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# Benchmark analysis of the energy sector and examination of its future trajectories: HVO as a potential groundbraker


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# CHAPTER 1

## INTRO

This chapter provides an engaging overview and a deep analysis of the energy sector, a field of immense significance and interest. It captures the starting point: the historical background and current context.

The assessment will review the developments that have led to today's scenarios regulating the economy nowadays.

Highlighting the emerging challenges associated with fuel consumption, linked both to the geopolitical tensions and the question of sustainability, the discussion will then shift to the significance of alternative energy resources as a mighty tool for our thriving growth and evolution, together with the respect of the environment, its boundaries and biodiversity. Treating nature as our most precious asset, as our economies, livelihoods, and well-being depend on it.

The chapter concludes with the study's objective, underlining the immense potential of these green resources to address our challenges and contribute to a sustainable future. This hopeful outlook results from the promising developments in the energy sector, offering a beacon of hope for a brighter, more sustainable future.

## 1.1 BACKGROUND AND CONTEXT OF THE ENERGY SECTOR

Since the solar regime, energy has been vital to human life, enabling crucial activities. It has always been and will continue to be a cornerstone of our development and growth. The pressing challenge now is to identify and adopt alternative sources of energy. We must urgently transform our current behavior, integrating nature and its resources into our lives. This is the key to our societal and individual prosperity, a journey intertwined with our history since the dawn of civilization.

Reflecting on our past, it is evident that we have not fully embraced the concept of sustainable coexistence with nature. The time has come for us to acknowledge our responsibility and commit to a more sustainable relationship with our environment. We all must bear this responsibility for the sake of our planet and the generations to come.

Intending to explain the point of view of this analysis, it is worth mentioning "The Dasgupta review," which is an independent, global review of *"The Economics of Biodiversity"* led by Professor Sir Partha Dasgupta. The review calls for changes in how we think and measure economic success to protect and enhance our prosperity together with natural resources. Based on a deep analysis of the ecosystem processes and their interactions with our financial activities, the new framework proposed by the Review incorporates nature into economic analysis and decision-making. The solution to our problem starts with understanding and accepting that our economies are embedded in nature and not external to it. (Dasgupta, 2024)

Indeed, humans have come a long way since the first energy source, fire (heat), used to perform the essential activities of prehistoric times.

Going on, there is the development of the wheel (around 3500 BCE), which drastically improved transportation, as well as the invention of the water wheel (around 200 BCE) and eventually the introduction of windmills ($7^{th}$-$9^{th}$ century).

These three inventions were the first significant changes transforming society: humans exploited natural resources (water and wind) to facilitate their lives.

In stark contrast, the first industrial revolution was a seismic shift that fundamentally reshaped the economy. Fuelled by energy, it revolutionized daily habits and transformed how people and goods were transported. This was a monumental turning point in history, marking the beginning of a new era.

It enlarged the boundaries of human development: society was given the possibility of a fresh and thoroughly reshaped future. On the other hand, the widespread adoption of coal as a primary energy source for industries and railways was also the starting point for pollution and environmental defilement due to rising anthropic pressure.

As time marched on, the evolution of energy sources continued to gain momentum, perpetually reshaping and influencing the economy. This relentless progression underscores the enduring impact of energy on our economic landscape.

Continuing the analysis, vital milestones in developing energy sources are encountered. The first commercial oil well, a landmark event in 1859, heralded the birth of the modern petroleum industry. Later, in the late 19th century, Nikolaus Otto's invention of the first internal combustion engine sparked significant advancements, paving the way for the automotive and aviation sectors.

Another monumental turning point in history was the introduction of electricity, with the first power plants coming online in the late 19th century. The subsequent development of the electric grid and the expansion of electrical infrastructure for widespread use, residential and industrial, ushered in a new era of progress and convenience.

Later, nuclear energy will be discovered (1938), a crucial player in the evolution of the energy sector. It has provided a significant low-carbon energy source, offering hope for a more sustainable future. A key milestone in this period was the Obninsk nuclear power plant in 1954, the world's first grid-connected atomic power plant, which began generating electricity for commercial use.

As can be seen, throughout history, these discoveries have led to the evolution and usage of energy resources for human activities and economies.

As time progressed, energy sources gained increasing importance and value, becoming the lifeblood of our interconnected world. These energy sources primarily fuel our world's movement and evolution. Their significance has led to governments and politicians engaging in endless conflicts of interest and power. While these conflicts benefit industrialized countries, they also threaten low-income communities.

The energy sector has evolved into a complex web of interdependencies, prompting governments worldwide to reorganize themselves to secure one of a country's most critical assets: energy.

In 1960, OPEC was established as an organization that enabled the cooperation of leading oil-producing and oil-dependent countries to influence the global oil market and maximize profits collectively. The collective aims to regulate the oil supply to set its price on the world market. The group achieves this by coordinating supply cuts when the price is deemed too low, and supply increases when its members believe the prices are too high. The OPEC's objectives are to unify member countries' oil policies to guarantee fair, stable prices for these petroleum-producing countries, efficient and regular supply for consumers, and a fair return for those investing in the oil industry.

Ten years later, a massive energy crisis occurred in the 1970s, disrupting global economies and redefining energy exports and imports. The oil crisis of 1970 had significant political ramifications as international disputes and conflicts related to access to energy resources took place globally. The oil embargo took place as oil-producing countries increasingly flexed their economic and political muscle, causing disarray in the global oil supply. In 1973, the oil embargo led by members of the Organization of the

Petroleum Exporting Countries (OPEC) and their perspective on oil prices yielded a significant shock and widespread economic repercussions.

Many economic challenges occurred during this period, and existing political tensions intensified. This crisis was a milestone that contributed to geopolitical conflicts, marking the outset of a new era of international relations in which energy and resource access have become essential for all nations across the globe. The conflict and its dynamics continue to influence global politics and energy policies.

This strife is a valuable example of how profoundly related a nation's wealth and resources constitute its comparative advantage. They are inevitably linked to geopolitical tensions that eventually lead to wars.

Using a specific example of oil, it can be said that it has been the backbone of global energy geopolitics since the First World War. The decision of Churchill to change the fuel source of the Royal Navy warships from coal to oil to make them faster than the German counterpart is an example that marked the commencement of a new era. The shift from having the security of a safe coal supply from Wales to an uncertain oil supply from the Middle East will become an increasingly crucial geopolitical epicenter over time as oil becomes a critical national security issue.

Since the second half of the 20$^{th}$ century, we can name many conflicts that took place due to oil and its supply as well as the control of oil itself that has played a central role historically: the Biafra War (1967-1970), the Iran-Iraq War (1980-1988), the Gulf War (1990-1991), the Iraq War (2003-2011) or the conflict in the Niger Delta (ongoing since 2004).

Nevertheless, during these decades, tensions between oil-producing and oil-consuming countries increased, peaking with the oil embargo of the OPEC countries and the oil crises of the 1970s. (The 1970s Energy Crisis, s.d.) (Oil Embargo,1973-1974, s.d.)

Talking about another type of unrenewable resource, it must be underlined that in other areas of the world, another fossil fuel has played and continues to play a central and geopolitical role: natural gas. The shale gas revolution in 2000 is worth mentioning, as the advancement of hydraulic fracturing and horizontal drilling techniques significantly boosted natural gas production in the United States. During the early 21$^{st}$ century, these innovations enabled the extraction of natural gas from shale formations, which had never been considered economic resources till that time. This exploitation of shale gas production significantly lowered natural gas prices and enhanced energy security by reducing America's dependence on imported fuels, making the nation a leading gas producer. However, this energy source also triggered environmental concerns, such as water use, potential groundwater contamination, and seismic activity associated with fracking, which were activities linked to this type of energy. (Richard S.Middleton, 2017) (Staff, 2018) (Derek Brower, 2023). (The U.S. Shale Revolution, s.d.)

Regarding Europe instead, natural gas markets have developed since the 1960s thanks to large pipelines built to connect Russia (the leading exporter) with other producers, such as Norway, Algeria, and the main European markets. This situation caused a strong bond of dependence for Europe on Russian natural gas supplies to form. For many years, including the Cold War, this type of alliance did not raise geopolitical concerns until 2009. In January 2009, Europe experienced a severe gas crisis, which was anticipated by a dispute between Russia and Ukraine. This quarrel began during the closing weeks of 2008 because a Russian natural gas company (Gazprom) refused to conclude a supply contract unless a Ukrainian gas company (Naftogaz) had paid its accumulating debts for the previous year. After a series of failed negotiations, on January 1st, 2009, Russia cut off gas supplies to Ukraine. The situation started to endanger other European countries when all Russian gas flows through Ukraine were halted for 13 days, cutting off the supplies to southeastern Europe completely, most of which rely on Russian gas, and only partially to the other European countries. At the end of January, the situation was fully restored, with a loss of $1.5 billion in revenues for Gazprom due to a lack of sales. On the other hand, Ukraine was also speculated to have incurred significant economic losses. (contributors W. , 2023)After this significant crisis, analysts pointed out that this severe plight had a negative and possibly irreversible impact on Russia as an energy supplier and Ukraine as a transit country. Analysts were right, as more than ten years later, a significant energy crisis took place due to the Russian-Ukraine war, which started because of the Russian invasion of the Ukraine territory on the 24th of February 2022. This invasion started a dangerous escalation that would affect almost the entire world. The Russia-EU gas dispute started after the Russian invasion as Russia and many EU countries clashed over the issue of natural gas payments, which the Russian Gazprom company pipelined to the EU. In June, after many sanctions on Russia that were expanded in response to its invasion of Ukraine, the company Gazprom claimed that it was obliged to cut the gas flows to

Germany due to leakages. On 26 September 2022, the Nord Stream pipelines 1 and 2 were sabotaged. The company claims that the shutdown is due to leaks in both pipelines, but it is just a way to pressure the European governments to lift the economic sanctions against Moscow. Nord Stream 1 is Russia's largest gas pipeline to Europe, supplying about 35% of the imported gas from Russia. Europe (mainly Germany) increasingly relies on Russia to meet its energy needs. Over the past year, Russia has cut its gas supplies by 88%, doubling gas prices in Europe over the same period. This price rise affected European household budgets and increased costs for families and manufacturing firms. After this move, European lawmakers have repeatedly accused Russia of weaponizing energy exports in an attempt to drive up commodity prices and sow uncertainty across the 27-nation bloc. (Kardàs, 2023) (Russia cuts off gas to two European countries.Who's next?, 2022).This act of 'sabotage' inflicted severe damage on citizens, companies, and the environment. In late September, Norway and Denmark reported four leaks in the two pipelines in the Baltic Sea, which demanded immediate attention. Seismologists also reported explosions under the sea in the same area, further escalating the situation's urgency. At that time, the pipelines were filled with gas, but it was not directly flowing through them.

The Danish Defence's photographs of giant gas bubbles in the same area where the pipeline leaks occurred painted a stark picture of the environmental devastation. This disaster resulted in a record release of 115,000 tonnes of methane and an equivalent of 15 million tonnes of carbon dioxide, a staggering contribution to global warming that cannot be ignored. In August 2023, the gas price fell again to a fraction of the 2022 peak price. Eventually, Russia continued with its small-quantity pipeline gas exports via the Turkstream pipeline, and the EU and the rest of the world started looking for alternate energy sources. (contributors W. , 2024) (Meredith, 2022) (BBC, 2022) (Manfred Hafner, 2009) (Tagliapietra, 2019)

These events brought natural gas to the top of Europe's list of geopolitical risks, forcing it to formulate a strategy for diversifying its natural gas supplies.

Oil and natural gas have been at the center of energy geopolitics for over half a century. Investigating how this will change due to the global energy transition, driven by decarbonization policies and rapid developments in renewable energy technologies, is very complex.

Many geopolitical changes occurred in the past decades, and people and countries had to adapt and understand their limits. Over the years, the question of sustainability has become increasingly important, and it has become clear that there is a severe need to change how we live and our economies. The urgency to switch our mentality is more accurate and tangible than ever, underscoring the importance of a needed and immediate adaptation. (Tagliapietra, 2019)

This change of direction began in the early years of the 21st century.

For this whole analysis, we will refer to the EU since it is the continent that has most clearly taken a firm and solid position regarding climate change, underlined by a series of regulations applicable to guide both country development and sustainable growth.

Chronologically, amongst the set of guidelines that have traced the path toward a more sustainable Europe in terms of sustainable energy and energy transition, it is relevant to mention:

- **EU Emissions Trading System (EU ETS)**
  Launched in 2005, it is one of the first steps taken by the EU to combat climate change and promote sustainable energy. The world's first carbon market aims to reduce greenhouse gas emissions cost-effectively by setting a cap on the total amount of greenhouse gases installed by the system. The price of carbon incentivizes businesses to invest in clean technologies and to take a step forward in the transition to sustainable energy sources, increasing energy efficiency and expanding renewable energy use. (Development of EU ETS (2005-2020), s.d.)
- **20-20-20 Targets**
  This set of ambitious goals to transform the energy landscape by 2020 was established in 2008 to emphasize the importance of sustainability and clean energy. These targets aim for a 20% reduction in greenhouse gas emissions at the 1990 levels, a 20% share of energy consumption from renewable sources, and a 20% improvement in energy efficiency. This approach has endeavored to reduce the dependence on fossil fuels, diminish carbon emissions, and promote the adoption of clean and renewable energy resources.
- **The European Green Deal (2019)**
  Born in 2019, the Green Deal sets a roadmap to achieve the goal of a climate-neutral EU while trying to drive up economic growth through green energy

investments. This comprehensive strategy is essential to achieve a sustainable energy future by 2050. The expected transformation aims to completely transform the energy system by substantially increasing the share of renewable energy, enhancing energy efficiency, and reducing greenhouse gas emissions. Some of the initiatives of the Deal are about boosting some of the already known renewable energy sources - wind, sun, and water - to improve the energy performance of buildings and promote clean mobility. A focus on modernization is also present: update the energy grid by supporting research and innovation in sustainable technologies and, at the same time, protect those regions and workers that will be affected by this energy transition as the shift from fossil fuel is complex and comprehends both workers with their families, and industries.

- **The European Climate Law**

  The regulation establishes a framework to achieve carbon neutrality within the European Union by 2050: a balance of EU-wide greenhouse gas emissions and their removal regulated in EU law. In addition to the binding objective of climate neutrality, it aims to reduce harmful emissions in the EU, providing a binding target of a net domestic reduction in greenhouse gas emissions by at least 55% by 2030. It also sets a climate target for 2040 within the first global stocktake under the Paris Agreement.

- **Fit for 55**

  It is a package of proposals by the EU aimed at reducing greenhouse gas emissions by at least 55% by 2030 with a strong emphasis on energy transition. This initiative includes significant revisions to the EU ETS to tighten even more carbon allowances. It also increases the renewable energy targets to ensure a larger share of clean energy, enhancing energy efficiency measures across sectors. This package also introduces the CBAM (Carbon Border Adjustment Mechanism) to prevent carbon usage and promote global climate action.

- **NextGenerationEU**

The recovery plan, a €750 billion program initiated by the EU, is a pivotal initiative to address the economic and social impacts of the COVID-19 pandemic. With an essential emphasis on promoting sustainable energy transition, a significant portion of the funds is allocated to green transformations to accelerate the shift towards renewable energy

sources and enhance energy efficiency across countries. This investment in sustainable infrastructure, innovative energy technologies, and clean projects is a testament to the EU's commitment to a greener future. The NextGenerationEU supports the EU's broader goal of achieving climate neutrality by 2050 and reducing greenhouse gas emissions by at least 55% by 2030. (European Council) (European Council) (European Council).
Thanks to all the information gathered above, it is possible to have a paramount vision of energy developments: from a primary resource for life on earth to an incredible and powerful value added to countries. Decades have passed, and energy usage has progressed thanks to the intellectual ability of human beings. It is impossible to deny that fossil fuels, oil, and most unrenewable energy sources are deeply embedded in our economies. Moreover, maintaining the relationships between countries could seem more straightforward without disturbing the vulnerable equilibriums that govern those partnerships. It might be added that it may be convenient not to revolutionize infrastructures, economies, and habits altogether for reasons concerning capital that needs to be spent and the ease of a path already traced, approved, known, and legislatively smoothed. However, change is what needs to happen. Revolutionizing everything, being ready to risk it all to engage in the quest for sustainability, going beyond limits, and embracing the challenging and complex path toward energy transition.

## 1.2 EMERGING CHALLENGES IN TRADITIONAL FUEL CONSUMPTION

In the second decade of the 21st century, the global economy has leaned on and benefitted from affordable capital and an essential energy supply.

The expansive monetary policy (which is, in general, adopted to grow the economy in particular in situations of distress and has the aim to increase consumer and business spending, expanding the money supply through a variety of measures that improve liquidity) was universally adopted after the 2008 and lowered interest rates and utilized quantitative easing, combined with the tremendous technological breakthrough of shale oil and gas, inaugurated a season of mighty prosperity in global energy markets.

Concurrently, the climate issue has gained significant importance, moving from the scientific niche and the creed of a few to international political agendas and TV, corporate strategies and cost structures, and even public consciousness. Gradually, more money has been moved in the direction of investments that not only meet the traditional financial indicators but are ESG-friendly, aligned with the three central criteria for sustainable analysis: Environmental, Social, and Governance.

In this picture, which can be considered seemingly correct and straightforward, lights and shadows are present. Above all, a dominant position on climate change is linked to the associated decarbonization of global economies. An essential step during the transition is to consider the need to support existing industries during the transition to the lower-impact sources as their contribution to this path toward more sustainable energy sources can be determinant.

The idea of a clean break from the past has a significant flaw: it ignores many issues far from marginal as they are deeply embedded in society. For example, to be mentioned are the need to replace resources, the adaptation of demand, the principle of technological neutrality, the central issue of security at all levels, and the complete awareness of the meaning of sustainability, which harmonizes environmental attention with the social and economic development of countries and their communities.

At the European level, this unbalanced narrative has been reflected in the legislation's definition, which effectively excludes fossil fuels, strengthening the mistaken assumption that the latter's development must necessarily be at the expense of renewable sources.

Over time, the fossil fuel industry has been changing its nature as it has evolved towards a more diversified business model for a significant reduction in the carbon footprint of its final products. At the same time, this long-standing industry sector relies on knowledge, skills, infrastructure, and technologies that are essential to support its evolution and are necessary to guide this inevitable transition process. All the gaps that have characterized and still permeate the debate on future energy systems were already visible in the absence of a state of crises, but they have been highlighted much more due to the war context we are in. Taking the Russian-Ukraine war as an example and how Russia behaved regarding energy supply, it can be said that it was an unforeseen test for energy transition.

The two situations are very different yet closely related to each other: climate change, which is a long-term issue, and the Ukrainian crisis, which instead insinuated a sense of urgency into a process that, if properly exploited, could benefit the transition.

Unrealizable or unrealistic plans in a timeframe undermine energy security and move us further away from environmental goals. Evidence of this can be seen in the fact that the escalation in energy prices was already well underway even before the conflict began: between January and December 2021, the cost of gas at European hubs increased by 450% solely due to the predictable increase in demand following the mitigation of the pandemic's effect on the economy. Against a supply of gas that has become more stringent due to the reduction of investments in E&P over the past ten years, the upstream segment of the oil and gas industry involves research and extraction of hydrocarbons.

The same reasoning previously mentioned applies to the transport sector, where defining a path centered on electric mobility only diminishes the other equally emission-sustainable forms: electricity cannot be considered the best possible solution.

This lack of diversification of tools for the decarbonization of transport and the absence of faith in other sustainable sources of energy, together with a missing clear strategy aimed at ensuring an efficient refining system capable of supplying the market with increasingly decarbonized products, risk jeopardizing the environmental goals and causing severe impacts in terms of economic, social, and provide security.

Without altering the ultimate goal, namely the decarbonization of energy and the economic system, the current context prompts a broader reflection on past choices and those to come. A more balanced and forward-looking approach is needed, as it must contemplate multiple equally feasible developments in compliance with current and future regulations.

### 1.3 SIGNIFICANCE OF ALTERNATIVE ENERGY RESOURCES

Energy is at the core of our lives and economies, but it is also the kernel of the climate challenge and its resolution.

A considerable portion of greenhouse gas emissions that trap the sun's heat is generated through energy production: burning fossil fuels to generate electricity and heat.

As previously analyzed, fossil fuels such as oil, gas, and coal are the most significant contributors to climate change, accounting for 75% of global greenhouse gas emissions and nearly 90% of all carbon dioxide emissions. Governments and scientists have a clear picture: to avoid the worst-case scenario of the impacts of climate change, emissions must be reduced by half by 2030 and reach net zero by 2050. To achieve this goal, our reliance on and faith in fossil fuels needs to end, welcoming alternative sources of energy that are clean, sustainable, affordable, accessible, and reliable.

Despite common beliefs, renewable energy sources are abundantly available worldwide: the sun, wind, water, waste, and heat from the Earth. All these sources rely on nature and are powered by it, releasing no greenhouse gases or pollutants into the air.

Fossil fuels still account for more than 80% of global energy production, but cleaner energy sources are gaining more and more space: currently, about 29% of electricity comes from renewable sources. This is still a tiny percentage, but baby steps are fundamental in such a fragile and problematic revolution.

Our world is tied to fossil fuels: about 80% of the global population lives in countries that are net importers of unrenewable resources, meaning that roughly 6 billion people depend on fossil fuels imported from other countries, making them vulnerable to geopolitical shocks and crises. In contrast, renewable energy sources are available in all countries, and their potential is still not fully exploited. For example, IRENA, the International Renewable Energy Agency, estimates that circa 90% of the world's electricity can and should come from renewable energy sources by 2050.

Renewables represent a way out of import dependency, allowing countries to diversify their economies while protecting them from price shocks. This drives towards inclusive economic growth, new job possibilities, and poverty alleviation.

There is a lot more to renewable energy than meets the eye.

Firstly, it is the cheapest power option in most parts of the world. Prices of renewables are dropping, taking the example of the cost of electricity from solar, which declined by

85% between 2010 and 2020, while onshore and offshore wind energy fell by 56% and 48%, respectively. This phenomenon of falling prices makes alternative sources of energy the most eligible solution for low – and middle–income countries, where most of the additional demand for new electricity will come from. Now, there is a real opportunity for the new power supply to be provided by low-carbon sources.

Renewable energy is undoubtedly healthier. According to WHO, about 99% of people worldwide breathe air that exceeds the quality limits, threatening their lives. Over 13 million deaths yearly are avoidable environmental causes, such as air pollution. The COP24 special report on health and climate change demonstrates that 2018 air pollution from fossil fuels caused $2.9 trillion in health and economic costs.

Switching to clean sources of energy helps address climate change but also air pollution and health.

This switch would also be significant economically, making financial sense and creating jobs. Every dollar invested in renewable energy creates three times more jobs than in the fossil fuel industry sector. The IEA estimates that the energy transition towards renewables will lead to an overall increase in energy sector jobs: 14 million new jobs will be generated in the energy supply by 2030. Over the same period, fossil fuel production could lose 5 million positions, resulting in a net gain of 9 million in this pathway. About $7 trillion was spent on subsidizing the fossil fuel industry in 2022, including through explicit subsidies, tax breaks, and health and environmental damages that were not priced into the cost of fossil fuels. In comparison, about $4.5 trillion a year must be invested in renewable energy until 2030 – including investments in technology and infrastructure – to allow us to reach net-zero emissions by 2050. Despite the amount of capital spent, investments in renewable energy will pay off. Reducing pollution and climate impacts alone could save the world up to $4.2 trillion annually by 2030. To conclude, efficient, reliable renewable technologies can diversify power supply options to create a system less prone to market shocks and improve resilience and energy security. However, to ensure a just transition, people's needs and rights must be placed at the heart of the energy transition, as no one can be left behind. (WHO, 2022) (WHO, 2022) (IRENA, 2021) (WHO, 2024) (IEA, 2021)

## 1.4 OBJECTIVES OF THE STUDY

Our world is changing; we need to keep pace.

The “pace” is not one of industries or money, consumerism, and exploitation of natural resources and human capital. Our planet has hosted us for thousands of years, gifting our eyes with incredible wonders. It is not just a matter of respect towards the Earth and each other; it is about understanding the situation.

We are all aware of the irrepressible decline in which we live, from the hardworking scientists who have been warning us for years to every household and family that has had to change its habits due to climate change's emergency. It affects us all indiscriminately.

A change is possible and must be carried out firmly.

We do not have to search for any solution because we already have them surrounding us: the earth is a perfect and resilient system that can heal itself. We should listen, watch, and understand it more. Energy is at the base of this revolution and, as we know it, is as vital as contended. It represents a country’s pillar and is tied to the international links with other nations. The fossil fuel industry is, in fact, deeply embedded in our lives, economy, and habits: changing everything would mean the disruption of our centuries-old routines, which are comfortable and might also seem safe in terms of expectations and profits.

Years have passed, and we have made peace with the idea that this reality can no longer belong to us. Changing is arduous and complex, as no industry, family, or individual needs to be left behind: everyone’s reaction is essential to embracing this revolution.

Some solutions could be better than others. My standpoint is that to make this change, every solution can come in handy, so everything that can be implemented must be used.

The study aims to explore and analyze the viability and feasibility of HVO's support for sustainable development, as well as the benefits and implementation of strategies to manage this alternative energy solution in the contemporary energy landscape.

# CHAPTER 2

# CURRENT STATE OF THE ENERGY SECTOR: THE HYDROCARBONS PERSPECTIVE

This chapter provides a comprehensive overview of the current state of the energy sector with a focus on hydrocarbons. It covers the problems and limitations concerning this type of energy resource: from an old world that discovered hydrocarbons and tried to implement them in every possible way to the present, in which an energy transition is needed. They are harmful to the environment and toxic to humans. Despite its widespread use in many industry sectors and businesses, which will be analyzed thanks to the business model canvas for hydrocarbons, the European Commission has expressed its point of view with market regulations and policies on alternative fuels. To conclude, an outline of the alignment with the SDGs will be constructive to understand the analysis better.

## 2.1 ANALYSIS OF HYDROCARBONS IN THE ENERGY SECTOR

It is advantageous to quickly clarify hydrocarbons and their usage today to enhance understanding of this analysis's subject.

Hydrocarbons are organic compounds that are composed solely of hydrogen and carbon atoms. Their primary natural source is fossil fuels, which are widely used as fuels. They are classified into various types based on their chemical structure:

- **Alkanes**, which are the paraffinic ones, are saturated hydrocarbons such as methane, ethane, and propane
- **Alkenes**, which are the olefinic ones, are unsaturated hydrocarbons such as ethylene and propylene
- **Aromatics**, which have the peculiarity of having one or more aromatic rings, such as benzene and anthracene

Now, it is possible to mention the sources of hydrocarbons, which are the forms of fossil fuels that are the most well-known ones:

- **Crude oil** is a liquid form of hydrocarbon extracted from underground and later refined into various products -extensively used among people and industries- like gasoline, diesel, and jet fuel.
- **Natural gas**, mainly composed of methane, is used for heating or electricity generation.

- **Coal** is a solid form of hydrocarbons used primarily for electricity generation and industrial processes.

These sources are highly combustible and produce carbon dioxide and heat when burned. As such, hydrocarbons are highly effective as a source of fuel. They originate from plant and animal fossils formed by the forces of temperature and weight over millennia. They are mostly found deep underground, in porous rock formations seldom found in large bodies of water, so a large quantity of hydrocarbons is trapped deep in the oceans. (Wikipedia, n.d.)

It is possible to understand that hydrocarbons have been the backbone of our society and growth. Since the first Industrial Revolution, fossil fuels began to play a pivotal role in the evolution of society as a whole and industrial growth. Nowadays, hydrocarbons power machinery and transportation, provide electricity and drive mass production in several industrial sectors. The availability of "cheap" and abundant energy from hydrocarbons enabled the development of modern infrastructure, contributing to urbanization and the creation of higher living standards. The vast importance of hydrocarbons can be highlighted by looking at three main points.

Starting from energy production, hydrocarbons are one of the primary energy sources worldwide as they have been ensuring energy security due to their high energy density and reliability. Countries with significant hydrocarbon resources have been able to secure a stable energy supply, reducing the vulnerability of the nations to external shocks. It is due to geopolitical tensions and disagreement between nations that sometimes cannot grasp the needs and limitations of people inhabiting countries, creating conflicts. There is a tight relationship between the energetic resources of a country and the acutely unstable equilibrium linked to the workforce employed in these industrial sectors. The strategic importance of hydrocarbons has influenced global geopolitics, with countries striving to control the energy resources and supply routes to power their national security and economic stability. It is now possible to analyze the second point linked to fossil fuels: the financial impact of hydrocarbons. The hydrocarbon industry is so vast that it contributes substantially to GDP and job creation globally, providing employment and driving economic growth in many countries, especially those rich in these resources. The extraction, processing, and distribution of hydrocarbons generate substantial economic activity. The workforce in this industry sector ranges from exploration and production to refining and transportation processes and, eventually, retailing. Fossil fuels also support various ancillary industries, such as equipment, manufacturing, and services.

Amongst the various reasons hydrocarbons have a mighty economic impact, their trade implications are worth mentioning. To understand this concept, dividing countries into hydrocarbon-rich and hydrocarbon-importing countries is useful. The first ones are those nations with abundant hydrocarbon resources, such as Saudi Arabia, Russia, or the United States. These countries benefit from export revenues, thanks to which other sectors of the economy can profit from reinvestments. Moreover, it is understandable why these nations have significant geopolitical influence as they have total control over energy supplies. Then there are the hydrocarbon-importing countries that instead rely on hydrocarbon imports, such as Japan and most European countries. They seldom face trade deficits and have economic vulnerability due to price fluctuations and supply disruption.

As we wrap up this section, it is crucial to underscore the third point about hydrocarbons' significance: their current use is a crucial indicator of their future industrial applications in the form of fossil fuels.

Examining the statistics on global consumption and the key industries that depend on hydrocarbons, it is possible to assess that they are essential in producing plastics, chemicals, fertilizers, and numerous other industrial products. Fossil fuel consumption has increased significantly over the past half-century, and there has been a shift from a sole reliance on coal to a combination of oil and gas. Nowadays, consumption is falling in many parts of the world, but oil and gas are still increasing. To have a clearer picture, looking at a graph where it is possible to understand global fossil fuel consumption briefly is helpful. (Fernando, Hydrocarbons: definition,companies,types and uses, 2023)

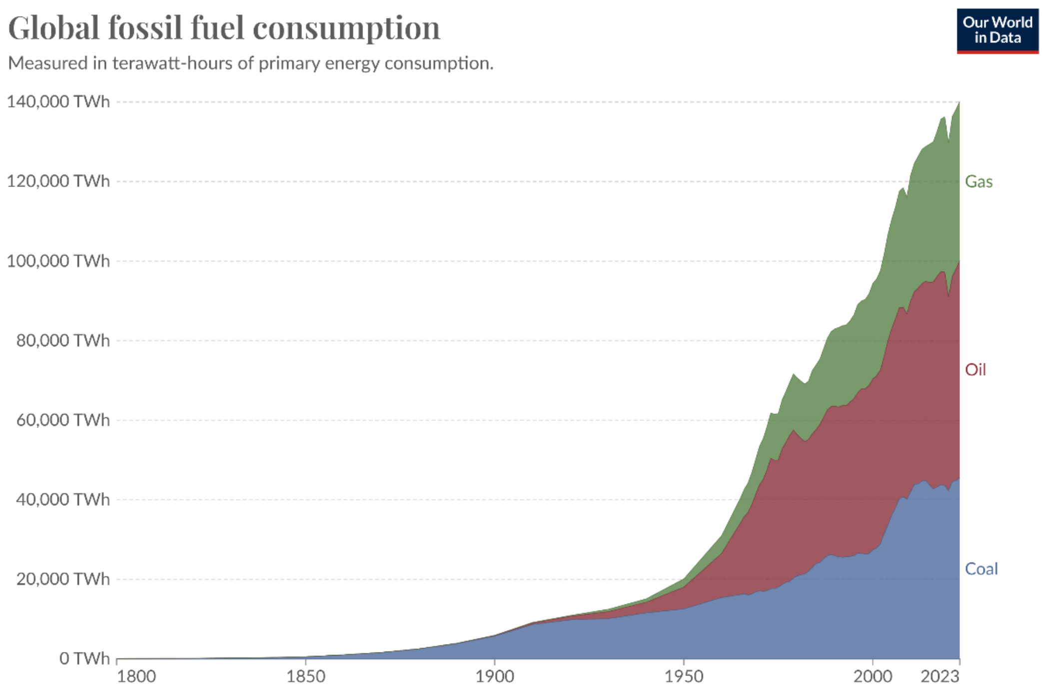


*Figure 1- Energy Institute - Statistical Review of World Energy (2024); Smil(2017) OurWorldInData.org/fossil-fuels | CC BY*

The graph measures the terawatt-hours of primary energy consumption, a crucial metric for understanding the energy resources available before they are transformed.

Watt-hour is the energy delivered by one watt of power for one hour. Since one watt is equivalent to one joule per second, a watt-hour is comparable to 3600 joules of energy.

Instead, primary energy is available as resources—such as the fuels burnt in power plants—before they have been transformed. This relates to coal before it has been burned, uranium, or barrels of oil. Primary energy includes energy that the end user needs, such as electricity, transport, and heating, plus inefficiencies and energy lost when raw resources are transformed into a usable form.

How much consumption has grown during the last decades is readily visible. It will also be worthwhile to look at fossil fuel consumption per capita and understand where people consume the most energy from fossil fuels to have a more precise picture. Energy consumption at the country level strongly reflects population size rather than actual fossil fuel consumption per person. In the chart, it is possible to see the amount of energy from fossil fuels consumed per person. This is the combined primary energy from coal, oil, and gas. Across the world, the largest consumers use more than ten times the amount of fossil energy they consume compared to some of the smallest consumers.

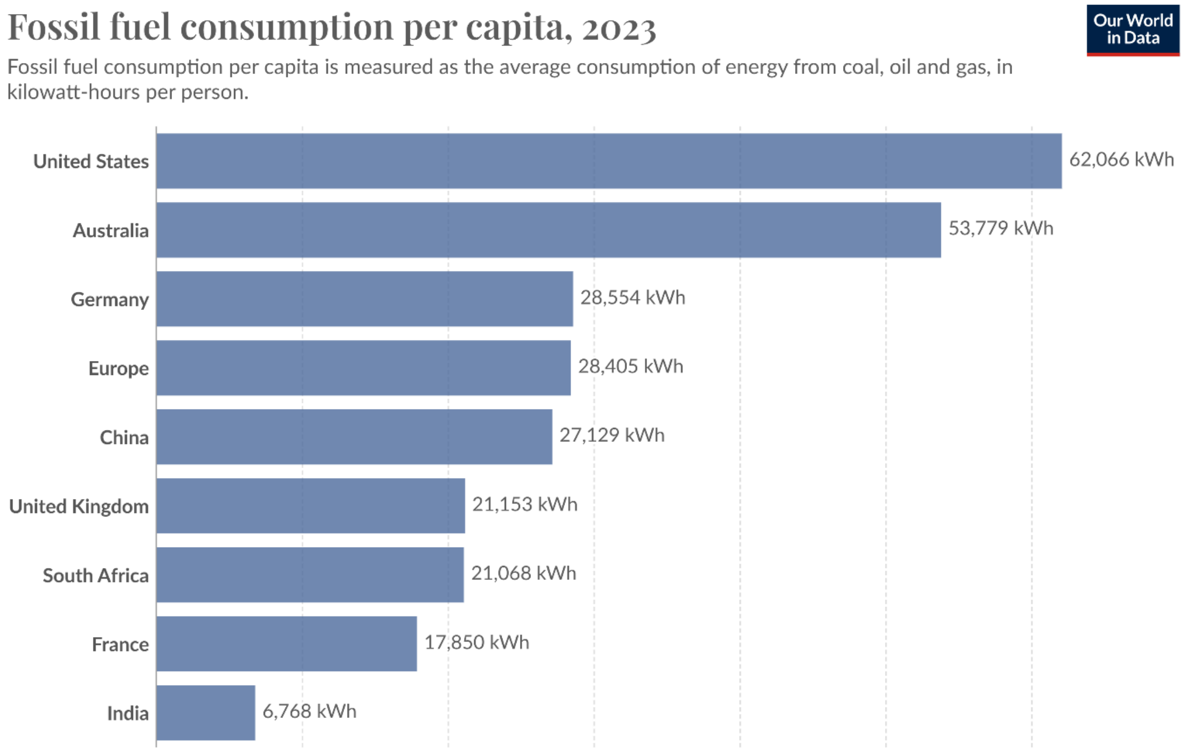


*Figure 2 – Data source: Energy Institute - Statistical review of World Energy (2024); Population based on various sources (2023) OurWorldInData.org/energy | CC BY*

The chart illustrates fossil fuel consumption per capita in 2023 across various countries and regions measured in kilowatt-hours per person. The U.S. leads by a significant margin, followed by Australia. Germany and the other European regions show similar consumption levels. Right after, it is possible to notice a slight decrease in the U.K. and South Africa, with India having the lowest consumption among the regions. This data highlights the stark contrast between areas: fossil fuel dependency and energy consumption patterns differ across nations, reflecting various levels of industrialization, energy policies, and economic development.

The above section analyzed the consumption of fossil fuels collectively. Still, it is relevant to examine the role of coal, oil, and gas individually, as their impacts are unequal. Coal, for example, typically produces more CO2 and local air pollution per unit of energy. The graph shows a stacked area chart, which helps see the relative contribution of each fossil fuel. Looking at a line chart is helpful to understand how consumption changes over time.

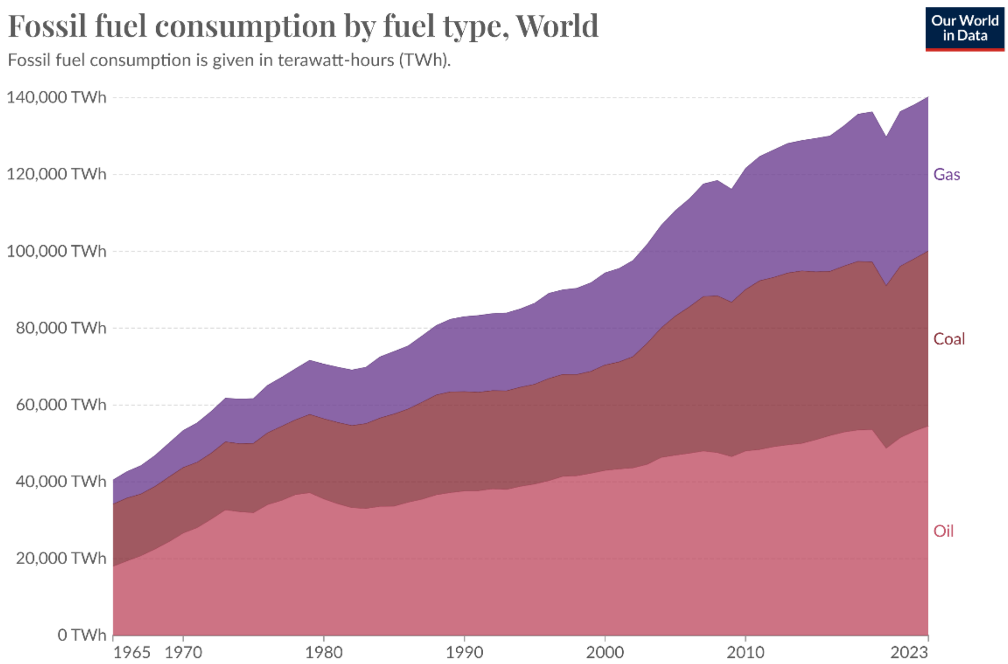


*Figure 3 – Data source: Energy Institute - Statistical Review of World Energy (2024) OurWorldInData.org/fossil-fuel | CC BY*

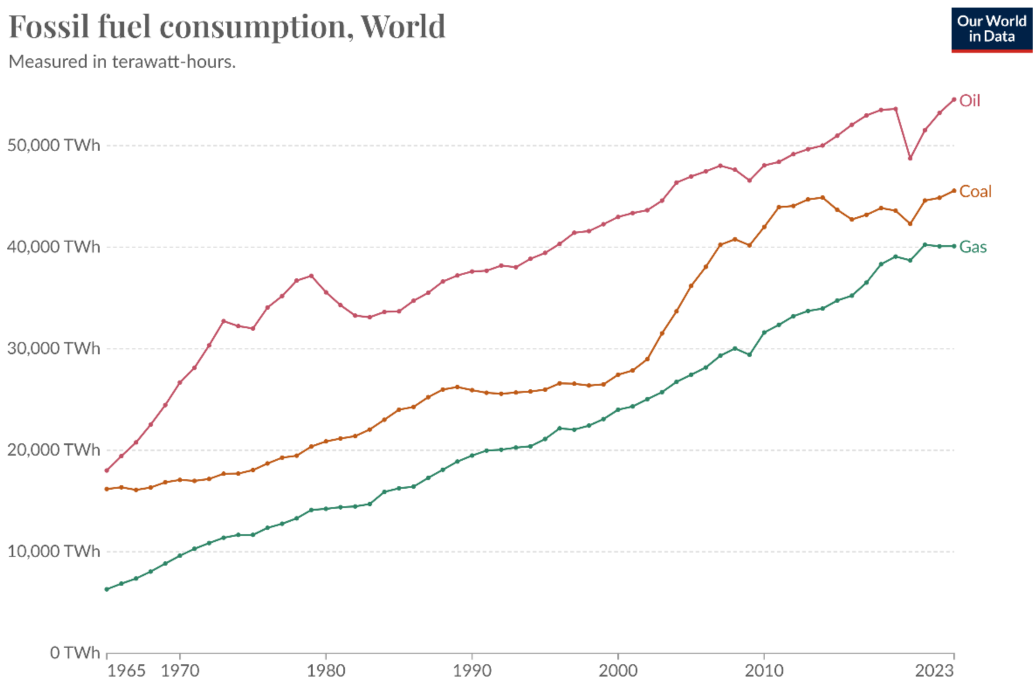


*Figure 4 – Data source: Energy Institute - Statistical Review of World Energy (2024) OurWorldInData.org/fossil-fuels | CC BY*

The first chart highlights a significant increase in the use of all three types of fossil fuels, with natural gas and coal having a more consistent rise. Oil consumption experienced fluctuations but maintained the highest overall consumption.
The second chart provides a more detailed view of specific fossil fuel consumption trajectories over the same period. It is confirmed that oil has been the dominant energy source despite some periods of decline, noticeable with a little downward shift in the late 70s (the oil embargo with OPEC) and during early 2020 (the COVID-19 crisis). Coal consumption instead shows a steady increase with minor fluctuations, while natural gas usage has risen more consistently, confirming its growing role in the energy mix.
These charts underline a persistent dependence and reliance on fossil fuels, driven by their essential role in various sectors, such as transportation, electricity, and industrial applications.
Around four-fifths of global primary energy comes from coal, oil and gas. Over the coming decade, this share must be rapidly reduced by displacing them with low-carbon energy sources. Hydrocarbons are pivotal in the modern economy, accounting for over 80% of global energy consumption. Despite the high number, the figure may understate hydrocarbons' role in the economy by a significant margin because they are used in a wide range of applications besides their use as a source of energy. (Hannah Ritchie, 2022)
Hydrocarbons play a crucial role in a wide array of industrial applications. Their versatility makes them indispensable in several industrial sectors. For the analysis, they will all be mentioned to understand how fossil fuels are deeply embedded in society and the economy.
Amongst the various industrial applications of hydrocarbons, it is possible to mention some key industries that rely on fossil fuels:

1. **Chemical feedstocks**: plastics and polymers and chemicals and fertilizers. Hydrocarbons, particularly ethylene and propylene, are foundational in producing plastics and polymers. They are also essential in producing chemicals and fertilizers: ExxonMobil and DuPont use hydrocarbons to produce ethylene oxide, methanol, and ammonia.
2. **Fuel production and transportation**: refined products and Liquefied Petroleum Gas (LPG). Propane and butane are used as LPG, a fuel for heating, cooking, and automotive applications. Companies like Phillips 66 and TotalEnergies produce

and distribute LPG globally. Aviation and maritime fuels also play a huge role, as both jet and bunker fuels are divided by hydrocarbons.

3. **Lubricants and waxes**: industrial lubricants and paraffin wax.
   Lubricants reduce friction in machinery and engines, extending their life and efficiency, while paraffin is used for coatings, sealants, and other products. Firms like ExxonMobil, Chevron, Sasol, and Repsol are examples of producers of these materials.
4. **Synthetic materials**: rubbers and fibers.
   Butadiene, which is derived from hydrocarbons, is used to produce synthetic rubber, which is used for automotive tires and other valuable industrial products. Goodyear and Michelin are significant suppliers of rubber in tire manufacturing.
   Hydrocarbons are also converted into synthetic fibers like nylon, polyester, and acrylic for textiles and industrial applications.
5. **Electricity Generation**: electricity production and cogeneration plants.
   Coal is currently the largest source of electricity globally, and for many countries, it remains the dominant source. Nevertheless, it is possible to see that a massive shift away from coal took place in recent years. Gas is now the second largest source of electricity production globally. Its contribution proliferates in many countries as they substitute it for coal in the electricity mix. From a climate perspective, this transition is considered positive since gas typically emits less CO2 per unit of energy. Still, a complete shift from gas to low-carbon sources with renewables is needed.

The analysis in this section underscores and shows hydrocarbons' pivotal role in shaping the modern energy landscape and their vertical integration in many industrial sectors. Hydrocarbons encompass a significant portion of the energy mix, including crude oil, natural gas, and coal, and have been fundamental in powering global economies since the first Industrial Revolution, enabling improvements in technology, transportation, and urbanization. Despite the essential advantages, such as energy density and reliability, this heavy reliance on fossil fuels has significant environmental and geopolitical challenges. The provided data highlights the considerable consumption of fossil fuels globally. This persistent dependence on hydrocarbons emphasizes the need for a substantial transition towards sustainable energy sources to mitigate the environmental impacts and align with global efforts to achieve sustainable development goals. (Fernando, Hydrocarbons: definition,companies,types and uses, 2023) (Mcclay, 2024)

Looking ahead, it is crucial to balance hydrocarbons' economic benefits with the urgent need to address climate change and environmental degradation. This will involve innovative approaches to energy production, increased investment in renewable energy, and, most importantly, a robust policy framework to ensure a sustainable and even-handed energy future.

## 2.2 PROBLEMS AND LIMITATIONS OF HYDROCARBONS

Despite their critical role in powering modern society and driving economic growth, fossil fuels present substantial problems and limitations. Due to their extensive use, they contribute substantially to environmental degradation: greenhouse gas emissions and pollution are two reasons climate change is exacerbated. Furthermore, the finite nature of fossil fuels raises concerns about long-term energy security and the economic and geopolitical implications of hydrocarbon dependence that cause price volatility and resource-driven conflicts, adding further complexity to their use. Additionally, health risks associated with hydrocarbons must be mentioned. Health hazards associated with the extraction and combustion of hydrocarbons pose severe concerns for communities, workers involved in these industries, biodiversity, and the importance of ecosystem conservation. Amongst the various concerns of fossil fuel utilization, the first things that come to mind are the climate, environmental, and health impacts of hydrocarbons. Using fossil fuels, such as coal, oil, and natural gas, results in significant climate, environmental, and health costs not reflected in market prices. These costs can be known as externalities, including ocean acidification, extreme weather, rising sea levels, plastic pollution, air pollution, water pollution, oil spills, and health issues. (WHO, 2022) (IRENA, 2021) (WHO, 2024)

Before exploring the various externalities, it is worth mentioning greenhouse gases. When fossil fuels are burned, they emit greenhouse gases, which identify as any gases that have the property of absorbing infrared radiation (net heat energy) emitted from the Earth's surface and rearranging it back to it, thus contributing to the greenhouse effect. Carbon dioxide is the most dominant greenhouse gas produced by burning fossil fuels, industrial production, and land use change. $CO_2$ is not the only greenhouse gas driving global climate change. Several others have contributed significant warming to dates, such as methane, nitrous oxide, and trace gases such as the group of "F- gases." Human-made emissions of greenhouse gases from fossil fuels, industry, and agriculture are the leading causes of global climate change. Greenhouse gas emissions measure the total amount of all emitted greenhouse gases. These are often quantified in carbon dioxide equivalents ($CO_2eq$), which accounts for the warming that each molecule of different gases creates.

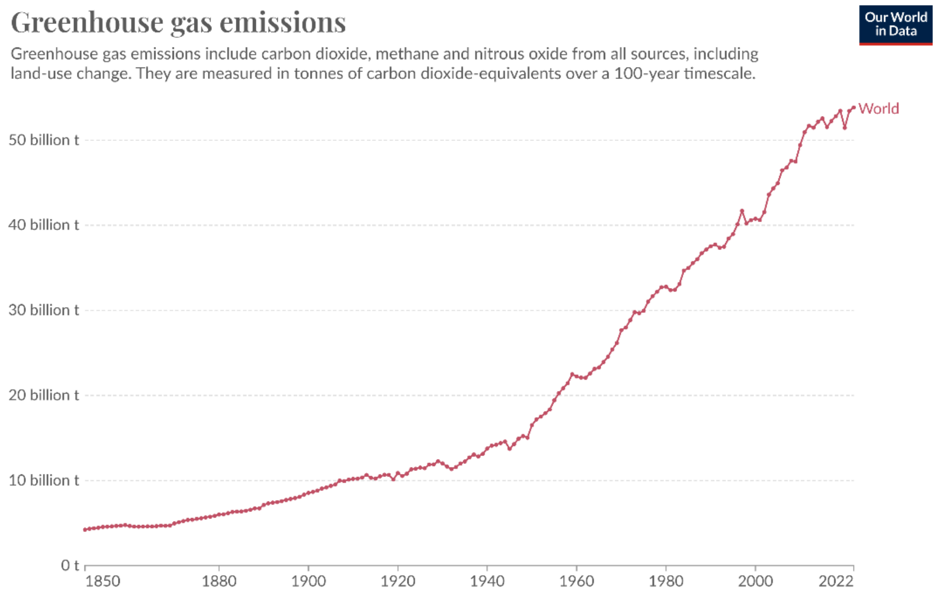


*Figure 5 - Data source: Jones et al.(2024) - Note: Land-use change emissions can be negative OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY*

This chart shows the global greenhouse gas emissions change over time to understand better the actual quantity of greenhouse gases emitted yearly.

The graph illustrates the global trend in greenhouse gas emissions from 1850 to 2022 measured in carbon-dioxide equivalents. The data reveals a sharp and continuous increase in emissions over time, with a particularly steep rise starting in the mid-20$^{th}$ century. This surge corresponds to industrial growth, increased energy consumption, and a widespread reliance on fossil fuels. This trend also highlights the growing impact of human activities on the environment, which have contributed significantly to climate change. Higher concentrations of these greenhouse gases in the atmosphere trap more heat on Earth, causing an anthropogenic rise in global temperature. As it is possible, emissions have exceeded 50 billion tonnes in recent years, underlining the urgent need for international efforts to reduce emissions.

Mentioning some of the most critical climate externalities of fossil fuels:

- **Ocean acidification**

  The ocean is a central component of the carbon cycle, thanks to which carbon constantly cycles between the sea, land, and atmosphere. Water absorbs about 20 to 30 percent of carbon dioxide emissions. As humans introduce more and more carbon dioxide into the atmosphere, the ocean will absorb a greater volume of carbon dioxide, which changes the ocean's chemical composition, called ocean acidification. Due to an increased quantity of carbon dioxide absorbed, the pH value of the sea has decreased by 0.1 pH units, which consists of roughly a 30 percent increase in acidity. This change in acidity is enough to affect the biodiversity of many marine organisms.

- **Extreme weather**

  According to the National Oceanic and Atmospheric Administration (NOAA), burning fossil fuels is a significant driver of climate change, which in turn is leading to an increase in the frequency and severity of extreme weather events. These events include wildfires, hurricanes, windstorms, floodings, and droughts, all devastatingly impacting communities and economies. These events lead to disasters costing at least a billion dollars each. This figure highlights the immense economic burden on a nation due to climate-related disasters, which often result in loss of life, property damage, and significant disruptions to daily life and business operations.

- **Sea level rise**

  Oceanic and atmospheric warming due to climate change is accelerating the melting of glaciers and land-based ice sheets, leading to a global rise in sea levels. Since the late 1800s, sea levels have risen approximately 23 centimeters, a change that has had significant and far-reaching consequences. This increase in sea levels results in more frequent and severe flooding, particularly during high tides and storm surges. Coastal regions are particularly vulnerable to these changes, facing destructive storm surges that lead to extensive property damage and loss of life. Additionally, due to rising sea levels, saltwater intrusion into freshwater systems threatens drinking water supplies and agricultural lands.

Then, it is possible to mention that fossil fuels have significant environmental externalities as well, which include:

- **Air pollution**

  Fossil fuels produce a variety of hazardous air pollutants, including sulfuric dioxide, nitrogen oxides, particulate matter, carbon monoxide, and mercury. These pollutants are incredibly harmful to the environment and human health. The release of sulfuric dioxide and nitrogen oxides into the atmosphere can lead to the formation of acid rain, which can severely damage crops, forests, and aquatic ecosystems. Additionally, nitrogen oxides contribute to eutrophication, a process characterized by excessive nutrient enrichment in water bodies. This can lead to harmful algae blooms and depleted oxygen levels, which can devastate aquatic life. Particulate matter, another by-product of fossil fuel combustion, can penetrate the lungs, causing respiratory problems and other health issues. Carbon monoxide, instead, which is a colorless and odorless gas, can interfere with the blood's ability to carry oxygen, posing severe health risks.

- **Water pollution**

  Fossil fuels significantly contribute to water pollution, impacting surface and groundwater sources. The extraction process, such as hydraulic fracturing, is known for its water usage and contamination risks. Each fracking operation can consume between 1.5 and 1.6 million gallons of water. The resulting wastewater is often highly toxic, containing harmful substances like arsenic, lead, chlorine, and mercury. These contaminants pose significant risks to groundwater and drinking water supplies, making it a critical environmental and public health issue.

- **Plastic pollution**

  This is another significant environmental issue linked directly to fossil fuels, as over 99 percent of plastics are derived from them. Globally, the production of plastic waste has reached alarming levels, with 300 million tons produced each year. Of this, approximately 14 million tons end up in the oceans, where they cause extensive harm to marine life and disrupt the food chain. The accumulation of plastic waste leads to the death of numerous wildlife species, from fish to birds to marine mammals. The global plastic industry is also responsible for producing substantial greenhouse gas emissions, expected to increase significantly in the coming years.

- **Oil spills**

  The extraction, transportation, and refining of fossil fuels frequently lead to oil spills, devastatingly affecting human communities and wildlife. Oil spills can destroy habitats, erode shorelines, and close beaches, parks, and fisheries, severely impacting local economies and ecosystems. The 2010 B.P. Deepwater Horizon spill, the largest spill in history, released 134 million gallons of oil into the Gulf of Mexico. This catastrophic event resulted in the loss of 11 lives and caused extensive damage to marine and coastal environments, killing countless birds, turtles, fish, and marine mammals.

- **Land degradation**

  Unearthing, processing, and moving underground oil, gas, and coal deposits significantly impacts landscapes and ecosystems. The fossil fuel industry leases vast land for infrastructure, such as wells, pipelines, access roads, and processing and waste disposal facilities. In the case of strip mining, entire swaths of terrain—including forests and mountaintops—are scraped and blasted away to expose underground coal or oil. Even after operations cease, the nutrient-leached land will never return to what it once was.

  As a result, critical wildlife habitat—land crucial for breeding and migration—is fragmented and destroyed. Even animals able to leave can suffer, as they are often forced into less-than-ideal habitats and must compete with existing wildlife for resources.

Finally, it must be noted that fossil fuels significantly impact humans and their health. Air pollution from fossil fuels poses severe health risks, including asthma, cancer, heart disease, and premature death. The combustion of gasoline additives such as benzene, toluene, and ethylbenzene produces cancer-causing ultra-fine particles. On a global scale, fossil fuel pollution is responsible for one in five deaths. The adverse effects of fossil fuel pollution are not evenly distributed as they disproportionately affect marginalized communities. Studies show that communities of color and low-income populations are exposed to higher levels of particulate matter pollution that they contribute to, exacerbating existing health disparities. For example, it is possible to think about areas with a high concentration of chemical plants and oil refineries, where residents face significantly elevated cancer risks and other health issues due to the pervasive environmental pollutants in their environment. (Bertrand, McGinn, & Johnson, 2021)

As commonly known, fossil fuels play a central role in the global economy and political landscape, profoundly influencing economic stability and international relations. The inherent price volatility of oil, gas, and coal markets can lead to significant financial instability, affecting everything from consumer prices to national budgets. Moreover, the strategic importance of fossil fuel resources has been a source of geopolitical tensions as countries vie for control over these critical energy supplies. These dynamics not only impact energy security but also shape alliances, trade relationships, and conflicts on a global scale. Understanding these economic and political issues is essential for comprehending the broader implications of our dependence on fossil fuels.

Recent events can serve as an example of the economic and political issues that arise from fossil fuels: Russia's deplorable invasion of Ukraine raises concerns about the West's energy policy. Dependence on fossil fuels creates geopolitical instability, allowing autocratic nations to survive and encourage conflicts. This demonstrates that fossil fuels are environmentally, socially, ethically, and economically unsustainable. Looking at the Russian–Ukraine war, it is possible to have a great example to understand how deeply interlinked things are for Western countries. The West has been directly funding the war by buying Russian hydrocarbons. Notwithstanding the imposed sanctions on Russian companies and the central bank, Russia continues accumulating amounts of foreign exchange thanks to its exports of oil and gas, which in turn can pay for all the military expenses. (Generationim, 2022)

Another problem and limitation of hydrocarbon worth mentioning is resource depletion. The finite nature of fossil fuel resources poses significant challenges for the global energy sector, as fossil fuels are derived from organic materials subjected to geological processes over millions of years. Unlike renewable energy sources, which can be replenished on a human timescale, fossil fuels are finite. Once extracted and consumed, they cannot be replaced quickly. This limitation raises concerns about the long-term sustainability of relying heavily on these energy sources. It is commonly known that fossil fuels are found in finite quantities beneath the Earth's surface. The reserves are unevenly distributed globally, leading to disparities in energy security and economic stability among nations. Countries rich in fossil fuel resources benefit from energy self-sufficiency and export revenues. In contrast, those lacking such resources face a dependency on imports and vulnerability to market fluctuations.

Another critical issue related to resource depletion is Hubbert's peak theory. This theory is based on the idea that because oil production is a non-renewable resource, global crude oil production will peak and eventually go into terminal decline, following a roughly bell-shaped curve. Although this model applies to various resources, it was created specifically for oil production. Hubber's peak theory assumes that maximum production from individual or global oil reserves will occur towards the middle of the reserve's life cycle. After the peak, production decline accelerates due to resource depletion and diminishing returns. According to that, if new reserves are not brought online faster than extractable reserves are drawn down, the world will eventually reach peak oil because there is a finite amount of crude oil in the Earth's crust. A peak in fossil fuel production would seriously affect the world economy. Increased fuel scarcity and rising energy costs would negatively impact almost every industry and directly increase the consumers' cost of living. Spikes in oil prices are often accompanied by economic recessions, raising the spectre of stagflation and making the standards of living decline worldwide. Hubbert predicts that U.S. oil production would have peaked in the 1970s and the world would hit peak oil around 2000. He was proven wrong. The technological revolution in the oil business has increased recoverable reserves and boosted recovery rates from new and old wells. While technological advancements and discoveries have periodically postponed the global peak oil scenario, the fundamental principle remains relevant. The implications of peak oil are profound. As oil production declines, the supply will be unable to keep up with the growing global demand. The International Energy Agency has highlighted that global oil demand is expected to continue rising, driven by population growth and economic development.

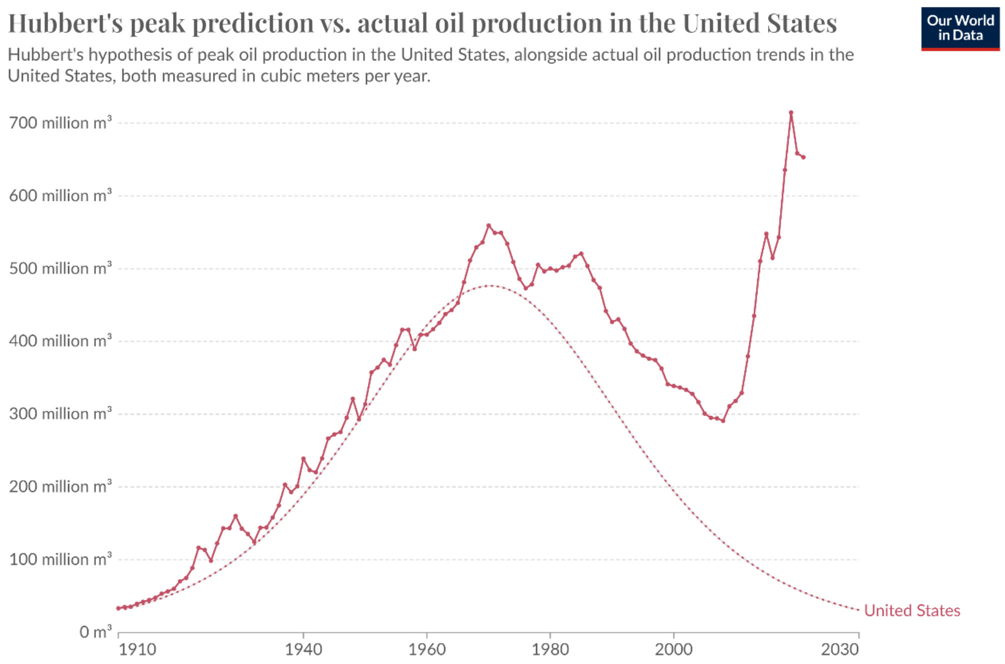


*Figure 6 - Data source: Cavallo (2004) & EIA*
*OurWorldInData.org/energy | CC BY*

The chart compares Hubber's peak oil prediction with the oil production trends in the United States from the early 1900s to the present. In contrast with the bell-shaped curve designed by Hubbert, the solid line illustrates the actual oil production, which peaked around the early 1970s, aligning with Hubbert's prediction. However, contrary to the predicted steady decline, the production experienced fluctuations and a notable resurgence in recent years. Despite the deviation from the expected decline, this resilience of the oil industry is attributed to technological advancements, which have unlocked previously inaccessible oil reserves. These technological innovations led to a significant increase in oil production starting around 2010, culminating in a sharp rise exceeding the earlier peak.

This graph highlights the dynamic nature of oil production, which is influenced by technological, economic, and regulatory factors that can significantly alter expected trends. This underscores the complexity of predicting long-term production patterns and the need to consider various factors beyond geological constraints. (Huo & Peng, 2023) (Shafiee & Topal, 2009) (Goldemberg & Guardabassi, 2009) (Fernando, Mansa, & Munichiello, Hubbert Curve: What It Is,How It Works,Example, 2022) (team, Rasure, & Velasquez, 2023) (University of Calgary)

The bottom line is that the depletion of fossil fuel resources will have a devastating impact on civilization. Because of this, great strides have been made to move away from fossil fuels, such as electric vehicles, and the implementation of renewable energy sources. If widely implemented in the future, these renewable energy sources can remove the concern for the depletion of fossil fuels and usher in a more sustainable energy future. The implications of peak oil are profound. This underscores the urgent need to find sustainable energy solutions and the importance of continued research and innovation in this field.

Discussing the problems and limitations of hydrocarbons enriches the speculation.

Fossil fuels also have technological and operational challenges, such as aging infrastructure and high extraction costs and complexity. Transition and adaptation issues are worth consideration: resistance to change and economic dependencies shape the energy transition. Fossil fuels can be considered integral to the global economy but also present significant technological and operational challenges threatening long-term viability. One of the most pressing issues is the aging infrastructure that supports fossil fuel extraction, transportation, and processing. Much of the existing infrastructure was built when fossil fuel's total environmental and operational costs were not fully understood. As a result, many facilities need to be updated, causing inefficiencies and leading to higher maintenance costs and increased safety risks. Pipelines transporting oil and gas are susceptible to leaks and ruptures due to corrosion, which can endanger the environment and require costly repairs and upgrades. To make a real-life example, it is possible to mention the 2010 San Bruno pipeline explosion in California, which killed eight people and destroyed 38 homes, highlighting the dangers of aging infrastructures. Such incidents are not to be considered isolated: similar issues are reported globally, demonstrating the need for modernizing fossil fuel infrastructure. The extraction of fossil fuels is becoming increasingly complex and expensive as the most accessible reserves are depleted. Companies are forced to explore more challenging environments, such as deep offshore locations or shale formations, which require advanced technologies and significant investment. The fact that the extraction of fossil fuels is being done from deep offshore, in challenging and environmentally sensitive locations, presents substantial technological challenges and risks: the 2010 B.P. Deepwater Horizon oil spill is one of the most significant environmental catastrophes in history. Approximately 4.9 million barrels of oil were released into the ocean, causing long-term damage to marine ecosystems and costing B.P. an estimated $65 billion in fines, cleanup costs, and settlements.

Economic dependencies and resistance to change hinder the transition from fossil fuels to more sustainable energy sources. Many regions and countries' economies rely heavily on fossil fuel production and exports. For instance, nations like Saudi Arabia and Russia derive significant GDP from oil and gas revenues. This dependency creates resistance to transitioning to alternative energy sources, as it can lead to economic instability and loss of jobs. Additionally, industries and companies that have built their business models around cheap and abundant fossil fuels may refrain from adopting new technologies that could disrupt their established operations. Countries like Saudi Arabia have started recognizing this challenge. They are attempting to diversify their economies through Vision 2030, which aims to reduce the country's dependence on oil by developing other sectors such as tourism and technology.

The fossil fuel industry faces increasing scrutiny over its social and ethical responsibilities related to energy transition and economic challenges. The transition to a low-carbon economy raises significant concerns for workers in the fossil fuel sector, who may face job losses and financial insecurity as demand for fossil fuel resources declines. In some regions, entire communities depend on fossil fuel industries for their livelihoods, and the social impact of this transition can be devastating.

Lastly, corporate responsibility and governance in the fossil fuel industry have also been highlighted. Companies are increasingly being held accountable for their contributions to climate change. Many major oil companies have faced lawsuits over allegations of misleading public investors about the risks of climate change. Moreover, there is a growing expectation and need for companies to adopt more sustainable practices and to contribute to the global effort to combat climate change. This includes reducing their carbon footprint, investing in renewable energy, and supporting policies promoting a transition to a low-carbon economy.

It should be conveyed that social and ethical implications of fossil fuel dependence extend beyond corporate governance: broader societal issues such as environmental justice are also part of it. Communities of color and low-income communities are often disproportionately affected by the negative impacts of fossil fuel production and pollution. In Louisiana’s “Cancer Alley,” a predominantly black and low-income area, residents suffer from elevated cancer rates due to the proximity of oil refineries and petrochemical plants.

In the German Ruhr region, the decline of coal mining has raised concerns about environmental remediation and the region's economic future. The transition from coal has left behind vast areas of polluted land and water that require extensive cleanup efforts. Meanwhile, the closure of mines has led to job losses and economic decline, prompting discussions about balancing environmental restoration with economic revitalization.

In the Netherlands, the Groningen gas field, once a significant source of natural gas, has been linked to increased seismic activity, damaging homes and infrastructure in the region. The Dutch government has faced criticism for its slow response to these concerns and has been forced to scale back production and plan for an eventual shut-down of the field. These examples and ongoing legal challenges major oil companies face highlight the growing demand for greater transparency and accountability in industries that traditionally prioritize profits over environmental and social considerations. Companies are increasingly expected to reduce their environmental impact and engage in responsible corporate governance that considers the well-being of affected communities and the long-term sustainability of their operations. (Denchak, 2022)

### 2.3 BUSINESS MODEL CANVAS FOR HYDROCARBONS

The Business Model Canvas will be used to analyze hydrocarbons in the energy sector in depth. It breaks down into nine essential components, as this approach allows for a more precise visualization of how various aspects of a business interact and contribute to the overall success of a product. The Business Model Canvas framework is handy for comparing different solutions within the energy industry sector.

This comparative analysis highlights the strengths and weaknesses of current hydrocarbon-based models and facilitates the inquiry and exploration of alternative energy solutions and business strategies. Thus, the framework serves as a critical tool for understanding and improving the complex business dynamics of the hydrocarbon industry in an increasingly competitive and environmentally conscious market.

Starting to analyze every segment of the framework from left to right:

| BUSINESS MODEL CANVAS FOR HYDROCARBONS | |
|---|---|
| **1. Key partners** | • **Suppliers (exploration and production companies)**<br>Companies engaged in the early production stages, such as exploration and production of hydrocarbons. These suppliers are essential for the initial stages of the hydrocarbon value chain as they provide raw materials needed for refining and distribution. Partnerships with service companies that offer specialized equipment and expertise for drilling, fracking, and other exploration activities.<br><br>• **Governments and regulatory bodies**<br>National and local governments grant exploration and production licenses, set regulatory |

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| | frameworks, and enforce environmental and safety standards. Regulatory bodies that monitor and regulate the hydrocarbon industry to ensure compliance with laws and regulations and promote safe and sustainable practices.<br><br>• **Technology providers (for extraction and refining)**<br>Companies that provide advanced technologies for extracting, refining, and processing hydrocarbons, such as those specializing in hydraulic fracturing, offshore drilling, and enhanced oil recovery techniques, are essential partners for improving efficiency, reducing environmental impact, and maintaining competitiveness in the market.<br><br>• **Logistics and distribution partners**<br>Companies involved with the transportation and distribution of hydrocarbons, including pipeline operators, shipping companies, and storage facilities. Collaborations with such partners ensure the smooth delivery of hydrocarbons from the production sites to the refineries and to end users. |
| **2. Key activities** | • **Exploration, extraction, refining, and distribution**<br>Activities related to exploring new hydrocarbon reserves, including geological surveys, seismic analysis, and drilling operations. |

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| | The extraction processes, such as drilling, pumping, and fracking, that bring hydrocarbons to the surfaces can then be included.<br>Refining activities that convert crude oil and natural gas into usable products like gasoline, diesel, jet fuel, and petrochemicals.<br>Distribution activities that allow the transport of refined products to markets through pipelines, tankers, and trucks.<br><br>• **Regulatory compliance**<br>Activities that ensure environmental regulation compliance include monitoring emissions, managing waste, and conducting environmental impact assessments.<br>Investments in technologies and practices that reduce carbon emissions and enhance sustainability and renewable energy integration.<br><br>• **Research and Development (R&D)**<br>Ongoing R&D efforts to improve the extraction processes and refining technologies, making firms more efficient and less environmentally damaging. The development of new products is also included to diversify the hydrocarbon portfolio and explore alternative energy sources. |
| **3. Key resources** | • **Proven and probable reserves**<br>The quantity of hydrocarbons confirmed to be extractable using the current technology. These reserves are crucial for hydrocarbon companies, |

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| | being the foundation of their future production and revenue.<br><br>• **Strategic access rights**<br>Secured exploration and extraction rights in hydrocarbon-rich regions are often granted through government licenses or partnerships. These rights are necessary to maintain a long-term production capacity and market presence.<br><br>• **Human resources**<br>Geologists and geophysicists are specialists who identify and evaluate potential hydrocarbon reserves. Their expertise is critical for guiding exploration efforts and minimizing the risks associated with drilling.<br>Engineers (petroleum, chemical, and mechanical) design and oversee extraction processes, refine crude oil and natural gas, and maintain infrastructures.<br>Environmental scientists and compliance officers ensure that operations meet environmental regulations and standards. They also develop and implement strategies to reduce the environmental impact of hydrocarbon production.<br>Operations and maintenance teams comprise skilled technicians and workers who manage day-to-day operations, including the maintenance of extraction sites, refineries, and distribution networks. |

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| | • **Infrastructure (extraction, refining, and distribution facilities)**<br>Extraction sites such as drilling platforms, both onshore and offshore, are associated with infrastructure such as storage facilities and pipelines, which are critical for the extraction of hydrocarbons.<br>Refineries are facilities where crude oil is processed into usable products such as gasoline, diesel, jet fuel, and petrochemicals.<br>Distribution networks such as pipelines, railways, shipping fleets, and storage tanks facilitate the transport of hydrocarbons from extraction sites to the refineries and then to the end markets. |
| **4. Value proposition** | • **Reliable and scalable energy source**<br>Hydrocarbons are crucial for powering economies and supporting various industrial sectors, given their consistent and dependable energy supply that can meet large-scale demand.<br><br>• **Established infrastructure and market presence**<br>A well-established global infrastructure for every value chain segment, from extraction to refining and distribution, ensures an efficient delivery to consumers. Strong market presence and brand recognition contribute to customer loyalty and trust. |

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| | • **Economic contributions**<br>Significant contributions to national GDP, job creation, and national revenues, especially in hydrocarbon-rich countries.<br>Hydrocarbons drive economic development by providing affordable and accessible energy to various industry sectors. |
| **5. Customer relationships** | • **Long term contracts**<br>Establishing long-term supply agreements with industrial customers such as power plants, manufacturing companies, and transportation firms. Partnerships with governments are also mentioned, especially in countries rich in hydrocarbons, often cemented through long-term contracts that ensure steady supply and political stability.<br><br>• **Customer support and services**<br>Technical assistance is offered to industrial clients to optimize the usage of hydrocarbon products, such as advising on the best fuel for specific machinery or processes. |
| **6. Customer segments** | • **Industrial sectors (transportation, manufacturing, and power generation)**<br>The primary consumers of hydrocarbons include the transportation sector, which provides for |

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| | aviation, shipping, and automotive industries. They rely heavily on gasoline, diesel, and jet fuel. Manufacturing industries also use hydrocarbons to produce plastics, chemicals, and other goods. Power generation facilities use natural gas and oil to produce electricity, especially in those regions where renewable energy sources have yet to be widely available.<br><br>• **Residential consumers**<br>Households that use hydrocarbons for heating, cooking, and transportation, including gas for home heating and gasoline for personal vehicles. More often, residential consumers are also interested in clean and sustainable energy solutions, prompting hydrocarbon companies to invest in greener alternatives and technologies.<br><br>• **Commercial and institutional users**<br>Businesses and institutions, such as hospitals, schools, and government buildings and facilities, all rely on hydrocarbons for energy needs such as heating or cooling and power generation. |
| **7. Channels** | • **Direct sales and distribution networks**<br>Pipelines are the most efficient and cost-effective method for transporting large volumes of hydrocarbons. This type of distribution network is used for crude oil, natural gas, and refined |

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| | products, ensuring a steady and secure flow from production sites to refiners and distribution centers.<br>Shipping fleets, such as tanker ships, transport hydrocarbons across oceans, connecting production regions with global markets. This channel is essential for international trade as it also connects areas that lack local production.<br>Railways and trucks are used instead for land-based transport, whereas pipelines cannot be used. They provide flexibility and are essential for distributing products to remote or less accessible areas.<br><br>• **Retail and wholesale outlets**<br>Gas stations are a primary channel for distributing refined hydrocarbon products directly to consumers.<br>Bulk sales are made to distributors, and then supply is made to smaller retail outlets or industrial customers.<br><br>• **Digital platforms**<br>Real-time and data analytics provide customers with real-time data on product availability, pricing, and delivery status.<br>E-commerce for petrochemical products, with a digital marketplace for smaller-scale consumers to purchase petrochemical products directly, enhances convenience and accessibility. |

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| | • **Strategic partnerships**<br>Joint ventures with local companies in regions where direct market entry is challenging due to political, regulatory, or cultural barriers.<br>Collaborations with technology providers, such as partnering with companies to develop and deploy new extraction, refining, and distribution technologies. |
| **8. Revenue streams** | • **Sale of raw hydrocarbons**<br>Revenue from crude oil and natural gas sales to refineries, power plants, and other industrial customers and income from export markets, where hydrocarbons are sold to international buyers, contribute to national trade balances.<br><br>• **Refined products and by-products**<br>Sales of refined hydrocarbon products such as gasoline, diesel, jet fuel, heating oil, and petrochemicals.<br>Revenues from selling by-products and co-products, including asphalt, lubricants, and sulfur, were used in various industrial applications.<br><br>• **Value-added services**<br>Revenues from services such as storage, transportation, and distribution logistics. Income from leasing and maintaining infrastructure such as pipelines, storage facilities, and shipping fleets. |

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| **9. Cost structure** | • **Exploration and extraction costs**<br>Costs associated with geological surveys, seismic analysis, drilling operations, and the development of extraction sites.<br>Expenses are relayed to deploying advanced technologies and specialized equipment for hydrocarbon extraction.<br><br>• **Refining and distribution expenses**<br>Operational costs for refining crude oil and natural gas into usable products, including energy, labor, and maintenance costs.<br>Expenses for transporting and distributing hydrocarbons and refined products<br><br>• **Compliance costs**<br>Costs for ensuring compliance with environmental regulations, conducting environmental impact assessments, and obtaining necessary permits.<br>Expenses for remediation and cleanup activities related to spills, leaks, and other incidents.<br><br>• **Research and Development (R&D)**<br>Funding initiatives aimed at improving extraction and refining technologies, enhancing efficiency, and reducing environmental impact.<br>Costs associated with developing new products and exploring alternative energy sources to diversify the portfolio. |

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| | • **Operational and maintenance costs**<br>Routine maintenance and repair of extraction and refining infrastructure to ensure safety and operational efficiency.<br>Operational costs are related to workforce management, training, and development to maintain a skilled and competent workforce. |

Thanks to this structure, it is possible to have a comprehensive overview of how companies in the hydrocarbon sector create, deliver, and capture value. Despite the vast and developed energy landscape, hydrocarbons remain a cornerstone of global energy supply, driven by established companies, the scalability of a product, and the widespread demand across industries. The sector faces many challenges: environmental impacts, geopolitical tensions, and the finite nature of fossil fuels, which are the three main problems in this sector. The wide range of essential resources, such as natural reserves and the highly skilled human capital, are critical to maintaining the competitive advantage. At the same time, steady customer relationships and strategic partnerships are essential to navigate the complexity of this market. As the industry changes due to increasing regulatory pressures and shifting toward a more sustainable path, companies must adapt their value proposition, exploring new channels to ensure long-term viability. Ultimately, the Business Model Canvas underscores the importance of balancing traditional strengths with innovative strategies to remain relevant and resilient in an era of energy transition.

## 2.4 E.U. MARKET REGULATIONS AND POLICIES ON ALTERNATIVE FUELS

As time has passed, the European Union has recognized the need to transition towards a more sustainable and resilient energy system, particularly under the pressure of environmental and geopolitical challenges posed by continued reliance on hydrocarbons. In response to the serious environmental challenges and geopolitical tensions related to the heavy reliance on hydrocarbons, the E.U. has implemented a series of market regulations and policies to reduce the dependency on fossil fuels and foster the adoption of alternative energy sources. These regulations attempt to target the reduction of greenhouse gas emissions while encouraging innovation, promoting energy efficiency, and supporting the development of renewable technologies.

As the E.U. strives to meet its ambitious climate goals, these policies are crucial in reshaping the energy landscape, establishing limits and rules, and influencing market dynamics. They guide an important sector towards an advanced and more sustainable future.

This section will explore the key E.U. market regulations and policies configuring the energy sector's transition, highlighting their impact on the usage of hydrocarbons and promoting alternative fuels. The analysis will be divided into three parts, covering the primary directives and the regulations promoting alternative fuels. Ultimately, the regulations' impact on the hydrocarbon sector will be analyzed.

Starting from the key directives and regulations, it is worth mentioning:

- The **Kyoto Protocol**, in the early 1990s, was one of the earliest milestones where the E.U. committed to reducing greenhouse gas emissions, marking the beginning of a regulatory framework that would increasingly shape its energy policies.
- The **Renewable Energy Directive** (RED) regulation, adopted in 2009, sets binding targets for member states to increase the share of renewable energy in the overall energy mix. This directive plays a pivotal role in reducing the block's dependence on hydrocarbons as it fosters the development of wind, solar, and bioenergy sectors across Europe. Later, the E.U. also developed the RED 2, which sets binding targets for the share of energy from renewable sources, aiming for at least 32% by 2030.

- The **Fuel Quality Directive** (FQD) is a significant piece of legislation within the E.U. that aims to reduce the environmental impact of transport fuels. It sets binding targets for reducing greenhouse gas emissions from fuel production and use, requiring a 6% reduction in gas emissions by 2020 compared to 2010 levels. This directive also establishes standards for the quality of petrol and diesel fuels, limiting harmful components like sulfur and aromatics to reduce air pollution and its health risks.
- The 2015 **Paris Agreement** further solidified the E.U.'s leadership role in global climate action. It committed to ambitious emission reduction targets and significantly accelerated the transition towards low-carbon energy sources.
- The 2019 **European Green Deal** is a comprehensive policy initiative that underscores the E.U.'s commitment to making Europe the first climate-neutral continent by 2050. This policy encompasses many measures, including revising the RED, introducing the "Clean Energy for All Europeans" project, and establishing the Just Transition mechanism to support regions and industries most affected by the energy transition.

These milestones have collectively contributed to creating a regulatory environment that prioritizes not only the reduction of greenhouse gas emissions but also encourages innovation and the development of alternative and greener energy sources. As the E.U. aims towards its climate targets, these policies prepare for a reshaped energy landscape, guiding a gradual phase-out of hydrocarbons and paving the way for a more sustainable and resilient energy system.

Moving to the second phase of this analysis, it is essential to highlight the various policies and subsidies that promote alternative fuels. These initiatives are vital in driving the transition towards a more sustainable, low-carbon energy future. Amongst the most significant subsidies and incentives for renewable energy and the policies promoting alternative fuels:

- **Horizon Europe** is the E.U.'s flagship funding program for research and innovation. This program supports research and innovation projects across various areas, including sustainable energy technologies. By fostering collaboration between research institutions, industries, and governments, this project aims to accelerate the deployment of clean energy solutions and contribute to the E.U.'s goal of climate neutrality by 2050.

- The **Connecting Europe Facility** (CEF) is a crucial E.U. funding instrument that supports the development of cross-border energy infrastructure to enhance energy security and integrate renewable energy sources. Specifically, in the energy sector, the CEF plays a crucial role in integrating renewable energy sources across the E.U. and creating a unified European energy market. By funding projects like electricity interconnectors, gas pipelines, and intelligent grids, CEF helps ensure that renewable energy can be efficiently distributed across borders, contributing to the E.U.'s energy transition.
- **National Renewable Energy Action Plants** (NREAPs) outline the specific strategies and measures to achieve renewable energy targets. These plans cover the electricity, heating and cooling, and transport sectors, setting how each country will meet its national targets for renewable energy. The NREAPs include measures such as expanding renewable energy infrastructure, supporting emerging technologies, and promoting biofuels in transport.
- The **Energy Efficiency Directive** (EED) is a cornerstone of the E.U.'s energy policy, setting binding measures to improve energy efficiency across the union. The directive aims to achieve a 32.5% improvement in energy efficiency by 2030 compared to the projected energy consumption levels. The EED includes mandatory energy audits for large companies, utility energy-saving obligations, and measures to renovate public and private buildings to higher efficiency standards. (European Commission)

The European Union's policies and subsidies promoting renewable energy profoundly impact the hydrocarbon sector, reshaping the landscape in which traditional energy companies operate. These policies are designed to accelerate the transition to a low-carbon economy and have introduced significant regulatory challenges, altered investment patterns, and increased competitive pressures within the hydrocarbon industry.

One of the most immediate impacts of E.U. policies on the hydrocarbon sector has been the introduction of stringent regulatory requirements to reduce greenhouse gas emissions and improve energy efficiency. Regulations like the E.U. Emissions Trading System

(ETS), the Fuel Quality Directive (FQD), and the Energy Efficiency Directive (EED) impose direct obligations on hydrocarbon companies to monitor, report, and reduce their carbon footprint. Compliance with these regulations has led to substantial costs for hydrocarbon companies. For instance, under the ETS, companies must purchase allowances for each ton of CO2 they emit, which has become an increasingly significant financial burden as carbon credits continue rising. Similarly, the FQD requires that companies reduce the life cycle of greenhouse gas intensity in fuels. These compliance costs are both economic and operational, as companies must invest in new technologies, adopt more rigorous reporting systems, and often face delays and uncertainties related to regulatory changes.

The E.U.'s strong push towards renewable energy and alternative fuels has led to a noticeable shift in investment patterns within the energy sector. Hydrocarbon companies, facing diminishing prospects in their traditional markets, have begun redirecting capital towards cleaner energy sources. This shift is evident in the growing investments in renewable energy projects, such as wind, solar, and biofuels, as well as in the development of carbon capture, utilization, and storage technologies. Moreover, financial institutions and investors, influenced by E.U. policies and global climate commitments, increasingly prioritize Environmental, Social, and Governance (ESG) criteria in their investment decisions. This has led to a decline in available capital for new hydrocarbon projects, with a corresponding increase in funding for renewable energy ventures. Thus, the hydrocarbon sector must transition its business models towards more sustainable practices or risk being left behind in the evolving energy landscape.

Competitive pressure needs to be considered as well. The rise of alternative energy sources, boosted by E.U. policies and subsidies, has intensified competitive pressures on the hydrocarbon sector. Renewable energy sources have significantly reduced costs and are increasingly competitive with traditional hydrocarbon-based energy. This competition is eroding the market share of hydrocarbons in crucial areas, such as electricity generation and transportation.

Additionally, the E.U.'s emphasis on energy efficiency further reduces hydrocarbon demand. As industries, businesses, and consumers adopt more energy-efficient technologies and practices, oil, gas, and coal demand declines. This trend is exacerbated by the growing adoption of electric vehicles (E.V.s), supported by the E.U.'s infrastructure development programs.

Hydrocarbon companies are also facing increasing pressure from new entrants in the energy market. Companies specializing in renewable energy, energy storage, and other clean technologies are expanding rapidly, often benefitting from policy support and subsidies. This shift challenges hydrocarbons' dominance and forces companies to innovate and diversify their energy portfolios to remain competitive.

To conclude, it is possible to say that the impact of E.U. policies promoting alternative fuels and renewable energy on the hydrocarbon sector is profound and multifaceted. The industry faces significant regulatory challenges and compliance costs, requiring substantial investments in cleaner technologies and alternative energy sources. Investment patterns shift away from traditional hydrocarbon projects towards renewables, driven by policy incentives and investor preferences for ESG-aligned ventures. Eventually, the hydrocarbon sector is experiencing heightened competitive pressures as alternative energy sources gain market share and new players enter the market. To navigate these challenges, hydrocarbon companies must adapt by embracing sustainable practices, diversifying their energy portfolios, and aligning with the E.U.'s broader climate and energy objectives.

## 2.5 ALIGNMENT WITH SUSTAINABLE DEVELOPMENT GOALS (SDGs)

The United Nations member states officially adopted the SDGs on September 25, 2015, during the United Nations Sustainable Development Summit held in New York. The Sustainable Development Goals are part of the 2030 Agenda for Sustainable Development, which was the result of considerable negotiations and consultations between governments, society, and international organizations for a period that lasted over three years. The SDGs were born after an in-depth analysis of the situation at that time, which turned into a realization of a global need to address the root causes of global challenges. The 2030 Agenda for Sustainable Development is an action plan for people, the planet, and prosperity. Signed in September 2015 by all the 193 UN member countries' governments, the Agenda encompasses 17 Sustainable Development Goals (SDGs) within a comprehensive action program comprehending 169 targets.

The 17 SDGs replaced the Millennium Development Goals (MDGs), established in 2000 and focused primarily on reducing extreme poverty. The SDGs have a broader scope as they address concerns and issues such as inequality, climate change, environmental degradation, peace, and justice. The SDGs are designed to be universal: the "common objectives" of the goals are designed to apply to all countries and all individuals: no one is excluded, nor should anyone be left behind on the necessary path that will be the world's road to sustainability.

Taking into consideration the modern energy sector and the hydrocarbons sector, it is possible to highlight some specific SDGs that the hydrocarbons sector must align with:

- **SDG 7: affordable and clean energy**
- **SDG 9: industry, innovation and infrastructure**
- **SDG 12: responsible consumption and production**
- **SDG 13: climate action**

Paving the way for a sustainable future, these five goals highlight and underline the main issues concerning the energy sector. The energetic transition will be about having affordable and clean energy for everyone and helping people and the environment. At the same time, future societies must power their lives and economies affordably and cleanly. The industry, innovation, and infrastructure will follow: the new industries and infrastructures will be designed according to this new energetic horizon. Responsible consumption and production will be at the base of a sustainable society and economy: what is consumed and produced must engage with climate action.

Alignment with the SDGs will be essential to transform the energy sector properly: harmonizing and adapting the hydrocarbon sector with them will be challenging as it will require a comprehensive strategy that balances economic interests with environmental and social responsibilities. Some contributions of the hydrocarbon sector can consist primarily of efforts to reduce emissions: implementing technologies and practices to lower greenhouse gas emissions, such as carbon capture and storage (CCS), transitioning to lower-carbon fuels, and improving efficiency in operations. Investments in cleaner technologies will also be essential, including investment in research and development of sustainable energy technologies, including renewable energy, biofuels, and hydrogen. Partnering with technology providers and research institutions to innovate and advance clean energy solutions will be essential for this investment. Lastly, energy efficiency and resource management will be the basis of this process. Enhancing energy efficiency across the value chain from extraction to end-use and adopting circular economy principles to minimize waste and maximize resource utilization contribute to aligning the hydrocarbon sector with the SDGs. (United Nations, 2023) (United Nations, n.d.) (United Nations, 2015)

Challenges and opportunities in this process are to be mentioned as well.

Balancing economic growth and environmental sustainability is one of the many challenges that must be mentioned. Navigating the transition to a low-carbon economy while maintaining financial stability and development can be ambitious. Addressing the socioeconomic impacts of transitioning away from hydrocarbons, such as job losses and community disruption, will be essential and mandatory to guide the “Just Transition.” The transition can be managed as a gradual phase-out of hydrocarbons and a slow scale-up of renewable energy capacity. Leveraging existing infrastructure and expertise could be the best opportunity: utilizing existing infrastructure and expertise to support the development and deployment of renewable energy and exploring synergies between hydrocarbons and renewable energy.

# CHAPTER 3

## ELECTRIC ENERGY: A SOURCE-AGNOSTIC SOLUTION

Electric energy's versatility as a source-agnostic solution is a beacon of hope in pursuing sustainable mobility. This adaptability allows it to transcend traditional fuel dependencies, making it a potential driver of the future of transportation. This chapter delves into the potential of electric power, starting with a brief overview of its advantages as an adaptable and scalable alternative. It also discusses the environmental impact, resource constraints, and infrastructural problems associated with it. The business model canvas for electric vehicles highlights the key elements underlining commercial viability, instilling a sense of optimism about the future of sustainable mobility.

Furthermore, the study underlines the limitations of relying solely on electric energy. This part of the analysis emphasizes the need for a balanced and diversified energy-use approach, instilling a sense of urgency in considering multiple energy sources in the transition to sustainable mobility. To have a paramount vision of this industry sector, a case study on Tesla’s innovative efforts to expand its distribution network sheds some light on the practical implications of scaling electric mobility. This chapter comprehensively analyses the complexities and opportunities associated with transportation electrification.

### 3.1 OVERVIEW OF ELECTRIC ENERGY AS A SOURCE-AGNOSTIC ALTERNATIVE

As a source-agnostic solution, electric energy has always represented a versatile and sustainable option in the global energy transition. Electric energy is source-agnostic, unlike traditional sources tied to specific fuels like coal and natural gas. This means it can be generated from various renewable and non-renewable sources, including wind, solar, hydro, nuclear, geothermal, and biomass. This adaptability to regional resources and technological advancements makes electric energy a key player in the energy transition, significantly reducing carbon emissions and enhancing energy security.

For instance, electric vehicles (EVs) are a prime example of a sustainable energy system that can reduce dependence on fossil fuels. EVs offer significant advantages: lower greenhouse gas emissions, reduced air pollution, and quieter operation than traditional internal combustion engines. Moreover, as the energy grid becomes greener, the environmental benefits of EVs are expected to increase. However, the widespread adoption of electric energy, particularly in transportation, is not without challenges.

The shift towards electric vehicles is a technological change crucial to a broader transition to sustainable mobility. As environmental groups urge governments to adopt more ambitious and realistic plans, electric vehicles are nearing a tipping point for mass adoption. Countries like China, which is leading in this sector, have recognized the potential of EVs as they also contribute to the rapid growth of the global market. However, significant challenges remain: the initial high costs of EVs, the environmental impact of battery production, and the still-developing infrastructure can deter consumers. Moreover, while EVs reduce greenhouse gas emissions compared to traditional vehicles, the environmental toll from the extraction of materials like lithium for batteries and the energy used in manufacturing cannot be ignored. Governments and industries must address these issues, such as ensuring the sustainable sourcing of raw materials and scaling up recycling efforts. At the same time, as the market evolves, economies of scale and technological advancements, such as the development of solid-state batteries, promise to overcome many of these obstacles, making EVs more accessible and efficient. This emphasis on the potential benefits of technological advancements in the electric vehicle industry installs a sense of hope for the future of sustainable mobility. The future of mobility hinges on the ability to navigate these challenges and embrace the benefits of electrification while mitigating its drawbacks, ensuring that the transition contributes positively to global climate goals.

## 3.2 BUSINESS MODEL CANVAS FOR ELECTRIC VEHICLES

The analysis will continue using the framework of the Business Model Canvas for electric vehicles. This strategic tool maps out the essential elements required for success in the EV industry. It serves as a blueprint to understand how EV companies create, deliver, and capture value in the market. It also captures the essential components driving this rapidly evolving industry. The framework outlines the key partners, resources, and activities crucial for sustaining innovation and scaling operations while emphasizing electric vehicles' unique value propositions to customer segments. The canvas clearly shows how companies generate and maintain revenue by detailing the channels through which the EVs reach customers' standards. This model highlights the financial aspects but also underscores the importance of strategic partnerships that are key in these modern times, as well as technological advancements that are critical to the success of electric vehicles a competitive market.

| BUSINESS MODEL CANVAS FOR EVs | |
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| 1. **Key partners** | • **Battery manufacturers**<br>Companies that supply lithium-ion or solid-state batteries, which are the heart of EVs, ensure high energy density, longevity, and safety.<br><br>• **Charging infrastructure providers**<br>Collaborations with firms and governments to develop and expand charging networks are crucial to supporting the widespread adoption of EVs.<br><br>• **Automobile manufacturers**<br>Partnerships between traditional automakers and EV startups or tech firms to leverage manufacturing expertise and scale production.<br><br>• **Government and regulatory bodies**<br>Working with governments to benefit from incentives, subsidies, and favorable regulations that promote EV adoption, such as tax credits, grants, and infrastructure investment.<br><br>• **Technology and software developers**<br>Collaborating with tech companies to integrate advanced features like autonomous driving, in-car entertainment, and AI-based vehicle management systems. |

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| | • **Raw material suppliers**<br>Securing reliable and ethical sources of critical materials such as lithium, cobalt, and nickel, which are essential for battery production, ensuring a stable supply chain<br><br>• **Recycling partners**<br>Establish partnerships with recycling firms to handle end-of-life batteries, focus on resource recovery and reducing environmental impact, and contribute to a circular economy. |
| **2. Key activities** | • **Manufacturing**<br>Efficient and scalable production of vehicles and batteries using advanced automation, optimizing supply chains, and reducing manufacturing costs through economies of scale.<br><br>• **R&D and innovation**<br>Ongoing research in battery technology to improve energy density, reduce costs, and extend range, along with development in autonomous driving and AI systems to enhance vehicle functionality and safety<br><br>• **Sales and marketing**<br>Building brand awareness through digital marketing, social media campaigns, and events, combined with direct sales via online platforms and exclusive showrooms tailored to different customer segments. |

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| | • **Partnership management**<br>Nurturing relationships with key partners, including suppliers, technology developers, and government agencies, to enhance the EV ecosystem and drive collaborative innovation.<br><br>• **Customer support**<br>Providing continuous and personalized support through apps, customer service centers, and in-vehicle systems, including software updates, maintenance reminders, and troubleshooting assistance.<br><br>• **Charging infrastructure development**<br>Expanding charging networks through partnerships, strategic investments, and in-house development, ensuring widespread availability and reliability<br><br>• **Data analysis**<br>Utilizing data from vehicles and users to improve product performance, enhance customer experience, and develop new services such as predictive maintenance and personalized features. |
| **3. Key resources** | • **Intellectual property**<br>Patents and proprietary technologies related to battery chemistry, autonomous driving systems, and vehicle design are crucial to maintaining a competitive edge and enabling licensing opportunities. |

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| | • **Manufacturing facilities**<br>Advanced and scalable production plants that integrate battery production and vehicle assembly, reducing costs and improving efficiency.<br><br>• **R&D teams**<br>Dedicated teams focused on continuous innovation in battery technology, vehicle performance, autonomous driving, and software development are crucial for staying ahead of competitors.<br><br>• **Brand Reputation**<br>A strong and trusted brand recognized for innovation, sustainability, and performance can attract early adopters and environmentally conscious consumers.<br><br>• **Supply chain networks**<br>Efficient and sustainable sourcing of raw materials, components, and finished products, ensuring timely delivery and minimizing environmental impact<br><br>• **Distribution channels**<br>A mix of direct-to-consumer sales and strategic partnerships with third-party dealerships: showroom and online dedicated platforms which are supported by service centers and mobile service units<br><br>• **Software platforms**<br>Integrated systems for vehicle management, customer support, and data analytics, enabling over- |

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| | the-air updates, enhancing user experience, and driving customer loyalty |
| **4. Value proposition** | • **Sustainability**<br>EVs offer zero tailpipe emissions, contributing to cleaner air and reduced greenhouse gas emissions, mainly when powered by renewable energy. This makes them appealing to environmentally conscious consumers and businesses.<br><br>• **Cost savings**<br>EV owners benefit from lower total cost of ownership (TCO) than owners of internal combustion engine (ICE) vehicles, thanks to lower fuel and maintenance costs and incentives like tax credits and rebates.<br><br>• **Innovation**<br>EVs are at the forefront of automotive technology, offering advanced features like autonomous driving, over-the-air software updates, and cutting-edge battery technology.<br><br>• **Performance**<br>Electric drivetrains deliver instant torque, smooth acceleration, and quiet operation, sometimes providing a superior driving experience to traditional vehicles. |

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| | • **Environmental impact**<br>By promoting the use of renewable energy and supporting battery recycling initiatives, EV companies contribute to a sustainable and circular economy, reducing reliance on fossil fuels and minimizing waste. |
| **5. Customer relationships** | • **Direct sales and personalized service**<br>Engaging with customers directly through online platforms and company-owned stores, offering personalized services such as vehicle customization, test drives, and tailored financing options.<br><br>• **Community engagement**<br>Building a strong community of brand advocates through events, forums, and social media interactions fosters a sense of belonging and customer loyalty and encourages word-of-mouth marketing.<br><br>• **Subscription and leasing options**<br>Providing flexible ownership models, such as subscription services for software features (autonomous driving) and leasing options, caters to different financial preferences and increases accessibility.<br><br>• **Continuous customer support**<br>Offering round-the-clock support through mobile apps, customer service centers, and in-vehicle |

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| | systems, ensuring high customer satisfaction and building long-term relationships through proactive communication and assistance. |
| **6. Customer segments** | • **Early adopters and tech enthusiasts**<br>Individuals eager to adopt cutting-edge technology and innovative products are willing to pay a premium price for the latest advancements in vehicle technology.<br><br>• **Environmentally conscious consumers**<br>People who prioritize sustainability and are motivated to reduce their carbon footprint are attracted to EVs for their environmental benefits and alignment with green values.<br><br>• **Urban commuters**<br>Individuals living in cities who seek efficient, low-maintenance vehicles for daily commuting are drawn to EVs for their lower running costs, convenience of home charging, and exemption from congestion charges in some cities.<br><br>• **Corporate fleets**<br>Companies look forward to reducing operational costs and environmental impact by transitioning to electric fleets. They are attracted by a lower TCO, potential tax incentives, and positive branding associated with sustainability. |

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| | • **Luxury market**<br>High-net-worth individuals are willing to invest in premium EVs with advanced features, superior performance, and luxury design. |
| **7. Channels** | • **Direct sales**<br>EV companies often sell directly to consumers through their retail locations and online platforms, bypassing traditional dealership models and allowing for more remarkable customer experience and pricing control.<br><br>• **Third-party dealership**<br>In some markets, partnerships with traditional dealerships can help provide more convenient vehicle access, especially in regions where direct sales are not feasible.<br><br>• **Online platforms**<br>E-commerce sites and mobile applications facilitate vehicle browsing, customization, ordering, and delivery. Offering a seamless digital experience and catering to the growing preference for online shopping.<br><br>• **Mobile apps**<br>Apps allow customers to manage their vehicles, find charging stations, monitor battery levels, and access customer support, enhancing convenience and providing real-time connectivity. |

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| | • **Charging networks**<br>Integration with proprietary and third-party charging stations ensures that customers can access reliable and fast charging options wherever they go.<br><br>• **Social media and digital marketing**<br>Leveraging social media platforms and digital marketing strategies to engage with potential and existing customers, build brand awareness, and drive sales through targeted campaigns and partnerships. |
| **8. Revenue streams** | • **Vehicle sales**<br>The core revenue stream is directly selling electric vehicles to consumers and businesses. This includes a range of models catering to various customer segments. Revenue streams from vehicle sales are a significant portion of the overall income, with potential for growth as EV adoption increases globally.<br><br>• **Battery sales and leasing**<br>Some companies offer a battery leasing option where customers can lease the battery separately from the vehicle, reducing the upfront costs of purchasing an EV. This model generates recurring revenue and provides flexibility for customers. Additionally, advances in battery technology can lead to new revenue streams, such as selling |

upgraded or higher-capacity batteries to existing EV owners.

- **Charging services**

Revenue is also generated from proprietary charging networks like Tesla's supercharger network. Customers pay for access to fast charging services, either on a per-use basis or through subscription models. Charging stations may include additional services that can generate supplementary income.

- **Software and subscription services**

Many EV manufacturers offer software features as subscription services, which include advanced driver assistance systems (ADAS), autonomous driving capabilities, in-car entertainment, and connectivity services.

- **Partnerships and collaborations**

Strategic partnerships with technology companies, renewable energy providers, and other stakeholders can lead to shared revenue opportunities. For example, partnerships in charging infrastructure development can create co-branded services that generate income from using infrastructure and the associated services.

- **Government incentives and carbon credits**

Government incentives and carbon credits may also benefit EV manufacturers financially, as they can be sold to companies that need to offset their emissions. These carbon credits can represent a significant

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| | source of revenue, particularly as regulatory pressures on emissions increase globally.<br><br>• **Data monetization**<br>As the EVs become more connected, the data generated from vehicle usage, driver behavior, and energy consumption can be monetized. This data can be valuable for various stakeholders, including insurance companies, urban planners, and marketers, creating additional revenue streams. |
| **9. Cost structure** | • **Manufacturing costs**<br>Significant investments in vehicle and battery production, including the cost of raw materials, labor, and facilities, with a focus on achieving economies of scale and improving production efficiency.<br><br>• **R&D investments**<br>Continuous spending on research and development to innovate in battery technology, autonomous driving, and software is essential for maintaining competitiveness and advancing the EV industry.<br><br>• **Infrastructure development**<br>The costs associated with building and maintaining charging networks, including acquisition, construction, ongoing operation, and partnerships with third-party providers, are also included. |

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| | • **Sales and marketing expenses**<br>Investment in brand building, advertising, digital marketing, and customer acquisition aimed at driving awareness, generating leads, and converting prospects into loyal customers.<br><br>• **Supply chain management**<br>Costs related to sourcing raw materials, managing logistics, and ensuring a stable supply chain are critical for maintaining production continuity and quality.<br><br>• **Employee salaries and benefits**<br>Compensation for the workforce, including engineers, designers, customer service representatives, and sales teams, and benefits that compensate top talent.<br><br>• **Regulatory compliance**<br>Expenses associated with meeting safety, environmental, and industry standards, including certification processes, testing, and compliance with government regulations. |

In conclusion, it is possible to say that the analysis given by the Business Model Canvas for electric vehicles reveals the intricate balance that is required to succeed in this rapidly evolving industry. The key partners and essential resources are fundamental in establishing a solid foundation for production and innovation, enabling companies to deliver on their value proposition of sustainable, high-performance vehicles. Key activities such as R&D and strategic marketing are pivotal in maintaining a competitive edge. At the same time, customer relationships and channels are essential for fostering trust and ensuring seamless product access. Examining customer segments highlights the importance of targeting diverse market niches, from environmentally conscious individuals to commercial fleet operators. The cost structure and revenue streams emphasize the need for efficient operations and diversified income sources to ensure long-term profitability.

The overarching findings emphasize that the success of the electric vehicle business hinges not only on technological advancements but also on strategic partnerships, effective resource management, and a profound understanding of market dynamics. This approach equips enterprises to navigate the challenges and seize the opportunities within the electric vehicle landscape.

### 3.3 ANALYSIS OF THE ENVIRONMENTAL IMPACT, RESOURCE AND INFRASTRUCTURAL CONSTRAINTS

The energy transition has led to a shift towards electric vehicles (EVs), often regarded as crucial in reducing global greenhouse gas emissions and combating climate change.

However, the environmental benefits of EVs are not without their complexities if the entire lifecycle of the vehicles is considered, from resource extraction for batteries to the development of necessary infrastructure.

This part of the analysis delves into the environmental impact of EVs, exploring the main challenges posed by resource constraints and the significant infrastructural requirements needed to support the widespread adoption of electric vehicles. It offers a comprehensive understanding of the broader implications of transitioning to electric mobility.

Electric vehicles have the great potential to significantly reduce greenhouse gas emissions, offering a clearer alternative to traditional ICE vehicles. The transportation sector contributes to global emissions, accounting for nearly 30% of total greenhouse gas emissions in the European Union and similar percentages in other developed regions. The peculiarity of the EVs is their zero tailpipe emissions: conventional vehicles with an internal combustion engine produce direct emissions through the tailpipe and evaporation from the vehicle's fuel system during fueling. Conversely, all-electric vehicles produce zero direct emissions.

For instance, a typical electric vehicle emits approximately 54% less CO2 per mile than a conventional gasoline car, assuming the electricity is sourced from a clean grid.

However, the environmental impact of EVs extends beyond their operation—the production of lithium-ion batteries, which power most EVs, is resource-intensive and carries significant ecological concerns. Extracting raw materials such as lithium, cobalt, and nickel involves energy-intensive and environmentally damaging processes.

For example, lithium extraction from brine in South America's lithium triangle (Argentina, Bolivia, Chile) requires vast amounts of water—up to 500.000 gallons per ton of lithium—often in arid regions where water is scarce. This can lead to water shortages, affecting local agriculture and communities.

Cobalt is another critical material in batteries. It is primarily sourced from the Democratic Republic of Congo, where mining practices have raised serious environmental and ethical concerns. Artisanal mining accounts for a significant portion of cobalt production. It often involves unsafe working conditions, including child labor, and causes environmental degradation through deforestation and water pollution.

The environmental challenges of the EVs are compounded by the carbon intensity of the electricity used to charge them. In countries like Norway, where nearly all electricity comes from renewable sources, EVs can achieve near-zero operational emissions. However, in countries where coal remains a significant source of electricity, such as India or parts of the U.S., the carbon footprint of EVs can be substantial. This variability underscores the importance of transitioning to renewable energy sources and adopting electric vehicles to maximize the environmental benefits.

The end-of-life disposal and recycling of EV batteries will also be mentioned as a further environmental challenge. Batteries containing hazardous materials and their improper disposal can contaminate soil and water. While battery recycling technologies are advancing, the process is complex and not yet widely implemented. Only a tiny fraction of lithium-ion batteries are recycled, leading to waste management and resource recovery concerns.

The rapid expansion of the EV market drives demand for essential materials like lithium, cobalt, and rare earth elements, leading to concerns about resource scarcity and supply chain vulnerabilities. The International Energy Agency estimates that by 2040, the demand for lithium could increase by over 40 times the current levels, driven by the growing production of EVs and energy storage systems. The supply of these materials is geographically concentrated, with lithium mainly sourced from South America and Australia and cobalt from the Democratic Republic of Congo. This resource concentration poses severe geopolitical risks, as supply disruptions in these regions could significantly impact global EV production. For instance, both political instability in the DRC and environmental regulations in South America could lead to supply shortages, driving up prices and potentially slowing down the adoption of EVs. Additionally, the social costs of extracting these materials are substantial. In addition to the environmental degradation caused by mining, the extraction processes often involve human rights abuses, particularly in the DRC, where child labor and unsafe working conditions are prevalent. These issues have led to increased scrutiny from government, NGOs, and consumers, pushing automakers to seek more ethical and sustainable sources of materials.

The industry is exploring alternatives, such as solid-state batteries, to address these resource constraints, which could reduce or eliminate the need for certain critical materials. Companies like Toyota and QuantumScape are leading research projects about these solid-state batteries, which promise higher energy density and faster charging times with fewer resource constraints. Furthermore, there is a growing interest in recycling and reusing battery materials to create a circular economy for EV batteries, even if it is more costly, as retrieving those materials from used engines is difficult. More and more firms are developing advanced technologies to recover valuable materials from used batteries, reducing the need for new mining and mitigating resource constraints.

The infrastructural constraints must also be considered. The widespread adoption of EVs relies heavily on the availability of charging stations, which remains a significant challenge. According to the IEA, as of 2023, there were approximately 2.3 million public charging points worldwide. Still, this number seems short compared to the infrastructure needed to support the growing number of EVs. The world must deploy approximately 40 million public charging points by 2030 to meet climate goals. (Tabuchi & Plumer, 2021) In many regions, the infrastructure is inadequate, leading to "charging deserts" where access to chargers is limited or non-existent. The issue is acute in rural areas, where the lower population density makes it less economically viable for companies to install charging stations. This disparity can deter potential EV buyers who are concerned about running out of charge without access to a charging station. Furthermore, the existing electrical grid in many regions is not equipped to handle the increased demand that a large-scale shift to electric vehicles would create.

In conclusion, while electric vehicles offer substantial environmental benefits, their adoption is accompanied by significant challenges related to source constraints and infrastructure development. The environmental impact of EVs, particularly concerning the extraction and disposal of battery materials, highlights the need for sustainable practices throughout the supply chain. Resource limitations, especially critical materials like lithium and cobalt, pose risks to EV production's scalability and require battery technology and recycling innovation. Infrastructural constraints, including the availability of charging stations and the capacity of electrical grids, represent significant barriers to the widespread adoption of EVs. Addressing these challenges will require coordinated efforts from the government, industries, and consumers to ensure the transition to electric mobility is sustainable and accessible.

### 3.4 LIMITATIONS OF SOLE RELIANCE ON ELECTRIC ENERGY

Relying exclusively on electric energy, particularly in the transportation sector, presents multifaceted challenges that could hinder the transition to sustainable mobility. The environmental benefits of electric vehicles are undermined by the resource-intensive processes required to produce them and the dependence on non-renewable sources for electricity generation. While electric vehicles are a critical component of reducing greenhouse gas emissions, the environmental and social costs associated with producing and disposing of their batteries cannot be overlooked. The heavy reliance on finite and geographically concentrated resources like lithium and cobalt exposes the supply chain to significant risks, including geopolitical tensions, supply disruptions, and ethical concerns. These vulnerabilities highlight the unsustainable nature of depending solely on electric energy without addressing the underlying issues in material sourcing and resource management.

The infrastructural constraints further complicate the adoption as inadequate charging networks and an overburdened grid could slow the transition and reduce consumer confidence in electric mobility.

A more diversified strategy is needed to address these limitations, incorporating a mix of renewable energy sources, battery technology advances, and resource management improvement. Exploring alternative energy sources such as hydrogen, biofuels, and advanced nuclear technology could complement electric energy and provide a more resilient and sustainable energy system.

Electric energy indeed offers substantial potential for reducing emissions and fostering sustainable development, but relying solely on it is fraught with limitations related to environmental impact, resource constraints, and infrastructure development. A comprehensive and diversified approach to energy use is essential to overcoming these challenges. It is necessary to mitigate the risks associated with resource scarcity and infrastructural inadequacies and ensure a more balanced and stable transition towards global sustainability.

To overcome these challenges and realize the full potential of electric energy, it is imperative to adopt a more comprehensive and diversified energy strategy. Doing so makes building a more resilient and sustainable energy system that supports global sustainability goals and ensures energy security, economic stability, and environmental stewardship possible. The path forward requires a balanced approach that leverages the strengths of electric energy while addressing its limitations, ultimately paving the way for a cleaner, more sustainable future.

### 3.4 CASE STUDY: TESLA'S DISTRIBUTION NETWORK EFFORTS

EVs can indeed be depicted as the new drivers of change. The concept of electric vehicles is not new, but it has been taken to a new level in the age of climate change activism.

Tesla Inc., founded in 2003, has emerged as a global leader in electric vehicles and sustainable energy solutions. With its innovative approach to technology and design, Tesla has revolutionized the automotive industry. Thanks to the visionary leadership of CEO Elon Musk, Tesla has popularised electric vehicles and redefined how cars are manufactured, sold, and serviced.

One of the most significant aspects of Tesla's distribution strategy is its direct-to-consumer sales model. The classic model of automakers, which relies on third-party dealerships, is replaced with a direct sales-to-customers model through company-owned showrooms and online platforms. In this way, Tesla can maintain greater control over customer experience, from initial inquiries to vehicle delivery.

This direct-sale model offers many advantages. The company can reduce overhead costs and reach a more competitive price by eliminating the need for a dealer network. Additionally, as the company directly sells the product, it is possible to establish a closer relationship with customers by offering a personalized and streamlined purchasing process. The online platform allows customers to order vehicles from the comfort of their homes. This method has also been particularly successful, reflecting the growing consumer preference for online shopping.

By selling directly to consumers, Tesla can maintain control over customer experience, ensuring excellent service and consistency in product presentation. This model contrasts considerably with the traditional one, as manufacturers usually rely on franchised dealerships to handle sales, customer services, and vehicle maintenance.

Tesla's new method has disrupted the automotive retail space and challenged regulatory frameworks in various regions. Many states and countries have laws that historically required vehicles to be sold through franchised dealers.

A significant advantage of Tesla's direct-to-consumer model is the ability to provide a unified and consistent customer experience. By controlling the sale process, the company ensures that the information provided is accurate and aligned with its brand values. Moreover, Tesla operates its service centers and mobile service units, providing efficient maintenance and repair services. This integration helps maintain customer satisfaction and ensures that the vehicles receive the necessary support throughout their lifecycle.

Regarding distribution and logistics, Tesla's distribution strategy is closely related to its manufacturing and logistics operations. The company's vehicles are produced at Gigafactories, strategically located to serve multiple markets. Tesla 's centralized control over distribution allows for a streamlined process, reducing the potential for delays and complications within traditional dealership networks.

Tesla's innovative sales and distribution model has also influenced other automakers in the automotive industry. Traditional manufacturers are increasingly exploring direct-to-consumer sales channels and digital engagement strategies. The rise of online sales platforms and technology integration in the retail experience reflects a shift toward a more customer-centric approach. This model has also emphasized the importance of a strong brand identity and customer engagement: automakers recognize the value of creating a cohesive and compelling customer experience to build brand loyalty and drive sales.

Tesla's distribution strategy will evolve as the company expands its lineup and enters new markets. Integrating advanced technologies like autonomous driving and artificial intelligence will further enhance customer and operational efficiency. Furthermore, the automotive industry embraces new sales models. Tesla's approach will serve as a benchmark for innovation and disruption, significantly departing from traditional automotive retail practices. With a direct-to-consumer approach, Tesla has reshaped how vehicles are sold and delivered, emphasizing customer experience, technological integration, and operational efficiency. (Roy, 2020) (Ramdattan, 2020) (Viglietti, 2024)

# CHAPTER 4

## HVO BIOFUEL: A POTENTIAL GAME-CHANGER

This chapter explores the transformative potential of Hydrotreated Vegetable Oil (HVO) biofuel within the energy sector. It begins with an introduction that outlines its characteristics, explaining how it differs from traditional biofuel and fossil fuel. The analysis then shifts to the supply chain, covering production, distribution, and retail. Insights into the complex logistics behind this alternative energy source are provided, followed by a detailed Business Model Canvas analysis. This analysis underscores the key components that drive business strategies for HVO biofuels. The chapter also emphasizes the potential benefits of adopting HVO in the energy sector, particularly its role in reducing carbon emissions and enhancing sustainability.

Later, the key players and competitors within the HVO biofuel market are analyzed, offering a comprehensive view of the competitive landscape. This leads to an impact analysis of the usage of HVO biofuel on the existing business model while also illustrating how this new fuel source could disrupt the traditional energy framework.

The chapter eventually presents a case study to ground these discussions in real-world applications: Nestle's My Renewable Diesel (HVO100). This case study is a practical example of HVO adoption, making the content more relatable. The chapter then concludes by evaluating the environmental and economic impacts of HVO biofuel adoption. This exhaustive exploration underscores the pivotal role HVO biofuel could play in the future of energy production and consumption.

### 4.1 INTRODUCTION TO HVO BIOFUEL AND ITS CHARACTERISTICS

Intending to reduce the consumption of fossil fuels and the consequent production of carbon dioxide, there has been an increasing discussion in recent years about biofuels. These fuels can be solid, liquid, or gaseous and are produced from biomasses such as sugarcane, palm oil, wheat, or corn. Their popularity is not only due to their status as a renewable energy source but also because they are carbon neutral.

Generally speaking, a biofuel is a substance burned to produce energy obtained by processing organic residues of plant or animal origin. These residues contain large amounts of carbohydrates (sugars) and fats; they can become fuels when appropriately transformed by microorganisms or chemical processes. The main advantage of biofuels is their lower environmental impact than their fossil fuel counterparts – such as oil and coal- especially regarding CO2 emissions. This does not mean that biofuels do not produce carbon dioxide. Still, it is possible to say that the amount of carbon dioxide they make is the same as what they had previously absorbed and converted into biomass through photosynthesis. So, essentially, they are carbon-neutral fuels.

When talking about biodiesel precisely, it is possible to say that it is produced from used oils and fats through a process called *"transesterification"* (Fangrui,1999) (Bonardo, Biocombustibili: cosa sono,come si producono, quali sono,vantaggi e svantaggi, 2022). Instead of starting with a biomass rich in carbohydrates meant to be transformed via yeast or bacteria, it is a biomass rich in fats that, through chemical reactions called "esterification," results in a biofuel comparable to diesel. This process is done by hydrocracking (breaking larger molecules into smaller ones using hydrogen) or hydrogenation (adding hydrogen to the molecules) of vegetable oil. As previously said, the main advantage of biofuels is that they are carbon neutral, meaning once burned, they release only the carbon dioxide previously trapped in tissues through photosynthesis. Moreover, another important characteristic is that they are compatible with the currently used engines without significantly compromising performance. This exact detail is not to be forgotten as it solves the problem of infrastructure, which is one of the main concerns of the energy transition process. During this period of change, many adaptations need to be made: how is it possible to create a whole new reality without so many disruptions while trying not to create even more problems simultaneously? With the current regulations of the European Union, automotive companies will no longer be able to produce vehicles with thermal engines. In this way, the parliament's proper aim is to disincentivize fossil fuel usage. While trying to solve a problem, another one has been created: What should be done about existing cars with thermal engines? Biofuel could replace fossil fuels while allowing people to keep their vehicles: this can benefit society and the environment by trying to recycle something that still works. The combustion of biofuels is not only carbon neutral but also cleaner, as it releases few impurities. They are a renewable source, meaning they can regenerate in a human time frame, and the ability to produce them anywhere makes them affordable and feasible, further reducing costs and environmental impacts for transportation and ensuring greater security of supply.

Some formulations comprise HVO mixed with other fuels, such as conventional diesel. However, fuels labeled “HVO100” refer to the fact that the formulations are not blended with different fuels and are 100% HVO.

The main disadvantages of biofuels stem from the environmental impact of cultivating the biomass used as necessary material. An important consideration is that to be sustainable, it needs to come from runoff or waste products: biomass that was not produced to make fuel. Biomass is explicitly produced to create fuel, potentially sacrificing resources that could serve other uses. Monocultures can lead to loss of biodiversity and increase the usage of fertilizers and land use in general, as well as water consumption, especially mining, and competition with the food market. This problem has been addressed by moving from first-generation biofuels to second-generation ones. Since biofuels originate from organic substances, entire fields were initially cultivated with crops that could be easily converted into energy. These include corn, rapeseed, sugar beet,plam, or plants typically used to produce first-generation biofuels. (Bonardo, Biocombustibili: cosa sono; come si producono, quali sono,vantaggi e svantaggi, 2022) (Goldsmith, n.d.).To add to the fact that monocultures are not always a good thing, using land to produce organic matter for biofuels can increase the cost of food. Arable land is not infinite, and dedicating land to energy production instead of food will reduce the food supply, raising prices. To avoid the competition between the food market and the use of land, second-generation biofuels were developed, which, unlike the first-generation ones, utilize organic residues, lignocellulosic materials, or pre-treated materials to avoid competition.

## 4.2 ANALYSIS OF HVO BIOFUEL SUPPLY CHAIN: PRODUCTION, DISTRIBUTION AND RETAIL

The supply chain of HVO biofuel is a highly sophisticated and well-coordinated process that spans from sourcing raw materials to delivering the final product to consumers and retailers. Each stage of the supply chain—production, distribution, and retail—plays a critical role in ensuring the efficiency and sustainability of HVO as a viable alternative to conventional fossil fuels.

Starting from the production segment begins with sourcing feedstocks, which primarily consist of vegetable oils and animal fats. Common feedstocks include waste cooking oils and animal fats. These raw materials are crucial for HVO production as they undergo hydroprocessing. Hydrogen removes oxygen from oils and fats in this refining method, resulting in a high-quality biofuel that can replace conventional diesel thanks to its similar characteristics.

The role of feedstock suppliers is critical in this stage as they ensure a consistent and sustainable supply of raw materials to HVO producers. These producers are often large refineries that have adapted their infrastructure and operations to handle biofuels. The flexibility of HVO production allows companies to source feedstocks globally, depending on availability and cost, which helps stabilize supply and production costs.

After the product is developed, the HVO enters the distribution network, which involves a complex logistics network to transport fuel from refineries to distribution centers and eventually to retail outlets. The distribution of HVO biofuel often leverages existing fossil fuel infrastructure, which includes pipelines, tanker trucks, and storage facilities. This compatibility with the current infrastructure is one of the many significant advantages of HVO, as it reduces the need for new investments in distribution channels, making the transition to biofuel more cost-effective and less disruptive. Logistics is crucial in ensuring that HVO reaches its intended markets effectively. Given the global nature of feedstock sourcing and production, HVO distribution networks often span multiple countries, necessitating a robust logistical framework that can handle international trade and compliance with varying regulatory standards.

The final stage of the HVO supply chain is the retail phase, where the biofuel is made available to consumers. Retail channels for HVO include traditional fuel stations, where HVO is often blended with conventional diesel, and dedicated biofuel stations offering pure HVO100. Retailers play a critical role in educating consumers about the benefits of HVO biofuel, such as its lower carbon emissions and compatibility with existing diesel engines. They also manage the pricing strategies and promotional activities that can influence consumer uptake. In addition to fuel stations, HVO biofuel is supplied directly to industries and fleets requiring large fuel volumes, such as transportation companies and agricultural operations, further broadening its market reach.

The adoption of HVO in the retail market is gradually increasing, driven by consumer demand for cleaner fuels and government policies that encourage using renewable energy sources. As the demand for sustainable energy solutions grows, the HVO supply chain is poised to play a crucial role in the global transition towards cleaner fuels.

### 4.3 BUSINESS MODEL CANVAS ANALYSIS FOR HVO

The growing demand for sustainable energy solutions has propelled HVO biofuel to the forefront of renewable energy discussions. HVO stands out because it can serve as a drop-in replacement for conventional diesel, offering significant environmental benefits while maintaining compatibility with existing diesel engines. As industries and governments increasingly focus on reducing carbon emissions, HVO represents a potential game-changer in the energy sector.

The Business Model Canvas provides a comprehensive overview of how HVO biofuel can be effectively produced, distributed, and marketed. It emphasizes strategic partnerships, resources, and activities essential for success in the emerging market.

| BUSINESS MODEL CANVAS FOR HVO | |
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| **1. Key partners** | • **Feedstock suppliers**<br>Essential partnerships with farmers, waste oil collectors, and animal fat suppliers ensure a steady and sustainable supply of raw materials critical for HVO production. These suppliers are the backbone of the supply chain, providing the diverse feedstocks necessary to maintain production efficiency and quality.<br><br>• **Technology providers**<br>Collaborations with companies specializing in hydroprocessing technology are crucial for optimizing production processes and ensuring that HVO meets industry standards. These providers bring cutting-edge innovations that enhance the conversion of raw materials into high-quality biofuel. |

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| | • **Government and regulatory bodies**<br>Engaging with government entities is vital for securing subsidies, meeting regulatory requirements, and aligning with environmental policies. These partnerships can provide financial incentives and ensure the business operates within legal frameworks, thus minimizing risks.<br><br>• **Logistics partners**<br>Efficient supply chain management requires reliable logistic partners to transport feedstocks and final products. These partnerships are essential for maintaining a smooth flow of materials and ensuring timely delivery to markets.<br><br>• **Fuel retailers and distributors**<br>Collaborations with fuel stations and distribution networks are critical for bringing HVO to the end consumer. These partners help expand market reach and ensure the product is accessible to a broader audience. |
| **2. Key activities** | • **Feedstock collection and pre-treatment**<br>This involves sourcing and processing raw materials such as used cooking oil, animal fats, and non-food crops to prepare them for production. The feedstock collection includes identifying reliable suppliers, negotiating contracts, and ensuring a steady supply. Pre-treatment involves filtering, heating, and chemical treatment to |

remove impurities and ensure the feedstock meets the quality standards for efficient conversion into HVO.

- **Production and refining**

This product's core activity is transforming raw feedstocks into HVO using advanced hydroprocessing technology. This process involves catalytic hydrogenation, which removes impurities and saturates hydrocarbons.

- **Quality control**

Rigorous testing and monitoring throughout the production process to ensure that the final product meets stringent fuel quality standards. This includes regular inspections of the production facilities, testing the feedstock and the final product for impurities and performance, and continuous monitoring of the production process to identify and address potential issues. This step is crucial for maintaining product integrity and consumer trust.

- **Distribution and logistics**

Managing the supply chain ensures that HVO is efficiently transported from production facilities to retail outlets. This includes optimizing routes, ensuring regulatory compliance during transport, and minimizing distribution costs.

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| | • **Marketing strategies**<br>Developing strategies to promote both HVO's environmental and performance benefits to both B2B and B2C markets.<br>Effective marketing can drive adoption and expand the customer base, while targeted sales efforts can secure long-term contracts with key clients. |
| **3. Key resources** | • **Feedstock sources**<br>A reliable supply of diverse feedstocks, including waste oils, fats, and non-food crops, is essential for maintaining production levels and ensuring the business's sustainability.<br><br>• **Production facilities**<br>State-of-the-art refineries equipped with hydroprocessing technology are necessary to produce high-quality HVO. These facilities are the heart of the production process, converting raw materials into the final product.<br><br>• **Human capital**<br>A skilled workforce, including chemical engineers responsible for the production process, logistics experts managing the supply chain, and marketing professionals developing and implementing strategies, is crucial for operating the business efficiently and effectively. Their expertise and dedication are vital to maintaining high-quality |

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| | standards, ensuring regulatory compliance, and promoting HVO effectively in the market.<br><br>• **Intellectual property**<br>Patents and proprietary technology related to the production process provide a competitive edge and protect the business from competitors.<br><br>• **Logistics network**<br>An established and efficient logistics infrastructure ensures the smooth transport of raw materials and finished products, minimizing delays and reducing costs, thereby enhancing HVO's environmental and economic benefits. |
| **4. Value proposition** | • **Superior environmental performance**<br>HVO offers a remarkable reduction in greenhouse gas emissions, up to 90%, compared to conventional diesel. This decrease in carbon footprint is achieved without compromising engine performance, making HVO an ideal choice for companies and governments committed to sustainability.<br><br>• **Seamless compatibility**<br>HVO, a “drop-in” fuel, offers a seamless transition for existing engines, eliminating the need for costly upgrades, vehicle fleets, and machinery replacements. This ensures a smooth and hassle-free shift to a more sustainable fuel option. |

- **Sustainability and circular economy**

Biofuel is produced from renewable resources, which supports the circular economy principle. This approach minimizes the overall environmental footprint but also solves waste management challenges.

- **Regulatory market advantages**

As governments worldwide introduce stricter emissions regulations, HVO provides businesses a competitive edge by ensuring compliance with these new standards. Moreover, this product can enhance a company's corporate social responsibility profile, improving brand reputation and customer loyalty.

- **Energy security and local production**

HVO can be produced from various feedstocks, many of which are available locally. This reduces dependence on imported fossil fuels, enhances energy security, and supports local economies. This flexibility in sourcing also allows for regional production, reducing transportation costs and the associated carbon emissions, further enhancing HVO's environmental and economic benefits.

- **Economic viability and scalability:**

HVO offers a promising and scalable solution with its cost-effective operation scaling as the demand for sustainable fuels grows**.**

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| | Production leverages existing refining technologies, allowing for cost-effective scaling of operations. As demand for sustainable fuels grows, HVO offers a scalable solution that can be ramped up to meet market needs.<br><br>• **Premium market positioning**<br>Given its environmental credentials, performance benefits, and regulatory advantages, HVO can be positioned as a premium product in the fuel market. This allows potential price premiums, appealing to eco-conscious consumers and businesses looking to enhance their sustainability profiles. |
| **5. Customer relationships** | • **B2B partnerships**<br>Strong relationships with logistics companies, government bodies, and large corporations focused on sustainability initiatives. These partnerships often involve long-term contracts and collaborative efforts to reduce carbon footprints.<br><br>• **Customer support and education**<br>Providing comprehensive support and education to customers about the benefits and usage of HVO. This includes technical assistance, training sessions, and informative campaigns to build trust and ensure customer satisfaction. |
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| **6. Customer segments** | • **Logistics and transport companies**<br>Businesses in the logistics sector are looking to reduce their environmental impact and comply with emissions regulations.<br><br>• **Government and municipalities**<br>Public sector entities seeking to promote sustainability, reduce emissions, and meet renewable energy targets through using HVO in public transportation and other fleets.<br><br>• **Individual consumers**<br>Eco-conscious consumers who own diesel vehicles want to reduce their carbon footprint by using a greener alternative to traditional diesel.<br><br>• **Fuel retailers**<br>Gas stations and fuel distributors interested in expanding their product offerings with sustainable fuel options like HVO, catering to a growing market demand |
| **7. Channels** | • **Fuel stations**<br>HVO is distributed through existing fuel stations, making it easily accessible to consumers and businesses. This channel leverages the current fuel distribution infrastructure for widespread market penetration. |

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| | • **Direct sales**<br>Agreement with large fleet operators, logistics companies, and government agencies for direct supply contracts. This channel focuses on B2B sales, offering bulk deliveries and tailored solutions for large-scale users.<br><br>• **Online platforms**<br>Utilizing digital platforms to promote and sell HVO, particularly in B2B markets. Online channels allow targeted marketing, streamline ordering processes, and enhance customer engagement.<br><br>• **Partnerships with OEMs**<br>Collaborating with original equipment manufacturers to endorse and promote the usage of HVO in new diesel vehicles. This channel helps integrate HVO into the automotive industry and encourages widespread adoption. |
| **8. Revenue streams** | • **Fuel sales**<br>Primary revenue is generated from the sale of HVO to consumers and businesses through retail fuel stations and direct contracts. This stream represents the majority of the company's income. |

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| | • **Government incentives**<br>Governments provide revenue from subsidies, tax credits, and other financial incentives for producing and using renewable fuels like HVO.<br><br>• **B2B contracts**<br>Income from long-term supply agreements with logistic companies, municipalities, and other large-scale fuel consumers. These contracts provide steady, predictable revenue.<br><br>• **Licensing and technology transfer**<br>Additional revenue from licensing the production technology or intellectual property to other companies or regions interested in HVO production.<br><br>• **Carbon credits**<br>Potential revenue from the sale of carbon credits earned by reducing emissions through the use of HVO. These credits can be sold on carbon markets, providing an additional income stream. |
| **9. Cost structure** | • **Feedstock procurement**<br>Significant costs associated with sourcing and processing raw materials. The price and availability of feedstocks can fluctuate, impacting overall production costs. |

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| | • **Production and refining**<br>High capital and operational expenses for running hydroprocessing facilities, including energy, labor, and maintenance costs.<br><br>• **Logistics and distribution**<br>The costs of transporting raw materials and finished products include fuel, vehicle maintenance, and regulatory compliance fees.<br><br>• **R&D**<br>Continuous investment is needed to improve production processes, explore new feedstocks, and stay ahead of industry trends.<br><br>• **Marketing and sales**<br>Budget allocations for promoting HVO to different market segments, educating customers, and driving sales growth through various channels. |

In conclusion, the Business Model Canvas for HVO biofuel illustrates a robust and multifaceted approach that captures the value inherent in this innovative and sustainable energy source. The framework underscores the critical importance of strategic partnerships, particularly with feedstock suppliers and technology providers, to ensure a consistent supply chain and cutting-edge production processes. It also highlights the seamless integration of HVO into existing infrastructure, which provides a significant advantage in market adoption and regulatory compliance. The enhanced value proposition of HVO, with its superior environmental performance, engine compatibility, and alignment with the circular economy principles, positions it as a premium product that addresses current and future demands for cleaner energy. Additionally, the canvas emphasizes the scalability and economic viability of HVO production, supported by potential revenue streams from government incentives and carbon credits. Overall, the Business Model Canvas reveals that the success of HVO biofuel lies in its ability to deliver substantial environmental benefits while maintaining economic competitiveness, making it a key player in the global transition to sustainable energy.

## 4.4 POTENTIAL ADVANTAGES OF HVO ADOPTION IN THE ENERGY SECTOR: ENVIRONMENTAL AND ECONOMIC ASPECTS

As previous analyses have shown, HVO can be a game changer for the energy sector in a specific way that has never been compared.

Transitioning from petrol/diesel fuels to an alternative source like HVO fuel can benefit the environment and decarbonize operations. HVO reduces greenhouse gas emissions by up to 85% and releases fewer nitrogen oxides than traditional diesel. These emissions can harm human health and contribute to the formation of smog and acid rain, as well as significantly impact the tropospheric ozone.

Moreover, when combusted, HVO creates fewer harmful particulates than standard diesel.PM contains liquid droplets that are so small that they can be inhaled and have been associated with severe health problems. As it is possible, this diesel alternative is less toxic than standard diesel. It is readily biodegradable, avoiding land and waterway pollution in case of a leak or spillage. HVO does not contain the harmful components present In fossil fuels (aromatics, for example) and is instead made of 100% renewable feedstocks.

Another important detail is that HVO is FAME-free. When Fatty Acid Methyl Esters are present in fuel, they become hygroscopic, which means they attract and hold onto water, where bacteria grow and sludge forms. This sludge then goes back to block filters, damaging engines and equipment. Unlike all the other biodiesel, HVO does not have this downside as it can resist the attack of water contamination by not absorbing moisture.

A higher cetane number indicates instead ignition properties. It also measures how well an engine can start in cold weather while contributing to cleaner and more efficient combustion: the higher the cetane number, the better the engine starts. It has an extended life and can be stored for ten years without degrading. It also does not solidify in cold weather, having a low cloud point of -32 °C.

From a manufacturer's perspective, this renewable diesel also meets the regulatory standards. Neste, one of the leading players in the renewable diesel market, has produced an HVO that meets the EN 15940 class in the European Union, which sets the benchmark for paraffinic diesel fuel derived from synthesis or hydrotreatment.

After mentioning the main environmental benefits, its interchangeability must also be mentioned. The drop-in fuel is compatible with diesel engines; that way, it can be used as an alternative to fossil diesel without needing to amend infrastructure or clean out existing stock. As discussed in this analysis, this is one of the biggest pros of this innovative biofuel: trying to fight climate change with the energy transition is undoubtedly something that could work, but all the “collateral effects” of this transition must also be considered. (Certas Business, 2024) (Girteka, 2021) (CTS Centre Tank services LTD, 2023) (Crown Oil, Fuel and Lubrificants).

It is called energy transition, requiring a proper shift and an actual conversion of the current energy sources. Trying to change also means abandoning all the outstanding achievements of the past: significant and established firms with thousands of workers who are employed and have a secure salary, infrastructure built for precise types of fossil fuels, and entire economies and industrial sectors that revolve around it. This part of the economy is generally embedded in society and strictly intertwined with human life. Changing would mean completely disrupting business models and ways of thinking about business.

With its versatility and innovation, HVO biofuel presents a promising alternative for energy resources. The adoption of HVO aligns with sustainability goals and carbon reduction commitments, offering both environmental benefits and a significant economic impact. The potential for job creation and new investments is just the beginning. Long-term sustainability could lead to substantial cost savings, sustaining businesses in the long run and enhancing market dynamics. This makes HVO biofuel a significant choice for companies looking to reduce their carbon footprint and environmental impact while achieving their operational targets. The economic benefits of HVO biofuel are not just a possibility but a promising reality.

In conclusion to this section, it is possible to say that adopting HVO biofuel presents a transformative opportunity for the energy sector, offering significant environmental, economic, and operational benefits. By reducing greenhouse gas emissions by up to 85% and lowering the release of harmful nitrogen oxides and particulates, HVO improves air quality and reduces public health risks. Its particular FAME-free composition, high cetane number, and resistance to water contamination make it a superior alternative to traditional biodiesel and fossil fuels, enhancing engine performance and longevity while being biodegradable and environmentally safer. Eventually, the HVO’s compatibility with existing diesel engines without requiring infrastructure modifications positions it as a practical and scalable solution for companies and governments looking to decarbonize their operations. Furthermore, HVO's alignment with the regulatory standards and the possibility of creating jobs, attracting new investments, and promoting energy security can strengthen its viability. It can be said that HVO offers a sustainable, versatile, and forward-thinking alternative that enables the energy sector to transition towards a low-carbon future without the costly disruption associated with other renewable energy sources.

## 4.5 IMPACT ANALYSIS AND POTENTIAL DISRUPTION OF TRADITIONAL BUSINESS MODELS IN THE ENERGY SECTOR: A CALL TO ACTION

The long-standing dominance of fossil fuels in the global energy sector is being increasingly challenged as the world shifts towards more sustainable energy solutions. HVO emerges as a strong contender in this transition, with its unique ability to replace traditional diesel without significant modifications to existing engines and infrastructure. Its environmental advantages, such as significantly reduced carbon emissions and fewer harmful particulates, position it as a critical alternative to conventional fossil fuels. As more governments and businesses prioritize sustainability and carbon reduction, HVO could play a central role in phasing out fossil fuels, particularly in sectors like transportation and logistics. By offering a cleaner, renewable alternative, HVO has the potential to replace and erode the dominance of fossil fuels and reshape the energy market.

The widespread adoption of HVO could lead to a significant shift in the balance of powers within the energy sector. Newly created companies with renewable portfolios will benefit the most, as they are better positioned to capitalize on the growing demand for cleaner energy sources. Traditional fossil fuel companies and established firms may face increasing pressure to diversify their energy offerings and invest in renewable technologies. As HVO gains traction, the priorities of the key stakeholders, government, investors, and consumers are expected to shift towards more sustainable energy solutions. This shift in priorities could lead to increased investments in renewable energy, with a greater emphasis on decarbonizing industries traditionally relying on fossil fuels. The focus on sustainability and climate action may also drive greater collaboration between governments and the private sector, fostering innovation and accelerating the transition.

Companies already investing in renewable energy portfolios stand to gain a competitive advantage in the evolving energy market. Leading players in the HVO biofuel space, such as Neste, Eni, Q8, and TotalEnergies, have positioned themselves at the forefront of the renewable energy transition by developing scalable production capacities and securing sustainable feedstock supply chains. These companies are equipped to respond to the growing demand for renewable fuels and are likely to benefit from favorable regulatory environments that incentivize the adoption of cleaner energy sources. Furthermore, companies with diversified renewable portfolios are more resilient to market fluctuations and regulatory changes. By expanding their offerings to include HVO and other renewable fuels, these companies can reduce their reliance on fossil fuels and enhance their sustainability credentials, attracting environmentally conscious consumers and investors.

The adoption of HVO has the potential to significantly impact global energy markets by shifting demand away from fossil fuels and towards renewable alternatives. As more businesses and governments commit to reducing their carbon footprint, the demand for sustainable fuels like HVO is expected to increase. This shift in demand could lead to a decline in the consumption of traditional diesel and other fossil fuels, particularly in sectors such as transportation, logistics, and heavy industry.

Moreover, HVO's ability to be produced from various feedstocks presents an opportunity for new trade dynamics to emerge. Countries abundant in feedstock can become the new key players in the global HVO market, exporting raw materials or refined biofuel regions with high demand. This shift can disrupt traditional energy trade patterns, reducing the influence of fossil-fuel exporting nations and increasing the prominence of countries prioritizing renewable energy production.

To have a paramount vision of the successful adoption of HVO biofuel, it must be said that its fostering depends mainly on the regulatory environment and the support that governments and policymakers provide. In many countries, governments have introduced policies to reduce carbon emissions and use renewable fuels. These kinds of policies include tax incentives, subsidies, and mandates that encourage the production and usage of biofuels like HVO. However, potential regulatory challenges could hinder the widespread adoption of HVO. Some regions can be slower in implementing renewable policies, particularly if they have strong ties to the fossil fuel industry. Additionally, feedstock availability and sustainability may pose regulatory hurdles as governments seek to ensure that HVO production does not contribute to deforestation (as with the output of HVO, which is done with rapeseed oil) or compete with food production. Countries and regions with progressive environmental policies are more likely to support the use of HVO through financial incentives, carbon credits, and fuel mandates. In areas with strong regulatory support, HVO adoption can accelerate, providing a viable pathway for industries to decarbonize their operations; however, in places where fossil fuels remain deeply embedded in the economy. The regulatory environment may be less conducive to

HVO adoption. In such cases, businesses may face higher barriers to entry, including limited access to government incentives and greater competition from fossil fuel providers.

Adopting HVO can potentially significantly disrupt traditional business models in the energy sector. It challenges the dominance of fossil fuels, shifts the balance of power, and reshapes market dynamics. Companies with a robust renewable portfolio will likely thrive in this evolving landscape, while those reliant on fossil fuels may struggle to adapt. The regulatory environment will play a crucial role in supporting or hindering the adoption of HVO. Regions prioritizing sustainability and decarbonization are more likely to see the most significant benefits, including reduced carbon emissions and a more sustainable energy sector. As demand for cleaner energy sources grows and trade dynamics shift, HVO could become a key player in the global energy transition, helping to achieve long-term environmental and economic sustainability.

### 4.6 CASE STUDY: NESTE'S MY RENEWABLE DIESEL ™ (HVO100)

Neste, a state-owned Finnish energy company, was founded post-war to ensure Finland's energy security. The company initially focused on refining Russian oil, starting as an oil firm. A critical distinction between Neste and other companies like Eni is that Neste does not engage in upstream activities (exploration and extraction of hydrocarbons) but focuses solely on downstream operations, specifically refining. In the energy sector, 'upstream' operations refer, in fact, to activities related to the exploration and extraction of raw materials, while 'downstream' operations involve the processing and refining of these materials into usable products.

Around ten years ago, Neste began refining renewable materials. Initially, the company started with first-generation vegetable oil and gradually shifted towards second—and third–generation materials. This move was pioneering, as few companies were making such a transition at the time. Against all odds, Neste successfully bet on renewable energy, transforming from a small Finnish refinery into the world's leading producer of renewable diesel. This transition is a compelling example of the potential of HVO biofuel and its opportunities in the energy sector.

Neste's essential products include HVO and SAF (Sustainable Aviation Fuel) for aviation, both derived from biomass refining. These products achieve up to 90% fewer emissions than fossil fuels and are chemically almost identical to fossil fuels, making them perfect renewable substitutes.

This company has developed such products, starting from the need to recreate a hydrocarbon molecule that is not based on coal and oil refining but on refining biomass products. This innovative approach has allowed Neste to create a fuel almost identical to the fossil one from a chemical-physical standpoint, a critical factor in their success in the renewable energy market.

Thanks to a company like Neste from northern Europe, this fuel type has begun to be developed all across Europe, for example, in Spain and the U.S.A.

At the European level, large companies such as Repsol, Total, and Eni have begun to introduce both the HVO and the SAF in their downstream. From a niche product unknown to the mass market, it has become inherent within companies willing to engage in sustainable energy. In fact, within many Italian filling stations, companies like Eni, Q8, and API groups have made the supply of HVO available through the same petrol pipes

that previously supplied diesel and gasoline. Moreover, it must be said that today's fuels already incorporate a bio component. Thanks to a European directive, in gas stations, it is possible to see labels on the cap or the tank door indicating the percentage of ethanol, biodiesel, and gaseous fuels with which the fuels are blended. For gasoline, the label consists of a circle containing the letter E with the percentage mixing with ethanol (5,10 or 85 percent). For diesel, instead, the letter B indicates the mixing of diesel with biodiesel (7 or 10 percent) derived from renewable sources or the acronym XTL for synthetic diesel. So, it is possible to say that this mixed form of gasoline and diesel has already been on the market for many years. The absolute novelty is HVO, which can be used in purity due to its chemical-physical characteristics, which are strongly similar to fossil fuels and can be used directly as a "drop-in" solution.
Having made the HVO known abroad as in Italy, Neste is the world's leading producer with a capacity of around 5.5 million tonnes. Its refineries are in Rotterdam, the Netherlands, Singapore, California, the United States, and Finland.
After briefly describing the company's generics, it is essential to talk about Neste MY Renewable Diesel™ (HVO100). Starting from the brand name, it emphasizes that individual choices matter and have a significant impact. Neste aims to help people and businesses reduce their climate impact and accelerate the transition towards carbon neutrality*: "MY choice. MY diesel"*. Reaching carbon neutrality is a joint effort where everyone's choice matters. It is "MY choice" to act towards a sustainable future. It is "MY choice" to make an impact. It is "MY choice" to do so today. This is the reason behind the name, which celebrates all the choices made for the benefit of the planet.
The core and Neste's processing technologies aim to ensure a flexible intake of different raw materials and have the option to ensure flexible intake of different raw materials and have the option to produce various products while having best-in-class operational performance. To turn a wide variety of renewable raw materials, even low-quality waste and residues, into high-quality renewable and circular solutions, Neste uses its patent NEXBTL™ (Next Generation Biomass to Liquid), a patented product of Neste's R&D efforts. This cutting-edge refining process converts a wide range of renewable raw materials into high-quality renewable diesel. This innovative technology enables the production of clean-burning fuels that are chemically identical to fossil fuels but with significantly lower carbon emissions. This technology makes Nestle MY Renewable

Diesel perform as well as fossil diesel. Still, it is made from renewable raw materials, reducing GHG emissions up to 90% and having lower emissions over the fuel's life cycle when compared to fossil diesel.

This HVO is also well-suited for icy weather conditions, up to -34°C: its cold performance is better than that of fossil diesel. The high cetane number (over 70) ensures efficient and clean combustion, as particle filter degeneration will decrease and exhaust emission will be reduced. Neste's product is also a cost-efficient solution to decreasing GHG, especially when considering the well-to-wheel approach and the total cost of ownership.

Neste MY is an HVO in its purest form (HVO100). Compared to other HVOs, it has the most extensive raw material portfolio, excellent production stability, and superior cold properties. HVOs come in all mixed forms: when blended with diesel, the sustainability benefits are reduced proportionally. For example, while HVO100 provides a $CO_2$ reduction of up to 90%, with HVO20, this is only 18%.

Moreover, discussing the sustainability of the raw materials is essential since it is one of the most controversial problems in HVO production. Neste has created a transparent, end-to-end value chain where it is possible to trace the renewable products back to their source material. The company has a solid process that requires all suppliers to meet strict sustainability standards. The supply chain's strength also uniquely positions the firm to enable any business or community generating waste and residue materials to partner with Neste to convert waste into fuels that certifiably power their fleets.

Despite being widely available and delivering the same high performance but with cleaner combustion, it also has excellent storage properties. Due to its purity, it can be stored over long periods. It does not attract water, which means there is zero risk of product quality deterioration or microbial growth with proper handling and storage. It has excellent stability, which provides outstanding storage properties.

Renewable diesel and biodiesel are different fuels. Neste MY Renewable Diesel uses only renewable raw materials, and suppliers meet strict sustainability criteria. It is an HVO purified and treated with hydrogen at high temperatures, giving it a chemical composition like that of fossil diesel.

As previously mentioned, biodiesel is based on Fatty Acid Methyl Ester (FAME). Its quality is lower and less constant. Biodiesel also differs in composition from both fossil and renewable diesel. Due to its chemical composition, Neste's HVO does not require additional vehicle fleet investment or maintenance. Biodiesel does, however, require engine modifications and increased servicing. (Neste, n.d.) . With a transparent, sustainable supply chain and a well-functioning product, Neste MY Renewable Diesel™ can lead the global transition towards carbon neutrality while providing significant environmental, economic, and operational benefits.

# CHAPTER 5

# OVERCOMING FEASIBILITY CHALLENGES AND ADOPTION STRATEGIES: EXPLORING THE POTENTIAL TRAJECTORY

The energetic transition is a critical priority for governments and industries worldwide, driven by the need to mitigate climate change and reduce GHG emissions. In this context, HVO has emerged as a promising solution, offering a cleaner, almost flawless, sustainable alternative to fossil fuels. With lifecycle emissions reduced by up to 90%, HVO has gained significant traction. However, the widespread adoption of HVO faces several feasibility challenges, from technical limitations to economic barriers. This chapter will explore the strategies and initiatives needed to overcome these challenges. Research and Development (R&D) plays a pivotal role in improving production efficiency and addressing feedstock limitations. As the demand for HVO grows, the need for innovative solutions to enhance scalability and reduce production costs while maintaining high sustainability standards becomes increasingly crucial. Eventually, collaborations and partnerships will be crucial to enhance regulatory compliance and market penetration, leading HVO in future energy and sustainability goals.

## 5.1 RESEARCH AND DEVELOPMENT INITIATIVES TO ADDRESS FEASIBILITY CHALLENGES

The future large-scale adoption of HVO biofuel depends on overcoming several feasibility challenges, such as feedstock sourcing, production efficiency, and maintaining fuel quality across different climates and applications. R&D initiatives and efforts are vital in addressing these limitations and ensuring HVO competes with traditional fossil fuels. Numerous firms have already implemented innovative solutions to overcome HVO's limitations and expand its use in various industries.

One of the critical challenges in HVO production is securing a reliable and sustainable feedstock supply. Biofuels are categorized according to the raw material used: either from the origin of the biomass or identified as waste. Engineers, with their pivotal role in continually developing technologies, are instrumental in creating a better formula. This ongoing innovation has led to the development of first, second, third, and even fourth-generation biofuels, each representing a step forward in biofuel production.

First-generation biodiesel is produced from food-based crops such as soybean, rapeseed, sunflower, palm, and other vegetable oils. These crops are later directly converted into biofuels through processes such as transesterification. However, these biofuels, which are now obsolete, raised significant environmental and ethical concerns—starting from the fact that given those types of feedstocks, the energy sector started to compete with the food industry, leading to increased food prices and contributing to deforestation in particular with palm oil and rapeseed. Moreover, using fertilizers and pesticides and the intensive land usage associated with food crops, biodiversity loss, and environmental degradation negatively affected ecosystems and contributed to greenhouse gas emissions. Additionally, even if these first-generation biofuels are renewable, their net carbon reduction is not as significant as the entire lifecycle is considered, including the emissions from agriculture and land use changes. (Demibras, 2009)

The second-generation biodiesel uses non-food biomass, such as waste vegetable oils, animal fats, lignocellulosic biomass, and agricultural residues instead. These types of biodiesels indeed overcome the food vs. fuel debate by using waste materials and non-edible crops. However, they have a slightly more complex and expensive production process than the first. They also have a higher sustainability profile as these feedstocks reduce the need to dedicate agricultural land and limit deforestation. With the hydrotreating process, some companies have successfully produced hydrotreated vegetable oil (HVO), which offers much higher fuel quality and improved engine performance than traditional biodiesel. However, the production of second-generation biofuels is more complex and requires advanced technologies, making it more expensive to produce. The availability and collection of waste feedstocks present logistical challenges that can limit scalability. Here, Neste made a difference with its patented technology NEXBTL™ as it scaled production efficiently by adhering to sustainability principles. (Rejinders & Huijbregts, 2008)

Third-generation biofuel is produced from algae and microorganisms. Algae are considered an ideal feedstock because they have a very high oil yield per hectare compared to traditional crops and do not require arable land or freshwater cultivation. Algae can produce up to ten times more oil per hectare than conventional crops like soybeans or rapeseed, making it much more efficient. It can be grown in non-arable areas and offers a significant carbon capture potential, as algae consume CO2 during growth.

This makes third-generation biofuels capable of having a net carbon-negative impact. Despite the considerable advantages, high production costs remain a significant barrier to commercializing these biofuels. Growing, harvesting, and extracting oil from algae is an energy-intensive and much more expensive process, which makes it economically unfeasible at a large scale with current technology. Researchers and engineers are still developing third-gen biofuels, so scalability and production remain challenging at the early stages of development. (Christi, 2007).

Eventually, there will be fourth-generation biodiesel, representing biofuel technology's cutting edge. It is carbon-negative and produced using genetically engineered microorganisms or algae to produce biofuels while simultaneously capturing and storing $CO_2$. Synthetic biology and carbon capture storage technology (CSS) play crucial roles. Having the potential to achieve carbon-negative status, these biofuels can remove more $CO_2$ than they emit during production and combustion. By combining biofuel production with CSS technology, this biofuel can help meet ambitious climate goals, including the net-zero emission targets by 2050. Despite the significant advantages, this technology is still experimental. In this case, large-scale production is not yet feasible as significant investments in R&D and advanced technological infrastructure are required for optimized production. The cost and complexity remain the major obstacles. (Antizar-Ladislao & Turrion-Gomez, 2008).

Each generation of biodiesel represents a step forward in the quest for sustainable energy. While first-generation biodiesel pioneered the concept, the subsequent generations have aimed to overcome the limitations of food competition, resource use, and carbon emissions. Third and fourth-generation biofuels are still in development, and feasibility is a crucial obstacle. However, second-generation biofuels remain the most promising, halfway with the third and fourth ones. As research progresses, biofuels are adjusted according to industry and environmental needs. As cited above, Neste has developed a patented technology (NEXBTL™) to overcome technical limitations. Initially developed in the 1990s, this platform has led the company beyond several technical limitations traditionally faced by biofuels, such as feedstock diversity, production efficiency, and fuel quality. As it is possible to understand, one of the main challenges in biofuel production is the dependency on specific feedstocks, which can affect both scalability and sustainability. NEXBTL™ stands out because it allows low-quality raw materials, including animal fats, used cooking oil, and residues from vegetable oil processing. This flexibility reduces the need for virgin crops and helps turn waste into a valuable energy resource. Then, the hydrotreatment process employed is unique as it is a hydrodeoxygenation process. Unlike traditional biodiesel production, this process uses hydrogen to remove oxygen and impurities such as sulfur from raw materials, producing pure hydrocarbons chemically similar to fossil diesel. This part of the production process ensures that the end product is compatible with existing diesel engines without modifications. Eventually, after hydrodeoxygenation, the hydrocarbons are further refined through isomerization. This process adjusts the molecular structure of the fuel to optimize its performance for different applications, such as cold weather performance and long-term storage stability.

Another primary challenge with early biofuel technologies was their limited application and poor compatibility with existing infrastructure. Traditional biodiesel, based on Fatty Acid Methyl Ester (FAME), has issues with water contamination, engine clogging, and poor cold-weather performance. NEXBTL™ has successfully overcome these limitations, producing a fuel that behaves like fossil diesel, ensuring smooth operation in all climates, from extreme cold to hot environments.

The flexibility of feedstock used, combined with these advanced refining processes, makes NEXBTL™ a key innovation in the renewable energy sector as they make Neste MY Renewable Diesel™ superior to traditional biodiesel in terms of stability, scalability, and efficiency. (Neste)

## 5.2 TECHNICAL AND ECONOMIC BARRIERS TO HVO IMPLEMENTATION

Despite its significant environmental benefits, HVO faces several technical and economic barriers that must be overcome to achieve widespread adoption.

Starting from technical barriers, one of the primary ones is the availability of sustainable feedstocks. HVO production relies on waste oils and fats often subjected to supply chain constraints. The scarcity of these feedstocks can present a challenge in scaling up production to meet growing demand, particularly as more industries look to decarbonize their operations. Expanding the range of feedstocks by incorporating third and fourth-generation materials could alleviate some of these pressures. However, the technology and infrastructure required to process these alternative feedstocks are still under development, and substantial R&D efforts are needed. Another significant technical barrier is ensuring consistent fuel quality across production facilities and batches. Variations in feedstocks and refining methods can lead to fluctuations in fuel performance, particularly regarding engine compatibility and emissions reduction. This is especially critical in industries such as aviation, where fuel consistency and quality are paramount. However, Neste's NEXBTL™ technology enables the production of high-quality renewable diesel, not all producers have access to similar advanced technologies. Ensuring HVO meets stringent global fuel standards requires continuous innovation in refining processes and strict quality control measures.

Moreover, there are challenges related to infrastructure compatibility. While HVO is a drop-in fuel that can be used directly in existing diesel engines without modifications, some industries, particularly heavy-duty transport and aviation, may require further certifications and extensive testing to ensure long-term compatibility, so more widespread attestation is needed to ensure full-scale adoption. Additionally, ensuring optimal cold weather performance in regions with harsh climates can be challenging.

On the economic front, the cost of production is a significant hurdle for HVO adoption. HVO involves complex and expensive hydroprocessing techniques, including high-pressure hydrogenation and advanced catalysts. This can result in higher production costs than conventional diesel. For instance, HVO's price is higher than fossil diesel's, especially in regions where government subsidies or carbon pricing mechanisms are not in place to offset these costs. Furthermore, the cost of feedstocks plays a crucial role in determining HVO's economic viability. Since the supply of waste oils and fats is limited, increased demand for these feedstocks can increase prices, making HVO more expensive. Competing industries, such as the food and cosmetic sectors, which rely on similar raw materials, further exacerbate the issue. As a result, the price volatility of feedstocks poses a significant challenge to maintaining stable production costs, particularly as HVO production scales up. Another economic challenge is the lack of financial incentives in certain regions. While in the European Union and other areas such as North America and parts of Asia, there are tax incentives, subsidies, and carbon credits to support renewable fuel production, other regions may lack similar incentives. In markets where fossil fuels are heavily subsidized or where carbon pricing mechanisms are not in place, HVO struggles to compete on price. This lack of consistent financial support can deter investment in HVO production infrastructure, slowing the adoption of renewable diesel on a global scale. Lastly, the uncertainty of long-term policy support creates additional economic risk for HVO producers. While current policies in the European Union and other regions favor renewable fuels, changes in political leadership or economic priorities could lead to shifts in policy, reducing or eliminating subsidies and tax incentives. Such policy volatility could make long-term investments in HVO production less attractive to companies, potentially hindering the expansion of HVO facilities and infrastructure.

In conclusion, while HVO has a mighty potential to transform the energy landscape and significantly reduce greenhouse gas emissions, overcoming feasibility challenges and technical and economic barriers is essential for its widespread adoption. Expanding feedstock availability, ensuring consistent fuel quality, and reducing production costs are essential in making HVO a competitive alternative to fossil fuels. The government must continue providing financial incentives, stable policy frameworks, and regulatory support to encourage investment in HVO infrastructure and innovation.

## 5.3 COLLABORATION AND PARTNERSHIP TO ENHANCE REGULATORY COMPLIANCE AND MARKET PENETRATION

The successful adoption of HVO hinges on fostering collaborations and partnerships across sectors to overcome regulatory challenges and accelerate market penetration. Public-private partnerships and government support are essential in establishing favorable conditions for HVO's growth in domestic and international markets.HVO producers must forge alliances with various stakeholders, including governments, vehicle manufacturers, fuel distributors, and feedstock suppliers. These collaborations can significantly enhance compliance with sustainability regulations and allow greater market access.

Governments are pivotal in supporting HVO adoption through policy incentives, subsidies, and regulatory frameworks favoring renewable energy. In particular, the RED directive mandates that 14% of transportation energy must come from renewable sources by 2030. This is just one of the directives that have created a favorable environment for the growth of biofuels like HVO, incentivizing companies to shift toward sustainable alternatives. For example, TotalEnergies, another major player in the energy sector, has invested heavily in renewable energy, including the production of HVO. The company converted its La Mède refinery in southern France from a conventional oil refinery into a bio-refinery. By collaborating with the French government, TotalEnergies has aligned its operations with national renewable energy goals, benefitting from subsidies and regulatory support. This transition helped gain a foothold in the renewable fuel market and demonstrated how governmental support can facilitate large-scale adoption of HVO.

Collaborations between HVO producers and automotive manufacturers are crucial to ensure that renewable diesel is compatible with existing engines and vehicle technologies. For instance, Daimler, the parent company of Mercedes-Benz, has worked with Neste to test and approve HVO for use in its heavy-duty trucks.

By securing Original Equipment Manufacturer (OEM) certifications, HVO producers can ensure that their renewable diesel is a reliable substitute for traditional diesel in both light and heavy-duty vehicles. This level of compatibility reduces resistance to adoption and allows for seamless integration into the existing vehicle market. Similarly, Volvo Trucks and Scania have embraced HVO as a viable alternative to fossil diesel. These companies have partnered with renewable fuel providers to ensure their vehicles are HVO-ready, enabling fleet operators to transition to lower-emission fuels without needing costly engine modifications. As a result, companies operating large truck fleets can reduce their carbon footprint while maintaining operational efficiency.

In the aviation sector, partnerships between HVO producers and airlines drive the adoption of Sustainable Aviation Fuel (SAF), a form of renewable diesel tailored for aircraft. Neste has formed agreements with major airlines such as Lufthansa, Finnair and KLM, enabling them to reduce carbon emissions by using SAF in their fleets. The ability to use SAF without significantly modifying existing aircraft engines makes it a practical solution for the aviation industry, which faces increasing pressure to decarbonize.

One of the key factors influencing the success of HVO is its distribution and availability at fuel stations. By partnering with significant fuel distributors, HVO producers can leverage existing infrastructure to make renewable diesel more accessible to consumers. For example, in Italy, companies like Eni, Q8, and API Group have introduced HVO alongside conventional diesel at their filling stations, allowing consumers to switch to renewable diesel without altering their refueling habits. This type of collaboration helps normalize the use of HVO in everyday transportation and encourages broader market adoption.

Preem, a leading fuel company in Sweden, has partnered with renewable diesel producers to make HVO readily available at its fuel stations. By ensuring that renewable diesel is as accessible as conventional diesel, Preem is helping accelerate the transition. The company has also collaborated with government agencies to comply with national renewable energy mandates, demonstrating how partnerships can drive the adoption of HVO.

Lastly, sustainable feedstock supply chain partnerships are the last part. The production of HVO depends primarily on a reliable supply of sustainable feedstocks, such as waste oils, animal fats, and residues from agricultural and industrial processes. Neste, for example, has developed partnerships with suppliers across the globe to secure a consistent feedstock supply. The company ensures that all of its suppliers meet strong sustainability standards, which helps maintain the integrity of the HVO production process. By collaborating with industries that generate waste materials, Neste can convert them into high-quality renewable diesel, thus supporting the circular economy. Also, TotalEnergies sources raw materials from various industries, including agriculture and food production, to produce its HVO. By working with suppliers to develop transparent and traceable supply chains, TotalEnergies ensures that its HVO production meets international sustainability standards. This collaboration not only enhances the company's ability to scale production but also mitigates the environmental impact of its operations. (Neste, n.d.) (Neste, 2024)

## 5.4 ENVISIONING HVO'S ROLE IN FUTURE ENERGY AND SUSTAINABILITY GOALS

As the world shifts towards carbon neutrality and aims to limit the impacts of climate change, HVO's versatility and sustainability will play a pivotal role in supporting the achievement of essential energy and environmental objectives.

HVO, with its unique ability to support global carbon neutrality goals, particularly in industries that are difficult to electrify, such as transportation and aviation, offers a ray of hope in the fight against climate change. The United Nations Sustainable Development Goals (SDGs), particularly SDG 7 (affordable and clean energy) and SDG 13 (climate action), underscore the importance of increasing the share of renewable energy and mitigating climate change. HVO, by reducing lifecycle emissions by up to 90%, provides a practical and direct solution for governments and companies to meet these goals. Its significant contributions lie in its ability to decarbonize hard-to-abate sectors, such as heavy-duty transport and marine and aviation industries, which are often challenging to electrify due to their energy-intensive operations. In the aviation sector, SAF offers a renewable alternative that can significantly reduce emissions without costly modification to aircraft. Airlines such as Lufthansa and Finnair are already using SAF produced from HVO to power their fleets, demonstrating the promising future of this renewable fuel.

HVO production is not just about fuel; it is about supporting the principles of the circular economy, where waste and by-products are reused to create value. One key advantage of HVO is that it is produced from waste-based feedstocks and other residues. This reduces reliance on virgin materials and helps minimize waste, contributing to a more sustainable and circular approach to fuel production. The innovative and sustainable production process of HVO inspires the future of fuel production, demonstrating that it is possible to create value from waste and reduce our environmental footprint.

Another critical advantage of HVO is its potential to enhance energy security and reduce reliance on imported fossil fuels. As it can be produced from various feedstocks available in different regions, HVO allows countries to develop their renewable energy industries locally, reducing dependence on volatile international oil markets. Countries like Finland, the Netherlands, and the United States have invested in expanding their HVO production capacities, creating jobs, boosting local economies, and ensuring a secure supply of renewable fuels. This economic aspect further underscores the significance of HVO in the energy industry.

## CHAPTER 6

## OUTRO

In this concluding chapter, key insights and findings will be explored throughout the paramount analysis of the comparisons of the Business Model Canva framework, which has brought up a comparative evaluation of hydrocarbons, electric energy, and HVO. Each solution presents distinct advantages and limitations as the world transitions to cleaner and more sustainable energy sources. Hydrocarbons have long been the dominant energy source, but their environmental impact is undeniable. Electric energy, while offering a source-agnostic solution with growing infrastructure, faces challenges related to battery materials and long-term scalability. HVO, on the other hand, presents a balanced alternative by leveraging renewable feedstocks and offering a drop-in solution compatible with existing diesel infrastructure. This chapter will then consider a comparison of the Business Model Canvas of the three energy solutions previously analyzed to understand the differences, highlighting the strengths and weaknesses of each and exploring how they align with global sustainability goals. This analysis aims to provide a clear understanding of the future trajectories and feasibility of the energy models.

### 6.1 SUMMARY OF KEY INSIGHTS AND FINDINGS

After carefully analyzing every energy resource, the data gathered has enabled us to unveil and understand the main findings and their reasoning.

Energy is a fundamental part of our life: it moves everything, thanks to which humans can flourish. Having understood that it is no longer possible to act like it has been done nowadays, it is eventually the moment to stop and take a big step back. Understand that a change is needed, but more of everything is due to ourselves as a species and our planet as a place that has been called *home* since the dawn of civilization. The time to be responsible has come, and actions are needed—profound reasoning on sustainable ways to sustain the economy and basic operations that regulate everyone’s lives and actions.

Energy resources must be analyzed to understand which are most suitable for Earth and its inhabitants.

After reflecting on the analysis, it is evident that hydrocarbons are a powerful energy resource, thanks to which humankind has flourished and has made several steps toward future emancipation, technology, and enlightenment. Using fossil fuel, humans have discovered lands, transported people and goods, and established trade patterns and relationships with neighborhood countries. For reasons beyond simple pollution or detriment to the environment or health, it is essential to abandon now fossil fuels. They have taken us far from where we were before their discovery, but it is now the moment to change and choose a more suitable solution for today's challenges and problems.

It is possible to say that the solution for the future is a mix of renewable energy sources and not the government of just one. Electricity is the final solution; it is just one of the many that will be used to go through this energy transition. Every resource to face this transition is needed, as every solution can help in trying to change. Just like now, many energy sources are used differently according to need. It can be said that the first technology implemented (EVs) could not be the final solution but just a step that leads toward the solution and can serve as an example for future technologies to learn from their mistakes. It is possible to assert that a string of renewable energy sources will be born thanks to technology and highly skilled human capital. HVO can be the groundbreaker and the trendsetter.

## 6.2 COMPARISON OF THE BUSINESS MODEL CANVAS ANALYSIS: HYDROCARBONS, ELECTRIC ENERGY AND HVO

Comparing the Business Model Canvas of hydrocarbons, electric energy, and HVO is useful for concluding reasoning with data. It gives a clear picture of every energy solution. Key differences emerge based on operational structures, environmental impact, and future scalability.

Hydrocarbons, the dominant player in the global energy sector for so long, have a well-established business model with vast infrastructure and global trade networks. The main strength of fossil fuels is their availability and the already established and developed infrastructure, making them highly scalable. However, the environmental impact of the reliance on finite resources and increasing regulatory pressures make this model unsustainable in the long term.

Electric energy, particularly from renewable sources, offers a cleaner alternative and is vital in the transition toward sustainability. Its business model focuses on electrification, battery production, and the development of charging infrastructure. The main strength of electric energy lies in its environmental sustainability, even if it is only in the short run, as the raw materials of electric vehicle components face several challenges to be supported on a large scale and in the long run. The scalability of electric energy is promising, but its current limitations in battery technology and infrastructure present barriers.

HVO, by contrast, offers a middle ground with a renewable, carbon-neutral biofuel that can be integrated into existing diesel infrastructure without throwing away thousands of thermal engines that still work. Its strength lies in its drop-in compatibility with existing engines, providing an immediate solution for reducing emissions, particularly in hard-to-electrify sectors. However, the availability of feedstocks for HVO production and the relatively high production cost pose scalability challenges: government incentives and policies play a crucial role in overcoming these barriers.

The original objective was to prove how important it is to understand that taking a step forward requires taking a big step back. To move forward, we must abandon what has been deeply embedded in our lives for centuries, creating from scratch a future that belongs to us more.

HVO *is* a valuable solution that can lead the energy transition.

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