Investigating the impact of Russia's seizure of energy exports on the Finnish chemical industry

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Abstract

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After Russia launched its invasion to Ukraine on 24th of February 2022 European union and other western countries placed sanctions upon Russia. As one of its counter measures to these sanctions Russia demanded payment in Rubles for the exporting of its natural gas. Finland was one of the countries that declined to pay Russia in Rubles and was thus cut off from Russian natural gas networks. This was a major problem for the Finnish chemical industry which relies on natural gas more than other industries for its energy.

The work on the thesis was conducted by first laying out the possible research question followed by investigative questions that aided the research. After deciding upon the questions, the author moved to look for sources and researched the theory on the subject, conducted an interview and finally came into conclusions and results to finish the thesis. For demarcation the thesis deals mainly with Finland and the ending of Russian energy's impact on Finland's chemical sector. Even though the Russo-Ukrainian war and the sanctions it caused to be placed upon Russia was the main reason for the ending of the energy imports it is only looked upon briefly in the thesis.

The empirical part of the thesis was executed as a qualitative and desktop study since the aim of the thesis was to find out the overall situation of an industry. One interview was conducted to strengthen the reliability of the thesis and research. The theorical framework in the thesis aims to research the impacts that the chemical industry of Finland suffered without access to Russian natural gas and energy. The focus of the theory is on Finnish chemical industry before the war, during the war, what impact the Russian sanctions had and the future of energy in the chemical industry.

The research found that Finland's chemical industry was struck hard by the sudden ending of Russian energy though it was able to recover quite quickly. Finland's chemical sector was forced to retain its energy usage on a large sector which led to minimizing of production, layoffs for employees, and overall energy saving. In some situation companies had to seize production in general since the prices of raw materials and intermediate products sky rocketed. Finland was able to recover its energy sourcing for natural gas with the help of obtaining LNG vessel's from The USA and through Balticconnector that secured its natural gas imports from Estonia which helped the chemical industry to remain operatable and keep the prices of energy, raw materials and intermediate products within reasonable pricing.

Key words
Finnish chemical industry, sanctions, Russia-Ukraine war, Natural gas

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1 Introduction

On 24th of February 2022 Russia launched an all-out invasion of Ukraine. Russia's illegal and unprovoked assault was condemned by The EU and all western countries which resulted in heavy sanctions implied upon Russia to hinder its economy and capability of waging war on a larger scale. As one of its counter measures Russia stopped all natural gas exports to unfriendly countries that refused to pay for the gas in Rubles. Finland was one of these countries. The sudden and unexpected ending of natural gas exports were a heavy hit especially for the local chemical industry which was extremely dependant on Russian natural gas as energy.

Russia was the main energy provider for European countries and the halt of energy exporting from Russia has forced Finnish chemical companies into a tight spot regarding their energy usage and operations of their factories. The implications caused by the stopping of energy exporting from Russia have caused Finnish chemical companies to either stop production on certain factories or the need to gather additional energy from other suppliers and sources.

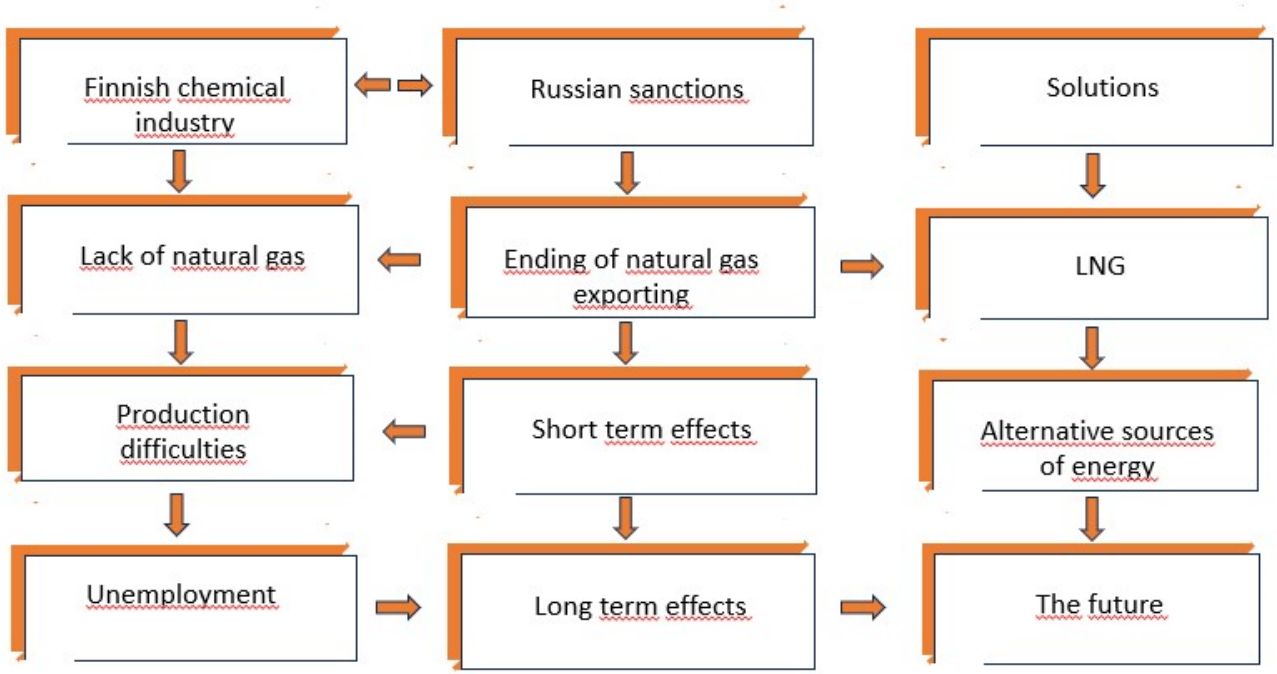
Finland's chemical sector required fast solutions for the lack of natural gas and energy in general to keep the industry operating. After the initial shock Finland needed to find alternative sources of energy fast. Finland aimed to find medium term solutions to secure its energy for the upcoming winter of 2022 – 2023. After the medium-term solutions were obtained Finland had to make general improvements and additions to its energy sourcing to further distance itself from Russian energy and to become completely independent from Russian energy. The sudden ending of Russian fossil energy also sped up the process of decarbonizing Finnish industries in general.

1.1 Demarcation

The thesis focuses on Finnish chemical manufacturing industry and how it has been affected by the ending of Russian energy imports. The thesis' main focus is on the Finnish chemical industry and aims to clarify how the effects of the lack of Russian energy have impacted the industry, how the sanctions themselves hurt the chemical industry in Finland, what the possible solutions for the energy situation there is and how will Russian energy be replaced in the future. The theory established in the thesis will aim to examine the situation from the view of the Finnish chemical industry. The thesis examines the energy supply from the start of the war February 24th 2022 to present day and future developments. All findings and results are based on the research made by the author.

1.2 Theoretical framework

Table 1. Theoretical framework



1.3 Research question and investigative questions

The aim of the research question is to find out how the lack of Russian energy has affected the Finnish chemical manufacturing industry after the start of the Russo-Ukrainian war. Finland refused to pay for Russian natural gas in Rubles and started its NATO application process. In response Russia stopped all natural gas exporting to Finland in May 2022. Many of the chemical factories are highly dependant on Russian energy. A mojority of these factories were forced to downgrade energy usage and make their operations more efficient and reducing production while the prices of the products sold have sky rocketed. The project objective is to research what was the state of Finnish chemical industry before the war, how the lack of Russian energy has affected Finnish chemical manufacturing industry, how the industry in Finland has been able to find solutions for the lack of energy and how the future will seem without Russian natural gas for Finnish chemical manufacturing industry.

RQ. How the lack of Russian energy affected Finnish chemical industry

IQ 1. The situation of Finnish chemical industry before the Russo-Ukrainian war

IQ 2. The effects of Russia's sanctions to Finnish chemical industry

IQ 3. Possible solutions for the lack of energy in the Finnish chemical manufacturing industry

IQ 4. Ideas for Finnish chemical industry to replace Russian energy in the future

Table 2. Overlay matrix

Research questions	Theoretical Framework	Research Management Methods *	Outcomes
IQ 1. The situation of Finnish chemical industry before the Russo-Ukrainian war	3, 3.1, 3.2	Desktop study, Qualitative research	9.1
IQ 2. What were the effects of Russia's sanctions to Finnish chemical industry?	4, 4.1, 4.2, 4.3,	Desktop study, Qualitative research	9.2
IQ 3. Possible solutions for the lack of Russian energy in Finnish chemical industry	5, 5.1, 5.2, 5.3, 5.4	Qualitative research, Desktop study	9.3
IQ 4. How will Finnish chemical industry replace Russian energy in the future	6, 6.1, 6.2, 6.3, 6.4, 7	Desktop study, Qualitative research	9.4

2 The importance of energy in the Finnish chemical industry

2.1 Energy modes used in the chemical industry

Without energy it is impossible to have an operating industry. Therefore, energy is always needed in some shape or form, whether directly or indirectly for all the activities we perform within sectors from transportation, commercial, industrial, and residential. The energy needs for these sectors are dependent on the sources that are available such as geographical location, availability, cost of harnessing and environmental effects. Availability of these energy sources aren't the same across the earth and neither are costs nor needs. All energy can be classified (widely speaking) as conventional and unconventional. Conventional sources of energy are the natural fossil energy which are coal, oil, natural gas, and nuclear energy resources. Unconventional energy sources are solar, wind, biological wastes, hot springs, tides, biomass, and others that may be used to generate heat and power. Unlike the conventional fossil energy resources, which are non-renewable, limited in availability and generate pollution, unconventional energy is renewable, are present in abundance in nature and generate less pollution throughout their lifecycles. (BMC Chemical Engineering 2019, 2-3).

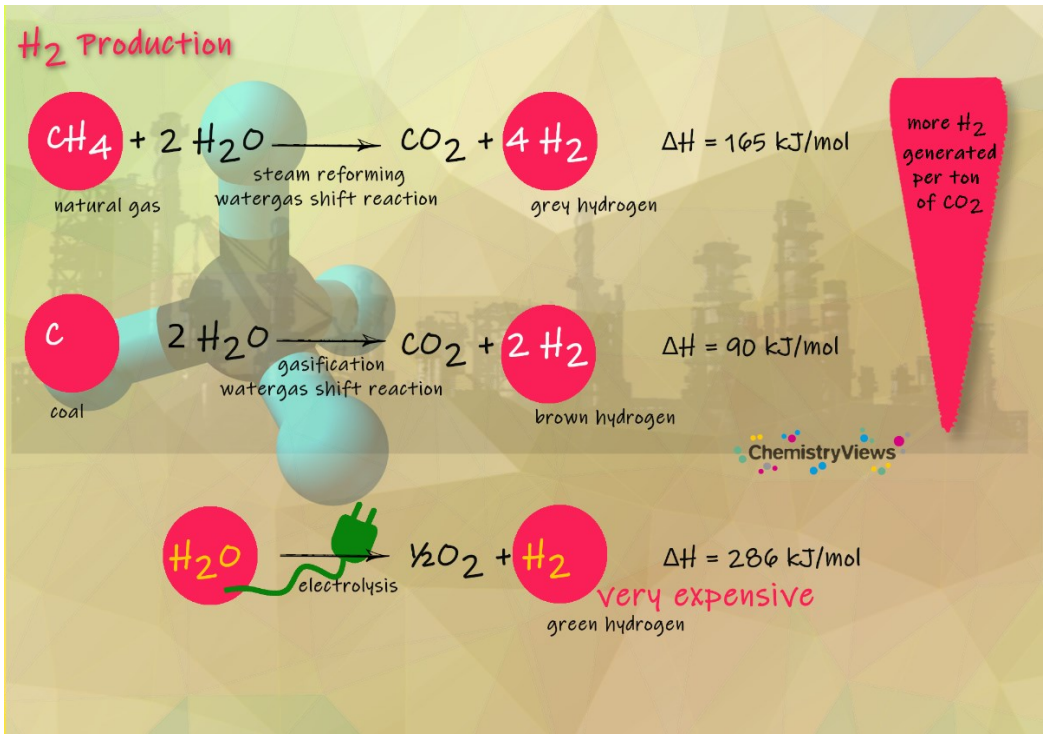
Chemical industry is considered as energy demanding industry since it operates many energy demanding technologies that need to be serviced by energy producing technologies which supply the demand in various forms. Chemical industry relies heavily on conventional forms of energy supply such as coal, oil, natural gas, and wood because of the high capacity of energy needed to operate the machinery and refineries. Also, the cost and availability of the most used resources of energy remain non-renewable. If the chemical sector were to move towards renewable and alternative energy sources the sector would have to restrict its energy consumption by 0,9% every year. The Finnish chemical industry uses mostly oil, natural gas, and electricity as its energy sources. With these sources now being non-abundant the industry had to find either alternative solutions or new sources for the existing modes of energy. (BMC Chemical Engineering 2019, 3).

2.1.1 The importance of natural gas for chemical industry

No industry needs natural gas as much as the chemical industry. The industry uses around 25% to 50% of the natural gas as a raw material and the rest is used for energy to create steam and power for plants and processes. Natural gas is needed as a raw material in creation of many highly important base chemicals ammonia and methanol being the most important base chemicals created. Methanol, hydrogen, ethylene, and propylene, oil/naphtha, biomass, and coal are also used as raw materials. (Koester August 2022).

For example, what comes to creation of green hydrogen (useful for manufacturing of ammonia and fertilizers) natural gas is far more useful than coal since with natural gas you get 1.5 times the hydrogen per carbon molecule than with coal. Both options produce a lot of CO_2 emissions, but natural gas (CH_4) is relatively much better feedstock. Currently steam reforming of natural gas produces most of the hydrogen available in the world. Hydrogen can be turned in to an essential energy-carrier and energy-storage application in the future. (Koester August 2022).

Figure 1. Hydrogen production per raw material. (Koester August 2022).

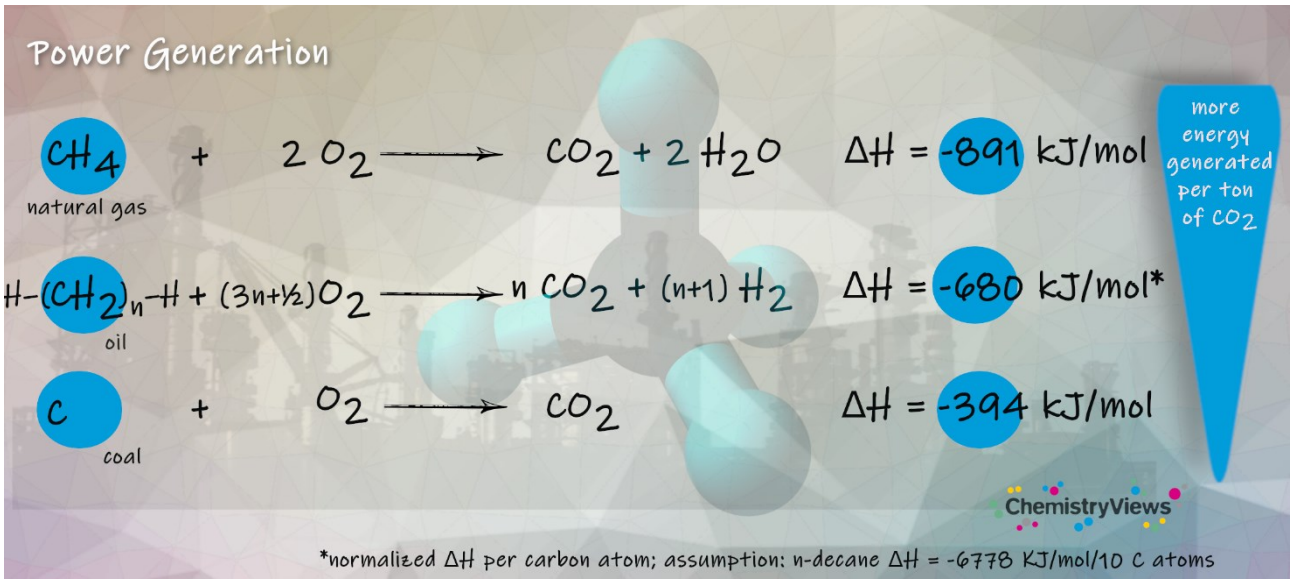


2.2 Generation of energy for plants and processes

Fossil resources are still the dominant raw material used to power manufacturing plants. The processing and reprocessing steps vary based on the raw material used whether it is natural gas, oil, or coal. Coal needs a very complex flue gas cleaning system where as methane (natural gas) combustion is quite clean. Methane (natural gas) has the highest energy combustion and lowest carbon dioxide emissions per kilojoule of energy which makes it extremely viable for the chemical industry. Natural gas has been particularly favoured among chemical industry as a fossil fuel in Europe and Finland. It does release CO_2 but does so less than oil or coal making it an ideal choice as of now. This has allowed Europe to remain competitive in the chemical industry while keeping CO_2 emissions somewhat low. However, methane (natural gas) is more damaging to the climate than CO_2 therefore alternative sources of energy must be found to power the plants and industry. The

Ukraine war and now non-existent import of Russian fossil fuels and energy has accelerated the innovation towards more renewable energy in Europe. (Koester August 2022).

Figure 2. Power generation per raw material. (Koester August 2022).



3 Finland's chemical sector before the invasion of Ukraine

Finland has one of the highest shares in renewables in its energy mix among European countries. The country produces 52% of its energy sources through renewable energy. 45% of the renewable electricity are produced with hydro power, 23% with wind power all the rest with wood-based fuels. 34% of the total energy produced were through nuclear power and 14% with fossil fuels and peat 10%. 2/3 of Finland's gas exports come from Russia and is used mostly in steel, oil refinery and chemical industries. (European parliament 2022, p. 22).

Finland was hit hard by the Covid-19 pandemic such as the rest of the world though it managed to revive its economy and was confidentially bouncing back its pre-pandemic levels. (Statistics Finland, 2021).

The trend before the invasion was good for the chemical manufacturing industry. The exporting predictions were better than usual before the start of the invasion. From the following months after the invasion the predictions stayed fairly neutral as the situation wasn't believed to be worsening or getting better than what it was currently. The overall production and order backlog were unexpectedly high in January of 2022. The order backlog measured by Tilastokeskus were 16% higher than 2 years ago within the industries of basic chemistry and medicine. Whether the change of the order backlog is examined by volume and quality the order backlog was at the same level as in 2019 which was a good year for the industry. Based on the Elinkeinoelämän keskusliitto (EK) economic survey the order backlog in January of 2022 secured the production for the next 3 months from January of 2022. This number was on par with the long-term average. From 2017 to 2021 the productions secured by the order backlog was around 4 months. (Kemianteollisuus Joulukuu 2022, 2).

Before the invasion of Ukraine, Russia was the main export partner of Finland in terms of oil based- and chemical products. Finland exported chemical products for 930 million euros to Russia in 2021 which equalled around 7% of the chemical exporting. In terms of euros oil and basic chemical products were exported the most both at around 286 million euros worth and refined oil products 284 million euros worth. From all product categories paint, varnish, and printing ink (29%), detergent and cosmetics (18%) had the greatest value for Finnish exports. (Aalto, 2022, p. 9).

3.1 Trade between Finland and Russia was vast before the invasion

Finland and Russia have been partnering within energy trade for a long time though the trade is very one directional. Finland doesn't possess any domestic fossil fuel supply of its own even though it has a high demand for energy. Russia on the other hand has vast amounts of energy

volume for its exploits. Finland has significant energy consumption per capita as it is located in an area with a cold climate and has several energy demanding industries. (Jääskeläinen et. al., 2018, 6).

Despite the Covid-19 pandemic Russia was Finland's largest business partner in 2020 and Finland Russia's fourth largest. In 2020 10% of all imported goods came from Russia. This was the largest portion of imported Russian goods of all EU countries. From Finnish exports 5,3% were to Russia only the Baltic countries exported more. Finland mainly imports energy and raw materials from Russia. The cash value of goods imported were around 8,6 billion euros in 2021. From the 8,6 billion euros 2,88 billion were used for crude oil, 800 million for natural gas, 635 million for refined gas, electricity 560 million and miscellaneous 170 million euros worth. Finland was Russia's fifth most important exporting partner with 3,8 billion euros worth of exported goods. Finnish exports to Russia accumulated to around 1% of Finland's GDP (2,5 billion euros). Finnish chemical industry exported 930 million euros worth of goods to Russia in 2021. Cash wise Finland exported basic chemistry the most (286 million euros) and refined oil products (284 million). The most important single products exported were paints, varnishes, ink products, detergents, and cosmetics. The whole Finnish chemical industry exported 12,7 billion euros worth of goods in 2021, only 400 million euros less than the forest industry. (Aalto 2022, 6).

3.2 Covid-19 epidemic had worsened Finnish chemical sector

The lack of raw materials and components had been in need globally for months before the invasion due to Covid-19 pandemic. The invasion of Ukraine wasn't viewed to relieve the bottleneck effect already existing, but its focus was seen as set to change. From the survey made by Kemianteollisuus to its partner companies it was found out that the rise in price of raw materials and components affected 96% of the companies that answered the survey. Only 16% of the companies were able to cover the risen costs by rising the prices of their immediate products. 4% of the companies answered that they are not able to cover the risen prices at all and 80% that they are only able to cover the costs somewhat. (Kemianteollisuus Maaliskuu 2022, 3).

Finland was just about to overcome its recession caused by the Covid-19 pandemic. Finland's GDP overcame its pre-pandemic level in 2021 and the economic rise continued strongly until the end of 2021. The models of the bank of Finland noticed that all the indicators pointed out that the economic rise would continue during the first months of 2022 as well. The revenues on all industries had surpassed the pre-pandemic levels and employment was on the rise. According to the statistics kept by Statistics Finland the overall production rose little bit less than the forecasts made by The Bank of Finland in 2021 3,3% (forecast was 3,5%). During the last quarter of 2021 Finland's GDP rose 0,6% from the previous quarter and 2,9% from the previous year. The growth in

investments, imports and exports were especially strong during the last quarter of 2021. In manufacturing industry, the order backlog and production had remained on a high level. The inflation had continued to rise rapidly during the start of 2022 in Finland. Yet it was still slower than in other European countries in general. The prices of energy rose in accordance with the prices of crude oil and electricity. The rise of the price in energy had been the main protagonist for the inflation in Finland. (Bank of Finland 2022).

4 Western sanctions on Russia had a high cost for the Finnish chemical industry

International sanctions are meant to hinder, restrict, or deny international trade, cooperation and diplomatic relations with certain states or groups. The sanctions work in part with other foreign policy restrictions to impact upon another state to limit its power if the forementioned state is threatening global peace or security. These actions may be distributing weapons of mass destruction, international terrorism, or widespread human rights violations. The repertoire of means of sanctions is to restrict export and import, financial sanctions, and traveling sanctions. Though trade embargos are not forced in the sanctions by EU. (Council of the European union 2022).

In 2022 Russia decided to pull back a major amount of its gas supply from its customers in the EU. Its aim was to fight back the sanctions placed upon it and aggravate the already growing energy crisis in Europe. The aim of this action was to make EU reduce the major political, military, and economic support EU was giving to Ukraine. (European council on foreign relations 2023).

On March 31st Russia by the order of its president Vladimir Putin called for companies in countries that had imposed sanctions on Russia to pay for their energy in roubles instead of dollars or euros as negotiated in the contracts. This change of currency was a straight breach for the sanctions placed upon Russia since the conversion of currency would mean conducting transactions with the Russian central bank which is prohibited in the sanctions placed. On May 3rd an outline of new measures was imposed by President Putin against individuals and companies from these “unfriendly countries”. Russian companies were banned from doing any business with companies that were located in the countries that had imposed sanctions against Russia even if they fulfilled the existing contracts and obligations. This included Finland and the chemical industry. (Reuters May 2022).

4.1 The problems of imported Russian natural gas were seen early on

The natural gas imported from Russia was significantly reliant upon by the nations of the European Union. Russia supplied over 38% of the imported natural gas in 2008. Due to the depletion of domestic gas resources and the planned phase-out of nuclear power in several European nations, 50 – 60% of all gas imports were anticipated to come from Russia over the course of the following two decades (the 2010’s and the 2020’s).

Most of the EU’s natural gas came from only three external producers Russia, Norway and Algeria with Russia being by far the largest exporter with 53.8% in 2021. Europe and Russia were both dependent on one and other respectively as a supplier and a buyer. This view doesn’t still negate the

fact that Russia had the advantage in the scenario of a war or other drastic change in world order. This is because demand will remain constant without the regard on price given the choice between warm and lighted European houses and cold and dark households with no electricity or heating. Any European will choose to have warmth regardless of the price. The European Union's energy policy was seen as forward thinking in its targets for renewable energy, economizing, and emission reduction, but it was also expected to fall short in recognizing security threats of the increased dependency on Russian hydrocarbons e.g., Natural gas. Russia was already seeking domination of the European gas markets and it was a clear and calculated goal of the Kremlin that they had worked towards for years already. Russia's domination of the European energy markets gave Kremlin high leverage potential in its dealing with some European states and would erode the sovereignty of Europe. (Anderson 2008, Chapter 1).

4.2 Russia's sanctions had immediate impacts on the Finnish chemical industry

Since Russia stopped its energy exporting to Finland in May of 2022 basically all the chemical manufacturing companies in Finland have suffered from high energy costs which has led to actions within the companies such as layoffs and minimizing of production. The business cycle in the chemical manufacturing industry had weakened clearly from summer of 2022. The energy crisis was reflected to all industries that were highly dependent on energy and electricity intensive manufacturing. 2 out of every 3 Finnish chemical companies had resulted in saving in energy costs. This resulted in mass layoffs and furloughs within the chemical companies. Energy was still used the most in the chemical industry in 2021. The industry used 6300 GWh of energy which was 7,5% of the energy usage in all of Finland. The vast usage of energy on top of a weak demand weakened the business cycle. (Kemianteollisuus Joulukuu 2022, 1).

Imported energy from Russia covered around 34% of the energy consumption in Finland in 2021. In the case of natural gas, the import percentage was the highest with 92% of the total consumption. This number was greater than expected and extremely viable for chemical manufacturing industries since natural gas is one of the most important energy sources for the industry. (Statistics Finland 2022).

4.3 The risen energy costs affected the revenue generated for Finnish companies

The seasonally adjusted revenue of the chemical manufacturing industry had taken a dip. The revenue grew heavily towards July of 2022 but had weakened massively ever since. In January of 2023 the revenue of the industry was 18% smaller than in July 2022. The reason for the uneven trend has been caused by changes in the costs of products produced. Typically, the chemical industry follows quite accurately the price changes of crude oil. The price of crude oil in January of

2023 was 83 euros per barrel, around 5% less than the year before. Chemical supplier prices have also been risen steadily from 2021. The rise of prices can be attributed to risen energy and input costs. In the industry prices were around 50% higher in 2023 than in 2021. Rubber and plastic industry prices were up 14% but medical industries price progress was more stable. (Kemianteollisuus Maaliskuu 2023, 3).

5 The possible solutions for the lack of Russian energy for Finnish chemical companies

During the first months of 2023 the European union was already sourcing its supply of natural gas from alternative sources outside of Russia. This meant a step up in EU's green transition since the European Commission proposed a temporary emergency regulation in order to use more renewable energy sources to steer away from the Russian sources. Finland started to seek alternative ways to import natural gas to keep its industries and infrastructure operatable and on-going. Finland made a choice to import natural gas from Estonia through the Balticconnector which connects Finland to the EU gas markets via Estonia and leased an LNG (liquified natural gas) vessel to work as a natural gas port. What comes to electricity, Finland is looking to become self-sufficient in 2023. The Nordic energy market, a common free electric-energy market in the Nordic countries, along with increased electricity generation from nuclear, water and wind power as well as other sources, should compensate for the country's loss of imported Russian electricity. (Embassy of Finland 2023).

5.1 Balticconnector

The Balticconnector is a natural gas pipeline connecting Finland and Estonia to each other. The aim of the pipeline was to end Finland's natural gas isolation after Russia stopped its natural gas exports to Finland. The Balticconnector serves multiple purposes. It retains the security of natural gas supply to Finland and will benefit the competition and energy market integration in the Baltic region. The connector comprises of three pipeline section: a 21 km-long onshore pipeline that connects to Finland, 77-km long offshore pipeline, and 54-km long onshore pipeline that connects to Estonia, in addition with auxiliary equipment including a pressure reduction station in Estonia and compressor and metering stations in both countries. The 152-km long gas pipeline is bi-directional and has a transmission capacity of 7.2 million cubic meters of gas per day. (Gasgrid 2022).

5.2 LNG (Liquified natural gas) terminal in Inkoo

The state of Finland tasked Gasgrid Finland Oy to find an additional source of natural gas to serve along the Balticconnector and ensure proper supply of natural gas for Finland and its many natural gas heavy industries. Gasgrid investigated the addition of a floating LNG terminal vessel, or a floating storage unit and regasification unit as an alternative to Finnish gas import in early 2022. The lease ensured that Finland could release itself from the dependence on foreign gas and ensure proper gas supply security during hard and unpredictable times was extremely important. The fastest solution for the shortage was chosen. With the LNG floating vessel terminal Finland's energy supply was ensured for both industries and households for the foreseeable future.

The floating terminal in Finland is 29 meters long and 43 meters wide and has a volume of approximately 151,000 cubic meters which means around 68,000 tonnes of liquified natural gas when fully loaded. This equals to around 1,050 GWh of energy content. The vessels evaporation capability is 140 GWh per day and even more than 40 TWh per year. This number exceeds Finland's annual natural gas demand which has been historically around 25 TWh annually. The terminal is anchored in Inkoo. The total cost of the LNG floating terminal project was estimated at 460 million euros under a 10-year lease agreement as well as costs related to the volume of use. (Gasgrid 2022).

5.3 Green hydrogen

Hydrogen and other hydrogen-based fuels are set to play important roles in the future energy and decarbonization of sectors where emissions are hard to abate, and alternative solutions are unavailable or difficult to implement. Hydrogen is best described as a versatile energy carrier that can tackle several energy challenges. Hydrogen is mainly used in the refining and chemical sectors and produced using fossil fuels such as coal and natural gas. There is an alternative way to create hydrogen though. Green hydrogen is produced with renewable or nuclear energy. Hydrogen powered machinery and industries would improve air quality and promote energy security. (International energy agency 2023).

Hydrogen is a cornerstone of Finland's push to climate neutrality through green hydrogen. The global market for green hydrogen doesn't only present huge potential but it is also playing a part in chemical industry as a viable energy source. Hydrogen is and can be used for chemicals, fuels, storage, and transportation. Finland took a concrete step towards a wider use of hydrogen when Gasgrid, a state-owned gas transmission system operator founded a hydrogen transmission company in 2022. The subsidiary is expected to establish a national transmission network for hydrogen, which is going to play massive role in Finland's sourcing of alternative and climate friendly energy sources. (Embassy of Finland 2023).

5.4 Nuclear power

Finland has 5 operating nuclear power plants, namely Loviisa 1, Loviisa 2, Olkiluoto 1, Olkiluoto 2, and Olkiluoto 3 which began operating in April of 2023. Finland is actively involved in developing new nuclear technology in terms of Small Modular Reactors known as SMR's and nuclear fusion. SMR's can be built close to residential areas and industrial complexes, which for they are ideal sources for low emission energy production. What comes to fusion energy, Finland is part of a project where 35 countries collaborate to build the world's largest tokamak, a magnetic fusion device that generates 500 MW of fusion energy for use of various industries and residents.

Finland’s reactors are some of the finest and efficient in the world. They have an average lifetime capacity factor of 90% which mean they can operate on 90% of power for their lifetime and average capacity factor over ten years is almost 95%. (Embassy of Finland 2023).

6 Countries reacted in different ways to the lack of Russian natural gas

Other countries were cut off from the Russian gas grid as well. Interestingly many EU countries had a different reaction to the ending of Russia's gas supply. Some countries were prepared with emergency plans, some had already started to diversify their gas sourcing, and some countries were caught completely off-guard.

6.1 Poland's reaction to the lack of Russian energy

On April 27th Russia turned off Poland's gas tap as they did Finland's as Poland refused to comply with Russia's demand of payment in roubles. Poland as well as Finland had prepared as they suspected the possible Russian gas blackmailing. Poland's gas reserves filled up to 76% of annual use whereas other countries on median had filled their gas reserves for 30% of the annual use. Warsaw understood the warnings of an imminent invasion of Ukraine before 2022 and started to prepare heavily on impacts on energy supply some weeks before the war started. Poland had long been diversifying their energy supply and gradually moving away from Russian gas and oil. According to the Polish government it has many different possibilities to substitute the now missing gas supplies from Russia. This can be done either by using the European pipeline systems via liquified gas terminal in Swinoujscie which was launched under the first PiS (Law and Justice party) government from 2005 – 2007 with small national gas production and onwards through the Baltic Pipe which supplies Poland with Norwegian natural gas. (Hillebrand April 2022).

On 29th of March 2022 Poland's council of Ministers made a revision to the Polish energy policy which lasts until 2040. This document sets out strategic directions of development which Poland will take for the fuel and energy sector. The document is aimed towards energy security towards larger diversification and independence of Polish energy supply. Emphasis was taken towards solar and wind energy. Also, intensified efforts were put towards developing the energy sector by utilizing more water, biomass, biogas, and ground heat. After the outbreak of war, Polish and Czech resumed discussions about an already abandoned Czech-Polish gas interconnector project Stork II. The capacity of the interconnector would have projected capacity of up to 1 bm3 though no decision to begin the construction has been made yet. Poland also invested in nuclear power before the invasion and derives viable energy through two established nuclear plants that can produce a capacity of 6 Gigawatts of electricity. In 2022 Poland also announced the plans to build a third nuclear power plant to increase the countries energy security. In 2022 Polish oil refinery company PKN Orlen and chemical company Synthos S.A. established a joint operation to build a new company called Orlen Synthos Green Energy S.A. that would be responsible to prepare and commercialize small modular reactors (SMR's) in Poland. OSGE wants to build as many as 76 reactors in

26 locations with the first ones being ready in 2028-2029. Other companies such as a mining corporation called KGHM announced an investment on SMRs. (Maj 2023, 9-11).

6.2 Estonia's reaction to the lack of Russian energy

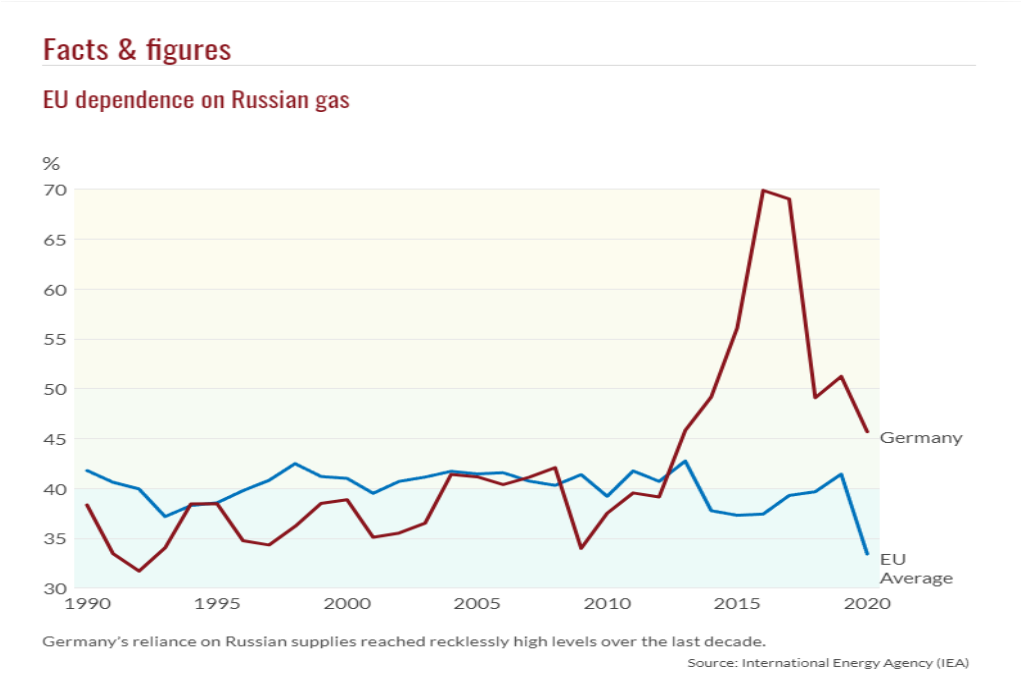
In order to distance itself from Russian gas and energy imports and to increase its national energy and gas security Estonia diversified its gas imports via LNG imports. The rapid completion of the Finnish LNG port was significant for the Estonian gas import sources. This is because Finland informed that it will not import any gas from Russia. Estonia followed Finland example of LNG ports and made agreements of the delivery of 10 total gas ships by the fall of 2023. Three of the deliveries will be made to the port of Klaipeda in Lithuania in winter and seven to the port of Inkoo in Finland during next spring/summer from both US and Norway. Although Estonia has existing gas networks still connected to Russian gas grids so that if the Russian gas prices collapse it may arouse Estonia's appetite for Russian gas once again. Estonia has recognized the importance of solar and wind energy. The total production of renewable energy didn't increase in Estonia in 2022. In fact, it decreased to 34% in 2022 from the previous 38% in 2021. The overall composition of renewables includes 54% biomass, biogas and waste, 26% of wind energy, 20% solar energy and 0% of hydro energy. The Estonian government realized the potential of wind energy in the country and comprised a plan to at least two more tenders in 2023 towards production of wind power stations in Estonia. Estonia has succeeded in energy consumption reduction on a large scale. In 2023 gas consumption reduced by 35% compared to the previous year's 29%. The reduction has been achieved through the usage of alternative fuels, energy saving, and introduction of heat pumps. Estonia also campaigned for energy savings and shifting its consumption towards hours of cheaper and more plentiful energy. According to the Estonian ministry of economy's forecast the energy consumption of Estonia will remain the same in 2023 as it did in 2022. Estonia has prepared gas grid improvements on its agenda. A more modern gas pipeline network is seen as an answer to use more gas with international non-Russian origins such as Lithuania's Klaipeda LNG terminal. Though Estonia will have tough time replacing gas with renewable alternatives since the gas is mainly used for heating instead of generating energy. (Lepments 2023, 12-14).

6.3 Germany's reaction to the lack of Russian energy

Unlike Estonia, Poland or Finland, Germany woke up too late to prepare itself on the risks of life without Russian gas imports. Germany found itself as one of the hardest hit economies in Europe in the gas crisis. In 2021 over half of Germany's gas supply was imported from Russia. Germany was by far the largest consumer of Russian natural gas by purchasing 53% of the total exports of

the EU countries. When Russia started its invasion of Ukraine the dynamics of the gas trade changed abruptly after Russia cut of its gas supply to the EU. A significant blow to the unprepared Germany. (Umbach September 2022).

Figure 3. Germany's dependence on Russian natural gas. (GIS reports online 2023).



Imports of Russian gas reached up to 501 TWh in 2021 and were reduced to the minimum late in the summer of 2022 as the Kremlin refused all gas exports to Europe in response to the sanctions placed caused by the Ukraine war by the western countries and the EU. To prevent the collapse of German chemical industries and the freezing of German homes in during the winter, Germany went on a purchasing spree of natural gas to secure its gas reserves and supplies for the upcoming times of uncertainty. The entity in charge of the German gas purchases Trading Hub Europe (THE) went on to purchase 50 TWh of gas from the world markets to ensure gas supplies for the winter ahead. In November of 2022, Germany reached its target of filling its gas storages to the point of 95%. (Kurmayer June 2023).

Germany, like Finland, Estonia and other countries put up a quick-thinking plan of importing Liquified natural gas (LNG) to ensure gas supply. As of now Germany is a host to three floating LNG terminals and is expecting a delivery or other three terminals in the end of 2023. The LNG terminals which of five are state owned and one privately owned will bring Germany's LNG import capacity to around 30 billion cubic meters of LNG. This amount is seen to be enough to replace all but fully the now replenished Russian gas imports that were the lifeline of German economy's

power supply and vital part of its vast chemical industry. In addition to the purchased natural gas from the world markets Germany now also enjoys the LNG terminals with constantly flowing gas to keep its industry machinery working. (Kurmayer June 2023).

On the political spectrum Belgium and Germany discussed the possibility of linking the two countries hydrogen networks in order to have more security on both countries gas supplies. After both countries agreed to connect their gas networks Germany was able to double its gas flow to the country. (Amelang, s. et. al., 2023)

6.4 What Finland did right and what it could learn from Poland, Germany and Estonia

Finland could fill its gas reserves to the maximum to have enough natural gas in storage the same as Poland. This reserve gas would work as insurance along the LNG received from the LNG port of Inkoo. The reserves would ensure the needed gas for upcoming winters and make sure the Finnish chemical industry receives the needed amounts of natural gas. Poland invested heavily towards water biomass, and biogas to have alternative and local sources of natural gas which would be beneficial to Finland as well. Estonia followed Finland's example with the lending of LNG vessels and started natural gas importing through the Balticconnector. Estonia's choice to work with Finland is a sign that Finland's solution to the energy problem was viable and working. Germany's example also shows that Finland did right decisions to ensure natural gas for its industries and households. Germany just like Finland leased LNG vessels to work as natural gas ports and secured its energy sector in the end. Germany is in discussions with Belgium to link the two countries hydrogen networks to ensure energy supply for both countries.

7 The future of the chemical industry without Russian energy

Finland after initial shock and high energy costs was able to retain its energy security within industries. Finland has now zero reliance on Russian energy as it is able to manage through LNG imports from its new LNG terminals, balticconnector pipeline and purchasing gas from the world markets that are not affiliated with Russian gas suppliers. Before the Russian invasion of Ukraine Russian imports accounted as much as 81% of Finland's crude oil imports, 75% of its natural gas imports and 19% of the electricity imports in 2020. Overall, one-third of Finland's energy imports came from Russia. Following the invasion Finland focused intensively to reduce the reliance of Russian energy and strived towards energy efficiency and increased of renewable energy of which Finland is a frontrunner in the world. Since the summer of 2022 Finland's energy imports from Russia have been completely terminated, except for some amounts of nuclear fuel to the Loviisa nuclear power plant. (Ministry of economic affairs and employment 2023, 6).

The Finnish manufacturing industry is moving towards carbon neutrality meaning getting rid of all carbon related raw materials. If methane is used as a molecule, it is to be manufactured from sustainable biomass or be manufactured by clean synthetical energy. Methane will no longer be obtained from within the earth itself. Nuclear energy is also seen as a potential substitute for the future as it is climate friendly. There is no particular answer for the future of the Finnish chemical industry for what comes to replacing energy that was used and is currently used in the Finnish chemical industry, but all the possible solutions and alternative sources of energy are expected to work together to replace current and lost energy sources in the future. What comes to replacing the Russian natural gas one of the possible alternative sources is hydrogen as hydrogen can be extracted from water though it requires vast investments such as infrastructure and more sources of electricity. In order to achieve the needed infrastructure for carbon neutral chemical industry in Finland approximately 14 billion euros should be invested into Finnish chemical industry for hydrogen manufacturing and other alternative climate friendly sources in the next 20 years though this is just a rough estimate. (Interview Tuomas Tikka Kemianteollisuus 2023).

Hydrogen is clearly seen as a potential solution and a source for power-to-X solutions replacing the natural gas and other fossil fuels. Finland has a working hydrogen strategy and two regional initiatives. Namely Gulf of Bothnia and one in south-eastern Finland. Some small-scale operations are ongoing within these two, but a bigger scale utilization is still in the works. As hydrogen production from water requires vast amounts of electricity Finland is also currently working on decarbonising its electricity production. This should be done easily. Wind power is growing rapidly which necessitates upgrades to the power grid requiring more monetary investments and upgrades to the power grid and solutions for intermittent production.

Finland has a wealth of opportunities to develop its hydrogen economy. When it comes to countries Finland obtains highly competitive onshore wind power and more wind power is built as the time goes on. Finland is also a source of vast amounts of clean water which is required for the electrolysis that is needed to create hydrogen as well as strong expertise and know-how of the topic. Finland's first industrial scale production plant for green hydrogen and synthetic methane is currently being built in Harjavalta, Finland. Construction of the plant began in the Autumn of 2022 and the plant is being completed in summer of 2024. However, the plant of Harjavalta will not be the only one. FINGRID plans to build up to 1,000 megawatts of electrolysis capacity in Finland over the next ten years. (FINGRID 2022, 11-13).

The chemical industry is moving constantly towards carbon neutral view. Meaning that all fossil raw materials producing energy will be discarded and changed to more climate and nature friendly options. The carbon neutral energy will be produced either from biodegradable raw materials or synthetically produced energy. No energy will be recovered from within the earth itself. The view also includes nuclear energy which is climate friendly option. There is no single solution for what comes to achieving carbon neutral chemical industry. The fact that Russia stopped energy exporting to Finland may accelerate the transition to renewable energy e.g., hydrogen, biogases, and other climate neutral and renewable energy sources which releases Finnish chemical manufacturing industry from the clutches of dependency on foreign energy. (Tuomas Tikka GE Kemianteollisuus interview).

Hydrogen is normally extracted from natural gas, but it can be done using water as well. Hydrogen extraction from water is a viable option but it requires vast investments and infrastructure (wind and nuclear power) to be possible for the chemical industry. Finland's chemical industry should up their investment percentage 70%, (roughly 700 million euros per year) until 2040 to achieve the needed infrastructure needed to harvest hydrogen from water. (Tuomas Tikka GE Kemianteollisuus interview).

8 Qualitative research

Qualitative research is a type of scientific research that consists of an investigation of a matter or matters that systemically use predefined set of procedures to answer questions, collect evidence, produce findings that were not determined in advance and produce findings that are applicable beyond the immediate boundaries of the study. Additionally qualitative research aims to understand a given research problem or topic from the perspectives of the local population it involves. In the case of this thesis the topic is viewed from the local Finnish perspective. (Northeastern university 2020).

This thesis is solely research based. No company is directly involved with the thesis and its content. The author is individually curious about the chemical industry in Finland and its aspects in the political surroundings in the current turbulent times. The author has his own experiences from within the industry in working life where he saw firsthand the impacts of the lack of Russian energy for the Finnish chemical industry. This prompted the author to pursue his thesis within the premises of the chemical industry itself but also to research its wider impact on the country of Finland and see how well Finland managed to sort its way out from a troublesome situation where it found itself from.

The guidelines for the thesis were set during spring of 2023 by setting up the initial research question and investigative questions and receiving a green light from the authors thesis advisor to start working on the thesis. A comprehensive plan for the thesis was first laid out and the author started working on the thesis starting from the first investigative question and gradually moving down the line. This approach helped the author to gain more basic understanding of the topic to effectively answer the research question and investigative questions. After the desktop study was completed, the author focused on finding an interviewee for the thesis to answer viable questions the author had, and to gain confirmation on the research done during the desktop study. After the interview the author moved to discussion and results to finalize the thesis.

The aim of the research is to find out how the lack of Russian energy has affected the Finnish chemical industry. The author chose to move forward with the thesis and the research question by qualitative research since the author had no commissioning company to work with and the lack of numerical data and statistics within the Finnish chemical sector. A decision was made to do a comprehensive study utilizing desktop study and an interview to gain further understanding of the previous, current, and future situation of the industry. As well as to provide an impactful and beneficial review of the Finnish chemical sector and the actions needed to keep the industry working during uncertain times. In terms of sources the author found a surprising amount of viable sources to conduct the research. The thesis is a census study aiming to understand the situation from a wider

perspective and not to focus on a single Finnish chemical company. The sources are analysed and researched to find answers for the research and investigative questions at hand and to find solutions for the problem claimed by the author.

What comes to the interview conducted, an access was gained to interview Tuomas Tikka who works as a leading expert in climate and energy matters for Kemianteollisuus, a group dedicated for research and information gathering regarding Finnish chemical industry. Only one interview was conducted by the author since no company or institution answered the interview suggestions of the author other than Kemianteollisuus. In addition, Kemianteollisuus and Tuomas Tikka were the best source of information for the research as the research was a comprehensive desktop study about the industry as a whole and no commissioning company was part of the thesis. The information gained from the interview was vast and informative and aligned mostly with the desktop research done by the author thus giving concrete confirmation for the research already done by the author. Only rough estimates about numerical data were given in the interview since interviewee Tuomas Tikka isn’t involved with any chemical manufacturing company. The sparce numerical data gained from the interview are used mostly to allow the reader a sense of scale when reading the thesis.

9 Results

9.1 The situation of Finnish chemical industry before the Russo-Ukrainian war

Finland's chemical industry was in an upward trend in during 2022. The countries GDP rose over its pre-pandemic level in 2021 and the economists predicted a steady rise until the end of 2021. Revenues and employment levels surpassed the pre-pandemic era. Before the invasion Russia was Finland's main exporting partner in oil-based and chemical products. Finland exported 930 million euros worth of products in 2021 which equalled to around 7% of the chemical exporting.

The trend before the invasion was very good for the Finnish chemical industry. The exporting forecast was better than usual before the start of the invasion. Some months following the invasion the forecasts stayed fairly positive as the situation wasn't believed to worsen or to get better as it was currently. The order backlog was surprisingly high in summer of 2022 almost 16% higher than in 2021 within the chemical industry.

9.2 What were the effects of Russia's sanctions to Finnish chemical industry?

It was feared that the ending of Russian natural gas imports to Finland due to the western sanctions would start a nation-wide energy crisis, but in the end the worst-case scenario was averted. When the natural gas exports ended in summer of 2023 Finland was in fortunate situation since less energy was used than during winter. This is caused by the smaller usage of energy within heating on all sectors.

According to an interview done with GE Tuomas Tikka who works for Kemianteollisuus, the leading data and info site for the Finnish chemical industry, Finland was swimming in unknown waters during summer of 2023 when natural gas imports from Russia ended. During the summer of 2023 Finland counted on the Balticonnector to provide the needed amounts of natural gas, but as prices started to skyrocket during the end of summer and autumn the trust for Balticonnector being the only source of natural gas started to waiver since Baltic countries also took their share of the gas. Meaning that the capacity of natural gas from Balticonnector might not be enough for Finland. The floating LNG terminal which was delivered to Inkoo, Finland was a security measure to ensure the steady flow of natural gas to Finnish industries. (Interview Tuomas Tikka, Kemianteollisuus).

Initially Finland was affected by the lack of energy which was mainly seen in rising energy prices within the chemical industry During the winter of 2022-2023. 2 out of every 3 chemical companies in Finland had to result to energy saving. The rise of energy caused companies to scale down their operations in terms of furloughs and layoffs of employees, seizing manufacturing operations, lessening sourcing of raw materials, and minimizing production which had wider impacts not only within

the chemical industry but all industries that used raw chemical products as base products for their own operations.

9.3 The possible solutions for the lack of Russian energy for Finnish chemical industry

After the news broke that Russia has seized its natural gas exports, Finland had to source for alternative natural gas sources fast. During the summer of 2022 Balticonnector was seen as the solution to replace Russian natural gas but as the prices kept rising towards winter Finland's energy security was questioned as the Baltic countries for example Estonia also took their share of the natural gas for their own purposes. As a backup plan Finland leased a floating LNG terminal from the United States and placed it in the port of Inkoo. The LNG terminal can provide liquified natural gas which is then vaporized into gas and was used to aid Finnish industries such as the chemical industry. Biogas can also be vaporized and be used as energy but only in minimal volumes and biogas has its limits for effective use as energy in the chemical industry.

Hydrogen and hydrogen-based fuels are also a possibility to replace natural gas as an energy source. Hydrogen is set to play an important role in the future energy. Hydrogen is a versatile energy carrier and is mainly used in the refining and chemical sectors. Hydrogen is normally produced using fossil fuels such as coal or natural gas, but it can also be created from water, but this requires vast investments for the chemical industry.

Finland reacted extremely well to the sudden ending of energy exports from Russia. Though better preparations could have been done for the sudden change from Russian energy just as Poland did. Poland had suspected possible Russian energy and gas blackmailing and was better prepared than other countries. Estonia diversified its energy sourcing fast and in collaboration with Finland. Estonia also recognized the importance of diversifying energy sources and is investing heavily on infrastructure such as wind, solar and hydro power. Germany was a good example of what happens without preparation to the worst and without a proper crisis prevention plan.

9.4 How is the war going to change the supply of Russian energy for Finnish chemical manufacturing industry in the future?

Finland is moving quickly towards a climate neutral and renewable energy sourcing. The country wants to get rid of all fossil fuels by the year 2040. Energy wouldn't be sourced from inside the earth anymore. The alternative energy sources would be acquired using renewable ways such as obtaining hydrogen from water using nuclear and wind power to achieve hydrogen electrolysis and therefore to replace natural gas. There is no one right answer in replacing fossil fuels as of yet, but all alternative solutions and sources of energy are expected to work together to replace current energy sources and those ones that were lost with Russia in the future. Hydrogen is seen as the best

option as of now. Though it requires quite big investments to be done for the chemical sector. More nuclear and wind energy is required to extract hydrogen from water in needed quantities to replace natural gas. The rough estimates rise to 700 million euros worth of investments per year until 2040 that are needed for infrastructure and further development of the Finnish chemical industry to achieve the sourced quantities. Meaning total investments of roughly 14 billion euros in the next 20 years. (Interview Tuomas Tikka).

For the future Finland should follow Poland's example and make additions to its natural gas reserves to make sure no additional problems arise from the use of alternative sources such as LNG or the Balticconnector. Collaboration with Estonia should be continued to ensure the sufficient sources of natural gas through Balticconnector. Diversifying of energy supply should be continued to ensure security of energy and natural gas in order to keep the Finnish chemical industry operatable.

10 Discussion

The main objectives with the thesis were to find out how Finland's chemical industry was before the ending of Russian energy imports, how the sanctions placed on Russia hindered Finland's chemical industry, what are the possible solutions for the lack of Russian energy in the Finnish chemical industry, and ideas for Finnish chemical industry to replace Russian energy in the future.

Finland was just recovering from Covid-19 pandemic before the Russian invasion of Ukraine. The trend for Finnish chemical industry was hopeful. The exporting forecasts were better than usual and stayed that way even after the first months of the war. The overall production was better than a month before the invasion and the war didn't seem to have a major impact on the Finnish chemical industry. The Russian sanctions biggest impact came within the ending Russian energy exports. Russia was Finland's greatest energy exporter and a lifeline for many industries including the chemical industry which relied on Russian natural gas to keep its production working. Without Russian natural gas the chemical industry had no energy to keep the industry operating. The energy situation caused 2 out of every 3 chemical companies to save in energy costs which resulted in layoffs and furloughs for employees within those companies. The lack of energy was reflected directly in the revenue of chemical companies in Finland. In January of 2023 the revenue of the industry was 18% smaller than in July of 2022. The reason for the change was caused by the change in costs of production which was increased because of the increased price of energy.

The Ukraine war wouldn't have had this much of an impact without the sanctions placed on Russia. Finland would have probably stopped some importing and exporting to Russia but the necessities like energy would have most likely continued without the sanctions and Russia's order to pay for the energy in Rubles. The initial impacts of the ending of Russian energy were devastating but medium-term solutions were found quickly.

Finland was extremely successful with its medium-term solutions. After it was certain that Russian energy exports will end, Finland turned its focus on the lease of LNG vessels from the USA. The liquified natural gas vessels worked as gas ports and supplied the chemical industry with the much-needed natural gas. Another medium-term solution was the Balticconnector. Balticconnector was finished in 2019 and was a joint expedition with Estonia to secure natural gas sources from Europe. The Balticconnector retains the security of natural gas supply to Finland and will benefit the competition and energy market integration in the Baltic region.

Green hydrogen is seen as the replacing factor for fossil fuels. Hydrogen can be extracted from water by using vast amounts of electricity and therefore requires heavy investments for the chemical sector for the electricity needed to get hydrogen from water. Green hydrogen is seen to replace

fossil fuels completely in the future. What comes to the future developments for the chemical industry in Finland hydrogen is clearly seen as the frontrunner for replacing natural gas and other fossil fuels within the chemical industry in Finland. Finland has a wealth of opportunities to develop its hydrogen economy. Nuclear technology could be used to generate energy and help to gain the needed electricity to extract hydrogen from water. Finland also obtains a highly competitive onshore wind power capabilities as well as vast amounts of clean water that is needed in the obtaining of hydrogen from water. Finland also has strong expertise and know-how in the matter of hydrogen.

Finland failed in its trust and dependency to Russian energy. It should have understood to diversify its energy sourcing to other sources than just Russia. Poland was able to detect the possibility of Russian energy blackmailing and had prepared its energy and gas reserves for the possible situation of the ending of Russian energy flow to the country. War has devastating and widespread effects on industries and economies. Finland must be more self-sufficient in the future in the energy sector and secure all the viable necessities needed to provide its industries and citizens the tools to keep the level of economy and social situation normal despite widespread changes in political situation in Europe.

11 Own learnings

Working on this thesis has given the author a sense of scale of the magnitude that war can have on countries and its industries. The need to diversify sources of energy cannot be understated during the constantly changing and unpredictable times we live in. It was interesting to see how well Finland had ultimately prepared for the unexpected events that occurred after Russia stopped its natural gas exports. Finland didn't waste any time on acquiring alternative sources of energy to replace it lost sources and managed to achieve independence quite fast from Russian energy after the winter of 2022-2023. Finland and the chemical sector showed their capability of surviving during turbulent times and managed to turn the difficult situation into somewhat beneficial thinking of the future since the situation forced Finland and its chemical industry to move towards renewable energy faster than it most likely would have without the crisis.

What comes to developing and researching the topic further most emphasize should be put on the future and research how Finland and the Finnish chemical industry did adapt the long-term energy solutions and how they managed to come to a conclusion with the alternatives they do use in the future.

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Appendices

Appendix 1. Interview questions

1. How the sanctions imposed by the western countries affect Finnish chemical manufacturing industry?
2. How did the lack of Russian energy affect the revenue generated by Finnish chemical manufacturing companies?
3. How the Finnish chemical manufacturing industry has been affected by the lack of energy supply from Russia?
4. What are or were the possible solutions for the lack of energy for the Finnish chemical manufacturing industry?
5. How was Finnish chemical trade to Russia before the invasion? How about after the invasion?
6. What alternative energy sources are used now that energy is no longer imported from Russia?
7. What could finland learn from other countries in terms of operating without Russian energy?
8. How have other countries adapted to the lack of Russian energy?
9. How is the war going to change the supply of Russian energy for the Finnish chemical manufacturing industry in the future?