last segment of this survey was an open text box for sales personnel to leave any other comments regarding the subject that was not already addressed. This was designed to close any gaps that might have been left by accident. However, nothing new was brought up in this section and most of its comments were stating how hydrogen combustion is a good and current topic, in need of research for Oilon's benefit. Most of the sales personnel do see the future in hydrogen and emphasize that to succeed experience and advancements in technology are needed.

All in all, the potential is recognized internally in alignment to the market study of the previous chapter of the thesis and the literature review.

The potential is seen in pure and mixed format and the challenges are the same as addressed in previous literature and by the governments. Therefore, the survey responses and the rest of the thesis enforce each other and create credibility.

The external interviews consisted of more general questions around the topic adjustable for the different fields of expertise interviewed. The interviews went on during September 2023 via Teams calls and email threads. This selection consisted of four participating companies from the manufacturing and supplier side as well as technology perspective and focused on the European, North American and Chinese markets.

In an email exchange with Siemens U.S. representative on the 1st of August 2023, they did have a more reserved outlook on the topic. Siemens is an internationally recognized company offering a variety of products and services related to industry, infrastructure, and transportation with a history of 175 years. (Siemens. 2023) The cooperation with Oilon is focused on the burner component level and Siemens is an important partner in the company's supply chain which is why they were chosen to represent the supplier and manufacturer perspective. They argued on behalf of electrification of heating over pure H_2 driven approach, claiming the inefficiency of modern electrolysis as one of the reasons why that is. The representative claimed propane being a main source of heating in the USA and stating that only a fraction of that will be replaced by green hydrogen and the same faith they said would experience the transportation industry. Instead, the representative believes in the consumption of natural gas, a gas often preferred to be mixed with hydrogen stating:

"Natural gas consumption is increasing in the USA and will continue to increase for the next 15+ years until all the coal fired electricity generation plants are converted. Natural gas consumption in the US stands at more than 90 billion cubic feet per day. This will probably peak near 140 billion cubic feet when the coal plants which account for approximately 20% of US electricity production are retired. Nuclear accounts for 20% of US electricity production. It is not clear if nuclear will transition to NG before its final transition to renewables."

While this does not necessarily invalidate the potential of North America as a whole it suggests there is an additional step in the process called transition to natural gas prior to renewables. However even if this is, renewable hydrogen adaptation could be started as a mixer even before the long-term transition to pure renewable use.

In a separate email forwarded by the same representative on September 3rd, a retired Siemens U.S. employee shared their thoughts on the European situation. They discussed the following key points affecting the H_2 market and demand from an infrastructural standpoint.

Starting with, while the prices of gas and oil especially at proximity are low the Russian influence should be avoided at all costs. As of this moment electrolyzer technology is not yet competitive but the rep estimates a roll out to take place within a few years by an Australian company Hysata who they estimate to drop the hydrogen prices even lower than imported natural gas. While in many countries renewable production is subject to seasonal fluctuations, during peak times utilizing hydrogen manufacturing would reduce constraint payments. This would allow the machinery to keep running and if adding the hydrogen produced to the gas grid would then subsequently reduce the demand for natural gas. The rep estimates this would work until 20% of the mixture consists of hydrogen.

They continue by enforcing the point made also in literature review: the Ukrainian Russian war has accelerated the transition away from fossil fuels, especially in Europe. As the prices increased the demand for fossil fuels decreased even more than before. The rep views it as European industries already being constructed on low energy costs, so the aftermath of the war has been rather devastating.

They see the transition away from fossil fuels taking place within the next decades and believe a more attractive alternative must take its place. Due to green hydrogen allowing energy independence and a positive environmental impact, the expert sees plenty of potential in it, especially in the future. As of this moment they question its availability and suggest mixing it with natural gas as a step-by-step approach. They wrap up by having doubts on the risks and yet undetermined legislative factors of residential level heating but state the following regarding the burner industry.

“Short term you can install electrolyzers decentralized near the wind parks and use overproduction of electricity to produce green hydrogen, which then would be injected into the gas grid as a by-component. That approach avoids evitable power generation losses and just adds a little hydrogen to the natural gas supply. European equipment manufacturers for gas boilers and also some for gas power burners have already committed to being able to handle up to 20% hydrogen as part of their gas supply.

Given the massive capacity of the gas infrastructure such a percentage is years - if not decades – away. However, and that is the important bit, industry has indicated to lawmakers: "We are ready". Pure hydrogen applications are decades away, for supply reasons."

Such insight is supported by the above market analysis and enforces Europe's position as a strong potential market. It suggests transitioning is necessary but will take time and is preferred to take place in small steps. Unlike the three-phase transition model on Watt scale basis this suggests industries are the first to benefit from this technology above residential use. Likewise, it predicts while hydrogen is a great alternative the transition should happen using mixing techniques as a steppingstone. On the basis of the prior North American perception this is also supported by a wider selection to markets as an initiation for the energy transition.

The Siemens Germany representatives were interviewed via Microsoft Teams on the 25th of September and in the meeting participated a representative from Siemens Sales, their Head of Product Management along with the Standards & Associations manager.

Unlike Siemens U.S. the German representatives expressed a lot of positive interest towards green hydrogen. They saw it very potential in combustion to decarbonize heating and emphasized its role in Power-to-X sector coupling.

the Standards & Associations manager addressed that its carbon neutral production, efficient use, and properties to match natural gas offer great opportunities for the industry. For the energy sector, it would also mean efficient and meaningful use of abundant power.

As the challenges the representatives agreed on the yet uncertain availability, ramping up costs stating that regulation is much needed to take charge of the hydrogen prioritization. This is at least until fuel becomes more common, to ensure that those who need it the most can get their hands on it. They see that the local German infrastructure for transportation is already quite good from the past with natural gas and adapting this fuel would allow the users to become more independent and naturally less dependent on the current fossil fuel producers. They also point out that though the price is a question mark and often seen as a threat, the potential future taxation and -sanctions on fossil fuels can ease the competitiveness. The value chain role and expenditure division should be regulated as well to ensure even distribution of costs and overall efficiency of the process flow.

Schedule-wise they agree that so-called readiness on customer and infrastructure basis can be reached at around 2030-2035 and they presented locally collected data to further support this suggestion. On an operational level they have researched literature and prepared tests on their components in preparation for hydrogen. They advise that on an industrial level the needed component changes for combustion are smaller while on a residential basis it may require a bit more work and thus affect the ease of transition process. The Standards & Associations manager agrees that during the initial adaptation phase mixing hydrogen with natural gas will work out more efficiently than jumping into pure hydrogen combustion as this should reduce costs and improve availability in the beginning.

On the 6th of September a Teams interview was held to study the China's market potential from an advanced internal perspective. In the meeting participated Oilon's CIBB Mr. Wang, Wuxi General Manager Mr. Jarno Rautén, GM assistant Bonne Sheng who also worked as a translator and Danny Wang, the local sales network department manager.

Mr. Wang was able to give crucial insight to the local Chinese and Asian market. He saw the hydrogen derivates very potential combustibles alongside mixing it with natural gas for more environmental results. In the long term he did see a potential for pure hydrogen combustion as well, but that the two prior examples could be used in short term implementation to lower threshold and study the technologies further.

His perspective was very future oriented and positive. His outlook on adaptation challenges, however, was different from the rest. Whereas most research has pointed out the challenges in prices and transportation, Mr. Wang pointed out NOx emissions as his main point of concern. While Mr. Wang's expertise was rather focused on Mainland China market area, he did point out that out of Asia he sees Japan as very potent market for this technology calling them the pioneers and points out that South Korea has already started experimenting with hydrogen derivate burners.

This confirms as the sales personnel survey suggested Oilon could be lagging a bit behind of the most potent and aggressive competitors, demonstrating the thrive for hydrogen-based heating potential but also creating challenges how the technology should be applied to become the most competitive yet account for customer readiness.

Alongside this it validates that the steppingstone model of derivate use or mixing hydrogen before adapting pure combustion is suggested adaptation method.

A week later, September 13th, 2023, another interview with the Chinese representatives was conducted, this time with an important local Oilon dealer. The representative has over 25 years of experience in the field of heating with appropriate engineering degrees to complement it.

His opinions for the most part complimented those of Mr. Wang of the previous interview. Seeing mixed hydrogen combustion as a more realistic goal to achieve on the resource basis and clientele Oilon currently has. His special remarks were concerning lost deals over lack of mixed and pure hydrogen combustion technology. He said while the number of lost projects for pure hydrogen burners was only about ten the inquiries requiring mixed fuels are more common and must be declined over the lack of appropriate technology. Therefore, this enforces the idea of hydrogen combustion demand seeing that inquiries are being made and interest is shown to the cleaner and more sustainable combustion technique. Also, it indicates urgency in the matter. The representative emphasizes that H_2 mixed fuels can be used as a pathway towards pure hydrogen combustion when and if green hydrogen achieves competitiveness in price and availability, yet stating this could, in his opinion be far away timewise. Also, like many others he addressed his concerns for the current lack of supporting infrastructure but did mention pipelines already being very much used in local transportation.

The last interview for this section was with P2X Solutions. They are a Finnish forerunner in the green hydrogen industry, pioneering related solutions and projects. They are a producer and distributor of green hydrogen making them a central player in the value chain, probably the best known for their innovative project concerning building an industrial-scale production plant for green H_2 alongside its derivate, synthetic methane, in Finland. (P2X Solutions. 2023) For these reasons, they were chosen to represent the producer's perspective for this thesis and representing them in the interview was their Vice President of Business Development. The interview was conducted on the 22nd of September 2023 via Microsoft Teams and interview questions were formatted to suit the producer and distribution perspective in question.

Their representative sees the most potential in green H_2 solutions that work in applications that cannot directly be electrified. According to him, there is always a loss of efficiency in converting the energy back and forth, but he does emphasize that in heating, there are always sites that cannot be electrified, either at all or doing so would be too challenging. Such sites may be those requiring a high-heat flame or lacking sufficient electrical infrastructure and wiring.

He sees the most market potential being in areas that are mature and have the ability to pay for the "greenium" aka the extra costs coming from creating this environmental fuel. He admits the current costs of H_2 being more expensive to the traditional customer but states that sanctioning polluting and regulating emissions will work together with the learning curve to bring the costs down. This, he says, is the key to competitiveness. His suggestion marketwise is alongside the earlier mentioned maturity also the driver, suggesting areas in which regulation plays a bigger role in the transition are more prone to be keen on adapting this fuel. While he admits transportation is a concern for many, he says that in order to get infrastructural improvements societies must start adapting the technology and the fuel and start really building the value chain. The time frame he predicts the biggest and the most rapid growth the green H_2 industry, use, and production-wise, will see between 2025-2035, falling into the same category as most of the internal survey predictions which stated the average of five to ten years. The adaptation would be ramped up even more during this timeframe and afterwards the regulations become clearer and preferably globally adapted, creating a stable and all-around established operating environment.

He said the H_2 industries are now waiting for the related EU regulations to step in in 2030 which would clarify the markets tremendously. He said projects and applications have already been constructed to anticipate the green transition. The applications, in this case in the marine industry, are modular so that they can utilize these green energy sources as the fuels become more common and better available.

The P2X interview has important insight into the market potential and emphasizes the importance of governance and infrastructure in the adaptation processes. His perspective supports the idea of mature markets as an entryway to innovation adaptation and suggests modularity is not only a way for application but also a form of anticipation. P2X Solution's perspective aligns with the rest of the primary- and secondary data granted it very diplomatic giving different scenarios different potential.

The main difference in this interpretation is the timeline which suggests a slightly more rapid adaptation than the standard 10-15 years on estimate.

Nevertheless, the primary data argues using maturity on the basis of entry and suggests that perhaps using pure hydrogen as the entry way to hydrogen combustion may not be the most efficient way to adaptation, but instead the shift should be gradual and mature alongside the markets and their infrastructure.

4.1.3 Qualitative Market Analysis

To contrast all regions researched let us make a comparison of them in this subsection. The areas discussed in the previous sections are ranked by hydrogen production and – consumption, governmental agendas on advancement, maturity e.g., current projects and initiatives alongside the global innovation- and green future index rankings. The numeral ranking can be seen in the table at the end of this section (table 4) and the total scores are listed underneath the criteria evaluations. Since the company wishes to target China from the Asian market specifically, special remarks are made in respect to this wish. Yet the continent is also considered as whole, as to not exclude any potential within it. These factors were chosen as they well reflect market potential and challenge the exist literature on the following areas: hydrogen for heating, locality, and transportation.

The analysis breakdown is a PESTEL style that considers a mix of political, environmental, social, technological, economic, and legal perspectives of each area. After the more general alternative evaluation a risk analysis will follow, going more into details on market specific risks and how to avoid them. A visual of it is table 4 (table) in which the regions can be found horizontally, the key measurements are presented vertically and on the very bottom is the explanation for the criteria. The analysis was chosen to evaluate the factors previous studies such as the 2020 Delphi study on the future of hydrogen have emphasized and what connections can be drawn from the geographics when comparing statistics and correlation with one another in scenarios such as production vs consumption. These are things like governmental support, infrastructure, innovativeness, resources, and geopolitics.

As seen from the table, Europe took the cake for most potential scoring four points more than the following North America. This analysis was based on the previous data on the regions broken down in the above section. The numeral evaluation was done by the author at face value given the specs that came up in the research. However, considering differences in approach and perception may change the ranking so a more detailed reasoning for scoring will now follow to allow critical thinking and perspective.

Starting with Europe, considering the massive efforts throughout the continent, the governmental support and high rankings in innovativeness and green initiatives it also ranked the best in this assessment. Oilon has a strong market in this area and an established presence allowing them a stable growth in this area. The European market follows the gravity theory enforcing proximity trade and thus allows Oilon to thrive in this Europe. Europe has invested in green hydrogen, P2X technology research and development, perhaps opening door for collaborations and new innovations. In addition, the country has a stable hydrogen consumption and the estimated production numbers look promising considering also hydrogen produced locally is often consumed locally. This has the potential of creating an ecosystem that Oilon fits into perfectly creating a channel for continental consumers utilise nearby produced P2X hydrogen, supporting local economy as well. The environment is politically stable making it a safe operating environment, especially for trial-and-error process of innovation prototyping. Competition exists but Oilon still withholds the power to become the green forerunner with the correct branding and corresponding green technologies.

In this market the European Union area seems to withhold the most potential for Oilon considering most governmental efforts are by it but in Oilon's case focus could be on the Northern- and Central parts of Europe as they have come up the most in the data dissected above.

North America is only a few points behind still holding great potential within. Competition size and technology wise in this market is more intense. Honeywell's ability to cut costs with their own technology imposes risks for Oilon since they could take the green leader podium with their extensive resources. The consumption and production are world class, and the economy is large, yet most efforts and investments are made by the US and Canada leaving behind Mexico which efforts drag the overall rating down a bit due to known socioeconomic limitations and instability.

The continent is investing into partnerships and collaborations but possibly prioritizing domestic ones over international ones. Overall, this market offers maturity but is home to intense competition with plenty more resources than Oilon or Finland possesses. Success is possible but risks market saturation. What this means for Oilon is opportunities if cross border collaboration can be established and competition can be met knowing it is more intense than in Europe.

Only one point behind North America is Asia. The continent, especially the East of it possesses massive potential for future. Though they have the most room for improvement emission wise their goals are nothing short. Due to being rich in natural resources the continent has a high quantity producer of hydrogen, India as well as the top list of consumers are producers. Resource efficiency can be linked to cost efficiency and since they are already avid consumers adaptation of greener version of the same good should come naturally. They might not be as mature yet as the two previous regions, but they are growing in importance as seen from the data in their market potential research. Regardless of the lack of innovativeness by GII they score well in Green Future Index demonstrating long-term orientation and forward way of thinking. Competition levels with Oilon's so even if the market has competing competences Oilon still possesses good chances of success due to their strategical input of becoming greener and thus adding value to their operations. China has especially stood out in the research due to estimates of them rising at any time due to the country's growth throughout the recent years panting a picture it is only a matter of time and their own decision.

Penetrating this market early could bring great partnerships and advantage to Oilon. The greatest risks in this market area are Chinese copycat brands (Kelly. R. 2023) and the continent's economic inequality, having wealth division not only amongst countries but also within them.

Also, when reading this evaluation, one must remember a note from the previous chapter emphasising the importance of partnerships and collaborations. In this case it means that the Chinese presence in the African resource rich markets indirectly shift some of that potential towards Asia as a market. This is something Oilon should remember when and if considering strategic partnerships in these market regions.

Criteria / Region	*Europe*	*North America*	*Asia*	*Africa & the Middle East*
Hydrogen Production	3	4	1	2
Hydrogen Consumption	3	2	4	1
Maturity e.g., Governmental Support + ongoing projects	4	3	2	1
Innovativeness by GII	4	3	2	1
Green Future Index	4	2	3	1
Totals:	18	14	12	6
Evaluation scale	4=Excellent potential	3=Good potential	2=Moderate potential	1=Low potential

Table 4: *A numeral market potential ranking for future markets.*

4.1.4 Risk Analysis

The earlier promised risks analysis can be found under this section (Table 5) with the regions presented horizontally and the risks on the vertical alongside measures on how to avoid them. Evaluation criteria can be found at the bottom of the table horizontally. While the general evaluation did touch on the topic a more thorough dissection had to be done to paint the picture of the present risks and how to avoid them. The table has each of the selected continents alongside some potential risks and tips on how to avoid them from preventative point of view. To create a fair comparison the risks, unite all countries but the likelihood, severity and tips for prevention vary as so do the specifics of the countries.

The risks are chosen based on the emphasis of previous literature and the company concerns to unite the two and create a collective picture.

Starting with competition, as seen from the competitor data tables, it is evident it exists throughout the desired market scope. However, in this field like many others it is inevitable and needs adaptation to overcome it. The most tech savvy and size wise intense competition was studied to be in the USA which is why the severity is ranked higher for that market. To combat this Oilon can focus on adding value with for example environmentalism to differentiate and emphasize the wide product range to stand out.

Likewise, Asia is ranked up but that is due to intellectual property rights in that area or moreover lack thereof, making innovation more prone to theft (Kelly. R. 2023) and competition through it riskier. In this market it is important to focus on creating brand awareness and protecting own technology via for example NDA's and IP protocols. Eventually as this market matures one could argue price becomes an important element of competition if local companies are able to scale production for a cheaper cost and reduce R&D costs by mimicking what already exists. On the other hand, European market area is stable with competition very similar to Oilon and with better protection on tech, thus one should proceed with caution but with emphasis now on the green values and concrete actions on it Oilon should add value to their operations to maintain if not better their market positioning. Finally, the Middle East and Africa do not possess such risk for Oilon competition wise due to lack of manufacturers in the area and less intensive supplier network. The focus is on retail and considering the previously analysed lacking the much literature identified infrastructure for green technology adaptation, penetrating here more intensely would have to be cost driven rather than focusing on sustainability like in the other markets. This is of course until the market matures and becomes more agile to adapt such technologies and by that perhaps the price of for example, P2X hydrogen would have come down to better meet the criteria.

Next to analyse is the governance related factors such as legislations, rules, regulations, funding and initiatives. The ranking basis is the government agendas and support analysed earlier and the severity of related issues is based on level of corruption as of 2022. This acts as a measurement tool to assess if problems were to arise if they would be fairly regarded or would there be a risk of bribery, favouritism or other unfair factor affecting the judgement of problem-solving parties.

Based on the information provided in market analysis on government support problems on this side in Europe and North America are unlikely or highly unlikely. The local governments and especially the European Union have addressed their keen interest in supporting and funding green energy projects as a sustainable future as the target. Projects all the way from R&D to production and consumption are encouraged and therefore just staying up to date with related rules and regulations should be enough to avoid problems.

Shall problems arise, being the least corrupted areas Mexico and some Eastern and Southern European countries aside, they should be easily and fairly resolved (Transparency International. 2022). Moving on to Asia, despite before described progress development, it is still not quite on the level of Europe and North America. The direction is correct, and governments are investing into sustainability. Yet despite some progression, corruption is still much more present throughout Asia than in the Western countries (Transparency International. 2022). To avoid issues, classified as likely to occur, it's important to stay updated on government agendas and build local partnerships for additional guidance to navigate in this kind of environment.

Moving onto Africa and the Middle East these two need to mature, before these very likely problems can be avoided. The continent is riddled with corruption making possible issues challenging to deal with and the poor governmental structure makes them very likely to occur and the situation will not ease until the political unrest in these areas does (Transparency International. 2022). These areas for innovation technology would not be considered optimal for these reasons. According to Mr. Kattelus in a company meeting regarding P2X risks on 25th of August 2023, the P2X emission and other such technology specific legislations are lacking worldwide and can possess either an opportunity, or a risk based on the direction they will be taken to. Until verified and applied they too should be seen as a risk over a possibility and acted accordingly to above suggestions. This is as the lack thereof add uncertainty and puts the company prone to unexpected changes and variables such as adjustment requirements of used technology. While there is no definite prevention method for something intellectual that does not exist the only moderation than can be done is to keep up with the related industry regulations and stay updated on any potentially affecting regulatory systems. This way any changes can be corresponded in a timely manner as they are spotted as they take place.

Next risk to analyse is innovation theft, which somewhat links to the two previous categories but the author considers very critical in the field of technology. Thus, it has been considered separately to draw extra caution to the topic. Globally international- and intellectual property questions are a concern. Theft of a property in the field of innovation technology would cause massive damages as innovation process is often costly with R&D processes and prototypes and stealing such tech would allow that party to produce a good more efficiently and rapidly.

Globally the US and Finland hold number one spots in intellectual and physical property rights respectfully. The success of a society has been positively linked with property rights, innovation index, adaptability and social flexibility which can be confirmed looking at other analytics relating to this risk analysis or above examinations of the markets. The same goes for corruption index that showed the strongest correlation with property protection in recent studies. So much guessed the same regions thrive and are the optimal in this section as in the previous two categories while the other's lag. While not all African or Middle Eastern countries have even gotten the rank, they imposed the most risks and mistrust in this field alongside Asia. (Property Right Alliance. 2022.) China especially has been known to have breached IP rights and trademarks. Notably it is not only the small brands they target but court cases against brands like Apple and Michael Jordan have been resolved in the brand owners' favour against the Chinese counterfeit products. And while India was above listed as a notable hydrogen producer of the future, they have also ranked very poorly in IP right enforcement sending Asia to the category of "very likely" on innovation theft. (Kelly. R. 2023) As this is crucial it can be noted that to be safe in this section the West is the market to be while as discussed before Asia does withhold a massive amount of future's hydrogen potential. If Oilon wishes to go to these riskier markets they must be tied to patents, trademarks and NDAs to protect both, physical- and intellectual property as well as to have a strategy in case of violations of these as local governments may not be of help in those scenarios.

Last but certainly not the least there needs to be an aspect separate from governance and the people. Considering these regions once critical thing to value- and supply chains is fluency. However natural disasters risk disruptions and the last risk is on that and how to minimize damage since total prevention rarely is an option when it comes to mother nature's will.

The rankings in the table below are based on the World Risk Index which is calculated with exposure to natural disaster combined with vulnerability aka resources to overcome and adapt during and after crisis and survive during it. (Welthungerhilfe. et al. 2022) Europe has the best results in this index meaning the risk being the smallest as well as the susceptibility combined with the best resources and tools to get back up. Perhaps surprisingly, Africa and the Middle East ranked second in natural disaster risks, followed by Asia and the Americas. While Africa is the most vulnerable as in has the least resources for recovery after crisis, the Americas still take the cake for having the highest overall natural disaster risks.

Asia is the home to the top three riskiest countries, the Philippines, India and Indonesia and hosts China which has the highest risk of exposure. (Welthungerhilfe. et al. 2022)

Now this in mind Europe has been ranked as unlikely to have natural disasters with minor severity while the rest of the markets were listed as very prone to them with a moderate to major severity ranking. A crisis avoidance is done by monitoring all markets, staying out of the countries with highest risks if deemed damaging to business and lastly what the Ukrainian War has taught is the less dependent the value- or supply chain is the better which is important to note here as well. So how to act in case of production facility- or raw material issue, where to find replacement and optimize logistics and how to minimize harm.

Supply questions and transportation are massive factors in the hydrogen economy as detailed in the literature review and interviews, and thus they are interconnected with this section. Much like lack of suitable infrastructure or governance, disruptions related to natural disasters or other factors make the already volatile transportation and logistics prone to disturbances. These must be accounted for and favouring local production can help the volatility and dependency while the logistical network develops and becomes more reliable.

Risks / Region	*Europe*	*North America*	*Asia*	*Africa & the Middle East*
Competition	Very Likely	Very Likely	Likely	Likely
How to avoid	R&D, green strategy	R&D, focus on adding value	Importance on brand reputation, IP protection	Different marketing strategy
Governance Related	Highly Unlikely	Unlikely	Likely	Very Likely
How to avoid	Stay updated on regulations and requirements	Stay updated on regulations and requirements	Build local partnerships and guiding connections	Wait for market maturity
Regulation related	Very Likely	Very Likely	Very Likely	Very likely
How to avoid	Impossible to avoid, keep up with governance	Impossible to avoid, keep up with governance	Impossible to avoid, keep up with governance	Impossible to avoid, keep up with governance
Innovation theft	Very Unlikely	Very Unlikely	Very Likely	Likely

How to avoid	Patents, IP protection	Patents, IP protection	Patents, IP protection, Brand enforcement	Patents, IP protection
Natural Disasters +Supply Chain issues	Unlikely	Very Likely	Very Likely	Very Likely
How to avoid	Focus key value chain partners in less risky areas	Create a flexible and non-dependent value chain	Flexible value chain, study/avoid most risky areas	Study riskiest areas and avoid them
Severity colour codes	Major	Moderate	Minor	Negligible
Likelihood	Very Likely	Likely	Unlikely	Highly Unlikely

Table 5: *Risk Analysis for the researched markets accounting for risks, severity and likelihood.*

Once the risks are accounted for, leaving the company aware of the pros and cons of each market, the next step is to put it all together. The next chapter of this thesis will go into discussion of all the research above and put together a roadmap and a preliminary, theoretical implementation plan.

4.2 Road Map

As the pros and cons of the markets, the case company and the Power-to-X technology have been studied, it has become the time to put it all together. As for the road map, the Mintzberg 5Ps of Strategy were considered to take account of important factors within strategic planning. (Mintzberg, Ahlstrand, Lampel. 1998) In the case of Oilon the strategic approach taken is product development strategy.

The first P is Plan, which in its concrete form will be seen below. It works as a framework and a guideline recognizing where we are currently and where we want to be, offering three different alternatives on how to get there. If being a pioneer of hydrogen combustion is the desired position, the next element to consider is pattern. The pattern expands beyond the road map plan itself and is already seen in the market analysis.

Leaving outside opinions such as there are other ways of sustainable heating and focusing on the primary and secondary data align with seeing potential in the long run if pioneering position is achieved early on and credibility is built on reliable technology. Now this pattern needs to be seen also on the road map and the market progression must be accounted for. Offering alternatives allows adaptability options even if conditions change unexpectedly while allowing the consistency of behavior which in this case means continuing of market adaptation and innovation development.

Position-wise, Oilon is known as an experienced player in the field and their market opportunities were dissected in the previous chapter. Over the company itself the product has the potential to be a rising star among the other combustion products, targeting existing and markets with new technologies. The fourth P is perspective which in Oilon's case is a clear sustainable and environmental objective.

Being profitable while offering green and responsible solutions is in the heart of Oilon's operations as evident from their strategy explained in the form of TBL in the first chapter. The final P stands for ploy which is a strategic maneuver to enforce one's position in the markets. The ploy in this case will be the visual road map and its alternatives offering flexibility, readjustment and focus oriented approaches depending on the situation at hand. The idea being that one set framework could be too risky and stiff as the environment regarding green hydrogen is rather volatile and prone to morph as it develops as discussed in the risk assessment.

For this reason, the alternatives were chosen to present as examples of approaching the technological adaptation for Oilon. Each have a different approach opting for different strategical outcomes but all working together towards a greener future. There is not one indefinitely above the others but instead the alternatives are presented so that the company may find the best out of them based on their internal resources left rather unknown to the author considering especially engineering perspective and financial investment readiness. Regardless the alternative solutions are presented with suggestions to what situations each apply the best, based on which part of the TBL the company chooses to specify first. Adaptation can be done with one or multiple alternatives at the same time based on the later made concrete technological advancements by the case company that are yet left undetermined.

Institutional Theory in this sense ties together as the solution reached for should embody the following three objectives: regulative support, normative support, and cognitive support. Regulative searches for market maturity on the basis of above analysis and supports related policies and procedures to advance the green transition. Normative comes in with societal expectations and the idea is that the approach would note the green values of nations tying them together with the market maturity with sustainable initiatives and targets, e.g., the sustainability index. Finally, cognitively as a paradigm for change comes Oilon's knowledge which comes together in a form of hydrogen combustion and innovation adaptation through experience and new technologies.

The roadmap is constructed with the literature review in mind in relation to the empirical secondary and primary data and it focuses on addressing the most potential with the analysis' in mind.

4.2.1 Alternatives

The alternatives are the low-risk approach, the higher risk the higher reward approach and the three-step model. They are now introduced and explained in the same order, first going in detail about the differences of the alternatives and then the similarities. The visual road map framework is available below as table 6 (Table 6) presenting the alternatives horizontally on the top of the table and the spec differentiation vertically.

Starting with the low-risk approach, as its name entails it aims to minimize the risks involved in the adaptation process. Meaning avoiding the high-risk areas based on the previously presented risk analysis e.g., governmental, and infrastructural threats. This alternative the best tackles the planet aspect of TBL aiming for energy transition the most paced way possible. The most mature markets are preferred for entry such as Europe and North America, not excluding the others as their maturity progresses. The technology would focus on residential and industrial use as prices will initially be a little high. The mature markets have high environmental awareness throughout consumer levels and the socio-economic balance would allow higher spending in contrast to developing countries. Industries whatsoever would increase revenue streams as their environmental targets surge.

However, this is a rather short-term solution, or at least a long progression one since risks are eliminated so are many of the opportunities. For revenue growth this would take time but could also offer a safer environment to test the waters and prototype technologies.

The next alternative is the one with a slightly higher risk but also a higher reward. While the author would suggest at least some level of mature market exploration for trial before taking the higher risk alternative, this one resonates with prosperity the most. Perhaps running trials in the mature markets first to gather experience and feedback and then stepping into this could be beneficial. The market focus on this alternative is Asia, and more specifically China. As an avid consumer and producer of hydrogen they have good foundations.

While still facing some more risks than the alternatives in the first alternative, the opportunities of the Chinese markets are amplified by the country's presence and role in the African energy production. This offers a two in one type of deal – while taking some IP and government related risks with Asia, they take the ones of Africa by collaboration, ensuring distribution and all-around mutual benefits. This approach therefore targets the opportunities and maximization of efficiency through collaboration especially. Finding strategic partners to locate potential Asian clients whether its Chinese or foreign companies in China, around Asia or further offshore, it can bring a lot of possibilities and a strong network. Eventually such alliances help navigate local governmental schemes and demands, easily otherwise deemed as risk factors. Since economic imbalances exist within Asia and China, the initial focus could be on the industrial heating over residential and expand as costs of P2X hydrogen fuels decrease. This is as Asia, especially in the East have invested in sustainability in the recent years the author sees the industry scale more adaptable and financially fit to initiate the energy transition of burners. Due to scalability the author sees this as a mid-term solution, offering immediate yet expandable potential, also to the riskier markets indirectly.

The last alternative follows the given estimation that the general transition beyond current industrial trials will take place from Kw scale to GW scale. Suggesting Oilon to follow this would go along the forecasted guidelines of the transformation. This could cover all markets equally based on production centres and the gravity model suggesting the nearest areas will experience green H_2 abundance faster than the rest in trade due to logistics. As this target all the markets, leaving again Africa for Asia to collaborate with, it offers long-term solutions.

However, this needs to be evaluated by the company if residential areas in which regions can afford the initiation of this technology and if the current technology by Oilon better supports kW, MW or GW scale and what would be the cost of adaptation for each. Meaning also which would leave the most room for trial and error and in which field the most experience is gathered in combusting hydrogen.

What combines all these alternatives are the resources needed and the key performance indicators. Also, while the technology needed varies from one another, modularity would allow adjustability given that the consumer education will take time. This would offer the consumer a chance to combust their fuel of choice and when the price of green hydrogen is right for them, and the availability is better they could modulate their burner to that standard efficiently. This would also lower the threshold for innovation adaptation.

In addition, extensive research and development is recommended to figure out to which power range the adaptation is the best suited for and what kind of changes are needed to the existing technology to adapt to green H_2. Keeping in mind conversion efficiency, fuel consumption levels, maintenance needs and reliability factors to make sure it's also competent for the customers. Once again this requires evaluation of costs and who the company wishes to target in the first place with the technology. If proficiency is not reached in all power ranges staff and customer training will be needed. The staff needs to be educated on component changes and specs, maintenance, technical support and commissioning wise in addition to the qualities of the new innovations. This information can then be taken to the customers in the form of marketing and training events to ensure correct use and thorough understanding. Timetable must be set once the needed specs for the innovation technology are known.

Since it is about adapting the combustion technology of a new environmental fuel, the success or the lack thereof needs to be monitored to see what works and what needs more work to accomplish. Sales queries and realized sales can be used as a measurement tool for adaptation rate. This helps to understand who is showing interest towards the combustion technology and to what kind of sites the burners are sold to. This can then be used to target market and know how efforts should be divided to reach the preferred target customers. Given, pre-selective surveys have been done to scout initial need beyond the ones of the thesis.

Naturally, since the thesis already demonstrated, there is a market and there is a researched potential for global CO_2 emissions decrease in the field of heating, measuring it will help to contextualise how big the impact is. Forecasting sales and adaptation rate can also be used as a sales pitch for goal-oriented consumer bases. Once adaptation takes place feedback must be gathered in the form of surveys and face-to-face interactions to understand the correspondence of the technology to the customer needs. Does it integrate to the designed use and support the existing technology or does something more need to be done to achieve that. Those are crucial to keep the customers interest and build trust around the innovative fuel and combustion. Field feedback shall not be overlooked as those are the opinions on the hands-on personnel who can help giving in depth views on the technology and its integration ability itself.

The pre-existing measurement tool NPS can be a great visual and quantitative instrument for measurement if it can be tailored to target the customers who have purchased or are keen on investing into getting a green hydrogen burner. This can help evaluating what is of value in this innovation, what needs to be worked on and how the general on look of the customers is regarding the technology.

Alternatives and the specs	*The low-risk approach*	*The higher risk the higher the reward approach*	*The three-step model (Kw, MW, GW)*	*Comments*
Strategical approach	To minimize risks	To penetrate as many markets as possible	To follow the three-step model forecasted for P2X & Green H_2 shift	
TBL target perspective	Planet	Prosperity	People	Each consider all yet have a special focus on one.
Entry Strategy	Maturity basis	Opportunity basis	Existing clientele basis	
Optimal entry markets	Europe, North America	Asia, focusing on China	Europe, North America, East Asia	Later expansion to other, remaining markets
Strategic goals	Minimize costs and risks	Maximize efficiency	Steady progression	
Technology	Focus on both residential and industry level solutions	Focus on industry solutions	Progression from Kw to GW	Modularity adds value to each and lowers threshold
Resources	R&D, staff training, consumer education	R&D, staff training, consumer education	R&D, staff training, consumer education	Keep in mind conversion efficiency, fuel consumption, maintenance needs and reliability
Solution type	Short term	Mid term	Long term	
KPI's and control	Adaption rate, CO_2 emissions, Integration success, NPS	Adaption rate, CO_2 emissions, Integration success, NPS	Adaption rate, CO_2 emissions, Integration success, NPS	

Table 6: *The visual road map of alternatives for innovation technology adaptation for Oilon Ltd.*

4.2.2 Suggestions

This section will provide the insight to the author's suggestion concerning the previously presented alternatives and given all the previous data affecting the company- and market dynamics. The solution accounts the information provided but also the lack thereof regarding the exact specs and resources unknown as the adaptation is only on the idea stage and nothing concrete has come of it yet.

The solution suggestion is coming from the perspective of a person with experience in the company, in the customer service department in various duties including technical support, warranties, spare part sales and managing purchasing and related processes.

To start with the literature review and interview replies in mind, the author would suggest modularity in all applications. Since answers were fractioned on the timeframe of adaptation as well as how the fullest combustion potential is achieved, the cautious method would be gradual introduction to markets. First firing hydrogen mixed would introduce the customer to its benefits and as the price decreases new ratios could in theory be tried until 100% pure hydrogen combustion is achieved. Modularity itself would allow a swift shift between ratios and fuels. Yet this does require engineering and practical standpoint to confirm. However, this would take the advantage out of mixing the fuels while allowing the infrastructure, legislation, and technology learning curve to develop on the behalf of pure hydrogen. Customers could then adapt to pure hydrogen as they see the price and return ratio is correct for them and Oilon can further push this by their own learning curve and efficient marketing tactics. The current experts in both secondary and primary data research suggest that the true acceleration can be expected between 5-10 years so one could assume the optimal market maturity is reached by or nearly reached by then after which the stability and standardization sets in. Taking this approach would account for the principles of institutional theory, ideal for realizing all three market potential dimensions affecting the adaptation: regulative, normative, and cognitive.

When the technology is out of the own labs and ready for field, the authors suggestion of adaptation would be sticking to the mature markets for testing. This would allow the staff to learn in proximity would decrease overseas commission travel expenses and allow monitoring maintenance by own staff if needed gaining not only experience but also cost savings.

Once reliability is achieved the author would suggest collaborations with China and in all of Asia focus on that specific market due to the opportunities it possesses.

While progressing according to the three steps provided would allow Oilon to proceed on this journey accompanied by other likewise working industries in supports, the author suggests Oilon to focus on initiating the adaptation with the technology they see it's the most efficient to integrate in existing uses and basing it off a more extensive customer inquiries on demand. This allows professional experience to lead over expectations of an ideology or a prediction.

Whichever alternative is chosen, if not a combination of multiple, the key is customer awareness. To achieve desired results outside of in-house innovation, the consumer marketing must be done targeting the defined segment by studying said market's consumer and buying behaviour further. What helps the situation is that the green hydrogen burner can be considered either as an incremental innovation in the opinion of the Author. Meaning existing technologies adapted to existing markets or as an architectural innovation meaning introducing existing technology to new markets depending on the implementation approach. Therefore, nothing drastic changes but the customers must be instructed the increased sustainability value this new variation can bring to their operations and the planet. However, on the positive note this is something the customers already value in Oilon above all else, suggesting in market penetration emphasis should be on customer relationship management (CRM) and corporate social responsibility (CSR).

5 Conclusions

The hydrogen economy is on the rise and interest in fossil fuels has decreased as environmental awareness has increased. The potential of green hydrogen in impacting the environment positively has been noticed and actions across the globe investments and projects have started to implement production, consumption, and transportation of it. One of the strongest pieces of evidence of this is demonstrated by studies like Green Future Index that shows concrete examples of the increasingly ongoing initiatives (MIT Technology Review. 2023). The energy transition has been accelerated by the recent world events and the research has shown green hydrogen possessing the potential of being the fuel of the future. The potential was already introduced in the literature by Peschka.W (1992). but also noted in Oilon CTO's related research materials in 2022.

Previous studies have shown governmental level interest in P2X and hydrogen implementation and Oilon's interest align with this. The previous research on megatrends such as that of Rahman Daiyan, Iain MacGill and Rose Ama (2020) also align with the future trends studied in this thesis, both of which suggest that Oilon's actions are on the right course. While an indefinite separation of hydrogen and its derivatives use in the future cannot be said for sure the study supports Oilon's vision of the need for hydrogen burners which for the case company was the main concern commissioning the thesis. As this was answered their secondary interest was to understand what the market adaptation could look like. However, the previous literature does not have definite group stability or conclusive arguments on whether hydrogen heating is the best application for P2X technology as the research at times contradict each other. Some argue that there are other ways to decarbonize the industry while other sources say this withholds plenty of opportunities for the heating industry as well. The study of this thesis does recognize where the beliefs of the first group originate but does resonate more with the second group, seeing market potential for Oilon based on in depth research and analysis.

The study focused on studying the case company's profile and reflecting it onto different continental markets to see which would be the best fit. The thesis found that the innovativeness of the continent was linked to their sustainability initiatives and environmental objectives.

Meaning continents that ranked well in innovativeness also ranked high in market maturity of green hydrogen and in setting and meeting their environmental targets, suggesting adaptability and openness towards new technologies. In addition, plenty of production was noted to be consumed locally, though this is to experience changes and become more trade oriented in the future. Starting from proximity and eventually popularise as transportation and storage are set out. Considering the case company's line of operations as the adaptor of P2X technology and a supplier of technology allowing its usage and combustion places them in a central role in the green hydrogen ecosystem. If placing Oilon in a value chain, it would fall in between the category of infrastructure and demand depending on the viewpoint. The Danish Energy Agency has divided the P2X technology value chain into three categories: production, infrastructure, and demand (2021). The agency has categorized for example pipelines as infrastructure and fuel cell engines as demand (2021). Oilon does in a way caters to both. They provide infrastructural technology across industries to allow energy transition in their own field of work but also offer a product for consumer demand as a part of the micro, customer level of the ecosystem.

After thorough analysis and evaluation three options were introduced as alternative routes for taking this innovative burner technology to the masses. The alternatives were the following: low risk one focusing on mature markets and near future cost efficiency, the higher risk and higher reward one suggesting risk taking on yet less mature markets in exchange for higher prosperity and the three-stage model which suggested following an energy transition forecast estimated of hydrogen adaptation. The alternatives follow separate strategies and align each the strongest with one of the set TBL principles. The case company may choose to adapt one or multiple, or proceed from one to another as the physical burner is ready and its specs are known and tested.

The author's suggestion is to establish hydrogen burner presence by testing in the mature market and proximity to the home market to polish the technology to its finest before riskier markets. Afterwards the author suggests proceeding not blindly according to projected three stages of adaptation from kilowatts to megawatts and gigawatts but instead following own expertise and experience and scouting technological possibilities according to known adaptability and integrational opportunities.

Meaning understanding the development stages and potential of own burners and seeing R&D and efficiency wise which ones are the smartest to be implemented first according also to customer expectations e.g., financially. As by many survey respondents and interviewees suggest product modularity and hydrogen mixed fuels are a significant steppingstone to pave the way for the rather futuristic pure hydrogen combustion. This is as they allow flexibility at both ends of the value chain, familiarity, and an opportunity for a positive learning curve in all factors deemed as hydrogen related risks, such as legislative and infrastructural elements. The Author's ideology is considering the constructs of institutional theory, the 5 Ps of strategy alongside theories and analysis around markets and innovations.

In theory the thesis managed to address all the questions issued by the case company. The goal was to assess whether Oilon has potential in the hydrogen combustion markets and find out its position in the hydrogen value chain. This study confirms that hydrogen combustion has its place in the future of heating. Should this all be adapted and invested in, according to studies globally the impact can reach massive results since it has been estimated that heating has a big impact on global carbon dioxide emissions and thus has the big role in reducing them as predicted by McKinsey & Company research in 2022. This projection is presented as the figure six in the thesis. Accordingly, expanding the progressive impact from organizational micro level to a global macro level. When it comes to the question of value chain positioning the study places Oilon in between infrastructure and demand product. This is as Oilon has a notable presence in industrial and residential combustion solutions, thus supporting the related infrastructural development and adaptation while also catering to households.

Similarly, this thesis advanced the general green hydrogen research in the niche burner and combustion field which previously was lacking by having industry professionals and market analysis confirm there is, at least theoretical potential in hydrogen as a fuel in this industry. By reading this thesis the reader will not only understand the main idea of green hydrogen and its production alongside pros and cons but also comprehend how its market potential and possible adaptation looks like from the perspective of a sustainable energy technology company.

In the future if the case company wishes to proceed with the implementation of pure hydrogen combustion research on price trends and consumer expectations should be advanced. This thesis aimed to figure out if there is potential for green hydrogen burners and in which markets according to hydrogen availability the potential is the largest. The more detailed strategy on implementation should be conducted as the research and development technology wise has advanced to address the specifics of the burner capabilities and cost structures. Thus, allowing understanding the cost-benefit situation to the company and the end user.

The key to approaching this thesis is to understand as this technology has not yet been made available and tested, the predictions, ideas and suggestions are rather theoretical based on primary and secondary data that do require an additional reflection at the time of concrete adaptation when all details are identified.

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Appendix 1. Internal survey questions. Translated to three different languages used in the company.

Q1	How do you see green hydrogen as a fuel in the future
Q2	Have you recently gotten queries regarding hydrogen burners
Q3	If yes, from which regions
Q4	What drives a customer now when purchasing a burner and choosing a fuel
Q5	Do you have any concerns about hydrogen burners or green hydrogen combustion: elaborate?
Q6	Do you think Oilon is ahead or behind the competition in H2 combustion
Q7	In what kind of timeframe, you see the transition to hydrogen taking place?
Q8	If you have any additional comments regarding the subject, feel free to express it here

Appendix 2: General interview questions used as the basis of in person and email interviews with professionals from different fields.

Q1	How do you see (green) hydrogen as a fuel from your perspective
Q2	What opportunities and threats does it possess in your field of work
Q3	What challenges do you think you/the adapting company would face if adapting green/P2X hydrogen
examples	*Technological challenges, prices, availability, lack of knowledge, customer hesitation*
Q4	What industries would most benefit from transitioning to (green) hydrogen
Q5	Do you have any remarks you would like to point out regarding the future or predictions of (green) hydrogen economy
Examples	*scenarios in which hydrogen would work the best/worst, trend forecasts, concerns, ideas for efficient adaptation, customer feedback or comments,*