Aalto-yliopisto
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Master's Programme in Information and Service Management

The Russia–Ukraine war and its impact on Finnish energy supply chains and energy security

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Master's thesis
2026

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Aalto University

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Title of thesis The Russia–Ukraine war and its impact on Finnish energy supply chains and energy security

Programme Master of Science in Economics and Business Administration

Major Information and Service Management

Thesis supervisor Associate Professor Seongtae Kim

Date 28.07.2026 **Number of pages** 100 **Language** English

Abstract

The Russia-Ukraine war created a major geopolitical supply disruption in European energy markets and forced energy companies and countries to assess their dependence on Russian-originated energy. This thesis focuses on how the war affected Finland's energy security, how Finnish energy companies were affected, and how they responded to the heightened supply risk and market uncertainty during the disruption period. The theoretical foundation looks into literature on supply chain resilience, energy security, and import dependence. The literature review also reflects on research on EU-level effects of the war.

The research was conducted as a qualitative explanatory study based on structured secondary data analysis. The empirical analysis consisted of two parts. First, a system-level analysis of Finland's energy mix, import structure, and key disruptions of the war was conducted to establish an understanding of the effects of the war on Finnish energy security. Secondly, a multiple-case analysis was conducted on selected Finnish energy companies: Neste, Fortum, Gasum, St1, and Neova. The company-level analysis included within-case analyses of each company, and a cross-case analysis to identify recurring patterns in supply chain impacts and company-level responses

The findings show that the war exposed Finland's vulnerability to the concentrated Russian-origin energy supply, especially in fossil fuels. The findings do show and support that the disruptions did not lead to a breakdown of the Finnish energy system. Instead, they caused a need to restructure energy supply flows, increased import costs, heightened energy-market volatility, and increased pressure on infrastructure. At the company level, impacts depended on the exposure to Russian supply, infrastructure dependence, the bindingness of contracts, and the substitutability of key energy sources. Companies responded by diversifying their suppliers, substituting supply sources and fuels if needed, increasing inventories and utilizing reserve capacities, and cooperating with authorities and key stakeholders. The thesis concludes that Finnish energy security and company-level energy supply chain resilience are closely connected in managing large-scale disruptions.

Keywords Russia-Ukraine war, energy security, supply chain resilience, Finnish energy sector, geopolitical risk, import dependence

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Aalto University

Tekijä Walter Lindqvist

Työn nimi Venäjän hyökkäyssodan vaikutukset suomalaisiin energiatoimitusketjuihin ja energiaturvallisuuteen

Koulutusohjelma Kauppatieteiden maisteri

Pääaine Tieto- ja palvelujohtaminen

Työn ohjaaja Professori Seongtae Kim

Päivämäärä 28.07.2026 **Sivumäärä** 100 **Kieli** Englanti

Tiivistelmä

Venäjän hyökkäyssota Ukrainassa aiheutti Euroopan energiamarkkinoilla merkittävän geopoliittisen disruption ja pakotti energiayhtiöt sekä valtiot tarkastelemaan riippuvuuttaan venäläisperäisestä energiasta. Tässä tutkielmassa tarkastellaan miten sota vaikutti Suomen energiaturvallisuuteen ja suomalaisiin energiayhtiöihin sekä miten yhtiöt vastasivat sodan vaikutuksien alla toimitusriskeihin ja energiamarkkinoiden epävarmuuteen. Tutkielman teoreettisessa taustassa tarkastellaan toimitusketjujen resilienssiä, energiaturvallisuutta ja tuontiriippuvuutta käsittelevää kirjallisuutta. Kirjallisuuskatsauksessa tarkastellaan lisäksi tutkimusta sodan vaikutuksista EU-tasolla.

Tutkimus toteutettiin laadullisena tutkimuksena, joka perustui systemaattiseen sekundaariaineiston analyysiin. Empiirinen analyysi koostui kahdesta osasta. Ensin tarkasteltiin Suomen energiajärjestelmää energialähteiden, tuontirakenteen ja sodan keskeisten disruptioiden vaikutusten näkökulmasta, jotta voitiin muodostaa kokonaiskuva sodan vaikutuksista Suomen energiaturvallisuuteen. Tämän jälkeen toteutettiin analyysi suomalaisista energiayhtiöistä. Tutkimuksen kohteeksi valikoituvat seuraavat yhtiöt: Neste, Fortum, Gasum, St1 ja Neova. Yritystason analyysi sisälsi yhtiökohtaiset analyysit sekä vertailevan analyysin, jonka avulla tunnistettiin toimitusketjujen vaikutusten ja yhtiöiden vastatoimien toistuvia teemoja.

Tuloksissa tunnistettiin Suomen rakenteellinen haavoittuvuus, joka johtui energian tuonnin keskittymisestä venäläisperäiseen energiaan. Sodasta aiheutunut disruptio ei kuitenkaan johtanut Suomen energiajärjestelmän toiminnan katkeamiseen tai laajamittaisiin toimituskatkoihin. Se muodosti kuitenkin tarpeen muuttaa toimitusketjuja, kasvatti kustannuksia, kasvatti energiamarkkinoiden volatiliteettia ja kuormitti infrastruktuuria. Yritystasolla vaikutusten vakavuuteen vaikuttivat venäläisperäisen energian aikaisempi käyttö, infrastruktuuririippuvuus, sopimusten sitovuus sekä keskeisten energialähteiden mahdollinen korvattavuus. Yhtiöt vastasivat vaikutuksiin muuttamalla toimittajaverkostojaan, korvaamalla energialähteitä, hyödyntämällä ja kasvattamalla varakapasiteettia sekä tekemällä yhteistyötä viranomaisten ja keskeisten sidosryhmien kanssa. Tutkielma osoitti, että Suomen energiaturvallisuus ja yritystason energiatoimitusketjujen resilienssi ovat tiiviisti yhteydessä.

Avainsanat Venäjän hyökkäyssota, energiaturvallisuus, toimitusketjujen resilienssi, Suomen energiasektori, geopoliittinen riski, tuontiriippuvuus

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1 Introduction

This chapter provides the introduction to the thesis's background and motivation, research questions and objectives, and the scope of the study.

1.1 Background and motivation

The Russian invasion of Ukraine in 2022 triggered one of the most significant commodity supply disruptions in recent European history. Before the war, Finland and many other EU countries were heavily dependent on Russian fossil fuels, particularly crude oil, natural gas, and coal. In 2021, the EU imported more than 40% of total gas, 27% of oil, and 46% of coal from Russia (European Commission, 2022). The need to decouple from Russian energy imports restructured sourcing strategies and logistics routes, and spiked energy prices across Europe (Liu & Lee, 2025; Sarwar & Rye, 2025).

Some studies on the Russia–Ukraine war mainly from broader perspectives, including EU-level energy policy and the European energy crisis (Goldthau & Youngs, 2023; Ilie et al., 2023; Kuzemko et al., 2022), while others have focused more on global supply chains and commodity markets and market volatility (Kim et al., 2025; Liu & Lee, 2025; Sarwar & Rye, 2025; Toygar & Yildirim, 2023). In addition, some studies focus on the effects of EU policy responses and the trade-offs between energy security and decarbonisation (Celi et al., 2022; Vezzoni, 2023). Previous studies mainly provide EU-level, global, or policy-oriented perspectives. Limited research and less attention have been given to how the same geopolitical disruption affected a specific national energy system and the supply chains of the energy companies operating within that system.

The thesis also aims to assess how companies were affected by the disruption and how the companies responded to the disruption by considering the resilience of supply chains. Existing literature on supply chain resilience emphasizes capabilities such as flexibility, redundancy, agility, collaboration, recovery, and learning as key to maintaining operations during systemic shocks (Ali et al., 2017; Ali & Gölgeci, 2019; Hohenstein et al., 2015; Rahman et al., 2022). However, as Rahman et al. (2022) suggest, despite growing interest in the topic of large-scale disruptions and resilience studies, there remains a lack of substantial, conclusive research on resilience strategies that can mitigate such widespread shocks, thus, additional research is called for.

As noted, energy security is often discussed at the policy or market level, as it has also mostly been discussed regarding the effects of the Russia-Ukraine war. This level of research may overlook some key factors in energy security

research, as in most energy systems, national energy sector and company-level supply chain resilience is closely connected, as in most Western countries the energy sector is operated by companies rather than the countries themselves. In the Finnish context, this is particularly relevant, and as Finland's National Emergency Supply Agency states on their website: *"Finland's security of supply is safeguarded through collaboration of the public, private, and third sectors"*, it should be addressed within this co-dependence in mind.

This study aims to address the identified gap by studying the war's effects on a certain country and its energy sector on two levels, considering two perspectives that are highly relevant to each other. The effects of the war on Finnish energy security will be studied by looking at how the energy system changed and what systematic effects the war had on energy supply chains. In the Finnish context, this matters a lot because, as stated above, security of supply is based on cooperation between public authorities, private companies, and other third-party actors, making it a relevant case for the thesis to also assess the impact of the war on Finnish companies' energy supply chains, and how these companies responded to the effects of the war. By combining these two perspectives, the study will create a comprehensive outlook on the effects of the Ukrainian war on the Finnish energy sector.

Finland's unique position as a geographical neighbour of Russia and its earlier heavy reliance on Russia for fossil fuels, especially in oil and gas, makes choosing it as a case country a relevant perspective for examining how the invasion affected countries within the EU that had high previous dependence on Russia.

1.2 Research questions and objectives

The objective of the thesis is to examine the Russia-Ukraine war as a geopolitical supply disruption and to analyse its effects on Finnish energy security and Finnish energy companies' supply chains. The study reflects theories on supply chain resilience and energy security through the context of Finland's energy sector. By analysing changes in energy supply structures and the selected company-level responses, the thesis aims to gain an understanding of how Finnish energy companies adapted to heightened supply risk, market uncertainty, and the need to reduce dependence on Russian energy.

The thesis has two main research questions, which guide the thesis along the research process and will be answered in the discussion section. The two research questions of the thesis are:

1) What were the effects of the Russia–Ukraine war on Finnish energy security and Finnish companies' energy supply chains?

2) How have Finnish energy companies responded to heightened supply risk and market uncertainty?

The thesis begins with a literature review on supply chain resilience and disruption management, energy security and the effects of geopolitical disruptions on energy security, as well as previous research on the effects of the Russia-Ukraine conflict at the EU level. Insights from the literature will then guide the empirical part of the thesis.

This study is conducted through qualitative analysis. The main objective is to understand how Finland's energy companies' supply chains have been affected by the Russia–Ukraine war and how the companies have responded to maintain supply continuity and resilience, while also considering the war's effects on Finnish system-level energy security. The analysis section of the thesis includes two parts:

Firstly in the empirical section, the study will include a descriptive analysis of secondary statistical reports and documents, focusing on reports from the Official Statistics of Finland (OSF) and Eurostat, supported by sources from the International Energy Agency (IEA), the National Emergency Supply Agency (NESA), and others. This will establish a system-level understanding of what the core effects of the war were on the Finnish energy system.

Secondly in the empirical section, a cross-case study will be conducted of Finnish energy companies that were affected by the war. A criterion is established for how the companies are picked, after which a within-case analysis for each company is conducted. After each case has been studied individually, a cross-case study is conducted to recognize patterns among the cases and compare the effects of the war between the cases. The studied material is based on companies' publicly published reports and reviews, which are then complemented by news, market publications, and other sources to triangulate the main source of data to enhance the credibility of the study.

This approach allows the study to link macro-level geopolitical effects with micro-level organizational effects and adaptations, providing a well-rounded understanding of Finland's energy security landscape and the effect on the energy sector during and after the disruption caused by the Russian invasion of Ukraine.

1.3 Scope of the study

The thesis is conducted under the following scopes: Firstly, the thesis focuses on the Russia-Ukraine war as a disruption affecting Finnish energy security and Finnish energy companies' supply chains. Other types of supply chain disruptions unrelated to the war, such as natural disasters, strikes, or ordinary demand fluctuations, are not considered unless they are directly connected to the war.

Secondly, the geographical scope of the study is Finland. EU-level energy market developments and policy responses are used as contextual background to understand the operating environment, but the empirical focus remains on Finnish energy security and Finnish energy companies.

Thirdly, the case study of the thesis focuses on selected Finnish energy companies. The study does not attempt to cover all Finnish energy companies, but analyses selected firms that are significant to the Finnish energy system and provides a relevant and exhaustive enough sample to answer the research questions.

Fourthly, the case study focuses on supply chain effects and responses, including changes related to sourcing, logistics, costs, and others. Detailed technical, engineering, and operational issues are outside the scope unless they are directly relevant to supply-chain disruptions or the responses taken.

Fifthly, the empirical analysis is based on secondary, public data. The study uses company reports and publications, along with news or market sources, for triangulation. Confidential internal company data or interview-based evidence was not gathered for the study.

Lastly, the timeframe of the study's empirical findings is set between 2021 and 2024. The year 2021 functions mainly as a pre-war baseline, while 2022–2024 is used to define a disruption period and company responses. Longer historical developments are included only if necessary to explain the pre-existing context in different parts of the study.

2 Literature review

The literature review introduces the key theoretical concepts that form the theoretical foundation for the study. It begins with an overview of supply disruptions and supply chain resilience and introduces how modern supply chains are exposed to vulnerabilities and systemic shocks. The literature review then introduces the ripple effect to explain how disruptions propagate through interconnected networks, followed by a discussion of proactive and reactive measures to manage and recover from such events.

The next sections after the initial review on disruptions and resilience examine energy security and its dimensions, especially regarding geopolitical risks and import dependence, to establish the broader context in which disruptions occur regarding energy systems. The review concludes with a review of recent research on the Russia–Ukraine war and the resulting shifts in the European energy environment, which together provide the background for both the system-level analysis of effects on energy security and the multiple-case study on Finnish energy companies and the effects on their supply chains and their responses to disruptions.

2.1 Supply disruption and supply chain resilience

Supply chains operate in conditions where disruptions are frequent and often originate from the wider network rather than from within a single firm. According to Christopher and Peck (2004), disruption risks can be grouped into three categories, which are: internal disruptions, which stem from a firm's own processes and controls, demand- or supply-related disruptions occurring within the supply chain, and external disruptions that, on the other hand, come from outside the supply chain. Disruptions can be understood as processes that unfold over time and affect a firm's performance in different stages of disruption. This is illustrated by Sheffi & Rice (2005) in their stages of disruption, as visualized in Figure 1.

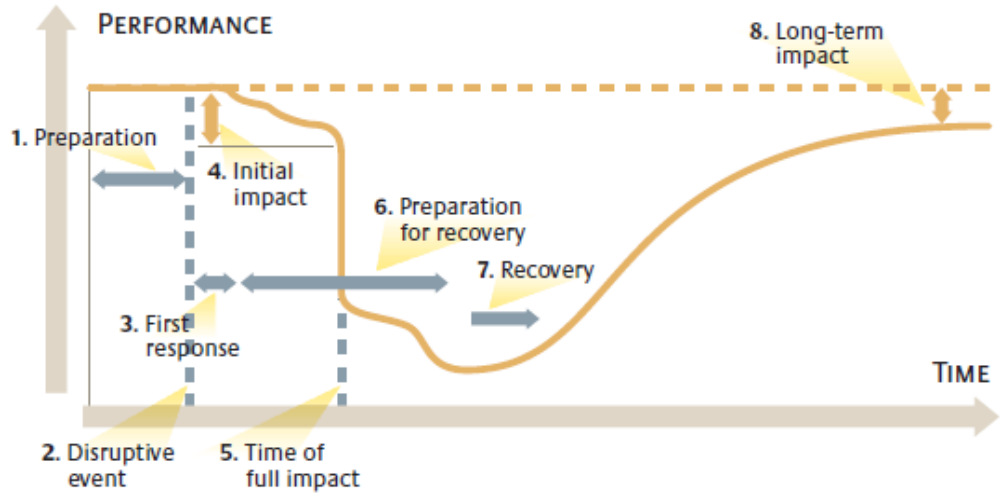


Figure 1 Stages of Disruption (Sheffi and Rice, 2005)

The disruption cycle by Sheffi and Rice (2005) includes preparation, the disruptive event, first response, initial impact, full impact, preparation for recovery, recovery, and long-term impact. The many stages of disruption show that disruptions continue to affect companies even after the immediate operational recovery. Regarding managing these disruptions affecting supply chains, Behdani et al. (2012) define supply chain disruption management as: *"a structured and continuous process to analyze the impact of disruptions across the supply chain on predefined objectives and to handle them in their entire lifecycle"*. Supply disruptions and supply chain disruption management are closely related to supply chain resilience literature, which in turn looks more into the capabilities needed in supply chains to endure the disruptions.

In early supply chain resilience research, it is stated that growing interdependence increases overall vulnerability and makes resilience a central requirement for maintaining continuity (Christopher & Peck, 2004). Christopher and Peck (2004) conceptualized supply chain resilience as three dimensions: robustness, flexibility, and adaptability. Robustness describes the supply chain's ability to endure disruptions by relying on redundancy and backup resources. Flexibility reflects how quickly the supply chain can adjust to shifts in demand, supply conditions, or external factors. Adaptability refers to the capacity to modify strategies and operating practices when confronted with unexpected disruptions. Ponomarov and Holcomb (2009) in turn describe supply chain resilience as the capability to prepare for disruptions, limit their impact, and restore functioning once they occur. In more recent research, a more comprehensive and complete definition for resilience has been proposed: *"Resilience is a complex, collective, adaptive capability of organizations in the supply network to maintain a dynamic equilibrium, react to and recover from a disruptive event, and to regain performance by*

absorbing negative impacts, responding to unexpected changes, and capitalizing on the knowledge of success or failure" (Yao & Fabbe-Costes, 2018).

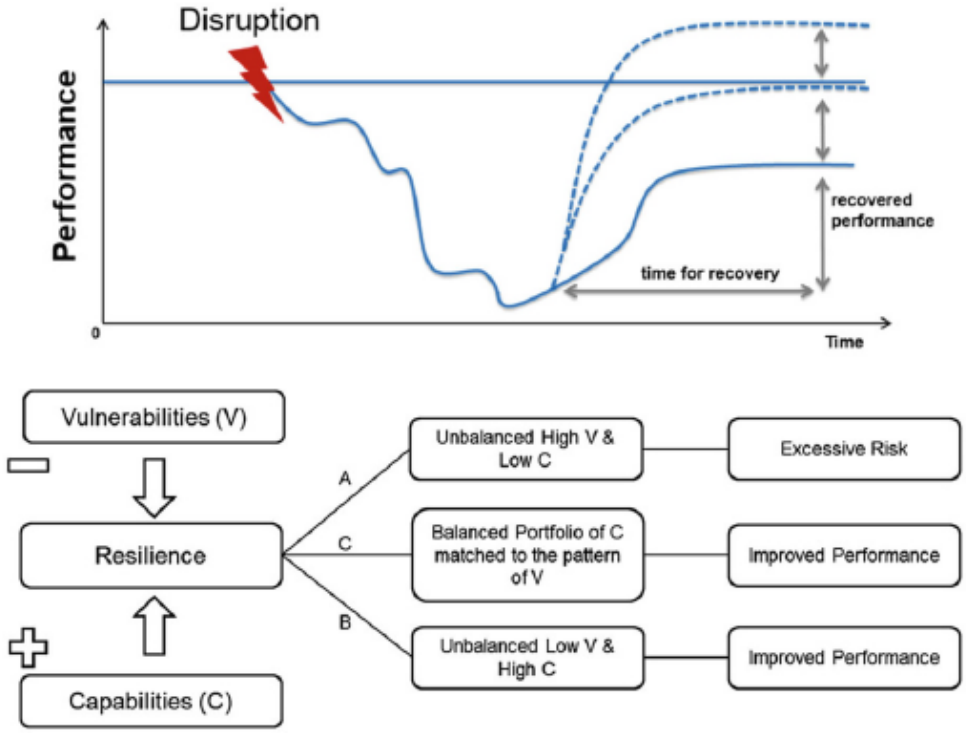


Figure 2 Supply chain resilience concept (Ivanov et al., 2021)

The effects of a disruption and the concept of recovering afterwards, with a framework describing vulnerabilities and capabilities in building resilience, and their relation to recovery time after a disruption, are illustrated by Ivanov et al. (2021) in Figure 2. As seen in Figure 2, the supply chain resilience concept is built on Sheffi and Rice's (2005) disruption stages. Ivanov et al. (2021) argue that supply chain resilience focuses on sustaining an acceptable level of performance when disruptions occur. Proactive capabilities, such as holding inventory, can help a supply chain absorb disruptions like supply shortages without an immediate loss of performance, and when these measures are not sufficient, performance indicators such as delivery reliability or revenue may begin to decline. In such cases, reactive capabilities are needed to restore operations and recover performance, although this process often requires time and resources (Ivanov et al., 2021). Managing resilience, therefore, involves finding an appropriate balance between a supply chain's vulnerabilities and the capabilities available to counter them (Ivanov et al., 2021). Supply chain resilience is a multi-faceted concept, as it is dependent both on internal supply chain processes and capabilities, and also on external factors (Ivanov, 2018). This balance between vulnerabilities and capabilities is increasingly important, as recent research shows that modern supply

chains have become more exposed to disruptions due to their structure and global interconnectedness. Modern supply chains operate as extensive global networks that link firms, suppliers, and logistics actors across multiple regions (Ivanov et al., 2021). Recent studies show that these networks have become increasingly interdependent, making them more vulnerable to external shocks and uncertainty (Zhao et al., 2023). The structural vulnerability of global supply chains has been exposed by large-scale disruptions over the last five years, such as the COVID-19 pandemic and the Russia–Ukraine war (Mishra et al., 2025). Cost-efficient supply chains, and their components such as prioritizing efficiency and costs through extensive globalization, Just-In-Time practices, and holding lean inventories, proved to be very fragile when system-level shocks like COVID-19 or the Russian invasion struck the global value chains (Mishra et al., 2025).

2.1.1 The ripple effect and supply chain risks

Ivanov et al. (2014) note that, although the details of frameworks and methodologies differ across the literature on supply chain disruption management, most share a set of three components. They mostly include: First, a disruption (or a set of disruptions), second, the impact of the disruption on operational and strategic economic performance, and third, the stabilisation and recovery. Within this set of attributes, most studies on supply chain disruption consider changes to a variable or set of variables. Building on this, when a disruption occurs, the impact of the disruption often *ripples* through the rest of the supply chain and impacts the rest of the chain's performance, which is called the ripple effect. This means that the ripple effect describes a domino effect in a supply network, which triggers failures downstream in the supply chain (Ivanov et al., 2014).

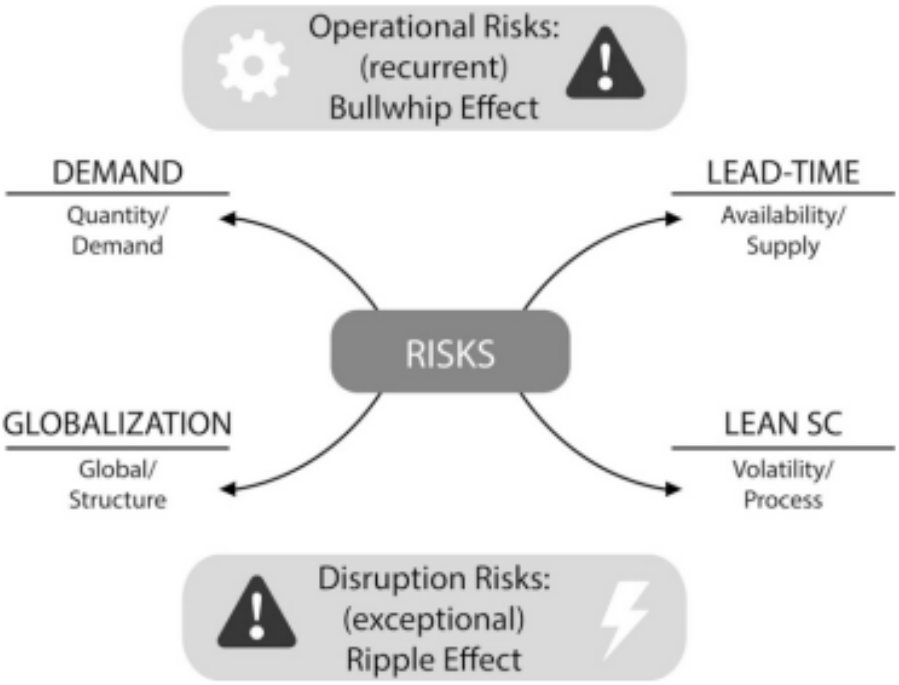


Figure 3 Supply chain risks (Ivanov, 2018)

In Figure 3, Ivanov (2018) divides the risk profiles of supply chain risks into two. First, operational risks, which are recurrent, constant risks that usually, as per the name, are recurring. Risks in this category include demand risks and supply risks, such as the availability of materials. At the bottom end of Figure 3, we can find disruption risks, which are risks resulting from larger, non-recurrent events that create a disruption affecting the whole (or many parts) of the supply chain. These risks include, for example, the global structure of modern supply chains. Additionally, the disruption risks stem from the lean structure of supply chains, which are particularly vulnerable to larger disruptions when buffers and excess inventories are small. Rahman et al. (2022) also noted in the literature review that the supply chain resilience literature divides disruptions into low-frequency, high-impact, unpredictable disruptions, that affect global supply chains for an extended period that often in research are referred to mega-disruptions, and the rest to low-impact, day-to-day operations disruptions that affect the supply chains for a short period and are easily mitigated and recovered from, such as fluctuations in supply and demand or costs, which is in line with Ivanov (2018) approach.

This study will focus particularly on these high-impact, low-frequency disruption risks, their effects on the supply chain, and mitigation approaches to address their impacts. Next, the review will examine approaches to handling the disruption risks and building supply chain resilience.

2.1.2 Resilience phases

Many risk-management models have been developed to mitigate risks in supply chains, but many have restrictions on their use cases. Supply chain resilience goes beyond traditional risk management by shifting the focus from simply avoiding risks to strengthening the supply chain's capabilities (Wieland & Durach, 2021). Supply chain resilience aims to ensure that the system can better withstand disruptions and continue functioning even when unexpected events occur (Wieland & Durach, 2021).

In managing supply chain disruptions, literature commonly divides resilience into two. The pre-disruption approach, which is a proactive approach that focuses on identifying vulnerabilities and implementing precautionary measures to limit potential negative impacts. Then, in turn, the post-disruption approach, which is a reactive approach that refers to actions taken to respond to and adjust operations after the disruption has materialized (Behdani et al., 2012; Hosseini et al., 2019). These approaches are not separate in practice but rather work together as components of a larger concept. Pomarov and Holcomb (2009) presented that supply chain resilience can be conceptualized as a construct with three central phases: prepare, response, and recover. Pomarov and Holcomb's (2009) definition is useful, as it presents supply chain resilience as a process that covers what happens before, during, and after a disruption occurs. So, as their concept, resilient supply chains can prepare for disruptions, reduce their impact, and recover afterwards. The prepare, respond, and recover logic provides a foundation for understanding what Ali et al. (2017) found in their study, that research often categorizes supply chain resilience in three phases, namely pre-, during-, and post-disruption. They defined capabilities for these phases and their corresponding elements to consider when assessing supply chain resilience, identified below in Table 1.

Table 1 Supply chain resilience phases, capabilities, and key elements (based on Ali et al., 2017)

Resilience phase	**Capability**	**Key elements**
Pre-disruption (Proactive)	*Ability to anticipate*	Situation awareness, robustness, visibility, building security, pre-disruption knowledge management
During disruption (Concurrent)	*Ability to adapt* *Ability to respond*	Flexibility, redundancy Agility, collaboration

Post-disruption (Reactive)	*Ability to recover* *Ability to learn*	Contingency planning and market position Post-disruption knowledge management and building social capital

Ali et al's (2017) phases, abilities and capabilities are now considered in more detail by describing each phase and the relevant supply chain resilience capabilities for each phase in more detail, considering relevant literature.

Pre-disruption resilience

Supply chain resilience originally only recognized the time after disruptions, but over the last decade, the importance of pre-disruption resilience has also been recognized and has quickly become one of the most researched parts of the field (Ali et al., 2017; Ali & Gölgeci, 2019; Rahman et al., 2022). The central pre-disruption capability is the *ability to anticipate*. The purpose of the capability is that proactivity is needed for anticipating disruptions, creating robust supply chains, and identifying and monitoring potential negative future events (Ali et al., 2017).

Situation awareness, robustness, and visibility are crucial elements of the ability to anticipate. Situation awareness includes the understanding of the supply chain's vulnerabilities and planning for events when the supply chain might become vulnerable (Pettit et al., 2013). Robustness refers to the ability of the supply chain to be able to resist disruption and have the possibility to proactively anticipate change before it occurs. Robustness includes designing the supply chain network in a way that can sustain operations during and after a disruption. (Wieland & Wallenburg, 2012). Visibility is enabled through collaborative mechanisms among supply chain partners, where timely information sharing provides relevant and accurate updates on the operational status of supply chain activities. This transparency extends across the end-to-end supply chain, including multi-tier networks, and supports performance measurement and monitoring at the overall supply chain level (Gligor et al., 2019).

Ali et al. (2017) also include building security and pre-disruption knowledge management in their categorization as proactive elements. Building security refers to a multi-dimensional concept, which includes parts such as building freight security and a security culture. Literature shares the consensus that security should be built via cooperation with supply chain partners (Ali et al., 2017; Pettit et al., 2013). Knowledge management then includes supply chain understanding, education, and training within the corporate culture, it in-

cludes internal capabilities and teams, such as risk-management departments (Christopher & Peck, 2004; Pettit et al., 2013).

During-disruption resilience

"During-disruption" capabilities consider the elements that are needed when the disruption is happening. The concurrent strategies' capabilities are the *ability to adapt* and the *ability to respond*. The capabilities are concurrent, as the ability to adapt can be considered more of a proactive action, and on the other hand, response abilities are of a reactive nature (Ali et al., 2017). The *ability to adapt* refers to the during-disruption capabilities needed to manage and possibly adjust the supply chain and its resources and flows during disruptions. (Ali et al., 2017).

Adaptation is then divided into two elements: increasing flexibility and building redundancy. Flexibility is the ability to make adjustments to the firm's relevant operations and supply chain to maintain an optimal level of performance (Gligor et al., 2019). Flexibility includes utilizing backup suppliers, having the possibility for complete supplier switching, utilizing various distribution channels and changing them, and having flexible production systems and volume flexibility. (Hohenstein et al., 2015). Redundancy can be understood as an operational-level approach that refers to maintaining slack within the supply chain, such as additional capacity, inventory, or backup resources, so operations can continue for a longer period after a disruptive change begins, or in some cases, so the disruption's impact is avoided altogether (Azadegan et al., 2021; Hohenstein et al., 2015).

The ability to respond is the capability that is needed to react to disruptive supply chain events and to efficiently handle the impact of disruptions or change the effects to ensure that the disruption does not lead to unnecessary negative effects, but lead to a desired outcome (Ali et al., 2017). The ability to respond consists of two capabilities, namely agility and collaboration. Christopher & Peck (2004) describes agility as one of the most powerful ways of achieving resilience in the supply chain. Research finds that agile supply networks are capable of a more rapid response in disrupted conditions, and they can quickly adjust their supply chain tactics and operations (Gligor et al., 2019; Ivanov et al., 2014; Wieland & Wallenburg, 2012).

Collaboration refers to the ability to withstand and respond to disruptions together with partners. This can be done and reacted to through collaborative planning and information sharing (Christopher & Peck, 2004; Pettit et al., 2013). Collaboration in supply chains and building resilience through collaboration involves both vertical and horizontal cooperation among supply chain parties to generate outcomes that benefit both (or all) parties. (Singh et al., 2019).

Post-disruption resilience

Typically, disruptions cause damage that affects the performance of the supply chain negatively, and many times the supply chain may remain unstable even after the disruptive event has passed, as many times it is not possible to return to the previous structure even after the initial disruption has passed (Chowdhury & Quaddus, 2016). This leads us to the post-disruption phase. The reactive strategies are divided between two capabilities: the *ability to recover* and *the ability to learn*. The ability to recover is essential and a critical component in the aftermath of a disruption event, to restore or return to normal operations, allowing the affected party to learn from the disruption, but also to continue its operations (Ali et al., 2017).

The ability to recover is divided into two elements, which are contingency planning and market position (Ali et al., 2017). Contingency planning in supply chain resilience is defined as an organizational and interorganizational capital resource that enhances a firm's ability to recover quickly and efficiently from a disruptive event (Blackhurst et al., 2011). Developing comprehensive contingency plans that specify response actions for different disruption scenarios strengthens supply chain resilience by improving coordination and accelerating recovery.

Market position is identified as one of the key elements to help companies overcome disruptions (Ali et al., 2017; Fiksel et al., 2015) Fiksel et al. (2015) identify multiple sub-elements that affect market position, such as brand equity, customer loyalty/retention, market share, product differentiation, and sustainability position. An increased market share also results in high margins, which technically allows higher investments in supply chain resilience (Pettit et al., 2010). Thus, financial strength and organizational efficiency allow faster recoveries from disruptions (Fiksel et al., 2015.; Ponomarov & Holcomb, 2009)

The ability to learn includes the capabilities required after a disruption to understand what happened and the ability to improve future performance, based on the experience (Ali et al., 2017). To be able to learn from a disruption that has happened exceeds the recovery phase by not just returning to the position that the company was in pre-disruption, but possibly eventually achieving an improved position (Hohenstein et al., 2015). Ali et al. (2017) divide the ability to learn between post-disruption knowledge management and building social capital. Post-disruption knowledge management improves the ability of a supply chain to learn from disruptions (Ali et al., 2017). Organizations that can learn from disruptions can look beyond risks to identify opportunities and develop innovative contingency and continuity plans (Gölgeci & Ponomarov, 2015).

Building social capital includes collaboration among supply chain partners and other entities to learn from each other (Ali et al., 2017). Social capital might emerge when facing and recovering from a disruption, as collaboration across organizational borders and competence sharing (Wieland & Wallenburg, 2012). Social capital includes and supports knowledge exchange among stakeholders and supply chain partners, the sharing of best practices to handle disruptions, and also includes possible joint efforts to address potential future disruptions effectively e.g., learning from each other's and collaborating to structure more resilient supply chains (Ali et al., 2017).

To conclude the chapter on supply chain resilience strategies, a rather relevant claim to consider from Rahman et al. (2022) is that the COVID-19 pandemic demonstrated that global supply chains have remained highly vulnerable to large-scale disruptions. Their review suggests that, despite growing interest in the topic, there remains a lack of substantial, conclusive research on resilience strategies that can mitigate such widespread shocks. Essentially, what they claimed is that there are no conclusive resilience strategies defined widely in academia that, to their knowledge, can mitigate large-scale disruptions.

2.2 Energy security

The IEA defines energy security as "*Uninterrupted availability of energy sources at an affordable price*." (International Energy Agency, 2022). Energy security research originally started as a very narrow and specific field of research, focusing on the stable supply of affordable oil, and the focus was on protection against threats like embargoes or direct price manipulation from suppliers (Cherp & Jewell, 2014). Energy security still lacks consensus on its definition in academic research, as the concept depends on contextual background and different national settings (Kruyt et al., 2009; Schmitz et al., 2025).

Energy is essential to ensuring the productive lives of the country's citizens, but it is also a strategic and politically important resource, and plays an important role in ensuring national security and socio-economic stability (Wang et al., 2024; Yang et al., 2022). A stable energy supply is the foundation for sustaining industrial production, transportation, and the overall daily life in a modern society. Any disruption in energy supply or unnaturally sharp price fluctuations can lead to higher production costs and increased inflation, which affects economic growth and social stability, which makes energy security an important component of overall national security (Wang et al., 2024). These points make energy security crucial to take into account when assessing national security matters. Energy security extends beyond

the availability of energy supply and also covers the stability of energy markets, the functioning and connectivity of global energy supply chains, and the long-term sustainability of energy resources, among others. And as such, energy security is a critical factor for the economic stability and growth of countries and regions (Wang et al., 2024).

Energy security is often conceptualized through the 4A's, which refer to *availability, accessibility, affordability*, and *acceptability*. Availability pertains to physical resources, accessibility to the geopolitical aspects of acquiring resources, affordability to energy costs and prices, and acceptability to environmental and social considerations (Kruyt et al., 2009). The four A's were originally introduced by the Asia Pacific Energy Research Centre (APERC) in 2007, and after that, have been largely adopted by research, but have also received criticism, as they lacked academic reflection and empirical observations (Cherp & Jewell, 2014). In addition, Schmitz et al. (2025) bring up other dimensions of energy security that are highlighted in the literature, such as infrastructure, dependency, and diversity of energy sources, and governance and energy efficiency. In one of the most foundational studies, energy security is discussed as the low vulnerability of vital energy systems (Cherp & Jewell, 2014). Cherp and Jewell (2014) state that vulnerability is a combination of exposure to risks and resilience capabilities.

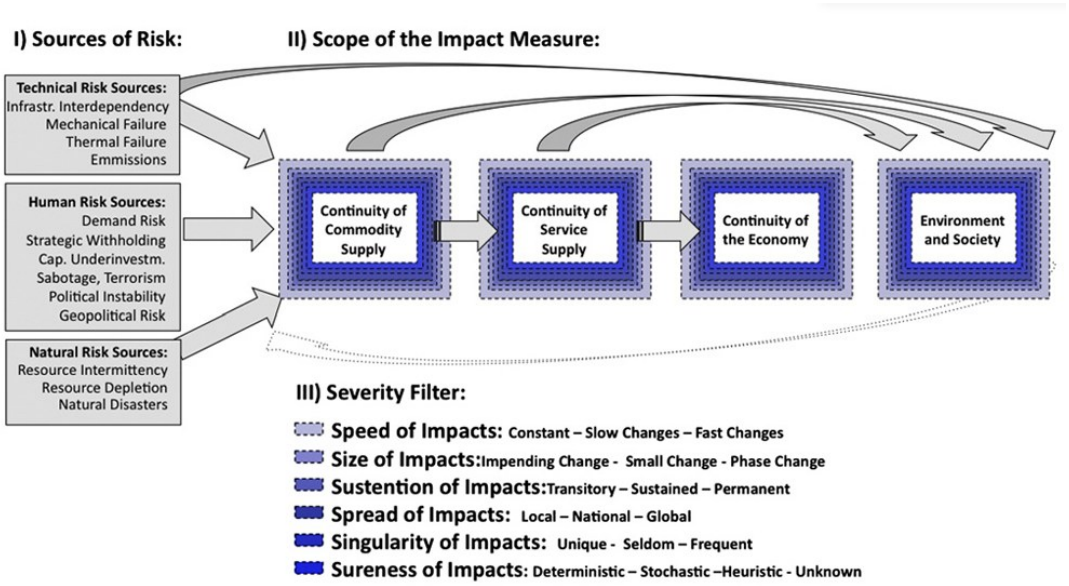


Figure 4 Dimensions of energy security (Winzer, 2012)

Figure 4 shows that assessing energy security and the effects of risks on energy security consists of three dimensions, which are: 1) Sources of risk. 2) Scope of impact measure, and 3) severity of the impact (Winzer, 2012). Sources of risk describe what type of risks are considered, and Winzer et al. (2012) divide sources of risk into three subsections, which are Technical, Hu-

man, and Natural risk sources. An example of human risks is, for example, geopolitical risk, which refers to events such as wars and export embargoes. The scope of the impact measure, in turn, describes how energy security is measured. When considering the impact on energy supply chains, it can, for example, be measured by continuity of commodity supplies, which affects the continuity of the price and availability of different energy supplies. From Figure 4, it can be seen that it further affects the Continuity of service and the Continuity of the Economy, linking energy supply chains and national energy security together. Lastly, a dimension that authors often adopt is a subjective severity filter that examines the severity of a threat and its impact on energy security.

This chapter will explore energy security and the vulnerability of import-based energy systems mainly to human risk sources (Winzer, 2012), especially considering concepts such as strategic withholding and geopolitical risk and disruptions, as the purpose of this study, as they are mostly related to the war in Ukraine and its effects on Russia as an energy supplier. In addition to this, infrastructure interdependency will be considered when assessing the concept of supply risk. A narrowed view of sources of risk by Winzer (2012) is considered. Following the chapter, a well-defined foundation has been laid to examine the effects of the Russia-Ukraine war on Europe's energy security and supply.

2.2.1 Import-dependence

Import dependence is a crucial source of energy risk recognized in energy security research. Countries that rely on imports when domestic production is insufficient to meet demand make their energy systems sensitive to political, economic, and institutional conditions in exporting countries. High levels of supplier concentration, particularly dependence on a single or very limited number of suppliers, constrain an importing country's ability to adapt to disruptions and to amend its supply base in response to shocks (Azzuni & Breyer, 2018; Bompard et al., 2017; Cherp & Jewell, 2014).

The relationship between the importer and exporter in energy trade forms a systematic structural asymmetry of leverage. Keohane and Nye (2013) introduce the concept of asymmetric interdependence (first introduced in the original edition in 1977). This refers to a relationship between two countries in which both parties are mutually dependent, but where the degree of dependence is uneven, leaving one side significantly more exposed to disruption than the other. Keohane and Nye further distinguish interdependence along two dimensions: *sensitivity* and *vulnerability,* which is a familiar concept from supply chain resilience literature by Ivanov et al. (2021). Sensitivity interdependence refers to how quickly and how costly the importer is affected

by changes initiated by the exporter, assuming the importer does not change its existing policies. Vulnerability is the importer's liability to suffer costs imposed by external events, even after policies have been altered, as the importer's options and the cost of alternatives ultimately determine the decision. Applied to energy trade, asymmetric interdependence highlights why importing countries typically experience higher exposure to risk than exporting countries. Many frameworks and case studies on energy security build on the concept of sensitivity and vulnerability. For example, Vivoda (2010) focuses on identifying and mitigating aspects of energy relationships that create dependence (i.e., vulnerability) for importing countries, which mirror the power an exporter gains from asymmetry. Smith Stegen (2011) developed a framework that assesses how an exporter can use the importing countries' vulnerability to their advantage, using Russia's position as a major supplier for European energy imports as a case study.

High-energy-importing countries and their positions have been at the core of understanding energy security, as their positions expose them to specific geopolitical and economic vulnerabilities. Countries relying on single suppliers or utilizing too narrow a supplier base face elevated risks and high vulnerability, and are exposed to disruptions (Azzuni & Breyer, 2018; Smith Stegen, 2011; Vivoda, 2010). High vulnerability can be especially seen in supply security in dimensions such as vulnerability to pressure from the more powerful party, as well as being exposed to high price fluctuations (Schmitz et al., 2025; Smith Stegen, 2011; Vivoda, 2010). In essence, for high-import countries, energy security acts as a vulnerability problem where their reliance on external parties exposes their vital energy systems (for example, national oil and gas flows) to external risks. In energy trade, the presence and price of alternatives are not only dependent on market access but also on the physical and technical substitutability in the energy system. This means that even if alternative suppliers are theoretically available, importers may be limited by infrastructure, such as being dependent on certain pipeline routes or not having essential storage or terminal capabilities (Sesini et al., 2020).

Research shows that overall, a high level of import dependence and supply concentration consistently increases vulnerability to geopolitical risks and reduces the overall energy system resilience (Azzuni & Breyer, 2018; Bompard et al., 2017). As stated earlier, energy security is not about energy self-sufficiency, but it should be thought of as the low vulnerability of vital energy systems (Cherp & Jewell, 2014). Concluding this chapter, import dependency is not inherently problematic or a ris, but rather vulnerability arises when this dependency is combined with risk factors, such as geopolitical instability of suppliers, limited supplier diversification, and an energy system that cannot adapt to disruptions.

2.2.2 Geopolitical risk

Geopolitical risk in energy markets refers to the likelihood that political events, such as conflict, instability, sanctions, or strategic policy shifts, disrupt energy production, trade, or investment regarding cross-border activity (Caldara & Iacoviello, 2022). For energy-importing countries, such risks represent an external source of uncertainty, as they originate beyond national control but still directly affect the reliability of supply. Wang et al. (2024) affirm the perspective that it is essential to consider geopolitical risks in energy security by claiming that the geopolitical stability of energy-exporting countries is a critical factor that shapes the reliability of their energy exports and continuous supply. Political instability, civil unrest, and war can disrupt energy production and supply systems, threatening the stability of global energy supply chains. The effect that geopolitical risk has on energy security has also been quantified, for example, Bompard et al. (2017) developed a national security index, where they examined energy risk explicitly from the perspective of geopolitical risk of suppliers.

Risk may also rise from strategic state behaviour, where exporting states can adjust export volumes, pricing, or destination priorities, or even cut supply in response to domestic or international pressures. While such actions do not necessarily result in immediate critical supply disruptions, they increase uncertainty and exposure for import-dependent countries (Wang et al., 2024). Additionally, Zhang et al. (2024) highlight that diplomatic relations between countries are a critical factor in energy security, as international sanctions, trade disputes, and diplomatic conflicts can limit energy trade and expose import-dependent countries to heightened risks of supply disruptions and price increases. The perspective of international relations is crucial to address regarding energy security, especially when we dive deeper into the Russia-Ukraine war and the implications of Europe's reaction and energy policy. From the perspective of an energy-importing country, geopolitical risk becomes relevant when it materializes as disruptions and uncertainty, which can be seen as reduced availability, reduced reliability, or increased energy supply costs. Energy security research conceptualises supply risk as a vulnerability problem, in which external shocks affect the importing country's energy systems and are translated into concrete security outcomes (Strojny et al., 2023; Wang et al., 2024; Winzer, 2012).

Energy security literature has a wide selection of perspectives on how energy security frameworks should be built. Studies highlight availability and affordability as core energy security outcomes, while also emphasising the role of infrastructure constraints and institutional conditions (among others) in shaping how supply risks affect importing countries (Cherp & Jewell, 2014; Kruyt et al., 2009; Schmitz et al., 2025; Siksnelyte-Butkiene et al., 2024;

Sovacool & Mukherjee, 2011; Strojny et al., 2023). Focusing on the above dimensions in our review provides a structured way to examine how geopolitical risks are transmitted into disruptions in energy security. These mechanisms and implications of geopolitical instability and its effects on energy supply are gathered in Table 2.

Table 2 How geopolitical instability turns into energy supply risk (synthesized from literature)

Transmission mechanisms	**Energy security implication**
Physical supply disruption	Geopolitical risk can reduce or interrupt the availability of imported energy
Price shock	Geopolitical risk increases uncertainty and risk premia, which translate into price volatility
Infrastructure and logistics	Energy imports are often dependent on infrastructure and transit routes, which can both be disrupted, resulting from geopolitical risk
Institutional and regulatory constraints	Sanctions, export controls, contract restrictions, compliance barriers, and regulatory changes can restrict access to energy, even when physical supply exists.

Note. Author's synthesis, based on Bradshaw (2009), Caldara and Iacoviello (2022), Cherp and Jewell (2014), Kruyt et al. (2009), Schmitz et al. (2025), Sovacool and Mukherjee (2011), Strojny et al. (2023), Van de Graaf and Colgan (2016), Wen et al. (2021), Winzer (2012), Wang et al. (2024), Yergin (2006), and Zhang et al. (2024).

The most direct way in which geopolitical risks affect energy-importing countries is through physical supply disruptions, where the available volume of energy is reduced or disrupted completely (Winzer, 2012; Yergin, 2006). Events such as political instability or armed conflicts that the exporting country is involved in can disrupt upstream production, export levels, or the available transit routes (Bradshaw, 2009; Strojny et al., 2023; Yergin, 2006). Export levels can also be strategically lowered and used as an energy weapon by an exporting country experiencing geopolitical instability (Vivoda, 2010; Wang et al., 2024). Many energy systems are infrastructure-bound and characterized by limited short-term substitute options, meaning importing countries often have few immediate alternatives when physical supply is interrupted (Kruyt et al., 2009; Schmitz et al., 2025).

Geopolitical instability in the operating environment and exporting countries also affects importing countries by creating price volatility and affordability risk. Geopolitical risk in major exporting countries can increase uncertainty in global energy markets, increase the risk premia in the market, and trigger major price volatility even if there is no risk of immediate shortages (Sovacool

& Mukherjee, 2011). Of course, for importing countries, this is seen as increased procurement prices. The empirical literature on geopolitical risk backs this with a strong theoretical basis. Caldara & Iacoviello's (2022) geopolitical risk index shows that increased geopolitical risk is associated with adverse macroeconomic outcomes and increased downside risks, reinforcing the claim that geopolitical instability can transmit to price fluctuations through expectations and uncertainty. In other energy market studies, such as a study by Liu et al. (2019), geopolitical risk is linked to forecasting oil market volatility, supporting the idea that geopolitical instability has an effect on volatility in energy prices.

Energy imports many times depend on fixed assets such as pipelines, ports, LNG terminals, and shipping routes, which limit flexibility in sourcing and transport (Bradshaw, 2009). Geopolitical instability affecting exporting countries or transit regions can therefore reduce effective supply capacity, force rerouting, or increase lead times and costs for importing countries (Winzer, 2012). Resilience-focused research in energy security highlights that disruptions ripple through energy system components and that performance can be affected in many different parts of the supply chain by creating bottlenecks in transport, network capacity, and others (Schmitz et al., 2025).

Also, geopolitical effects can be seen affecting supply through institutional and regulatory-based disruptions. In practice, sanctions, export controls, and trade restrictions can constrain cross-border trade by restricting transactions, altering compliance requirements, or undermining contract enforceability (Van De Graaf & Colgan, 2016; Wen et al., 2021). From the perspective of importing countries, such institutional constraints can effectively limit legal or commercial access to energy supply even when physical resources remain technically available.

Now the study has defined how importing countries' vulnerability and increased geopolitical risks are tied together and what concrete effects and disruptions importing parties may face. This thesis deliberately adopts a very narrow view of energy security and focuses on human risks and import dependence. In Finland, a large share of fossil fuels, especially crude oil, has historically come from a single source, the source being, in this case, Russia, making import dependence an important issue to consider. The Russia-Ukraine war and rising geopolitical tensions made many countries review and reassess how much they rely on fossil energy imports.

2.3 The Russia–Ukraine war and European energy market shifts

It is essential to understand the effects of the war on the EU level before diving deeper into the Finnish energy security and supply chain context, as Finland does not operate in a vacuum, but is part of the EU, and its supply chains are affected by other countries' (and the EU's) decisions, infrastructure, and policies.

The European Commission reported that, in 2021, the EU imported more than 40% of total gas, 27% of oil, and 46% of coal from Russia (European Commission, 2022). Russia's invasion of Ukraine in 2022 started a major reconstruction of energy policy in Europe. The Russia-Ukraine war has represented one of the biggest geopolitical shocks to global supply chains in decades, following closely after the disruptions caused by the COVID-19 pandemic and its global effects (Toygar & Yildirim, 2023).

The impacts of the conflict in Ukraine have exceeded the immediate conflict zone, generating significant effects across global supply chains. These disruptions have been particularly visible in sectors that depend on stable cross-border flows, including energy markets and other essential commodities. In addition to constraining energy supply, the conflict has also especially affected the agricultural industry heavily, but also other industries (Sarwar & Rye, 2025). Although the war and its impacts on global value chains have attracted research, they primarily adopt a macro-economic perspective, are conceptual in nature, or concentrate purely on sanctions (Kim et al., 2025), despite the interest in the war, the impact on the firm level and on supply chains has remained under-researched.

The energy interdependence between the EU and Russia has long been a key element of their trade relations. In 2021, two-fifths of the gas used in Europe, and more than a quarter of crude oil imported into the EU, originated from Russia (Ilie et al., 2023). As European fossil energy reserves declined, and as the EU's own policies restricting the production of fossil fuels to fight climate change strengthened, Russia increasingly strengthened its position as a major energy supplier to the EU before the war's escalation (Ilie et al., 2023).

The tensions related to the conflict in Ukraine and the energy dispute between Russia and Ukraine in 2014 highlighted the problem of dependence on Russia as the largest energy supplier and Ukraine as a transit country (Sauvageot, 2020). Despite continuous previous gas transit disputes and the 2014 invasion of Crimea, the EU continued to rely heavily on Russian natural resources. Eventually, in 2022, the EU finally decided to rapidly sever energy relations with Russia, as a response to their aggression and invasion of Ukraine.

2.3.1 The war as a supply shock

The European energy crisis of 2022 was already developing in 2021, before the war, as demand increased with the post-pandemic economic recovery, but gas supply remained constrained. Strong global competition for natural gas, higher EU carbon prices that supported a shift from coal to gas, and low European storage levels going into winter all together tightened the supply in markets and left Europe exposed at the beginning of 2022 (Goldthau & Youngs, 2023). Russia's invasion of Ukraine and the progressive reduction of gas exports to Europe escalated the energy crisis. Russian pipeline exports to Europe reduced by 74% between July and September 2022, when compared with the previous year (Goldthau & Youngs, 2023). Russian gas deliveries to Europe via the Nord Stream effectively ended in late 2022, with flows stopping and exports falling to minimal levels by year-end. This meant a break from Russia's long-standing position as a major supplier to Europe, which had previously covered a substantial share of EU gas consumption (Goldthau & Youngs, 2023). Europe, already suffering from an energy crisis that was intensified after the phase-out of Russian imports started, immediately began to have issues with energy supply and started to take measures to improve the situation.

Western countries imposed a series of sanctions after the Russia-Ukraine war escalated in February 2022. The sanctions aimed to disrupt Russia's energy exports, worsening an ongoing energy crisis (Sun et al., 2024). On March 8, 2022, the United States announced a stop to imports of Russian energy products, including oil, natural gas, and coal. Shortly afterward, the United Kingdom also announced plans to stop importing energy products from Russia within the same year (Sun et al., 2024). In 2022, G7 countries set a price limit on Russian oil exports, and European Union countries banned exports of oil equipment to Russia and imposed a total ban on importing crude oil, petroleum products, and all forms of coal from Russia (Liu & Lee, 2025). Western governments also adopted measures that heavily pressured major multinational energy firms, leading many to end their cooperation with Russian counterparts (Sun et al., 2024). Meanwhile, UK and EU restrictions on marine insurance limited Russia's ability to ship oil internationally, restricting access to global markets. In response to Western sanctions, Russia took countermeasures in early 2022, quickly after the escalation, including cutting energy supplies to certain countries. On September 2, 2022, Russia announced it would indefinitely shut down the Nord Stream 1 pipeline transporting natural gas to Europe (Kuzemko et al., 2022).

The Russia–Ukraine war increased volatility in energy markets and exposed key weaknesses in European energy security. The conflict and subsequent sanctions intensified pressures on energy and commodity prices, contributing to adverse macroeconomic risks, including lower GDP growth and

weaker employment in affected economies (Celi et al., 2022). Although the war has affected many countries and industries, its impacts have been geographically asymmetric. Countries with high import levels, large energy-intensive manufacturing industries, or countries with low capabilities of alternative energy, such as renewables, are the most affected (Celi et al., 2022). According to the results of Liu & Lee's, (2025) analysis, energy prices in Western European countries were significantly affected by the Russia-Ukraine war. The results indicate that the pricing mechanism for energy is strongly influenced by geopolitical risks arising from the Russia-Ukraine conflict and find a strong correlation between Nord Stream pipeline information and the subsequent market reaction in a European gas market. Also, their findings confirm the claim that the energy prices of countries with energy dependence greater than zero, which are mainly European countries, were significantly affected by the Russia-Ukraine war, while the energy prices of countries with zero dependence were not significantly affected by the war. Their results show that energy prices increased by 9% across all OECD countries, but make an important distinction: significant effects were only observed in EU and NATO member countries, not in non-EU and non-NATO member countries. For example, energy prices in southern Europe increased by 22%.

Energy prices became much more volatile during the war as uncertainty increased and supply expectations changed quickly. One clear sign of near-term supply pressure was the widening of crack spreads. This means that prices for refined fuels rose faster than crude oil prices, so refined products became relatively more expensive than the crude oil used to make them (Inacio et al., 2023). The same near-term pressure was also seen in the relationship between spot and futures prices. When immediate supply is harder to secure, buyers pay a premium for quick and certain delivery, so spot prices and near-term contracts can trade above later-dated futures. The pattern was visible in refined products such as heating oil, gasoil, and RBOB, and the same pattern also appeared in natural gas contracts (Inacio et al., 2023). Concluding, spot deals of refined products were prioritized to ensure continuity of supply and security of supply, and actors in the market were ready to pay a markup for available refined products, highlighting the uncertain state of the energy market.

2.3.2 Immediate EU policy responses and reactions

The EU's energy policy response to Russia's invasion of Ukraine in February 2022 rapidly reframed energy from a predominantly market-and transition-governance issue into a question of geopolitical security of supply (Kuzemko et al., 2022). This type of securitisation framing changes policy-making and decision-making settings, and can downplay other policy goals drastically,

potentially leading to short-term thinking (Kuzemko et al., 2022; Patterson et al., 2021). The war allowed immediate responses to take place, as the political climate in Europe demanded policy actions to rapidly steer the supply away from dependence on Russia. This allowed direct policy steering in a traditionally liberal market, which was a large change in the usual operating environment.

Policy responses

Beyond sanctions, the EU's electricity policy responses focused on reducing reliance on fossil fuels and especially natural gas by substituting fuels in the short term while accelerating decarbonization of the energy system and industry, which involved a temporary increase in coal use alongside measures to scale up renewables and other low-carbon technologies (Celi et al., 2022). On the other hand, the EU's REPowerEU package and subsequent industrial policy initiatives aimed at speeding up the clean energy transition and reshaping long-term demand in sectors such as transportation and heating (Goldthau & Youngs, 2023). Some of the research argues, that while the energy crisis might temporarily affect environment-friendly policies in the short run negatively, it may ultimately catalyse green transition, prompting an EU-wide industrial policy focused on addressing current energy vulnerabilities (Celi et al., 2022).

To assess policy responses in Europe after the war's eruption, the initial responses and their goals will first be examined through the initiative introduced by the European Commission, RePowerEU, which was designed to reduce dependence on Russian fossil fuels. The review of the package will be conducted by examining Kuzemko et al.'s (2022) analysis, which was conducted in August 2022. There are three main elements in REPowerEU, which are *accelerating clean energy transformation, reducing energy demand,* and *diversifying fossil fuel supply away from Russia*.

Regarding accelerating clean energy transformation, Kuzemko et al. (2022) highlighted the EU's efforts to raise the 2030 renewables target from 40% to 45%, to push rapid scale-up of solar capacity, and the announcement of a recommendation from the European Commission to minimize slow and complex permitting for major renewable projects. Clean energy policies gained a more explicit energy-security framing during the crisis response. As Kuzemko et al. (2022) note, accelerating renewables and other low-carbon supply is increasingly presented as a pathway toward an energy system in which the risks of fossil fuel being weaponized by external actors are minimized, since renewables and nuclear are often treated as home-grown options that strengthen independence. This reframing also shifted attention away from concerns that had previously existed about the reliability of high shares of renewables within domestic electricity systems.

Reducing energy demand was also part of the EU policy response, especially regarding natural gas. Kuzemko et al. (2022) highlight that the Commission introduced energy savings as a direct way to reduce the dependence on Russian fossil fuels and to minimize exposure to supply-side disruptions. The EU's policies included both short-term and longer-term approaches. In the short term, they promoted voluntary savings and behavioural changes, while longer-term measures focused on energy efficiency improvements, particularly in buildings (Kuzemko et al., 2022). The authors note that these measures were presented as important because they can permanently reduce import needs, thereby overall lowering the risk of supply disruptions.

The main objective of diversifying the fossil fuel supply away from Russia, according to Kuzemko et al. (2022), was to reduce Europe's immediate dependency on and exposure to Russian natural gas by replacing it with alternative sources. The authors describe it as a way to secure alternative imports and supply routes to reduce exposure to geopolitical risk. They note that the response was most visible and politically urgent regarding natural gas, as Europe was heavily dependent on pipeline gas coming from Russia, and the plan included the reopening of coal plants and the use of nuclear energy (Vezzoni, 2023). One of the main ways of securing the needed supply was through LNG procurement, which, on the other hand, requires large investments in terminals, pipelines, and other gas-related infrastructure (Kuzemko et al., 2022; Vezzoni, 2023). This part of the RePowerEU has received criticism. Not because diversifying was not needed, but authors saw that the investments in infrastructure for fossil fuels and the reopening of coal plants may lock Europe into continued fossil fuel use for longer than planned, due to too high sunk costs, which can slow down the fossil fuel phase-out (Kuzemko et al., 2022; Vezzoni, 2023). The diversification and alternative fuel policies have been described as trade-offs, as they help manage short-term supply security, but can complicate longer-term decarbonization (Celi et al., 2022; Kuzemko et al., 2022; Vezzoni, 2023).

After the initial RePowerEU policies, the EU has taken steps in its policies, for example, toward supporting the long-term decarbonisation of industry and reducing fossil fuel demand structurally (Goldthau & Youngs, 2023). In early 2023, European countries also signed off on the Green Deal Industrial Plan, which aimed to speed up the progress towards climate neutrality in industry. The EU also had other climate and energy security policies efforts, such as a ban of fossil-fuel-based engines by 2035 and efforts to revise the Energy Performance of Buildings Directive to affect demand patterns in transportation and heating (Goldthau & Youngs, 2023). In addition to EU-level responses, individual governments have also enhanced and intensified clean energy targets.

Commitments, actions, and investments

The EU made several commitments and took action in 2022 to respond to the changed energy security climate, which had returned to account for geopolitical risks more directly than before (Goldthau & Youngs, 2023; Kuzemko et al., 2022) Goldthau and Youngs (2023) reviewed various European Commission and European Union reports and reported the key commitments and investments made by EU parties in response to the war, the energy crisis caused by it, and the overall changed energy security landscape. The following review of the actions is based on their article.

The EU and its member states took actions to increase oil and gas imports during 2022 from countries other than Russia. These diplomatic efforts focused on contracting additional gas from producer countries such as Norway, Qatar, and the United States. The EU also signed an agreement with Azerbaijan to double gas supplies, while negotiations around East Mediterranean gas produced a new contract with Egypt and Israel. Several member states negotiated their own supply arrangements with other countries, including Algeria, Angola, and Libya. In contrast to previous contracts, many of the new gas deals included clean energy components. The EU framed its shift to alternative gas supplies as a short-term response, while emphasizing that external cooperation on transitioning to renewables remained a priority. This cooperation targeted both support for energy transitions in partner countries and the expansion of renewable and low-carbon energy imports into Europe.

The EU also agreed on a new Critical Materials Act, which is meant to improve access to key minerals for the energy transition. At the same time, agreements on critical mineral supplies with partners such as Kazakhstan and Namibia progressed. Separately, the Carbon Border Adjustment Mechanism moved into a new implementation phase at the end of 2022 after the European Parliament and the Council reached a provisional agreement, later approved by the Parliament in April 2023.

Alongside creating new trade relationships to account for the lost supply from Russia, the EU pursued measures aimed directly at gas import prices. It devoted significant effort to introducing a cap on the price of gas imports, a step that would previously have run counter to the EU's traditional and liberal approach to external energy policy. The EU also advanced a common purchasing mechanism, the EU Energy Platform, intended to strengthen collective bargaining and help reduce the cost of imported gas. The European Union collectively and national governments individually mobilized significant funds in reaction to the energy crisis. Much of this funding was meant to buffer high energy costs. By October 2022, energy subsidies promised or spent in support of industry and households had surpassed 700 bil-

lion EUR. Spending was uneven across Europe and reflected European governments' differing abilities to spend their way out of the crisis

Goldthay and Youngs (2023) concluded that the EU's approach to the changing environment of energy security and ecological challenges in 2022 and early 2023 can be summarized in three points, which are: 1) securitization of renewable energy, meaning reducing dependence on Russian fossil fuels, reducing exposure to price shocks, and increasing autonomy. 2) A bolder renewables extractivism, meaning accepting and taking an active stand on infrastructure and other disruptive ecological trade-offs required to utilize renewables effectively. 3) More state-interventionist energy policy, meaning price interventions and market regulation of a historically liberal market, pushing faster permitting for infrastructure projects, and coordinated subsidies to industrial actors to accelerate investments.

Now the thesis has defined the context of what actions were taken outside of Finnish national borders in response to the Russia-Ukraine war, and how the war has affected the energy supply overall. This context is crucial to understand to assess why supply chains were disrupted and why Finnish energy policy steered away from Russian fossil fuels so quickly.

3 Methodology

The methodology chapter will present the research methodology used in the thesis. It starts with going through the research methods utilized, the data collection process, the analysis process, and finishes with addressing the study's limitations and trustworthiness.

3.1 Research approach

The thesis adopts a qualitative explanatory research design and is based on structured secondary data analysis. A qualitative explanatory design is appropriate when the thesis's purpose is not only to document a phenomenon but also to research how and why the phenomenon was formed. Yin (2018) defines an explanatory study as a study whose purpose is to explain how or why some condition came to be (e.g., how or why some sequence of events occurred or did not occur). The thesis aims to explain how the Russia–Ukraine war affected Finnish energy security, disrupted energy supply chains, and how Finnish energy companies responded to heightened supply risk and market uncertainty during 2022–2024. For this reason, the explanatory qualitative research design fits well with the goal.

The study is conducted as two-stage research to comprehensively answer the set research question. The first part of the analysis is a descriptive analysis of statistical secondary sources and reports, done by conducting document analysis (Bowen, 2009), analysed to establish an understanding of the system-level context and developments, which are needed to successfully answer the set research questions proposed at the beginning of the thesis. The second part of the analysis is a multiple-case study (Yin, 2018), where a purposefully selected body of case companies will be firstly analysed one-by-one, and after that, cross-analysed to identify recurring themes and patterns recognized between the cases to provide better generalization for the research and a structured comparison to help the author to answer the research questions.

3.2 Data sources and collection

The thesis's empirical material consists of purposefully selected secondary data, such as institutional documents, company reports and publications, secondary statistical data, and other supporting material. A broad range of different data sources was used to gather data to accommodate the rather complex database needed to study the defined case and answer the research questions. In total, 78 secondary sources, including 57 reports, 12 company, governmental, and industry online publications, and 9 statistical online

sources and news articles, were collected and utilized in the analysis process. All of the utilized sources and materials are specified in Appendix A.

The empirical section and the data collection around it have two clear and distinctive parts. First, to address the research question: "*How has the Russia–Ukraine war affected Finnish energy security and Finnish companies' energy supply chains?"* are the sources used for section 4.1 are visualized in Figure 5 below.

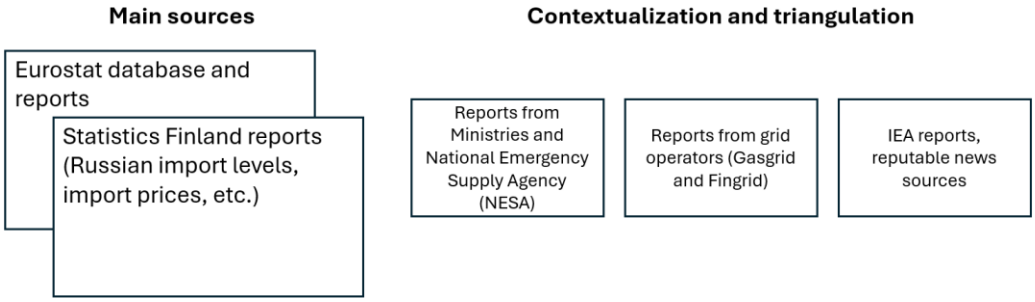


Figure 5 Data sources used in section 4.1

The included documents and publications were also picked by applying the idea of purposive sampling, resulting in choosing only documents and publications related to the study's objectives. Firstly, statistical data from Statistics Finland and Eurostat were acquired to create a baseline regarding the state of Finnish energy consumption and import structure and price development between 2021 and 2024. Secondly, official publications from Finnish governmental bodies and international organizations were gathered. Documents include, for example, reports and press releases from the Finnish Ministry of Economic Affairs and Employment, which holds primary responsibility for national energy policy, publications from the National Emergency Supply Agency (NESA), including its annual reviews and other reports on security of supply, the International Energy Agency (IEA), and its "Finland Energy Review" and other publications. Lastly, news articles regarding both Finnish energy security and the sampled companies were gathered from reputable news or market publications from public sources to create triangulation. Some of the publications and articles were used mostly for triangulation, meaning they were not necessarily referred to in the analysis, but were used to confirm the information provided by the companies and to create an understanding of statistics and make statements regarding the Finnish energy system.

Moving on to section 4.2, the company-level analysis, a purposive sampling approach based on establishing inclusion criteria was used to select compa-

nies for the study that were relevant to the study, but also likely provided deep enough information for the purpose of the research (Palys, 2008). Purposive sampling is a non-probability sampling method in which cases are selected intentionally based on characteristics relevant to the research purpose. The method relies on the researcher's judgment to identify and include units that are likely to provide the most relevant, information-rich, and useful material for addressing the aims of the study. A limitation of this approach is its very limited external validity, but in return, it offers the advantage of making it easier to identify comparable samples and utilize companies appropriate for the study. The goal was to identify Finnish energy companies that were affected by the Russia-Ukraine war.

To be included in the study, a company was required to meet the following three conditions established by the authors: (1) The company must operate as a significant actor within the Finnish energy sector. (2) The company's supply chains or operations must have been exposed to the geopolitical shock from the Russia-Ukraine war. This includes but is not limited to dependence/reliance on Russian fuel imports before the war, exposure to energy price volatility, and reliance on cross-border infrastructure (such as pipelines) affected by the disruption. (3) The company published regular, publicly accessible documentation in English or Finnish, such as annual reports, financial statements, sustainability reports, and other releases during 2021-2024, sufficient and comprehensive enough to conduct systematic content analysis. In conclusion, the selection of specific companies is justified by their central role in the Finnish energy system, their distinct exposure to the geopolitical disruption, and publicly available reporting. These criteria resulted in selecting five companies: ***Gasum, Fortum, Neste, St1,*** *and* ***Neova***. These companies together form an exhaustive outlook on the energy sector in Finland. The companies included in the analysis, their basic information and characteristics, and their main line of business and contribution to the energy sector are specified in Table 3 at the beginning of the within-case section. The case-company selection and utilized data sources are visualized in Figure 6 below.

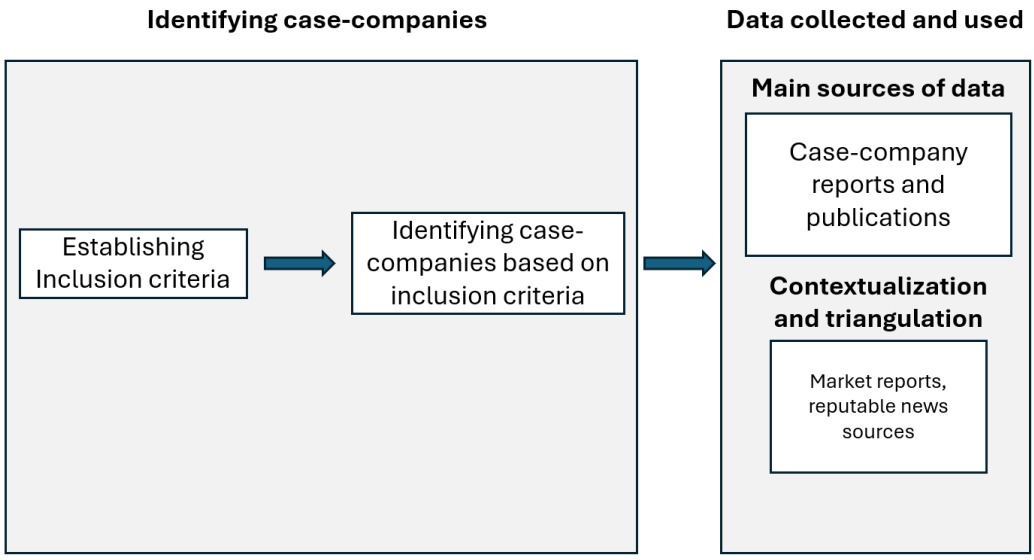


Figure 6 Case-company selection and data sources used in section 4.2

The effects on companies' supply chains and their responses are looked into by analysing publicly available and published data. While secondary data is subject to limitations, including potential bias in corporate self-reporting (Johnston, 2014), the method is deemed viable to utilize when a systematic procedure is followed. Also, the comprehensiveness of the sources gathered nonetheless provides valuable insights into firms' responses. As most of the selected companies are either publicly or state-owned and most documents are either the firm's own publications or governmental parties' publications, the quality of the sources is rather reliable. The inclusion of third-party sources, such as industry publications and media reports, aims to further mitigate this limitation by enabling triangulation and reducing sole reliance on company-produced material when considering effects on firms and their responses.

3.3 Data analysis and research process

The secondary data is analysed utilizing the concepts of content and document analysis (Bowen, 2009; Schreier, 2012). This method is suitable because it enables the systematic examination of qualitative content while allowing the analysis to be guided by prior concepts and the research questions. In this study, firstly, the analysis focuses on establishing a baseline and background information on Finnish energy security, identifying the pre-war baseline in 2021 and developments in the Finnish energy mix and import structure, and the disruptions affecting Finnish energy supply between 2022 and 2024. After this, recurring patterns related to effects on companies' supply chains and responses to supply risk and market uncertainty are analysed us-

ing a multiple-case study, utilizing a cross-case analysis approach (Yin, 2018).

For the first part of the analysis (4.1), statistics from OSF and Eurostat were used to create the baseline for the process. The analysis was guided by former energy security concepts, which conclude that energy security can be conceptualized through the 4A's, which include availability, affordability, accessibility, and acceptability. The goal for the chapter was to establish how the Finnish energy mix changed and how the war affected the energy security of Finland. No particular research method was applied for this section, other than analysing the qualitative statistical data and reports around them thoroughly, and triangulating from supportive sources that were gathered purposively by the author to establish credibility for the analysis.

For the second part of the analysis (4.2), a more structured analysis was conducted, the analysis process of Chapter 4.2 is visualized in Figure 7 below.

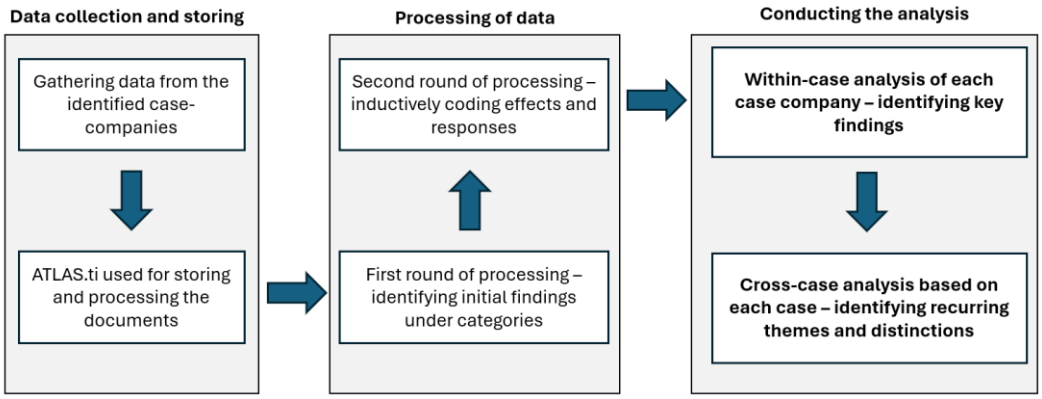


Figure 7 Analysis process of Chapter 4.2

The analysis for chapter 4.2 was done by conducting a multiple-case study, including a cross-case analysis (Yin, 2018). The analysis began by choosing the case companies and gathering extensive reports and publications from the chosen cases, mainly from the time period 2022-2024. The documentation was gathered into ATLAS.ti software to provide the author a platform for handling and processing the documents structurally, leaving a clear trail of the used documents.

The documents were processed and read through by the author, starting with two main categories in mind. First, they were marked based on the effects of the Russia-Ukraine war on the companies' supply chains and operations, and secondly, the main responses of the companies to the disruption and market environment. These categories were deductively drawn from the established research questions at the beginning of the thesis. For each category, the author marked direct quotations and sections, which allowed the author to ini-

tially ensure that the third condition of the selection criteria is met. After the initial skimming and ensuring that the gathered documents were sufficient and comprehensive enough to conduct systematic content analysis (as per the third condition of choosing the case companies), the author started the second round of processing. This time, additional specified themes were inductively added as codes to parts of the documents and to direct quotations, still divided under the two main categories.

After a company's documents were analyzed more carefully, the within-case section (in chapter 4.2.1) was conducted for each company. After completing the within-case analyses, the author proceeded to the second part of the case analysis by utilizing the same codes established for sections within the documents in the within-case analysis, allowing the author to cross-analyze the documents and conduct the cross-case analysis (chapter 4.2.2) to identify recurring themes and patterns recognized between the cases. These recognized themes were then elaborated on in the analysis.

The structure allowed the analysis to identify specific findings in the study within the within-case analysis section, as well as enabling to identify recurring themes and a more general understanding of the phenomenon in the cross-case analysis.

3.4 Current approach and trustworthiness

This study has multiple considerations regarding trustworthiness that should be addressed. The gathered data for the study is secondary public data, as the analysis uses company reports, financial statements, sustainability reports, company publications, statistical sources and reports, government publications, and reputable news or market sources. While this material provides a broad view of the disruption and company responses, it does not provide access to confidential internal insights, sourcing decision-making, risk assessments, or overall management reasoning. Company-produced material may also contain reporting bias. Annual reports and sustainability reports are written for external stakeholders and may emphasize certain actions while leaving some less visible. This limitation is attempted to be mitigated by triangulating company materials with institutional sources, market publications, and news sources, but the interpretation remains constrained by the availability and quality of public documentation.

In a qualitative case study, a commonly adopted framework for assessing the trustworthiness of a qualitative study includes evaluating the study in terms of credibility, transferability, dependability, and confirmability (Guba & Lincoln, 1982).

Credibility refers to the extent to which the findings and conclusions of the study reflect and provide a representation of the phenomenon being studied (Guba & Lincoln, 1982; Yin, 2016). For this study, a source of credibility stems from the sources utilized in the thesis. Firstly, chapter 4.1 is mostly based on the Official Statistics of Finland reports, which one could argue are highly credible sources, as they are using state-provided information. Secondly, the main sources for chapter 4.2 are based on company reports and publications. The companies chosen for this research are public Finnish-based companies, bound by the Limited Liability Companies Act in Finland, which requires the reporting to be truthful. Credibility was attempted to be strengthened by triangulation, when possible. This was done by searching for reputable news sources and market reports about the studied phenomena and companies included in the case analysis. In addition to triangulating with sources, the empirical chapters themselves provide triangulation for each other by triangulating through different empirical methods (Yin, 2016). Chapter 4.1 introduces the operating environment on a system-level and introduces the main disruptions that the companies were exposed to by describing the changes in Finland's energy mix and import structure. Then, in turn, Chapter 4.2 itself talks about the companies that operated in this environment. The findings from the case analysis, therefore, are interpreted against the broader national energy context, which shows consistency between the system-level disruption patterns and the company-level impacts. This confirmed that the phenomenon that was introduced in Chapter 4.1 was also the one that the companies operated under.

Transferability of the research method refers to the extent to which the findings may apply to other contexts and situations (Guba & Lincoln, 1982; Yin, 2016). Transferability is supported by providing a clear description of the research context, the scope of the study, the case selection criteria, the time period, research methods, and the data sources used. Due to the study adopting a secondary data analysis approach, depending on materials such as companies' reports and official governmental-party reports, generalization of results is not supported outside of the Finnish context. If the study was aimed to be highly transferable, a more generalized research plan would have been formed. The transferability of the study's overall conclusions is also limited, as the case targets Finnish companies operating in a unique environment and concerns Finnish energy security, resulting in the analysis being highly geographically and systematically context-specific. Although the empirical findings regarding the companies' responses do include general conclusions that shed light on why certain companies were affected more than others, which can to a certain degree be generalized.

Dependability in this study refers to the consistency and transparency of the research process and findings, i.e., can the study be replicated and the same

or similar findings made (Guba & Lincoln, 1982). This study's dependability is supported by conducting a clear and thorough research process, being transparent in the methodology section of the thesis, and establishing clear inclusion criteria for the study, which allows further research be made with considering the same or similar inclusion criteria for the case companies.

Lastly, confirmability, which refers to the objectivity of the study (Guba & Lincoln, 1982). The objectivity of the study was strengthened by conducting a thorough findings chapter, including direct quotations of the cases that are included throughout the interpretation of findings to support confirmability. The strength of the thesis regarding the confirmability of the study is that the author was not involved in any way in gathering the content in the data itself, for example, by conducting interviews or establishing a questionnaire targeted to gain findings for this study. But in contrast, the strength of the source material is also a weakness, as the source material was not intended for this use, some of the causal relationships presented as a finding are up for interpretation by the author. For example, causal relationships between reactions after the disruption and the effect of the war may not be completely self-explanatory. Before the war escalated, there was an energy crisis already developing, and the market had shown other uncertainty. Additionally, throughout the chosen time period for the study, there were other disruptions, such as escalations in the Middle East in 2024, which also contributed to uncertainty and price fluctuation in the energy market. Because of the uncertainties and the interpretability of some findings, the author had to use extra caution when choosing what to include in the findings, but as there was no possibility to confirm the findings from company representatives, the uncertainty in some findings and their interpretation should be recognized and taken into account when interpreting the results of the study.

4 Empirical findings

The goal of this chapter is to provide a basis for answering the research questions stated at the beginning of the thesis, and the analysis of secondary sources is done purposefully toward this goal. Chapter 4.1 first frames the environment in which the Finnish energy sector operated in and its development throughout the disruption period, and goes through the key disruptions in supply affecting energy supply chains and energy security. Chapter 4.2, in turn, looks at several companies between 2022 and 2024 and aims to analyse how their supply chains and operations were affected during this time period, and how they have responded to the heightened market uncertainty and supply risk.

4.1 System-level effects on Finnish energy security

While Finland's broader energy transition toward low-carbon sources is an ongoing structural process, this section focuses specifically on those elements of the energy system that directly influenced supply security following the 2022 geopolitical disruption. To analyze this, the section examines Finland's national energy supply structure and the advancement of Finland's energy security using secondary statistical data, policy documents, institutional reports, and other reports and releases to identify structural changes in Finland's energy landscape and supply security following the 2022 disruption caused by the geopolitical tension regarding Russia's invasion of Ukraine.

Although Finland's pre-war dependence (in 2021) on Russian energy looked proportionally high, Finnish Energy (a trade association representing the Finnish energy sector) stated in an article written shortly after the war escalated that the practical implications for energy security were less severe than the dependency figures suggested. The main reason for this was Finland's energy-use structure, especially regarding its relatively small reliance on natural gas in household heating and cooking compared with many other EU countries. Additionally, most of the Russian-supplied energy sources were regarded as technically and even operationally replaceable with other sources by Finnish Energy in their publication. They stated that oil could be sourced from global markets, Russian electricity imports could be offset over time through new domestic generation, nuclear fuel could technically be produced elsewhere, and imported wood fuels could be substituted with domestic supply or alternative fuels. Their publication argues that import-dependence regarding especially fossil fuels did not impose an immediate supply threat, but rather the disruptions would increase costs, complicate procurement, and weaken overall resilience.

When Russia invaded Ukraine in February 2022, it started a chain of reactions that has resulted in a literal new world order in many ways. This led many companies, countries, and the EU as a whole to change their approach to relations with Russia in various ways, including restricting trade, especially in necessities such as energy, which amplified the already-rising energy crisis in 2022.

Russia had already started to utilize its strategic leverage and independence regarding energy relations with Europe even before the final full-scale invasion, which followed closely on what Smith Stegen, (2011) had already highlighted while developing his framework years ago. The Ministry of Economic Affairs and Employment of Finland states on its website:

> *"Russia attacked Ukraine in February 2022, but it had already started the energy war against Europe by restricting the supply of natural gas in autumn 2021. Restricting energy is a tool with which Russia attempts to exert influence in other countries. This measures the resilience of societies."*

The Ministry states that although the invasion officially began in February of 2022, the disruption of energy supply in Europe had already started before this. The Ministry of Economic Affairs and Employment of Finland continues:

> *"Finland has adapted to the new situation fully and quickly. The transformation is based on the use of clean energy and exceptionally strong preparedness."*

The official policy states that Finland was able to adapt to the new status quo. This chapter aims to assess in more depth what the effects were on Finnish energy security and security of supply after the invasion began. This chapter also aims to look behind this statement made by the ministries, looking at the pre-war dependence and its developments throughout the disruption of the Finnish energy structure, the concrete disruptions to energy supply that were caused by the war, and the measures taken to strengthen Finnish energy security.

4.1.1 Finland's energy mix and its developments

Earlier research had already identified Finland's dependence on Russian fossil fuel energy imports as a potential energy security risk if negative developments in the geopolitical landscape should happen. Jääskeläinen et al. (2018) studied Finland's reliance on energy imports from Russia and assessed whether this dependence constituted a threat to Finnish energy security. Their analysis approached energy security from dimensions of resilience, se-

curity of supply, affordability, and sustainability. The author concluded in the research that the dependence did not at the time pose an acute threat but also noted that the possibility of geopolitical tensions developing, which would cause disruption to a large portion of Finland's energy supply, should not be ruled out. The Russia-Ukraine war demonstrated that the findings in the research were not only theoretical, but the geopolitical risk identified in the study materialised in practice as the Russian energy supply was disrupted.

Starting with energy consumption, when considering that almost all of Finland's fossil fuels are imported, the share of fossil fuels and peat, along with net imports of electricity, made up around 40% of all consumed energy in 2021. After 2022, there has been a clear downward trend in fossil fuel consumption (from 34% in 2021 to 29% in 2024) and net imports of electricity in the total consumption, and in return an slight increase on renewable energy and a clear increase in nuclear energy (from 18% in 2021 to 26% in 2024), highlighting the steps taken toward a more autonomous and independent energy structure. Consumption levels are visualized in Figure 8 below.

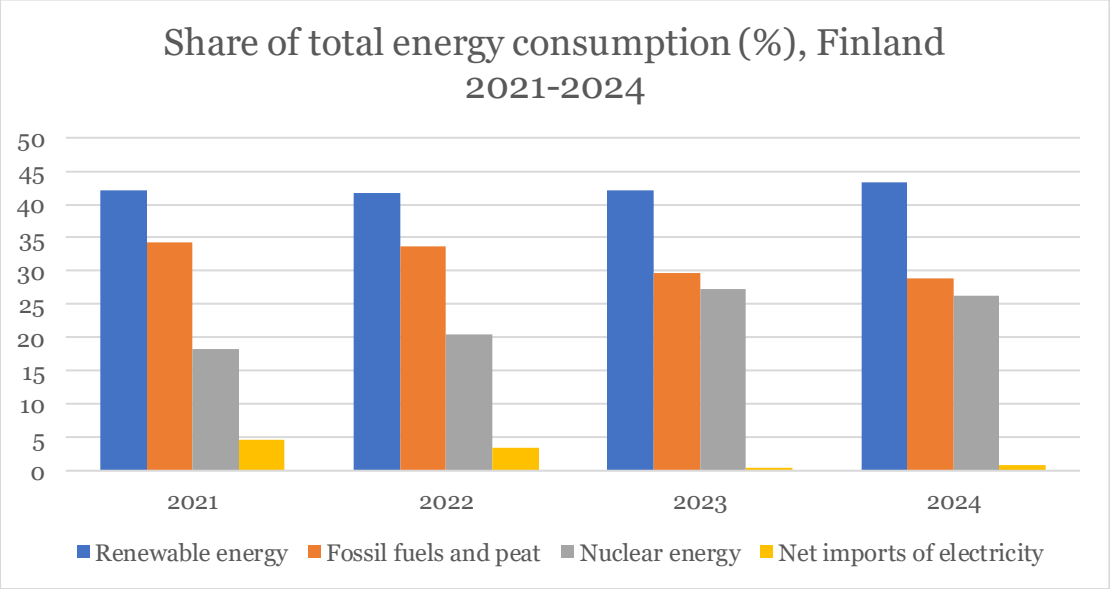


Figure 8 Share of total energy consumption, Finland 2021-2024 (OSF database, 2026. Author's visualisation.)

When considering only fossil fuels, the decrease in consumption is seen in all other energy sources, but not in oil. Oil accounted for 19% of total consumption in 2021, and in 2024 it was still 19%. Coal and natural gas consumption have declined by two percentage points each. Coal's decrease was slightly smaller than that of natural gas, and coal consumption increased in 2022 from the previous year. For natural gas, the change was more drastic as it dropped drastically after major pipeline disruptions and was partly replaced

by LNG, resulting in consumption between 2021 and 2022 being halved. See Figure 9 for the consumption levels of fossil fuels.

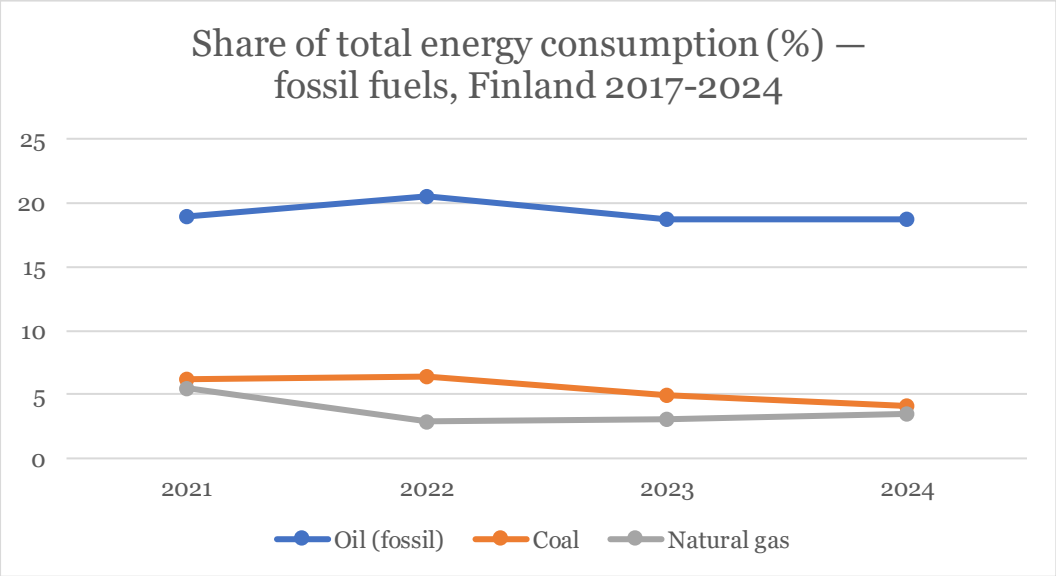


Figure 9 Share of total energy consumption – fossil fuels, Finland 2021-2024 (OSF database, 2026. Author's visualisation.)

Figure 10 shows that Finland's energy import dependency increased from approximately 38 per cent in 2021 to 41 per cent in 2022, before falling to 30 per cent in 2023 and rising slightly to 33 per cent in 2024. The figures suggest that the immediate impact of the war was not a reduction in Finland's overall reliance on imported energy, but import dependency initially increased in 2022, indicating that imported energy continued to play a central role during the initial disruption before other measures to replace the formerly imported energy were taken. The substantial decline in 2023 points to a period of adjustment in which Finland became less dependent on net imports than during the acute crisis phase. Overall, the figures indicate that while Finland's dependence on imported energy decreased after the initial shock of the war, energy imports remained an important part of the Finnish energy system throughout the period.

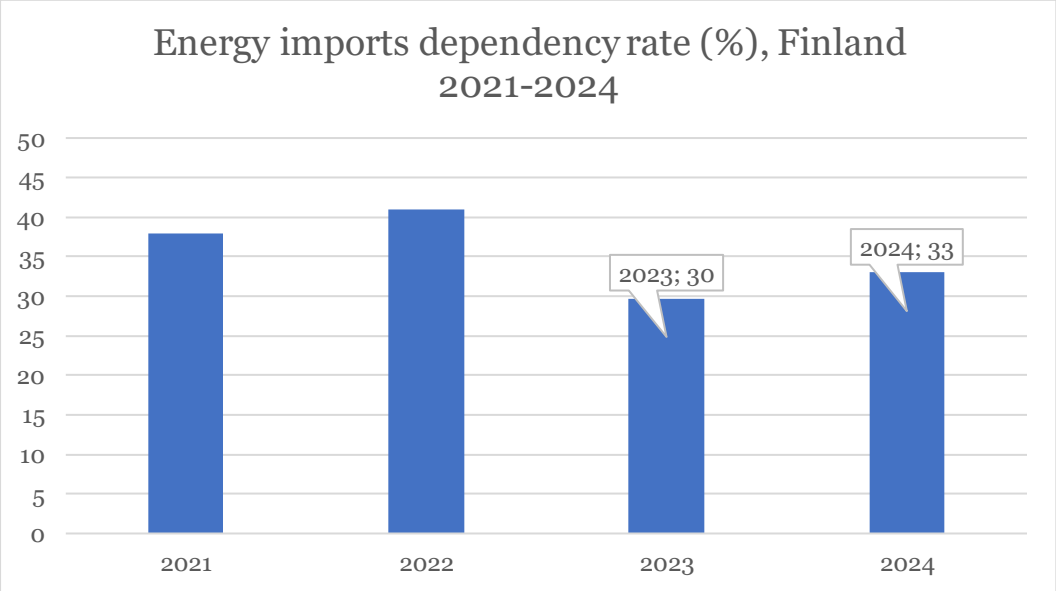


Figure 10 Energy imports dependency rate (Eurostat, 2026. Author's visualisation.)

The energy import dependency rate describes the portion to which an economy relies on net energy imports to meet its domestic energy demand. In Eurostat's formulation, the indicator is calculated as the share of net imports, defined as imports minus exports, in gross inland energy consumption, which consists of domestic energy production and net imports. As such, the indicator provides a useful overall measure of how dependent a country is on external energy sources in relation to their total consumption and domestic production.

4.1.2 Russian energy usage and energy security developments

In 2021, Finnish energy still had a relatively high import dependency compared to the situation after a few years. Figure 11 from Statistics Finland's publication of energy supply and consumption in 2021 in Finland highlights Russia's role as the majority external supplier of energy, especially in fossil fuels, even when considering the total energy consumption. For total energy consumption, imports from Russia accounted for 92% of natural gas, 67 % for crude oil, and 52 % for coal.

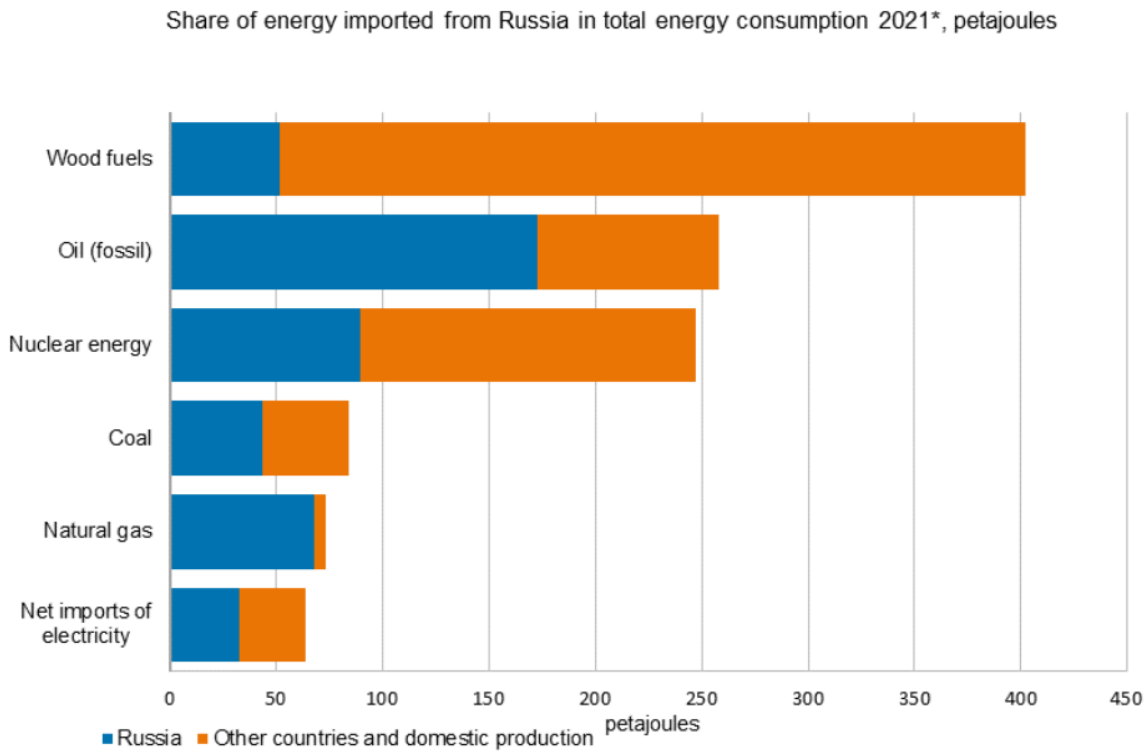


Figure 11 Share of energy imported from Russia in total energy consumption, 2021 (OSF, 2022)

Statistics Finland concludes that in 2021, energy products were imported mostly from Russia, which accounted for approximately 52 percent of the total value of all imported energy products, making it by far the country's most important energy supplier. Among these imports, crude oil was the most significant category, with around 80 percent of Finland's crude oil imports originating from Russia. In 2021, Russian energy accounted for 34 percent of Finland's total energy consumption, highlighting the structural importance of Russian-origin supply to the Finnish energy system before the outbreak of the war. The dependence was particularly large in natural gas, of which 92 percent was imported from Russia.

Compared with 2021, wood fuel recorded the largest relative decrease, at 79 percent in 2022. Coal declined by 72 percent, fossil oil by 69 percent, net electricity imports and natural gas by 60 percent, and nuclear energy by 4 percent. When looking at the changes in relative shares in 2022, visualized in Figure 12, the decreases were 47 percentage points for fossil oil, 37 percentage points for coal, 22 percentage points for net electricity imports, 21 percentage points for natural gas, 10 percentage points for wood fuels, and 4 percentage points for nuclear energy.

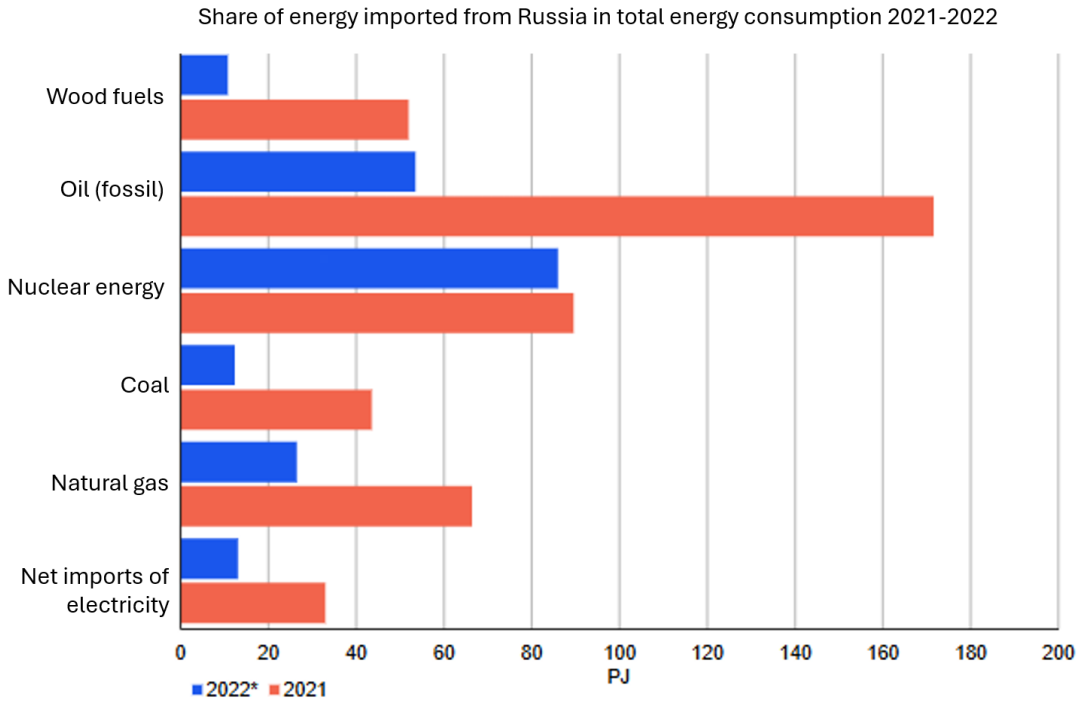


Figure 12 Share of energy imported from Russia in total energy consumption, 2022 (OSF, 2023. Author's visualisation.)

The European Union imposed an import ban on Russian hard coal at the end of August 2022, which sharply declined coal's import levels after the second quarter of 2022, and essentially, imports had stopped by the third quarter of 2022. Crude oil imports from Russia were banned in December 2022 by the EU, which was part of the sixth sanction package, and imports of other oil products were banned in February 2023. Crude oil imports were still high in the first two quarters of 2022 but declined in the third quarter and were already completely halted in the last quarter of 2022.

The share of natural gas imported directly from Russia, including LNG, accounted for 50% of Finland's total natural gas imports in 2022, compared to the last year the share was 75%, marking a decrease of a third of the previous amount. The supply of pipeline gas from Russia halted on 21 May 2022 when the Russian supplier Gazprom refused to deliver further quantities as the Finnish importer would not pay in rubles instead of euros. According to an estimate by Statistics Finland, the Russian share of natural gas supplied through Balticconnector was 37% in 2022 and 63% in 2021. Taking these indirect deliveries into account, the share of Russian natural gas in total imports of pipeline gas and LNG was 68% in 2022 and 89% in 2021.

As pipeline deliveries were halted by Gazprom, the demand for gas was still there, which led to pipeline gas from Russia being partially subsidized with

LNG. Imports of LNG originating from Russia in contrast increased by 33% compared with 2021. LNG accounted for 21% of total natural gas imports in 2022, of which as much as 91% originated from Russia. In 2021, the corresponding share of LNG was 11%, of which 73% came from Russia. Imports of natural gas from Russia had not been banned, and LNG was imported to Finland throughout the year, even though the supply of pipeline gas was halted. Other than relying on LNG, pipeline deliveries from the Baltics through the Balticconnector pipeline increased to improve the security of supply. The Finnish LNG capabilities grew exponentially, as Finland had already leased an LNG terminal vessel before the halt on gas deliveries was announced. The transmission network company responsible for gas, Gasgrid Finland Oy, was authorized to handle the matter, and it started operating in winter 2022, on the same day, 20th of May 2022 as Gazprom cut natural gas supplies to Finland, Gasgrid and a US company signed a 10-year lease agreement for an LNG terminal ship, which capacity allows to cover all of Finland's (and Estonia's) natural gas security of supply needs.

Electricity imports from Russia to Finland were halted by the Russian supplier RAO Nordic in May 2022. Before this, imports from Russia had long played a significant role in Finland's electricity import supply. Concerns arose in Finland about the adequacy of the electricity supply. Although supply disruptions were avoided, electricity prices rose so high during the autumn and winter that the government had to support citizens struggling with electricity prices.

However, in addition to the end of Russian electricity imports, several other factors contributed to the high electricity prices, such as the high price of natural gas and increased electricity prices in Central Europe, which were partly direct or indirect effects caused by the war in Ukraine. The commissioning of a new nuclear facility, Olkiluoto 3, which had its trial runs in 2022, is highly significant for Finland's electricity self-sufficiency. On its own, it can produce more electricity than could have been imported from Russia in total.

In 2023, the share of imports from Russia in Finland's total energy consumption had declined from 34% to 7% in two years. As visualized in Figure 13, energy imports from Russia in Finland included only nuclear fuel used for nuclear energy production, natural gas, LNG, and a small amount of oil products. No wood fuels, coal, or crude oil products were imported from Russia in 2023.

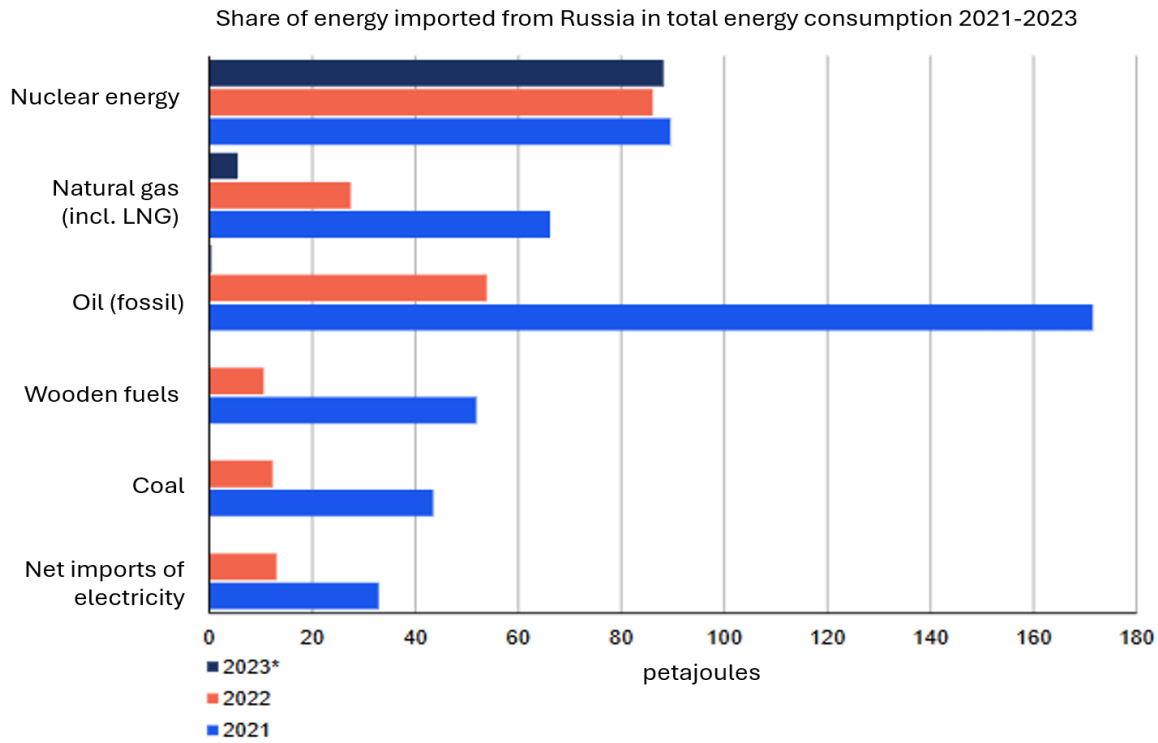


Figure 13 Share of energy imported from Russia in total energy consumption, 2023 (OSF, 2024. Author's visualisation.)

In 2023, nuclear fuel was still imported from Russia, making 25% of all nuclear energy. The imported nuclear fuel made a substantial difference in the Finnish energy supply in Finland, as it allowed the operation of Olkiluoto 3 and other smaller plants, which supplied a significant share of the electricity production in 2023. Overall, in 2023, domestic production covered almost all electricity consumption in Finland.

> *"Domestic electricity production covered as much as nearly 98 per cent of Finland's electricity need. The share of domestic electricity production has last been of this magnitude at the end of the 1970s."* – **Statistics Finland, Energy supply and consumption 2023**

The section explained how Russian import levels changed after the disruption and what the main energy security outcomes and disruptions on energy supply were, along with touching on the topic of what Finland did to improve the energy security situation.

4.1.3 Energy price developments

Moving on to the overall amount and price developments of imports affecting energy security, the 2022-2024 OSF's value of energy import reports between 2022-2024 show that imported energy became extraordinarily expen-

sive in 2022, before stabilizing in 2023 and 2024. Notably, the energy prices were already rising before the war escalated. The energy import values to Finland are visualized in Figure 14.

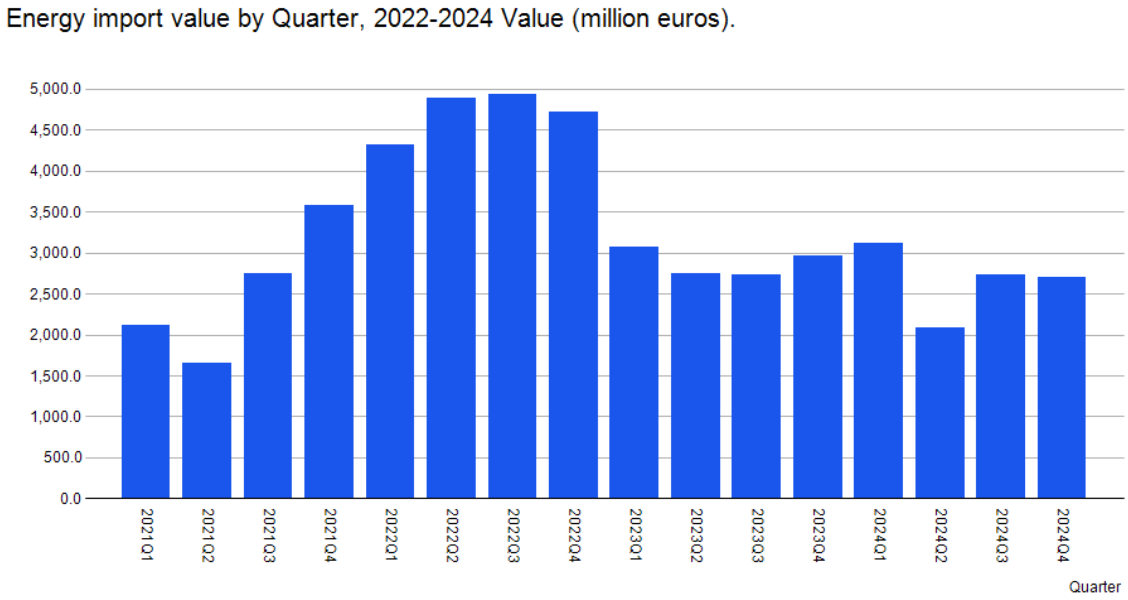


Figure 14 Energy import values 2021-2024 (OSF Energy supply and consumption, 2026)

Values of energy imports in 2022 totaled 18.8 billion euros, which was 86 per cent higher than in 2021. The 2022 figures show that volumes of imports overall decreased, and, for example, imports of electricity decreased by 21 per cent. Also, import volumes of natural gas fell by 52 per cent, but the total value during the year still rose by 48 per cent, the import volumes of LNG only grew by eight per cent from the previous year to replace the decreased natural gas.

In 2023, the most acute price increases were over, and prices decreased, and the total value of imports fell to 11,5 billion euros, which was 39 per cent lower than in 2022. The report by Statistics Finland highlights a deeper structural shift, as the values of Russian imports had fallen to account for only one per cent of the total value, the main import countries now being Norway, Sweden, and the United States. One of the most drastic changes was again in pipeline natural gas, as in 2023, the import volumes decreased by 67 per cent compared to the previous year. LNG, in turn, increased sixfold from last year, which correlates directly with the opening of the Inkoo LNG terminal.

By 2024, the value of Finland's energy imports had declined further, now marking a total of 10,6 billion, decreasing by 8 per cent from the previous year. Structurally, there were no drastic changes between 2023 and 2024, but

pipeline natural gas imports still decreased further by 63 per cent, while LNG imports increased by 19 per cent, further highlighting the role of LNG in the new import structure.

The baseline has been defined for Finnish energy consumption levels and import dependency before the war and the developments in it throughout the disruption. Also going through the main disruptions in energy supply. This enables a better understanding of the context going forward when discussing concrete effects on energy companies and the energy sector in Finland within this timeline.

4.2 Company-level supply chain effects and responses

Individual companies have a central role in the security of supply in Finland. NESA (National Emergency Supply Authority) states, that the security of supply in Finland is built on functional markets and a competitive economy. They also add that Finland's security of supply is safeguarded through collaboration of the public, private, and third sectors. They also recognize, that in Finland, most of the critical infrastructure is owned by the private sector, and that the state itself does not hold a backup system for critical infrastructure and continuity of critical services such as the supply of energy, and these critical functions must function under all circumstances. Moreover, for example, Neste, among other companies, in their publications regarding the war in Ukraine, state that they and other Finnish companies and organisations have a central role in securing the security of supply of energy in Finland.

Next in the analysis, the study will look more into how companies' supply chains were disrupted during the established period, how the companies altered their operations to ensure continuity in their supply chains, and how they have responded to the heightened market uncertainty and supply risk caused by the Russian invasion of Ukraine. Through conducting the cross-case analysis, an exhaustive picture of the effects of the Russia-Ukraine war on Finnish companies' energy supply chains and Finnish energy security can be formed.

4.2.1 Within-case analysis

Next, each case is examined one by one, and the section intends to look into each case, gain insights and understanding on how their supply chains and operations were affected by the result of the war in Ukraine, and how they responded to the heightened uncertainty in the market environment. Following this, a base for conducting the cross-case analysis is formed, which aims to compare the different cases.

Table 3 specifies the companies included in the analysis and their main line of business relevant to the energy sector and the analysis.

Table 3 Companies included in the analysis (2024 information)

Company	Company size and operating scope	Line of business relevant for the analysis
Neste	Headcount: 5876 employees, operating in 16 countries globally	Oil refining, renewable fuels, fuel retail, and fuel supply
Fortum	Headcount: 4466 employees, operating mainly in Nordic countries and Poland	Electricity generation, district heating, power market sales, and nuclear power
Gasum	Headcount: 349 employees, employees in the Nordics and Germany, energy market services in the Nordic countries, LNG distribution also in Central Europe	Natural gas, LNG, biogas, and gas market services
St1	Headcount: 1047 employees, operating in the Nordics and UK	Fuel retail, renewable fuels, and energy solutions
Neova	Headcount: 777 employees, operating in multiple countries around Europe along with operations in the USA, Mexico and China	Domestic energy peat, wood fuels

Neste

Neste Oyj is a public, partly state-owned Finnish company (36 % state-owned in 2022) that in 2022 was the world's leading producer of renewable diesel and sustainable aviation fuel, while also operating a conventional crude-oil refinery in Porvoo, Finland. Neste makes a relevant case, as in 2021, approximately 77 % of the crude oil and feedstock used at its Porvoo refinery was sourced from Russia. When Russia invaded Ukraine in February 2022, Neste was compelled to rapidly replace Russian crude with alternative grades such as North Sea oil.

As Neste is a buyer of oil and does not own any shares in a company producing crude oil, they were not structurally bound to any operations in Russia, allowing them to immediately react to the war, and they did so by deciding to condemn Russia. Neste immediately cut off Russian crude oil entirely and phased out its feedstock supply contracts at the end of the year:

"At the start of the war in Ukraine, Neste decided to stop using Russian crude oil entirely and started replacing it with other qualities. The last crude oil cargo with Russian origin was supplied to Neste in July 2022 and the supply contracts ended. Supply contracts for other fossil raw materials from Russia ended at the end of 2022"- **Neste Annual review (integrated report) 2022**

In the 2022 annual report, Neste reported increased operating costs affecting their margins stemming from overall market uncertainty:

"Oil refining margins in 2022 were impacted by a hike in operating costs. This is due to a combination of overall heightened oil supply risks, and the significant increase in refineries' utility costs. The latter was primarily driven by skyrocketing natural gas prices in Europe caused by Russia's substantial reduction of natural gas exports to Europe."- **Neste Annual review (integrated report) 2022**

In addition to increased operations costs, there were other major indirect effects in Neste's operations and supply chains in 2022. They report an effect on the renewable fuel market, firstly, the war's effects drove up prices for vegetable oils and, in turn, other residue feedstocks used in their refinery operations. As the war affected the cost of fossil transport fuels, it led to a few EU members (including Finland) freezing or even lowering their biofuel blending obligations in 2022 (and after that). Although the biofuels' overall impacts evened out throughout the growing demand in other markets in the EU and globally.

To secure continuity in the heavily price-volatile environment, Neste deliberately increased inventories and stockpiled crude oil and feedstocks to mitigate risk regarding the availability of the supply resulting from the war.

"The Group's net cash generated from operating activities totaled EUR -639 million during the first quarter of 2022. The difference compared to the corresponding period last year mainly resulted from a significant increase in net working capital due to the inventory volume build-up to mitigate potential risks related to the Ukraine war, and price increases of crude oil and renewable feedstock." **- Neste Interim Report January–March 2022**

Neste still reported that the increased costs, and for example, resulting from the unavailability of the natural gas previously used in their refinery, which was then replaced by propane, resulted in them being a month behind in their refinery operations.

In the 2022 annual report, Neste predicts major uncertainty regarding supply availability and costs of crude products, which will be realized after the Russian oil products ban:

> *"With an embargo on Russian oil products coming into force in the EU in early February 2023, uncertainties related to the oil product availability, subsequent cost development for natural gas in Europe and macroeconomic developments impacting demand make the exact direction for refining margins going forward difficult to predict."* – **Neste Annual review (integrated report) 2022**

Overall, for Neste, the war resulted in the need to quickly restructure their crude-supply chains, as they almost immediately cut off Russian crude oil after the start of the war. Them not being bound to operations in Russia allowed a quick exit from Russian relations and suppliers. They had to respond to the new conditions of the energy market by replacing natural gas in their refinery operations, stockpiling large amounts of crude oil and renewable feedstocks to secure business continuity, and overall operating in a volatile and relatively complicated market environment.

Fortum

Fortum Oyj is a Finnish energy company majority-owned by the State of Finland (51.26 % after a directed share issue in November 2022). In 2022, Fortum was the third-largest energy generator in the Nordics and the largest Nordic electricity retailer, and through its subsidiary Uniper based mainly in Germany, it was a leading European gas importer and trader. The company was also heavily invested in Russian power and heat generation. Fortum makes a compelling case because Russia's invasion of Ukraine has affected and destroyed critical fossil-fuel and nuclear-fuel supply lines, it also eventually caused the de facto loss of its Russian assets and forced the near-collapse of Fortum's then German subsidiary, Uniper, when gas supply was halted by the Russian gas company Gazprom.

Fortum's initial response to the war was a complete halt to its Russian activities. As early as March 2022, Fortum announced it had stopped all new investment projects in Russia and is not providing any new financing to its Russian subsidiaries, and that it was pursuing a controlled exit from the Russian market, with a divestment of its Russian operations as the preferred path. In the second quarter of 2023, Russian authorities seized Fortum's assets in Russia, resulting in a complete loss of control of Fortum's Russian operations, resulting Fortum to discontinue their operations completely in Russia. This resulted in a total non-cash negative effect of 3,6 billion euros.

The other dramatic disruption resulting directly from the war occurred within Fortum's German subsidiary, which was Germany's top importer of Russian gas. Starting in June of 2022, Gazprom and Russia essentially weaponized gas supplies, cutting deliveries to only approximately 20-40% of the daily gas volume ordered. This resulted in Uniper needing to purchase gas on the spot market to fulfil delivery contracts, resulting in significant losses. By September 2022, the accumulated financial losses were close to 8,5 billion euros. Eventually, after some turns of events and negotiations, the crisis forced Fortum to agree to sell its entire Uniper stake to the German State for under 6 billion euros, resulting in a drastic loss on the initial investment of 7,2 billion.

In addition to the losses linked to Uniper's gas procurement, the geopolitical tensions in 2022 also affected Fortum through the electricity derivatives market. As power prices rose rapidly to historically high levels, Fortum's hedged power volumes on Nasdaq Nordic's commodities exchange led to unforeseen margining requirements. This resulted in unforeseen liquidity pressure for the company, as the collateral requirements connected to its hedging positions increased sharply with the rising futures prices, resulting in total collateral of approximately 5 billion euros. As a response, Fortum agreed in September 2022 with the Finnish State on a 2.35 billion bridge financing to secure its liquidity position in case power prices increased further.

Fortum in Finland was not heavily dependent on Russian fossil fuels for its power plants, but a more complex challenge existed regarding its nuclear plant, which was completely dependent on the procurement of the fuel supplied by a Russian company called TVEL

> *"In Finland, Fortum does not buy coal, pellets or biomass from Russia for its power plants. However, Fortum buys nuclear fuel for its Loviisa nuclear power plant in Finland from Russian TVEL (part of Rosatom), and it is not possible to quickly change suppliers, e.g. due to required certification and permitting processes"* **– Fortum Interim report January-March 2022**

Fortum recognized the dependence on TVEL as something that could result in a shortage. To address the risk, Fortum signed an agreement with American Westinghouse Electric Company in November 2022 to conduct the design, licensing and supply of a new fuel type for the Loviisa nuclear power plant to eventually replace its dependence on TVEL. To replace the fuel is a multi-year project requiring regulatory approvals, and TVEL's contract is valid until 2030.

"The current geopolitical situation has raised a new risk of nuclear fuel shortage in the Loviisa power plant. In order to mitigate this risk, Fortum has signed an agreement with Westinghouse Electric Company to have a parallel supplier for the current Russian supplier of nuclear fuel, but until the new fuels are approved by the Authority and delivered to site, a possibility exists for a limited period of fuel shortage" – **Fortum 2022 Financial review**

The first batch of Westinghouse's supply was loaded in 2024 during the annual outage. Fortum also mentions in its 2023 Financial report that it additionally wanted to look for an additional alternative Western fuel supplier, which highlights the time of great uncertainty, when Fortum did not want to be dependent on a single supplier from the United States, but was looking for additional Western alternatives.

On 9th of June 2022, Fortum announced that it had, together with Gasgrid Finland, signed a Letter of Intent for Finland's first floating LNG terminal vessel FSRU, Exemplar, to be placed at Fortum's Inkoo port. They stated that Inkoo port is located on the south coast of Finland, and it provides an optimal deep-water port near the pipelines distributing gas mainly to industrial end-users in the Baltic region. Gasgrid Finland leased the floating LNG terminal vessel for a duration of 10 years, and the capacity of the vessel is sufficient for the gas needs of both Finland and Estonia. The floating LNG terminal vessel arrived in Inkoo 28th of December 2022. The solution solely replaced the supply of earlier Russian gas supplies through the Imatra entry point that were stopped in May 2022.

Fortum's Meri-Pori coal plant had stood ready to be activated as part of Finland's peak load reserve system from July 2017 to June 2022. When it was not selected to continue in the peak-load reserve, Fortum started to prepare the plant for commercial use to help maintain security of supply, and in December 2022, the plant was operating and already participated in the spot market. This changed in March 2024, when Meri-Pori was no longer operating commercially, but was again reserved for severe disruptions and emergencies to secure supply in the electricity system in Finland by the National Emergency Supply Agency

The war's effects also contributed to efficiency improvement programs and the development of Fortum's new strategy, which was aimed at pivoting them away from the past towards a new purpose of a "Nordic focus" and new strategic priorities, which were: *Deliver reliable clean energy* and *Drive decarbonisation in industries*. They reported that their growth initiatives are selective, and they would target clean energy and decarbonisation projects.

Fortum also partly benefited from the situation, as they were able to generate good results in their power-generation segment, as power prices were at a record high.

> *"The segment benefitted from high power prices in the Nordics and good physical optimisation supported by high price volatility, posting an all-time high comparable operating profit of EUR 1,679 million and an achieved power price of 63.1 euro per MWh for the full year."* – **Fortum 2023 Financial review**

For Fortum, the effects of the war were drastic. It altered and shrunk the company's operations proportionally, resulting in the sale of shares of the subsidiary Uniper, loss of their Russian assets, skyrocketing collateral for its hedging position, and created many indirect effects resulting from the price fluctuations and unavailability of supply of fuels, spare parts, and others. Fortum responded to the many disruptions in different ways, including looking for alternative suppliers, divesting itself from unwanted business operations, assisting with the security of supply by activating its coal plant, and developing new strategic priorities for the upcoming years.

Gasum

Gasum Oy is a fully state-owned Finnish energy company (73.5 % through the state holding company Gasonia Oy and 26.5 % directly held by the State of Finland) that, in 2022, was the sole importer of pipeline natural gas into Finland, they were also the largest biogas producer in the Nordic countries and an important supplier of LNG for maritime and road transport. Gasum makes a relevant case, because until May 2022, almost all of Finland's pipeline gas was imported from Russia under a long-term contract with Gazprom. When Gasum refused to comply with Russia's demand to conduct payments in rubles, Gazprom halted all pipeline gas deliveries, forcing Gasum to secure an alternative supply through LNG, accelerate its biogas production, and fundamentally restructure Finland's gas supply infrastructure overnight to ensure security of supply in Finland.

The volatility of the energy market, combined with Russia's war against Ukraine and the resulting geopolitical tensions, had significant impacts on Gasum's performance and operations in 2022. Being faced with uncertainty and extreme price fluctuations, gas sales volumes fell by 37% to 15.6 TWh (down from 24.8 TWh in 2021). However, despite the reduced volumes, a sharp increase in market prices led to a substantial rise in revenue compared with 2021. The war triggered extreme turbulence in energy prices, which resulted in the European gas benchmark TTF-index fluctuating between 62.27€ and 342.86€ per megawatt-hour.

For Gasum, having based their business model heavily on natural gas and pipeline deliveries, the war resulted in a large amount of turbulence in the energy markets and led to many extraordinary developments throughout the year, both from the market-side view and in Gasum's supply base. In April 2022, Russian gas supplier Gazprom Export demanded that payments for gas be paid in rubles instead of euros. Gasum refused the demand and referred the matter to an arbitral tribunal in accordance with its agreement with Gazprom. In mid-November, the arbitral tribunal gave a decision that Gasum is not obligated to pay in rubles and further ordered Gasum and Gazprom Export to continue contract negotiations to resolve the situation. After Gasum refused to pay in rubles, Gazprom Export stopped pipeline deliveries immediately. This resulted in Gasum having to completely restructure its supply chains, but reportedly, they managed to endure and adapt to the initial shock-disruption

> *"Natural gas pipeline deliveries from Russia have been discontinued since May 2022. Because of the situation, we have had to arrange for an entirely new supply and logistics chain to secure natural gas deliveries for our customers. We have managed to do this without any interruptions in the deliveries during 2022, which has been a fantastic demonstration of the dedication and expertise of the Gasum staff."* - **Gasum Financial review 2022**

While natural gas deliveries ended from Gazprom in May 2022, Gasum sought alternative sources, resulting in natural gas being supplied via the Balticconnector pipeline from other sources until it was damaged in 2023 when a Chinese vessel's anchor hit the pipeline. The damage to the Balticconnector is not currently known to be related to Russia or the war in Ukraine. When this disruption occurred, Gasum had to rely on large volumes of LNG to supply its customers and keep the security of supply afloat regarding natural gas.

Although natural gas imports from Russia stopped in May 2022, Gasum was contractually bound to continue LNG purchases from Russia and could not refuse the deliveries without major financial consequences, as it was obligated to pay the minimum requirement for the deliveries, no matter if it accepted them or not. At the time, Natural gas or LNG deliveries coming from Russia were not sanctioned by the EU or other countries Gasum operates in, which meant that there were no legal grounds to end the contract.

> *"While Gasum procures liquefied natural gas from a number of different sources, we are contractually obligated to continue LNG purchases also from Russia. The LNG supply contract with Gazprom Export is a so-called take-or-pay agreement, which means that Gasum has to pay for a certain amount of LNG per year, even if we didn't collect it. Natural gas or LNG*

deliveries from Russia have, until March 2023, not been sanctioned by the EU or any country Gasum operates in, which means there are no legal grounds to stop the purchases."- **Gasum Financial review 2022**

Gasum reported in its 2022 Financial Review that although the majority of the LNG directly sourced by Gasum is coming from outside of Russia, for example, sanctions and some other measures against the Russian gas sector, or countermeasures imposed by Russia, could have significant impacts on Gasum's operating environment, the surrounding markets, and the company's LNG supply chains and hedging. They implied that they attempted to mitigate the risk of supply cuts, e.g., by exploring alternative supply methods and decreasing the hedging of Russian sourcing exposures.

In June 2024, the EU approved the 14th sanctions package against Russia, which included a ban on the import of Russian LNG through terminals that are not connected to the EU gas network. Since Gasum's terminals fell under this, the company ceased all purchases of Russian LNG on 26 July 2024. Although the sanctions did not directly allow Gasum to terminate its long-term contract with Gazprom Export, they acted as a force majeure, legally preventing any further imports. Gasum successfully replaced the Russian volumes by sourcing LNG from other countries without supply interruptions.

The war also had other effects on Gasum's operations, as they launched extensive improvement programs to improve the company's profitability, which included several actions to reduce the costs of operations and to improve profit margins, and the restructuring of the organisation. Among the improvement efforts made in response to the new status quo, a new strategy was formed, and the main driver of the new strategy became a goal to bring 7 TWh of renewable biogas to the market annually by 2027. Among ways of reducing their operating costs, Gasum also took extensive action to mitigate the impact of market volatility by reducing hedge levels, which led to a lower financial impact through the valuation of financial instruments and reduced requests for cash collateral as guarantees for hedge positions despite continuing market volatility.

Gasum also launched a separate group to monitor the situation and coordinate Gasum's operations to ensure security of supply and to monitor the changing operating environment actively. They also report that the group maintained active dialogue with relevant national authorities and stakeholders to ensure full compliance with EU policies, legislation, and regulations.

"From the start of the war, an internal crisis group has coordinated work at Gasum to ensure the security of supply to all our customers and assess

the implications to our business." – **Gasum Sustainability Report 2022**

Gasum faced a lot of turbulence between 2022 and 2024, most resulting from the uncertainty in the energy market as a result of the war, but also some from other sources, including the damaged Balticconnector pipeline. The disruptions resulting from the war in Ukraine resulted in Gasum having to rethink its whole supply chain, as previously, both natural gas and LNG were mostly sourced from Russia. Overall, their responses included restructuring their supply chains, utilizing alternative supply sources, creating new partnerships, and launching a new strategy and improvement programs, which included a goal to bring an extensive amount of biogas into the market.

St1

St1 Nordic Oy is a privately owned Finnish energy company that in 2022 operated one of the Nordics' largest fuel-retail networks with over 1,200 stations and a 30-million-barrel-per-year oil refinery in Gothenburg, Sweden, alongside a growing portfolio of biogas, advanced ethanol, and wind-power businesses. St1 makes a relevant case, as when Russia's invasion of Ukraine increased global oil-product and natural-gas prices and disrupted energy supplies across Europe, St1's fuel supply and logistics chain became essential to Finnish security of supply. St1 also opted to increase industrial gasoil deliveries to replace Russian gas and to help to ensure security of supply in the industrial sector.

St1 differs from the previous cases, as its sourcing was not heavily reliant on Russian fuels or crude oil but on refineries and supply in the Nordics. Thus, the effects of the war are more indirect than in the previous cases, making it an interesting case to consider in the analysis and making the analysis more heterogeneous.

"Due to the fact that we do not use Russian crude oils and our station network utilizes petroleum products produced from St1's Gothenburg Refinery and other nearby refineries located mainly in Finland, Sweden, Denmark, and Norway, the war has not directly impacted our operation." - **Game Changer 2022 ST1 Nordic Oy Integrated Report**

For St1, the volatile energy markets, which included the heavy price changes in many different energy sources, especially in oil, had effects on St1's performance, margins, and overall supply chains.

"Our operating environment in 2022 was very volatile and challenging. Changes were rapid and the energy market experienced a number of un-

precedented events, particularly in terms of prices, as a result of the war in Ukraine." - **Game Changer 2022 ST1 Nordic Oy Integrated Report**

As the energy market was volatile, and disruptions occurred at the beginning of the supply chains, St1 reports that the effect on the supply chain rippled downstream throughout the value chains, all the way to the end, in this case, all the way to the customers, which is directly related to what is described in literature about the ripple effect (Ivanov, 2018). St1, having a business model that includes supplying fuel directly to consumers, made the ripple effect even more notable.

"The volatile price changes over the year relate not only to fuel, but energy in general, which created ripple effects for our business and indeed our customers." - **Game Changer 2022 ST1 Nordic Oy Integrated Report**

St1 recognized the uncertainty of the energy market as a persistent condition, rather than a short-term disruption. In 2023 annual review *"Geopolitical instability, protectionism and security concerns"* were listed as top challenges and in 2024 the report stated that the ongoing conflict in Ukraine and the Middle East have led to volatility in the oil market, also which highlights that the state of the energy market was not only dependent on the situation in Ukraine between 2022-2024, but other conflicts, such as in the Middle-East played their part.

St1 reported that the uncertain environment also opened up new opportunities, indicating that St1 were able to adapt to the new scenario well and create new opportunities even amid uncertainty.

"These unprecedented changes led to the creation of new customers, agreement types, and new ways to optimize limited energy sourcing while maintaining good customer experience. This was accomplished through close cooperation with our customers, thus creating growth in many customer segments." **- Game Changer 2022 ST1 Nordic Oy Integrated Report**

The war had a massive impact on the demand for certain fuels, as others essentially ceased to exist in certain markets. St1 was able to increase the supply of industrial gasoil (IGO) in Sweden and Finland, offering a replacement for natural gas at a time when gas prices heavily increased, and the availability of natural gas was uncertain.

For St1, the effects of the war were more indirect than for the other cases. They mostly reported uncertainty and price volatility, but also new opportunities to utilize their capabilities, which resulted in positive outcomes in both revenue and results in the initial disruption periods.

Neova

Neova is a Finnish state-majority-owned company (State of Finland 50.1%, Suomen Energiavarat Oy 49.9%) that in 2022 was a major producer of solid fuels, including peat, and the leading growing-media company in Europe. Neova makes a relevant case, as when Russia's invasion of Ukraine abruptly halted the import of Russian wood chips, pellets, and other energy supplies, Neova's energy-peat business became central to Finland's security of supply, forcing the company to reverse a previous decision made just months ago to exit energy-peat production.

The most direct supply effect on Neova's operations was the immediate cessation of energy-related imports from Russia. This resulted in Neova having to reconsider how to replace the lost Russian supply of wood, which eventually also increased prices, which Neova then had to pass on to their customers by raising prices of their products. Neova reported that although they increased prices, they were not able to transfer the increased costs to higher prices completely in 2022.

> *"Immediately after the war began, Neova Group discontinued all purchasing and sales activities with Russia and Belarus. In the energy business, this created the need to quickly find alternatives to fuel wood imported from Russia to ensure the availability of fuel for customers."* **- Neova 2022 Q1 Interim report**

A critical effect on Neova's supply chains after the outbreak of the war was the increased shipping and raw material costs.

> *"The spill over effects of the war in Ukraine on energy prices and logistics costs, for example, have had a rather exceptional impact on the Group's divisions."* **- Neova 2022 integrated annual report**

For Neova, road shipping costs increased by around 15 per cent during 2022. Neova had hedged the prices of bulk sea shipping with annual agreements, which kept their prices stable in 2022, which was a key factor in why Neova's profitability stayed at a tolerable level. Having annual agreements in sea shipping resulted in being highly advantageous as the volumes of sea shipping of peat to Europe grew considerably. They also report on other increased costs, such as packaging materials prices doubling.

Likely the most direct effect of the war on Neova's operations was that Neova had to reconsider a cancelled energy product to help ensure the security of supply in Finland. In November 2021, Neova had decided to discontinue milled energy peat production in Finland. To fill the gap left by Russian imports, Neova had to rapidly restart milled energy peat production, aiming to produce 2 TWh of energy peat for the upcoming summer in 2022 and reverse their decisions made just a few months ago.

> *"To help Finland manage the process of breaking away from energy imports from Russia, we decided in March 2022 to resume the production of milled energy peat. This decision was motivated by the need to protect the security of supply and delivery reliability of Finland and Finnish energy companies."* - **Neova 2022 integrated annual report**

In 2022, the Finnish National Emergency Supply Agency also included peat as part of its portfolio of security of supply fuels, which made a significant change in the declining peat market. Neova reported that they managed to fulfill both their own large customers' needs, which were critical to the national energy supply, and the National Emergency Supply Agency's needs through their stocks from previous years.

To optimize their processes and to reinforce the security of supply structures, Neova established a separate entity to centralize their energy peat sales and other operations, Vapo Terra Oy. Neova explicitly linked the entity's role to handling security-of-supply obligations and their fuel sales, among other responsibilities.

A unique response in this case to the energy crisis was a heightened focus on direct lobbying. Neova actively engaged with EU policymakers to ensure that peat was not categorised as unsustainable under the EU taxonomy, as it would have complicated the availability of financing. The company stated:

> *"Neova Group is making every effort to inform the parliaments of various EU countries and EU officials to have the future of peat as growing media, animal bedding and raw material for new high-value-added products classified as sustainable going forward."* **- Neova 2022 integrated annual report**

Whether the lobbying and advocating for peat with policymakers was connected to the ongoing situation and the developed energy crisis, or if it would have been done by Neova either way, even without the development of the war and the crisis, is impossible to say with current information, but it likely started as Neova had to restart their energy peat production as a result of the war.

Further down the line, in 2024, Neova launched different types of projects to reduce the dependence on peat and other volatile and vulnerable sources towards higher-value products, for example, by developing wind and solar parks on top of decommissioned peatlands.

Overall, the war had particularly significant effects on energy and material imports, logistics, and material costs, and amplified the company's role in security-of-supply obligations. Neova responded by reversing critical decisions regarding phasing out peat production, reinforcing security of supply structures, and taking measures to accelerate its energy supply toward sustainable energy and materials.

4.2.2 Cross-case analysis

The previous chapter described how the Russia-Ukraine war affected the chosen companies individually and how each firm responded to the disruptions and uncertainty it created. The purpose of this cross-case analysis section is to move from individual case descriptions to recognizing patterns across the companies.

The cross-case analysis is structured around two main units of analysis. Firstly, the analysis examines impacts on supply chains, especially focusing on how the war disrupted sourcing, logistics, affected costs, contracts, infrastructure, operations, and supply continuity. Secondly, the analysis looks into reactions and responses, focusing on how companies adapted to the disruption and how they altered their operations under the uncertain environment.

The units of analysis were drawn from the research questions, the themes within the units of analysis were identified inductively during the within-case analysis phase. The cross-case matrixes below summarize the main findings of the analysis. A mark in the matrix indicates that the theme was clearly visible in the within-case analysis. A mark inside parentheses means that the theme appears or affects the case indirectly or only partly.

Impacts on supply chains

The cross-case analysis regarding the effects on supply chains shows that the Russia–Ukraine war affected all five companies, but the type and severity of the impact depended on the company's pre-war exposure to Russian energy, the substitutability of its materials, and the degree to which its supply chain was tied to specific infrastructure, or, for example, supply contracts. The cases, therefore, show that the war did not create a certain and uniform disruption across the Finnish energy sector. The disruption materialized differ-

ently depending on each company's position in the whole energy system. The results of the cross-case analysis regarding supply chain effects are visualized below in Table 4.

Table 4 Cross-case impacts on supply chains

Identified impacts on supply chains	Neste	Fortum	Gasum	St1	Neova
Direct exposure to the Russian-originated supply	X	X	X		X
Infrastructure-bound or market-mediated disruptions	(X)	X	X	(X)	(X)
Increased prices, price volatility and cost pressure	X	X	X	X	X
Ripple effects on downstream supply chains and security of supply	X	X	X	X	X

Direct exposure to Russian-originated supply

The clearest pattern across the cases was that the companies that had direct Russian-origin dependence regarding their supply were most disrupted and needed the most immediate changes in their supply chains. Neste, Gasum, Fortum, and Neova all had direct exposure to Russian supply, but the nature of their dependence or exposure differed between cases.

For Neste, their exposure and dependence were mainly related to the fact that their crude oil and refinery feedstocks were mostly sourced from Russia, and they reported that in 2021, 77% of the crude oil and feedstocks used in the Porvoo refinery in Finland were Russian-originated. Neste stopped using Russian crude oil very quickly, before the summer in 2022, and replaced it with alternative supply qualities such as North Sea oil. Last Russian feedstock supplies arrived at the end of 2022, and after that, Neste did not use Russian-originated supply in their refinery and reported that the replacement of supply was done successfully without disruptions. As an indirect effect, Neste reported that due to different types of issues, and for example, natural gas being unavailable, they had to replace it with propane as it was used in their refinery, resulting in them being a month behind in their refinery operations.

For Gasum, their dependence was very infrastructure-bound, and their operations were very much affected. Until 2022, all of Finland's pipeline gas was supplied from Russia by Gazprom under a long-term contract. Gazprom

demanded at the beginning of the war that Gasum should pay for the gas in rubles. When Gasum refused, Gazprom halted their deliveries, forcing Gasum to completely restructure their supply chains. Even with the complete disruption in their supply, Gasum reacted quickly and reported that no critical deliveries were missed to their customers, which would have affected the security of supply in Finland.

Fortum's exposure and disruption were the most multi-layered and complex. In Finland, Fortum reported that they were not particularly dependent on Russian coal, pellets, or biomass to power their power plants, but they were exposed to Russian nuclear fuel in their Loviisa power plant, which was single-handedly supplied by the Russian TVEL. In addition to this, their subsidiary Uniper was heavily disrupted. Uniper was one of the biggest importers of pipeline natural gas in Germany, which suffered drastic financial losses when Russian pipeline deliveries were cut down to 40% of the average daily volume, leading to eventually Fortum divesting from Uniper.

For Neova, the exposure was linked to their energy-related imports from Russia, especially regarding fuel wood. After the invasion began, Neova discontinued procurement from Russia and Belarus, which created the need to immediately find alternatives to ensure continuity.

St1 was the contrasting case. Unlike the others, St1 did not use Russian crude oils or other fuels, but mainly relied on a refinery in Gothenburg and other Nordic sources. As a result, the war did not affect St1 directly as it did in the other cases, but the effects were more indirect, affected by the market volatility and energy price changes, eventually affecting downstream in their value chains.

Overall, the results suggest that among the cases, pre-war dependency on Russian supply was the biggest determinant of direct supply chain disruptions. However, the St1 case shows that also companies without direct exposure were affected, through price volatility, demand changes, and overall wider market uncertainty.

Infrastructure-bound or market-mediated disruptions

A second cross-case pattern concerns infrastructure-bound and market-based disruptions, which also shows that disruptions affect the company differently, depending on whether the company's operations were dependent on a certain infrastructure, which was affected by the disruption, or if it was simply just a matter of buying from a supplier in Russia.

To start with the infrastructure-bound disruptions, Gasum's pipeline gas imports were cut off, and they had to rely on alternative gas flows. They were

able to change their supply by procuring through the Balticconnector and strengthening LNG capabilities, which required them to rethink their whole supply chain. For Fortum, on the other hand, their dependency included nuclear fuel, which was powering a power plant that was solely dependent on a Russian supplier, and the fuel used was not a matter of only switching a supplier, but required intensive certification and permitting processes to be able to switch the nuclear fuel used for the plant.

In contrast, Neste and St1 were more exposed to a market-based or market-mediated disruption. Meaning that they operated in a globally traded oil, feedstock, and fuel markets where alternative crude grades and other products were able to be sourced from elsewhere than Russia, but at a higher cost and with greater uncertainty. Neste was able to replace Russian crude oil and feedstocks but had to manage increased costs. St1 did not face a direct supply cut from its then-current suppliers, but volatile fuel and energy prices eventually also rippled through its value chains. Neova is a borderline case and does not necessarily fit into either category. For Neova, they were dependent on Russian wood and some other materials, which are not in the same sense available on the global market, or if they are, they are not necessarily cost-effective to source from far. When Neova was able to steer away from the Russian supply, they reported increased logistics and material costs in the domestic market.

This theme is central, as it shows that not all energy supply chain disruptions can be solved through just quick supplier switching, but some are more systematically bound to infrastructure or to other physical assets, such as pipelines, terminals, or other restrictions, such as a certain nuclear fuel. In cases where the energy supply is more market-mediated, resilience and continuity are more dependent on agile procurement practices and supplier diversification capabilities.

Increased prices, price volatility and cost pressure

Unlike the direct supply disruptions, price and market volatility affected all five case companies, making it the most common effect pattern among all cases.

Neste faced increased and very volatile crude and feedstock costs, along with utility costs regarding its refinery operations. Gasum experienced extreme gas price turbulence and reduced volumes, both stemming from targeted cut-offs, but also from the overall volatility in the market. St1 reported a challenging and volatile market, especially regarding high market prices and a volatile energy market, but also reported that the increased uncertainty and unavailability of natural gas led to new opportunities in the industrial sector. Neova faced increased shipping logistics and material costs. For Fortum, they

had a two-way effect on the price fluctuations, and reported that they were not able to fully transfer the increased costs to customers. In the beginning, for Uniper, there were drastic effects, resulting in Fortum eventually divesting from its share. They were also affected by the fluctuating energy markets, leading to their hedging positions skyrocketing, creating a 5 billion euros collateral position at its highest point. On the flipside, Fortum reported record-high revenue in its power-generation segment as a result from the record-high electricity prices.

The cases shows that the war not only had the effect of a physical supply shock, but also, even more drastically, contributed as an affordability and cost shock. Comparing the different effects that the price volatility and energy market uncertainty caused shows that the volatility did not only have one single effect. For Gasum, sales volumes fell, but revenue clearly increased, for Fortum, hedging and Uniper operations took a hit, but elevated power prices increased revenue. For St1, volatility created challenges but also created new business opportunities. For Neova and Neste, costs regarding materials and logistics costs affected margins and predictability. It can be concluded that the effects depended on each company's position in their value chains.

Ripple effects on downstream supply chains and security of supply

Often the effects of the disruptions did not stay inside one company and their operations, but ripple through to, for example, customers or, in this case, many times, also uniquely towards the broader Finnish energy system and security of supply.

Starting from Gasum, which had a central role as Finland's pipeline gas importer, meant that the disruption for them had central implications for the security of supply and many industrial customers, which were often dependent on gas. St1, on the other hand, reported ripple effects stemming from the volatile market both for their business and their customers, as St1 supplies fuel directly to end-users and industrial customers, the volatility was transmitted quickly downstream in their supply chain. Neova's case shows a ripple effect in the solid-fuels market, and the disruption created effects resulting in them restarting milled energy peat production as it became essential for the security of supply, resulting from decreased volumes in the energy system after the imports from Russia ended. Fortum also had broader energy-security roles in the energy system, and the effects of the war affected both customers and the security of supply. High electricity prices effected customer directly, but Fortum had quite a large involvement in securing supply in Finland during the initial disruption. Firstly, they provided the Inkoo port terminal for the use of the LNG vessel, which dismantled the dependence on pipeline gas. Additionally, they utilized their Meri-Pori coal plant to first pro-

vide spot sales for commercial customers and later turned it into a security of supply reserve plant.

Comparing how the effects on the firms' supply chains and operations rippled forward, it can be concluded that the effects on energy companies were not only affected as commercial companies, but also as nodes or parts of the overall security of supply system, and the disruptions in their supply chains had implications for all levels, i.e., to industrial users, consumers, and the overall national energy security resilience.

Responses and reactions

The second unit of analysis looks at how companies reacted and adapted to the effects of the war and the uncertainty created by it. Across the cases, responses can be grouped into six broader categories that are: immediate decoupling from Russian operations and supplies, supplier diversification, substitution, buffers and redundancy, and strategic reorientation. The responses show a combination of short-term reactive actions and longer-term resilience-building. The results of the cross-case analysis regarding responses and reactions are visualized below in Table 6.

Table 5 Cross-case identified reactions and responses

Identified reaction or response	Neste	Fortum	Gasum	St1	Neova
Decoupling from Russian supply and operations	X	X	X		X
Supplier diversification and substitution of energy sources	X	X	X	(X)	X
Buffers, safety stock build-up and redundancy measures	X	X	(X)		X
Risk management and strategic adaptation	(X)	X	X	(X)	X
Contractual and regulatory constraints to responses		X	X		X

Decoupling from Russian supply and operations

The first response theme was the immediate reduction or termination of Russian-related sourcing and business. Neste and Neova were able to quickly de-

couple from the Russian supply. Neste reported that they received the last crude shipments in July 2022, and the last feedstock contracts from Russia phased out by the end of 2022. Neova reported immediately discontinuing purchasing and sales activities with Russia and Belarus.

Fortum reacted quickly by stopping all new investment projects in Russia, ending financing to their Russian subsidiaries and planning a controlled exit from Russia, which was disrupted as Russian authorities seized their assets in 2023. Gasum's response was more constrained; pipeline deliveries did stop in May 2022 after Gasum refused to pay Gazprom in rubles, but LNG purchases from Russia were continued as Gasum was contractually bound to pay for the shipments. On the contrary, St1 did not need to take measures to alter its operations and decouple from Russia, as it was not utilizing Russian sources, but their responses were in turn built around managing volatility, customer needs, and taking advantage of the emerging fuel-substitution opportunities.

The analysis shows that decoupling and restructure of supply operations depended on the exposure type. Companies with flexible procurement positions were able to stop procurement from Russia rather quickly, but companies tied to long-term contracts or other constraints had more complex and slower paths to ending the dependency and relations with Russian parties.

Supplier diversification and substitution of energy sources
Supplier diversification was the most common response. Neste was able to replace Russian crude with alternative grades from other suppliers from the spot market, Gasum secured alternative natural gas through Balticconnector and increased LNG sourcing. Fortum signed a contract with Westinghouse to develop an alternative nuclear fuel for their Loviisa nuclear power plant and later reported that they were looking for even more (Western) alternatives in addition to Westinghouse, highlighting the interest in diversification of their supply base. Neova searched for alternatives for Russian fuel wood and was able to find alternatives from, for example, domestic suppliers.

Diversification, although operated at different speeds, in oil and fuel, alternative sourcing was implemented quickly. Nuclear fuel diversification requires multi-year licensing and regulatory processes, and in gas, diversification not only required new suppliers, but also depended on physical infrastructure, such as pipelines and establishing a whole new LNG terminal. In solid fuels with Neova, alternatives were found nearby, but at a higher price.

The second major response was substitution. Neste was able to replace Russian crude with other grades and had to replace natural gas used in their refinery operations with propane, resulting in delays in their refinery opera-

tions. Gasum increased its reliance on LNG and accelerated its strategic emphasis on biogas, St1 increased industrial gasoil supply to replace natural gas in industrial use, and Neova resumed formerly discontinued milled energy peat production to replace lost Russian energy imports.

From the substitutions, we can see that some of them also involved trade-offs, as some substitutions clearly supported decarbonisation efforts, such as Gasum's emphasis on biogas or Fortum's goals and strategy regarding clean energy. Others, on the other hand, had to increase reliance on fossil or carbon-intensive fuels, such as St1 increasing industrial gasoil sales, Neova re-utilizing peat, and Fortum commercializing a formerly retired coal-powered power plant.

Buffers, safety stock build-up and redundancy measures

A third response pattern found among the cases was the use of buffers and other redundancy measures. Neste deliberately increased inventories and stockpiled crude oil and renewable feedstocks to mitigate availability risk and price uncertainty. Neova also reported relying on stocks from previous years to fulfil both large customer needs and the National Emergency Supply Agency's security of supply needs. Fortum and its Meri-Pori coal plant also became a form of system-level and commercial redundancy, as when it was no longer selected for the peak-load reserve in June 2022, Fortum prepared it for commercial use and had it working by October 2022 to help in the energy crisis over the winter.

For Gasum, they grew the reliance on LNG right away when the pipeline deliveries became uncertain and secured an alternative pipeline supply through Baltic suppliers, but this does describe more a reactive restructuring of supply chains than prepared redundancy.

The cases show that resilience was built during the responses, which in some of the cases led to some degree of steering away from lean supply logic towards buffers and spare capacity to decrease volatility, which stemmed from the uncertainty in the energy market.

Risk-management and strategic adaptation

The cases show that the company's responses were not just limited to operational adjustments such as replacing Russian supply or adjusting logistics. In some cases, the disruption also triggered organizational measures and longer-term strategic reorientation. Of course, there is a limitation on proving the correlation between the strategic measures and the war when only considering publicly available material, but the measures in this chapter were either conducted in 2022 or 2023, or the measures were clearly outlined as

responses to the changed energy environment that the companies had to adapt to.

Gasum provided the clearest example of a formal organizational crisis risk management response. The company launched a formal internal crisis group at the start of the war to coordinate security-of-supply work, monitor the operating environment and sanctions, and maintain dialogue with authorities and stakeholders. The response shows that the war also required measures than just procurement-related actions. Gasum later put strategic emphasis on renewable biogas and also reported a long-term attempt to reduce dependence on imported natural gas and strengthen resilience. Their strategy included focusing on bringing 7 TWh of renewable biogas to the market annually by 2027.

For Neova, the response also demonstrated organisational restructuring. The company created Vapo Terra Oy, which was solely created to centralize Neova's energy peat sales and operations, including security of supply obligations. Additionally, another strategic response initially was that Nevoa reversed its former decision and re-continued its peat production and sales, which created the need to establish Vapo Terra Oy.

Fortum's post-disruption strategy, which was released in 2022, emphasized a stronger Nordic focus and going forward, targeting clean energy and decarbonisation projects, additionally, Fortum had to launch improvement programs. St1's response, on the other hand, was more market and commercially oriented. St1 adapted to the volatile market environment by developing new commercialisation opportunities regarding Gasoil and came up with ways to optimize their sourcing. Also, Neste's response appeared to be more operational in the case analysis, but its central role in renewable fuels connects the case to longer-term energy transition efforts.

The findings show that the war's effect not only required companies to react to the immediate disruption but also made them reassess their exposure to imports and dependence on suppliers, their focus on renewable fuels or vice versa, to re-utilize fossil fuels. The responses were, therefore, overall, both operational and organizational.

Contractual and regulatory constraints to responses

The last theme and findings were that the companies' abilities to respond quickly depended partly on contractual or regulatory constraints. Gasum's case is the clearest. Although Russian pipeline gas stopped in May 2022, they were contractually bound to continue LNG purchases from Russia, as they had a "take-or-pay" agreement, meaning that they had to pay, no matter if they took the provided LNG shipment or not. This contract stayed as legally

binding due to the fact that LNG from Russia was not sanctioned at the beginning of the war, but finally, in 2024, EU sanctions created a legal basis to end the contract.

Fortum also faced institutional and regulatory constraints. Firstly, its Russian assets were unlawfully seized by Russian authorities in 2023. In addition to this, its nuclear fuel substitution also required long certification and permitting processes, making supplier switching slower than regarding the usual commodities. In addition, Fortum is also bound to the contract with TVEL all the way until 2030.

Now, if taking a contrasting case, Neste was less structurally bound to Russia because it was purely a buyer of oil from Russia and did not own any Russian crude production assets, which is why they were able to quickly steer away from Russian-originated crude and feedstocks. The comparison shows that the speed of restructuring suppliers and supply chains was not only up to agility in the organisation or infrastructure, but also affected by contracts, assets, sanctions, and other regulatory processes.

5 Discussion

The discussion chapter discusses the findings of the thesis in light of the relevant literature. The first section discusses the disruptions in Finnish energy supply and effects on national energy security, reflecting on energy security literature. The second section in turn, discusses the phenomena and the disruption and its effects more in detail by reflecting on supply chain resilience and disruption management literature.

5.1 Disruptions in Finnish energy supply and lessons for national energy security

The first research question of the thesis asked *What were the effects of the Russia–Ukraine war on Finnish energy security and Finnish companies' energy supply chains?* The findings show that the war affected Finland primarily by exposing and materializing the risks created by import dependence on a geopolitically unstable supplier. The immediate effects of the war on energy security and energy supply chains were the loss/phase-out of Russian supply, increased energy prices and import costs, higher energy market volatility, and pressure on critical infrastructure. These effects created a constrained operating environment in which replacing Russian-origin energy flows, securing alternative import routes and sources, and adapting to a more volatile and costly energy-market environment became necessary. However, the disruption did not lead to a breakdown of the Finnish energy system or severe supply shortages, but it did reveal uneven vulnerability across energy sources. Globally traded fuels, such as crude oil, were more substitutable, while pipeline natural gas, nuclear fuel, and other infrastructure-bound energy flows created more complex disruption effects.

The 4A's introduced by the Asia Pacific Energy Research Centre (APERC) in 2007 are used to discuss the findings of the thesis. Even though literature often criticizes the 4A's and especially their original introduction due to its academic reflection (Cherp & Jewell, 2014), and other dimensions in addition to the 4A's have been proposed in current literature (Schmitz et al., 2025), the concept has still been widely used as a baseline for frameworks and a lens to consider energy security. As said, energy security is often conceptualized through the 4A's, which refer to *availability, accessibility, affordability*, and *acceptability*. Availability refers to physical resources and supply availability, accessibility to the aspects of acquiring resources, affordability to energy costs and prices, and acceptability to environmental and social considerations (Kruyt et al., 2009). In one of the most foundational studies, energy security is discussed as the low vulnerability of vital energy sys-

tems (Cherp & Jewell, 2014). The section below discusses the effects on Finnish energy security through the effects on the 4A's.

Availability

The most direct effect of the war was on the availability of energy. Availability was drastically affected when Russia cut off pipeline gas and electricity imports in 2022, while imports of coal and crude oil were phased out through EU sanctions, company-level sourcing decisions, and the overall market consensus, especially in Finland, which shifted toward detaching from Russian supply. At the company level, this appeared as a direct sourcing disruption for the companies using Russia as a supplier. When considering the system-level effect, the findings show that physical availability risk and effect varied between energy sources. For example, crude oil and coal are more easily substitutable, as they are available from global commodity markets and are usually not bound to specific infrastructure or other constraints, which meant their supply was not fully interrupted, although it was affected, since most of both commodities were previously mainly imported from Russia. Natural gas was, on the other hand, more vulnerable, as the sudden loss of supply removed a source of supply. The effect of Natural gas's disruption on Finnish energy security was not that severe, as gas has a much lesser role in the Finnish energy system than, for example, in most countries in Europe. Electricity imports from Russia were also cut off, but the system avoided shortages due to relatively low import levels of the total consumption. The missing volumes were also later replaced with nuclear fuel as Olkiluoto 3 started its operation, increasing the domestic capabilities of electricity production in Finland proportionally.

Accessibility

The war also affected accessibility, meaning Finland's and Finnish companies' ability to access energy, which in this case was affected by overall availability, but also by infrastructure, contracts, logistics, regulation, and technical arrangements. The distinction is important, as alternative energy sources may exist in the market, but do not automatically become accessible for a company or country during a disruption.

The effect on accessibility was especially visible regarding natural gas, which was not so easily replaceable when the supply was cut off, as the supply had been strongly connected to the Russian pipeline infrastructure, and the Finnish LNG capabilities were still limited. Also, nuclear fuel replaceability was constrained, as it includes regulatory approval and technical measures rather than just supplier switching. Nuclear fuel did not create an availability issue, and the Russian company TVEL continued its deliveries to Finland. Although nuclear fuel did not impose a shortage or a cut off, it did reveal an accessibil-

ity risk, as it was the only fuel that could have been used for a nuclear plant operated by Fortum.

Accessibility was also affected by sanctions and binding contracts with suppliers. For example, Russian coal and oil remained physically available in global terms for some time after the invasion, but sanctions, general pressure, and company-level decisions reduced the legal and commercial accessibility of the supply. Then, on the other hand, some companies were bound to their contracts, which bound them to keep buying from a Russian supplier, although it was not a desired scenario from the buyer's side.

If concluded together, the availability and accessibility findings help explain why the disruption affected energy sources differently. Crude oil and coal were easier to replace as they were more globally available and accessible through alternative suppliers. Natural gas and nuclear fuel were, on the other hand, more complex because access depended on infrastructure, technicalities and regulation, and contracts. This supports this thesis' conclusion based on the relevant literature that import dependence becomes mostly problematic when it is combined with risk factors, such as supplier concentration, geopolitical risk, and limited accessibility to alternatives.

Affordability

One of the most important findings is that affordability was affected more broadly than physical availability and accessibility. Finland managed to avoid serious supply shortages but was seriously affected by the price fluctuations caused by the disruption. The energy market was extraordinarily uncertain, and commodity prices reached historic highs and became highly volatile, while logistics costs rose alongside energy prices. From 2021 to 2022 alone, import prices of energy rose by 86 per cent in Finland. This supports the energy security literature on supply risk, which said that geopolitical instability can affect importing countries through price volatility and risk premia even when physical shortages do not materialize (Wang et al., 2024; Zhang et al., 2024). To conclude, energy security should not be reduced to only counting for supply continuity alone, but a system can remain physically supplied, but its energy security can still suffer from expensive, uncertain, and difficult energy market conditions.

Acceptability

The effects on the acceptability, which is in this case considered as the sustainability dimension of energy security is more complex. On the other hand, the reduced dependence on Russian fossil fuels aligned with the longer-term direction of the European energy transition, and the crisis eventually strengthened domestic electricity production, reliance on renewable fuels,

focus on alternatives such as biogas and nuclear power, and overall reduced dependence on fossil fuel imports. These support the EU's responses discussed in the literature, where clean energy was now framed as a security measure and policy tool rather than just climate policy (Kuzemko et al., 2022). On the other hand, the short-term responses included measures such as temporary reactivation of coal plants, increasing the role of domestic milled energy peat in the security of supply portfolio and reserves in Finland, and freezing or even lowering their biofuel blending obligations in 2022. These measures were less aligned with the decarbonisation goals set in Finland. This opposition describes well what was also recognized in the EU-level measures, that short-term energy security measures may support the availability and continuity, but hurt the wider sustainability goals (Celi et al., 2022; Kuzemko et al., 2022).

Lessons for Finnish energy security

A central lesson from the findings is that the structure of the dependence seems to matter more than the level of dependence alone. Finland did not become energy self-sufficient regarding the previously Russian-supplied volumes after the war, nor was this the goal in the responses. Instead, their import structure changed. Dependence on Russia was reduced and initially phased out, but the responses included various dimensions, such as reliance on diversified supply sources, improvement of infrastructure, Nordic and Baltic focus on sourcing, domestic energy production, and company-level sourcing adaptation. The findings support the literature on its arguments that energy security should not be thought of as eliminating imports but rather reducing vulnerability in the energy system.

The findings also confirmed that geopolitical risk mostly becomes problematic when it is combined with concentrated supply, infrastructure dependency, and limited substitutability in the supply chain. Before the invasion, Russian energy was attractive as it was geographically close, relatively affordable, and had become part of the existing supply structure. After the disruption, the same characteristics became vulnerabilities, reflecting directly on the concept and risks of asymmetric interdependence (Keohane & Nye, 2013) and the risks of asymmetric interdependence regarding energy supply recognized in previous studies (Smith Stegen, 2011; Vivoda, 2010).

The findings support the point that energy security should not be separated from company-level supply chain resilience. The findings show that companies were affected by energy security developments but also that they were active participants in maintaining the national supply continuity. This supports the idea that Finland's security of supply is built between the public sector, companies, infrastructure operators, and a functional energy market.

5.2 Implications for supply chain resilience in the energy sector

The thesis's second research question asked: *How have Finnish energy companies responded to heightened supply risk and market uncertainty?* The findings related to the second research question show that Finnish energy companies' responses combined reactive measures aimed at mitigating effects and maintaining supply and business continuity with building proactive resilience after the disruption, which was aimed at reducing future exposure and building overall resilience in their operations. The main responses included a phase-out of Russian supply and business relations where possible, diversifying and substituting suppliers, substituting fuels and feedstocks, increasing and/or utilizing inventories and reserve capacity, and adjusting their strategy to accommodate the changed environment.

The findings on company effects and the company responses on the disruptions are analyzed through supply chain resilience literature, namely the resilience phases and capabilities discussed by Ali et al. (2017). The supply chain resilience literature often divides resilience into pre-, during-, and after-disruption phases, and outlines the capabilities and elements relevant to these phases (Ali et al., 2017). The findings of the thesis are mostly related to the during- and after-disruption phases.

During-disruption responses

The during-disruption capabilities in supply chain resilience are often divided between the ability to adapt and the ability to respond (Ali et al., 2017). The ability to adapt refers to the capabilities needed to manage and adjust critical supply chain resources continually during disruptions to support business continuity. The ability to adapt, then further, is divided into the elements of flexibility and redundancy.

Flexibility includes the ability to adjust your crucial operations and supply chain to maintain and improve performance in your supply chain and overall continuity (Gligor et al., 2019). During the disruption caused by the war, flexibility was one of the most important capabilities to help mitigate the effects of the war. Flexibility was seen in all of the cases, as companies had to adjust sourcing, logistics, and customer solutions quickly. For example, Neste replaced Russian crude oil with alternatives quickly. Gasum shifted from Russian pipeline gas to Balticconnector and LNG. Neova replaced Russian fuel woods with other sources and domestic peat production. St1, on the other hand, adapted to the customer demand for replacement for industrial energy use. The findings also show that flexibility measures are not always just a managerial choice. In energy supply chains, flexibility is shaped by physical,

infrastructural, and technical characteristics of energy sources. For example, Crude oil supply was relatively more substitutable, as it is a globally traded commodity, available from multiple sources, although different crude qualities may create operational constraints in refinery operations. Pipeline gas and its supply chains were, in turn, less flexible, as supply depends on infrastructure and, in Gasum's case, on long-term contracts. Nuclear fuel supply was even more constrained because substitution required technical measures, licensing, and regulatory approval. Even though the findings show that flexibility depends on the company's capabilities and it also depends on infrastructure, regulations and physical attributes of the sources, but a conclusion that flexibility cannot be influenced or controlled by a company should not be made. Often, how flexible a company can be when facing a disruption depends on its pre-disruption capabilities and strategic choices made in preparation for different types of disruptions.

Redundancy among the cases was also identified in the analysis. Redundancy can be understood as an operational-level approach that refers to maintaining slack within the supply chain, such as additional capacity, inventory, or backup resources, so operations can continue for a longer period after a disruptive change begins, or in some cases, so the disruption's impact is avoided altogether (Azadegan et al., 2021; Hohenstein et al., 2015). The findings showed several forms of redundancy. For example, Neste deliberately reported on stocking up on inventories and created feedstock buffers to ensure continuity and to manage price uncertainty. Neova relied on its existing reserve stocks to support customer deliveries and security of supply obligations. Fortum reactivated a reserve coal plant for commercial use. Also the development of LNG infrastructure was a form of redundancy, which was conducted in collaboration between many operators in the energy sector. The cases showed that redundancy in the energy sector is more than just reserve inventories, as it also includes spare infrastructure and plant capabilities, increasing the utilization of domestic capabilities, and emergency supply arrangements. The findings challenge a purely lean- or efficiency-oriented supply chain logic, which was also noted in literature (Mishra et al., 2025). Before some recent global disruptions in supply chains, cost efficiency, lean inventories, and global value chains were the standard, but lately the literature argues that such structures create vulnerability to large-scale disruptions (Mishra et al., 2025; Zhao et al., 2023). The findings of the thesis support the argument made by recent studies. When disruptions materialized, resilience in the supply chains required buffers, alternative suppliers, and some spare capacity to ensure continuity. The implication is that the energy sector should accept some level of inefficiency and utilization of working capital in the form of redundancy and preparedness for crises.

Ability to respond refers to the concurrent capabilities that are essential to react to disruptive events affecting supply chains on time and efficiently to soften or lessen the impact of disruptions or change the effects to ensure minimal effects on operations to ensure continuity and overall a more desirable outcome (Ali et al., 2017). The ability to respond consists of two capabilities, which are agility and collaboration.

Agility refers to the ability to respond quickly in changing conditions, agile supply networks are capable of a more rapid response in disrupted conditions, and they can quickly adjust their supply chain tactics and operations (Gligor et al., 2019; Ivanov et al., 2014; Wieland & Wallenburg, 2012). Agility was seen in the company responses, but within sector-dependent limitations. The findings showed that the ability to respond cannot be evaluated solely by the speed of decision-making, but, as when considering the responses mentioned in the flexibility part of the discussion, agility should be evaluated by how quickly the surrounding infrastructure, regulation, contracts, and market conditions allowed the change to happen.

Literature emphasizes collaboration as a central element of resilience because firms rarely respond to large disruptions alone and do not operate in a vacuum. Collaboration refers to the ability to withstand and respond to disruptions together with partners through collaborative planning and information sharing (Christopher & Peck, 2004; Pettit et al., 2013). In the case of the Finnish energy sector, collaboration referred to collaboration with public authorities, infrastructure operators, customers, and other stakeholders. Collaboration with suppliers did not play a central role in the findings, but it could be a limitation resulting from the research method and gathered data. The findings show that resilience was often built through networks and not always solely by isolated company actions. Also, the findings showed that in the Finnish energy sector, in addition to collaboration being a supply chain capability, it is also part of national preparedness and security of supply. This point is particularly important when considering the energy sector, as often in supply chain resilience, collaboration refers to supplier relationships, customer relationships, and information sharing. In this study, on the other hand, collaboration included public-private coordination, regulatory measures, infrastructure access and development, and national energy security obligations and measures. This suggests that the interpretation of supply chain resilience in the energy sector should be understood as a wider concept than just a single-firm issue, rather a system-level capability. Companies can improve their own resilience, but their ability to respond is also dependent on infrastructure, security of supply obligations, and the functioning of the markets.

Post-disruption responses

Typically, disruptions cause damage that reduces supply chain performance, and supply chains may remain unstable even after the initial disruptive event has passed (Chowdhury & Quaddus, 2016). This leads us to the post-disruption phase. The stage is divided between two resilience capabilities: the ability to recover and the ability to learn. The ability to recover is divided into two elements, which are contingency planning and market position (Ali et al., 2017). The ability to learn is divided between post-disruption knowledge management and building social capital. As the insights into these elements inside the capabilities regarding post-disruption responses were limited in the analysis, the post-disruption responses section will not strictly follow the element-structure recognized in the literature, but it will still consider the recognized abilities to recover and to learn.

The ability to recover is essential in the aftermath of a disruption event to restore or return to normal operations, and the ability to learn refers to understanding what happened and the ability to improve future performance, based on the experience gained from the disruption period (Ali et al., 2017). The findings suggest that several companies did more than just restore pre-war operations. For example, Gasum increased its focus on renewable biogas, Fortum turned its focus to a stronger Nordic and clean-energy focus, Neova reconsidered a cancelled energy product, and St1 developed new customer models to accommodate the changed demand. Recovery did not, in this case, indicate a return to the pre-disruption state and supply structure, but it meant moving on to different directions, which in all cases included a restructuring away from Russian dependency. The above implication is an important contribution to the resilience discussion. The findings of the thesis suggest that in a geopolitical energy disruption, returning to the previous state may not be possible or desirable, as the pre-disruption state included vulnerability that allowed the disruption to materialize in the first place. Thus, recovery and learning in this case mean transformation rather than restoration. The Finnish energy sector and the whole system did not simply recover the Russian supply but transformed the whole supply structure and the functionality of the energy system to reduce dependency on geopolitically risky suppliers.

Concluding both during and post-disruption response sections, the findings align with Rahman et al. (2022) argument that there is no single resilience strategy that can mitigate widespread shocks. This was also seen in the analysis that company responses were not uniform, as companies start from different premises, and that resilience to this scale of disruptions requires a wide body of resilience capabilities and cannot be simplified to a single resilience strategy.

Pre-disruption capabilities

The limited visibility on pre-disruption resilience is acknowledged below. The findings provided less direct evidence regarding pre-disruption capabilities than during and post-disruption capabilities and responses. This does not mean that companies lacked pre-disruption capabilities but rather reflects the unexpected nature of the disruption and the data used in the analysis. Things such as internal risk monitoring or scenario planning, and earlier contingency planning, are not visible in publicly available data, the analysis was able to assess visible responses more reliably than internal preparedness before the war.

Nonetheless, some pre-disruption capabilities could be indirectly identified. Companies that had planned their operations to include more flexible sourcing options, strong market positions, safety stocks, and other forms of redundancy and less infrastructure-bound supply chains were better positioned to respond to the disruption. Pre-disruption resilience was built into supply-chain design, infrastructure, and market position, and at the system-level, into the energy-mix and security-of-supply capabilities.

Lessons for supply-chain resilience

The findings also support broader implications for understanding supply chain resilience in the energy sector. The Russia-Ukraine war began as a geopolitical disruption outside Finnish company boundaries, but its effects propagated through several parts of the energy system. This reflects the ripple effect discussed in the literature, where a disturbance in a part of the supply network spreads downstream and affects operational and strategic performance (Ivanov et al., 2018). The findings indicate that in this case, the disruption was not limited to loss of supply but also affected, for example, energy prices, sourcing and logistics costs, customer demand, infrastructure, and others. The energy sector and its supply chains differ from many other sectors' supply chains because resilience is also highly constrained by physical or regulatory structures. In more regular supply chains, companies could mostly mitigate the effects of a disruption by supplier switching or rerouting logistics. In energy supply chains, the options are more limited, as many energy sources are constrained by infrastructure, technicals, or regulations, advocating for more complex disruptions and fewer possibilities for companies to influence how much they are affected by the ripple effect.

The findings also showed that resilience involved trade-offs, just as it did in the EU-level measures, where diversification and alternative fuel policies were described as trade-offs, as they helped manage short-term supply security but could complicate longer-term decarbonization (Celi et al., 2022; Kuzemko et al., 2022; Vezzoni, 2023). The cases showed that measures to improve resilience were often costly or ran counter to other objectives of the firms, such as long-term decarbonisation efforts. Supplier diversification and

substitution eliminated dependence on Russian suppliers but increased sourcing and logistics costs. Inventories and reserve capacity secure continuity but require working capital and reduce efficiency. LNG infrastructure improved access to alternative gas supplies but created tensions around long-term decarbonisation efforts and the REPowerEU plans. Also, domestic re-continuing energy peat production and reactivating coal plants created additional power supply and strengthened security of supply objectives but also conflicted with environmental acceptability and decarbonisation efforts.

Overall, the main implication and lesson from the findings is that energy-sector supply chain resilience cannot and should not be understood and studied only inside the boundaries of single companies. The Russia-Ukraine war showed that companies need flexible and adaptive supply chains, but their ability to respond also depends on the energy system they operate in. Resilience in this sector, therefore, should be understood as a system-level capability that is affected by the efforts of companies, infrastructure, the energy market, regulation, and national security of supply.

6 Conclusions

This chapter firstly presents the summary and key findings of the thesis, including concise answers to the posed research questions. Secondly, the policy and managerial implications are presented, which will represent the practical implications that can be drawn from the thesis. Lastly, the limitations and suggestions of the thesis are presented.

6.1 Summary of findings

This thesis looked at the effects of the Russia–Ukraine war and its effects on Finnish energy security and selected Finnish energy companies' supply chains. The purpose of the study was to understand both the system-level effects on Finland's energy supply and the company-level impacts and responses. The study was guided by two research questions: *"What were the effects of the Russia–Ukraine war on Finnish energy security and Finnish companies' energy supply chains?"* and *"How have Finnish energy companies responded to heightened supply risk and market uncertainty?"*

The system-level analysis shows that the Russia-Ukraine war affected Finnish energy security primarily by exposing the risks connected to import dependence and concentrated Russian-origin energy supply. Before the war, Russian energy had a structurally important role in Finland's energy system, especially regarding fossil fuels. In 2021, Russia was the top supplier of energy for Finland, accounting for a majority share in oil, coal, natural gas, and imports of electricity. The findings show that Finland's energy system was not equally vulnerable across all sources of energy. Pipeline gas and electricity imports from Russia were cut off in the second quarter of 2022, Russian coal and crude oil were phased out through EU sanctions and companies' own decisions (i.e., market adaptation). However, despite the large-scale disappearance of the former supply, the effects did not result in a complete breakdown of the Finnish energy system, but were managed through substitution, alternative import routes, and improving infrastructure and domestic capabilities.

The system-level analysis also shows a significant change in Finland's energy structure during the studied time period. Fossil fuel consumption declined from 2021 to 2024, net electricity imports decreased, and the share of nuclear energy increased significantly, partly due to the commissioning of Olkiluoto 3, which is not classified as a response to the war, but still changed the system-level energy security during this period. Finland's general energy import dependency actually initially increased in 2022, showing that imports remained necessary during the acute disruption and energy crisis phase, but

then declined substantially in 2023, before rising again in 2024, indicating that the response on a system-level was a restructuring of the import structure. The findings show that the war also resulted in increased procurement complexity, majorly increased import costs (86% increase in import values in 2022), increased reliance on and the need to restructure infrastructure, and the need to take measures to improve the security of supply in Finland. Concluding the system-level analysis, the main findings suggest that Finland's energy security improved by terminating the reliance and dependence on Russia, and the improvement was achieved through market adaptation, infrastructure measures, domestic production, and the continued reliance on selected imported energy sources.

The findings related to the supply chain impacts on Finnish energy companies show that the severity of impacts was dependent especially on three conditions. First, the degree of Russian supply dependence was a big influencing factor. Secondly, the substitutability of the energy source or input in a company's operations also majorly affected the severity, and lastly, the degree of infrastructure or contract dependence of the company's operations. Across all cases, the Russia-Ukraine war's effects materialized as a systemic supply shock that affected Finnish energy companies through different mechanisms. The most severe, direct impacts occurred in companies that had high exposure to Russian supply, binding contracts, infrastructure that was somehow bound to Russia, or Russian assets. However, all companies were affected by price volatility and market uncertainty, even if they were not directly dependent on Russian supply.

Regarding company responses and reactions, the findings showed that responses also differed, but several recurring themes were identified. Companies responded by exiting Russian supply and business relations when possible, diversifying suppliers, substituting fuels and feedstocks, increasing inventories and reserve capacities, and others. The responses showed a combination of reactive responses, which were aimed to mitigate effects and maintain supply and business continuity, and building proactive resilience measures, which were aimed to reduce future exposure and overall build resilience to their operations.

The findings also clarified that company-level supply chain effects, resilience, and national energy security were closely connected. Gasum, Fortum, St1, and Neova all took actions that directly supported Finnish security of supply, which supports the broader consensus that in Finland's energy sector, security of supply is not only maintained by the state but through interaction between companies, markets, infrastructure operators, and authorities.

Concluding the company-level findings, they showed that the effects of the war varied depending on firms' exposure to Russian supply and other business relations. The most severe impacts occurred when companies were directly dependent on Russian-origin energy flows or when their supply chains were tied to infrastructure, long-term contracts, or assets connected to Russia. In contrast, companies with more flexible sourcing options or less direct Russian exposure were affected indirectly through price volatility, cost increases, and general market uncertainty. Although the responses also differed between companies, several common patterns were identified. Companies responded by reducing or ending Russian sourcing and business relations where possible, diversifying suppliers, substituting fuels and feedstocks, increasing inventories or reserve capacity, and reorganizing supply chains. Overall, the findings show that Finnish energy companies combined immediate reactive measures with longer-term resilience-building actions. The thesis concludes that Finnish energy security and company-level supply chain resilience were closely connected, as companies played an important role in maintaining energy supply continuity during the disruption.

6.2 Policy and managerial implications

The findings have implications and lessons for both policymaking and a managerial context. From a policy perspective, the study showed that energy security and import dependency should be considered from a wide perspective, such as supplier (country) concentration, infrastructure dependency, and the substitutability of different energy sources. The study especially highlighted the importance of maintaining a flexible and diversified energy infrastructure. The study showed that alternative supplies are only useful if they can be accessed and the switching of energy supply is not constrained. Policymakers should continue to strengthen the public-private partnership, as demonstrated in the findings, Finnish security of supply depends on the actions of companies and infrastructure operators along with the country-level energy policy.

From a managerial perspective, the findings suggested that energy companies should continue to consider geopolitical risk as a central supply chain risk. Companies should not only assess direct supplier dependence but also should focus on their exposure through different mechanisms, such as contracts, market volatility, and regulatory conditions. The cases showed that resilience requires a whole portfolio of capabilities, and there is no one-size-fits-all resilience strategy for these types of disruptions. The findings also suggest that supply chain resilience should be treated as a strategic issue instead of an operational one, meaning that supply chain resilience should be integrated into long-term sourcing strategies, investment planning, and risk management, as the level of disruption was largely dependent on how vul-

nerable companies' supply chains were to disruptions and Russian dependency.

6.3 Limitations and suggestions for future research

The study and its research methods had limitations that should be addressed. Firstly, the study is based solely on secondary publicly available data. The analysis used company reports, financial statements, sustainability reports, other company publications, along with statistical sources, reports, and government publications. Additionally, reputable news or market sources were used for triangulation. While this material provided a broad view of the disruption and company responses, it did not provide access to internal insights, sourcing decision-making, risk assessments, or overall management reasoning of decisions. Additionally, company-produced material may contain reporting bias. Annual reports and sustainability reports are written for external stakeholders and may emphasize certain actions while leaving some less visible. This limitation was attempted to be reduced by triangulating company material with institutional sources, market publications, and news sources, but the interpretation remains limited by the availability and quality of public documentation.

Secondly, the study focused on selected Finnish energy companies and does not cover the entire Finnish energy sector. The selected companies were chosen because they are significant to Finnish energy security and provide sufficient public material, but smaller energy companies, industrial energy users, and upstream suppliers may have experienced different impacts and responses.

Thirdly, the study is geographically and temporally limited. Finland is a relevant case because of its proximity to Russia and earlier dependence on Russian energy, but the findings may not be directly generalizable to countries with different energy systems, infrastructure, or security-of-supply models. The study also focuses mainly on 2021–2024, meaning that longer-term effects of the war and later strategic changes may not yet be fully visible.

Future research could build on this thesis by using interviews with company representatives, policymakers, or security-of-supply experts. This would provide deeper insight into internal decision-making, preparedness, and trade-offs behind company responses. Comparative studies between Finland and other Nordic, Baltic, or EU countries with either similar or alternatively completely different previous dependency on Russia and energy structure could also help identify how different energy systems responded to the same geopolitical disruption. Finally, future research could examine the long-term effects of the war on Finnish energy supply chains, especially whether the re-

sponses observed during 2022–2024 lead to lasting resilience or create new dependencies.

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Appendix A.

Table 6 Materials used in Chapter 4.1 and 4.2

Name of material	Reported by	Type of material
Neste Annual Report 2022	Neste	Company report
Neste 2023 annual report	Neste	Company report
Neste Financials 2023	Neste	Company report
Neste Annual report 2024	Neste	Company report
Neste Financial Statement Release 2022	Neste	Company report
Neste Interim Report Q3 2022	Neste	Company report
Neste Interim Report Q1 2022	Neste	Company report
Neste Half Year Financial Report Q2 2022	Neste	Company report
Neste Financial Statements Release 2023	Neste	Company report
Neste Interim Report Q3 2023	Neste	Company report
Neste Half-Year Report January-June 2023	Neste	Company report
Neste Interim Report Q1 2023	Neste	Company report
Neste Financial Statements Release 2024	Neste	Company report
Neste Interim Report Q3 2024	Neste	Company report
Neste Half-Year Report January-June 2024	Neste	Company report
Neste Interim Report Q1 2024	Neste	Company report
Neste Sustainability Report 2023	Neste	Company report
Neste Sustainability Report 2022	Neste	Company report
Neste's response to the war in Ukraine	Neste	Company publication
Fortum sustainability report 2022	Fortum	Company report
Fortum financials 2022	Fortum	Company report
Fortum CEO business review 2022	Fortum	Company report
Fortum financial statements 2022	Fortum	Company report
Fortum January-September 2022 interim report	Fortum	Company report
Fortum has signed a bridge financing arrangement with the Finnish state to cover collateral needs in the Nordic power commodity market	Fortum	Company publication
Fortum to fully divest Uniper to the German State	Fortum	Company publication
Fortum half-year financial report 2022	Fortum	Company report
Fortum January-March 2022 interim report	Fortum	Company report

Fortum financial statements bulletin 2024	Fortum	Company report
Fortum CEO business review 2024	Fortum	Company report
Fortum financials 2024	Fortum	Company report
Fortum financials 2023	Fortum	Company report
Fortum CEO business review 2023	Fortum	Company report
Fortum sustainability report 2023	Fortum	Company report
First batch of Westinghouse fuel loaded at Fortum's Loviisa nuclear power plant	Fortum	Company publication
Gasum Group financial result Q1 2022	Gasum	Company report
Gasum Group financial result H1 2022	Gasum	Company report
Gasum Group financial result Q3 2022	Gasum	Company report
Gasum Group financial result Q4 2022	Gasum	Company report
Gasum sustainability report 2022	Gasum	Company report
Gasum Financial Report 2022	Gasum	Company report
Gasum Annual Review 2023	Gasum	Company report
Gasum sustainability report 2023	Gasum	Company report
Gasum Group financial result Q1 2023	Gasum	Company report
Gasum Group 2023 H1	Gasum	Company report
Gasum Group 2023 Q3	Gasum	Company report
Gasum interim review Q4 2023	Gasum	Company report
Gasum Group Annual Review 2024	Gasum	Company report
Gasum sustainability 2024	Gasum	Company report
Game Changer 2022 ST1 Nordic Oy Integrated Report	St1	Company report
Game Changer 2023 ST1 Nordic Oy Integrated Report	St1	Company report
Game Changer 2024 ST1 Nordic Oy Integrated Report	St1	Company report
Neovan vuosiraportti 2024	Neova	Company report
Neova integrated annual review and sustainability report 2023	Neova	Company report
Neova integrated annual review and sustainability report 2022	Neova	Company report
Neova osavuosikatsaus t2 2022	Neova	Company report
Neova interim report t1 2022	Neova	Company report
Neova integrated annual review and sustainability report 2024	Neova	Company report
Finland 2023 Energy Policy Review (IEA)	IEA	Industry/Third-party report
TEM 2024 energy and climate document	TEM	Industry/Third-party report
Hvk vuosikatsaus 2022	National Emergency Supply Agency (NESA)	Industry/Third-party report
Energy supply and consumption Review 2021 (Finland)	Official Statistics of Finland	Statistical online publication

Energy supply and consumption Review 2022 (Finland)	Official Statistics of Finland	Statistical online publication
Energy supply and consumption Review 2023 (Finland)	Official Statistics of Finland	Statistical online publication
Energy supply and consumption Review 2024 (Finland)	Official Statistics of Finland	Statistical online publication
Energy Import Dependency	Eurostat	Statistical online database
Venäläinen energia korvattavissa	Finnish energy	Industry/Third-party publication
Electricity trading with Russia will suspend – no threat to the sufficiency of electricity in Finland	Fingrid	Company publication
Neste still has contracts for Russian oil lasting until year-end - executive	Reuters	News source
Finland's Fortum uses US nuclear fuel to cut Russia dependence	Reuters	News source
Finland's Gasum to end Russian LNG imports in line with EU sanctions	Reuters	News source
Russia cuts off Finland's electricity exports ahead of NATO announcement	Brussels Times	News source
State signs bridge financing agreement with Fortum to cover collateral needs in electricity derivatives market	Ministry of Economic Affairs and Employment	Governmental publication
Fortum granted licence to operate Loviisa power plant units until end of 2050	Ministry of Economic Affairs and Employment	Governmental publication
Wood imports and the exports value of forest industry decreased in 2022	Luke	Industry/Third-party publication
The collapse of trade with Russia has had a limited effect on Finnish manufacturing	Bank of Finland	Industry/Third-party publication
Investments and the Western market replaced Russian energy - prices reflect the new reality	Bank of Finland	Industry/Third-party publication
Implementation of Inkoo LNG terminal	Gasgrid	Company publication

Appendix B

The author has utilized generative artificial intelligence (AI) tools in the preparation of this thesis in accordance with Aalto University guidelines regarding the responsible use of artificial intelligence in academic research.

These tools were employed during the writing process for assistance in drafting, editing, or increasing the clarity and coherence of the text. In addition, the tools were used in identifying initial relevant literature and key concepts for the thesis, along with assisting in conducting the analysis section. The author has reviewed and/or reworked all the used content and made all decisions about final wording, which literature to utilize, how to conduct the analysis, and eventually how to interpret the results.

The author takes full responsibility for this thesis.