LAPPEENRANTA-LAHTI UNIVERSITY OF TECHNOLOGY
School of Energy Systems
Degree Programme in Energy Technology
Master’s Thesis

Pinja Salhoja

GAS TRADE DEVELOPMENT OF AN ENERGY COMPANY ON THE FINNISH OPEN GAS MARKET

Examiners:	Professor, D.Sc. (Tech.) Esa Vakkilainen Docent, D.Sc. (Tech.) Juha Kaikko
Supervisors:	Professor, D.Sc. (Tech.) Esa Vakkilainen M.Sc. (Tech.) Marko Ketola, Tampereen Sähkölaitos Oy

ABSTRACT

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98 pages, 5 tables, 30 figures, 1 equation and 1 annex.
Keywords: natural gas, gas market, biogas, hydrogen, energy production, gas trade

When the Finnish gas market was liberalized in 2020, companies needed to alter their gas procurement and investment strategies to meet the characteristics of an open market. Now that the basic knowledge of the markets has been gained, reassessments can be made in gas consuming and trading companies. The focus in this thesis is on the local energy provider, Tampereen Sähkölaitos, who consumes, retails and distributes gas. This thesis answers to the questions: how to develop the gas business in Tampereen Sähkölaitos with reasonable inputs, and what is the possible future role of gas in the renewable energy system.

There are multiple ways of tackling the optimization problem that is the gas market operations in Tampereen Sähkölaitos. One could focus on the wholesale market operations, as it is the one with the highest volumes, or expand the revenue and improve the retail sales to gain profit. Multiple research methods were used, such as scenario development and market analysis and this resulted into three possible strategies for Tampereen Sähkölaitos to implement: low, mediocre and high investment strategies. The most rational was found to be the mediocre investment strategy. Due to the need for controllable energy production as the renewable electricity methods increase, it is seen to be profitable to maintain the gas business in the upcoming years with possible utilization of sustainable gases. The low investment strategy could prove to limit certain future roles from Tampereen Sähkölaitos for low profits, and the high investment strategy could prove to be too extensive and thus too costly for the near future. The gas markets are highly affected by policy changes and technology improvements, like any other operation in the energy sector. Gas sector is bound to face changes in the upcoming years as high goals are set for the sustainable energy system of the future in Finland as well as in the European Union.

TIIVISTELMÄ

Lappeenrannan-Lahden teknillinen yliopisto
School of Energy Systems
Energiatekniikan koulutusohjelma

Pinja Salhoja
Energiayhtiön kaasuliiketoiminnan kehittäminen Suomen avoimilla kaasumarkkinoilla
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Suomen kaasumarkkinat avautuivat kilpailulle vuonna 2020, minkä takia kaasualan yritysten täytyi muokata kaasunhankinta- ja investointistrategioitaan. Nyt kun markkinat ovat olleet avoinna vuoden, voi kerätyn datan perusteella analysoida kaasuliiketoimintaa. Tässä työssä keskitytään paikalliseen energiantuottajaan, Tampereen Sähkölaitokseen, joka toimii kaasun kuluttajana, myyjänä sekä jakelijana. Työssä etsitään vastauksia kysymyksiin: kuinka kehittää Tampereen Sähkölaitoksen kaasuliiketoimintaa kohtuullisella panostuksella, ja mikä on kaasun rooli tulevaisuuden energiajärjestelmässä.

Mahdollisia tapoja Tampereen Sähkölaitoksen kaasuliiketoiminnan kehittämiseksi on useita. Toisaalta painoarvon voi antaa tukkumarkkinatoiminnoille, sillä tukkumarkkinat pitävät sisällään suurimmat volyymit, tai alkaa kehittämään vähittäiskauppaa liikevaihdon kasvattamiseksi. Työn tutkimusmenetelmänä käytettiin muun muassa skenaariokehitystä ja markkina-analyysiä, joiden tuloksena saatiin kolme mahdollista strategiaa Tampereen Sähkölaitoksen kaasuliiketoiminnalle: matalan panostuksen, keskipanostuksen ja korkean panostuksen strategiat. Strategioista järkevimpänä pidetään keskipanostuksen strategiaa. Tulevaisuuden tarpeet säädettävälle energian tuotannolle uusiutuvan energian kasvaessa mahdollistavat kaasuliiketoiminnan säilyvyyden seuraaville vuosille, jota keskipanostuksen strategia hyödyntäisi ottamalla myös kestävät kaasut huomioon. Matalan panostuksen strategia voi rajata Tampereen Sähkölaitoksen tulevaisuuden mahdollisuuksia vähäisillä tuotoilla, ja korkean panostuksen strategia voi osoittautua liian laajamittaiseksi ja täten liian kalliiksi lähitulevaisuudessa. Kaasumarkkinat ovat kytköksissä vahvasti poliittisiin muutoksiin sekä teknologian kehitykseen, ja lähitulevaisuudessa onkin varmasti nähtävissä muutoksia kaasusektorissa johtuen uusien valtakunnallisten tavoitteiden asettamisesta.

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Tampere 28th January 2021
Pinja Salhoja

CONTENTS

LIST OF ABBREVIATIONS

BGSI	Baltic Gas Spot Index
CCS	Carbon Capture and Storage
CEGH	Central European Gas Hub
CHP	Combined Heat and Power
COP-21	Conference of the Parties (twenty-first session)
DSO	Distribution System Operator
ETCR	Energy, Transport and Communications Regulation
ETS	Emission Trading System
EU	European Union
GDP	Gross Domestic Product
GHG	Green House Gas
GIPL	Gas Interconnection Poland-Lithuania
GPL	Gaspool
HHV	Higher Heating Value
LNG	Liquified Natural Gas
NBP	Britain’s National Balancing Point
OTC	Over the Counter
PtX	Power-to-X
RED	Renewable Energy Directive
SNG	Synthetic Natural Gas
TKS	Tampereen Sähkölaitos
TSO	Transmission System Operator
TTF	Dutch Title Transfer Facility
VTP	Virtual Trading Point

SUBSCRIPTS

th	Thermal

1 INTRODUCTION

Over the last decade, the European Union (EU) has been increasingly setting more and more ambitious goals towards carbon neutral society. In 2002, EU Members States ratified the Kyoto Protocol and committed to reduce collective greenhouse gas (GHG) emissions from the 1990 levels by 8 % in the 2008-2012 period. Following the political momentum emerged from the Kyoto Protocol, the European Commission stated three pillars for common and coherent European energy policy: Sustainable, Competitive and Secure Energy. These pillars have remained as the key elements for today's energy policies. (Hafner & Tagliapietra, 2017)

After tough negotiations between the Member States in 2008, the European Parliament adopted an endorsed package by the European Council that would drive the EU yet another significant step towards decarbonization. In addition to the triple paradigm, sustainability-competitiveness-security, Energy and Climate Package was adopted to characterize the European energy policy. The Energy and Climate Package is known for the 20-20-20 targets. These targets represent EU's commitment to cut GHG emissions, increase renewable energies and efficiencies by 2020. Compared to the levels in 1990, the targets are 20 % reduction of GHG emissions, decrease of final energy demand by 20 % and obtaining 20 % level of renewable energy of total energy consumption. (Hafner & Tagliapietra, 2017)

After these 20-20-20-targets were approved, the EU started to create a roadmap for 2050 and a framework for 2030 that would increase the demands and continue to move towards 100 % renewable energy consumption. By 2050, the targets were set as high as 80 % in GHG emissions reduction from the 1990 level (European Union, 2012). These documents reiterated the concept that the decarbonization of the energy system is possible and started the shift in the energy politics. Problematic with these new 2030 and 2050 targets compared to the 2020 framework is that these have not yet been transformed into national targets via legislation. Officially this is due to the flexibility of the Member States to meet the targets in a cost-effective way utilizing the specific energy mixes and circumstances of each Member State, although the publication by Hafner and Tagliapietra (2017) state that this might be due to the lack of a common vision among the Member States on the future trajectory of the decarbonization path. (Hafner & Tagliapietra, 2017) The legislation might be facing upcoming changes as in 2020, the European Green Deal program suggested turning these targets into binding goals and by the June of 2021, the Commission will review and propose to revise all the relevant climate-related policy instruments in accordance with the European Green Deal's suggestions (European Council, 2020).

The increasing demands and targets for a carbon neutral energy system has created a rush to move from coal power to less-emitting options. Also, the current attitudes towards nuclear power create a need for other options for base load power, and seasonal renewable energy production create the need for regulating power options. Even with the high targets for the energy system, the focus has been on removing coal out of the energy mix rather than cutting all fossil fuels and this has helped natural gas remain its status. Even the German Energiewende, the transition process of Germany's energy system to renewables, does not intend to abolish natural gas usages by 2050. In fact, in the recent years natural gas use has been increasing in Germany as the phaseout of nuclear and coal power has begun (Appunn et al. 2020). Another example is Belgium, where natural gas is considered a transitional fuel and a key element when trying to reduce nuclear energy by 2030 and thus the use has been increasing lately (European Commission, 2018a).

In the current European market, natural gas is considered relatively expensive, CO_2 polluting, less secure than some alternative fuels and working in mono- or oligopolistic market structures. It is network based and available from remote sources outside the European Union. Upsides of gas fired power stations are lower investment costs, quick built, 40 % less CO_2 emissions than coal and relatively flexible use. Energy production is moving towards renewable and thus seasonably resourced production, yet the consumption is not changing to fit the complex supply and therefore the need for more flexible production is needed. Even considering the technical advantages, for gas to maintain its competitiveness, the market needs more integration, liquidity and storage capacity. Looking further into the future, moving to a carbon neutral society is a risk to the gas investments. Without carbon capture, gas may be limited to only a backup and a balancing capacity. (European Union, 2012)

European gas markets are affected by the rapidly changing political, commercial, and geopolitical evolutions since it is the second largest imported fuel after crude oil. (Eurostat, 2020). In the Eurostat's energy statistics overview published in July of 2020, is stated that natural gas covers 9,3 % of primary energy production in the EU (Eurostat, 2020). Natural gas is used in many Member States as a transitional fuel due to the existing infrastructure and possibility to replace it with biogas in the future, but the magnitude and pace varies. The transition to 100 % renewable energy system creates economic and political difficulties. Member States wish to stay competitive and thus the energy prices should remain at adequate levels. The role of natural gas in the future in the EU's energy system remains undefined as the situation regarding the decarbonization path in each Member State remains uncertain.

Although European countries are interconnected and mainly share the same currency, their wholesale gas markets are still highly heterogeneous. Natural gas can be made more competitive and secure by adapting a mature liberal market that would allow healthy competition over the prices and products. The harmonization and liberalization of the EU's inner energy market is high on the regulator's agenda, given the strategic importance of natural gas. There are short-term and long-term strategies to address the difficulties for gas supply. Looking at the situation in a short time span, measures to be taken are improving the emergency mechanisms and coordination between member states in case of a disruption of supplies. Long-term measures are strengthening the internal market and regulatory framework. This would mean upgrading and expanding the gas storage, regasification and transportation infrastructure. The limitations for unified gas markets are seen especially in Eastern Europe due to historical reasons behind the existing infrastructure and market structures. (Baltensperger et al. 2017.) The physical limitations for connected European markets were decreased in Finland, as a new pipeline through The Gulf of Finland was built and the Finnish market was liberalized in the beginning of 2020. (Gasgrid Finland)

As the Finnish gas market has recently gone through a significant transformation, energy companies must rethink and evaluate their strategies concerning their gas use and possible supply. New targets are being set for emission reduction as well as renewable energy production for 2030 to 2050 in the EU, and to meet these ambitious targets, innovations like biogas, hydrogen-fuels and Power-to-X technologies are being tamed. Residential as well as industrial gas use is decreasing, operative expenses are raised and new investments should be made to renewable gas solutions and at the same time, companies' revenues should be increasing. There is pressure coming from European and governmental perspective as well as from the end users to make the energy supply at the same time more secure, less polluting, sustainable, affordable, competitive, stable, innovative and locally produced. Finding a right balance between these qualities is a complex task to tackle.

1.1 Objectives

This thesis is written from Tampereen Sähkölaitos's perspective. Tampereen Sähkölaitos is a local energy producer with electricity and district heating being produced from natural gas amongst other fuels, like biomass and municipal waste. The company also distributes and retails gas. As the Finnish gas market was liberalized in 2020, now with some data being collected about the operations, market analysis can be made and optimal market participant roles can be estimated. Gas trade is not the company's most crucial business unit, but it possesses potential contained mainly in the distribution network. Gas is used in the area as a balancing heat source as well as viable securing fuel option, which is why its future trajectory is important. For Tampereen Sähkölaitos to be competitive in the renewable energy system of the future, sustainable gas innovations should be looked at and their potential evaluated. This thesis focuses on the gas market overview and an evaluation on the most optimal and potential gas trade. The gas system is in a turning point and energy companies need to be prepared to react to changing legislations, technologies and attitudes.

This thesis aims to answer the question: How the gas business in Tampereen Sähkölaitos should be developed to gain more profit with reasonable inputs utilizing the recently liberalized gas market and considering the evolving energy system. The paper also gives comprehensive outlook on the future role of gas, which can be utilized in a further development of the gas business unit. The research method in this paper has been a literature overview, market analysis, scenario forecasting as well as comparative analysis on different business strategies.

1.2 Scheme

The theoretical framework for this thesis is conducted in chapters two to four. After this introduction, the second chapter looks at the current gas markets in Finland as well as explains the market roles. Third chapter focuses on the natural gas price formation and different pricing methods. In the third chapter, there is also an evaluation of the risks relating to gas pricing at the retail and the wholesale markets. Then the focus is turned to a long-distance future as new gas technologies and political changes are evaluated. In the fourth chapter, four different future scenarios for gas are looked at and from this evaluation, a possible timeline is formed for the gas market changes.

Fifth chapter lays the ground to the gas trade development as the consumption and sales in Tampereen Sähkölaitos are looked at in more detail. In the fifth chapter, there is also the current gas business units' operations explained to identify the current facilities for business development. Sixth chapter gives three different investment strategies for the gas trade and answers to the question, how to develop the gas business unit.

2 GAS MARKETS IN FINLAND

In Finland, natural gas can be used in many purposes; industry, transportation and energy production, like supplying heat or electricity for peak demands. Industrial gas is used mainly in chemical and forest industry. Another significant use is combined heat and power (CHP) production and district heating. Gas use has been the highest in the early 2000's, when energy use was higher than industrial use. Since 2010 all gas use has been decreasing in Finland, energy use most rapidly. (Kaasuyhdistys) Existing network and infrastructure can be used for biogas, liquefied natural gas (LNG) or bio-based synthetic natural gas (bio-SNG) and this favors the use of natural gas currently. Figure 1 shows the gas use in 2019.

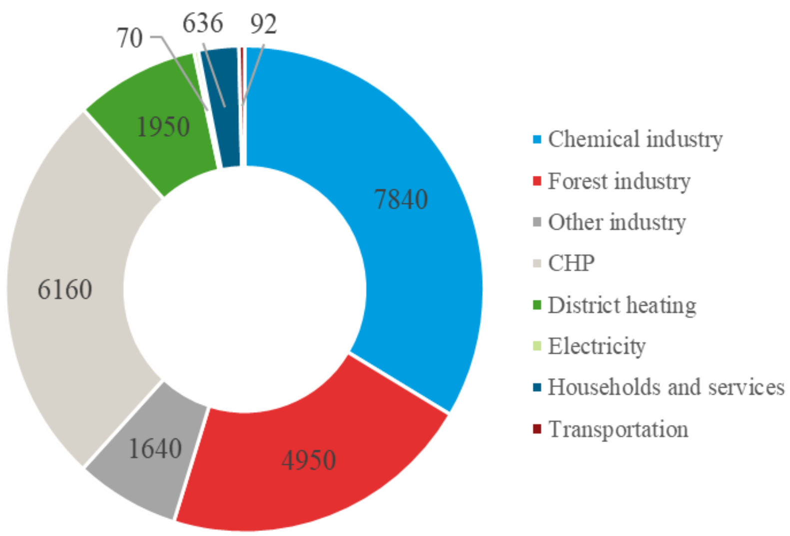

Figure 1. Gas use in Finland in 2019 in GWh (Kaasuyhdistys).

In the beginning of 2020, the Finnish energy markets started a new chapter, when the natural gas import and wholesale markets opened for competition. This meant that the monopoly of Finnish government owned gas company, Gasum Oy, was disabled. Due to the market change, Finnish industry and energy producers can now buy their natural gas from the company of their choice. One of the main objectives of the market change was that natural gas would improve its competitiveness in the energy sector. By opening the market, gas companies must compete not only with the prices but also with the flexibility of the contracts.

The aim of the open markets was to attract more market participants and thus one party would not have significant effect on the gas prices. The more there are buyers and sellers on the market the more liquid and efficient the market will be. It can also be possible that this market integration would enhance the status of biogas and some environmental benefits from the integration would be achieved. Possible negative effects of the integration come from the risks of opening a new market and making investments into the infrastructure. Open and competitive markets are seen as a trend to pursue. But if there are not enough market participants, the cost of the investments will be seen as an increased gas price for the end consumers. So far, the beginning of the year does not indicate this as seen in the low gas prices. (Gasgrid Finland)

In closed gas markets, the gas price was based on the six months average of the oil and coal prices. In an open market, the fluctuation of the price is more visible and seasonable variables contribute to the prices more effectively as the pricing is made using the monthly indexes of different gas hubs. Even if the open markets lower the average price of gas, economical hedging strategies are needed. (Vainio, 2015) When the markets opened, companies needed to alter their gas procurement and strategies to meet the characteristics of an open market. Now that the basic knowledge of the markets has been gained as it has been open from the beginning of 2020, reassessments are being made in gas consuming and trading companies.

2.1 Gas network and its security

The open markets would not have happened if the import of natural gas to Finland would not be diversified. Previously, all the natural gas was imported from Russia, excluding LNG (Koistinen 2020). In 2019, a pipeline through the Gulf of Finland was completed and the networks in Finland and Baltic were connected creating a second option for the natural gas import. This Balticconnector can transfer gas from Estonia to Finland and vice versa. The transmission capacity is up to 72 GWh in a day. The project increased the reliability of delivery, made the market increase possible and was the key element in opening the gas markets in 2020. At the same time as the Balticconnector, the pipelines from Estonia all the way to Poland were improved making the integration to the European Union's joined gas markets possible. (Baltic Connector)

Comparing Finland to the rest of Europe, Finnish gas use and transmission differs. In the Central Europe for example, gas is used to heat up buildings and water in the cities and in the countryside and this requires a very comprehensive network. In Finland, the network does not cover the whole country. The pipelines are located from the south-east part of Finland to the south part and they go only as high as Tampere (Baltic connector). The end use of gas is also quite different in Finland compared to Central Europe. Currently, the main users of natural gas in Finland are 40 big industrial and energy companies. They use mainly all the gas from the pipelines. (Koistinen, 2020) In 2017, about half of the gas was used in energy sector and about half in industry in Finland. At the same time, average in Europe was one third in energy sector, one third in industry and one third in households. (Siira 2019) In the spring of 2020, 7 TWh was imported from Russia and 3,8 TWh from Estonia to Finland (ENTSOG). Figure 2 demonstrates the current gas network in the Baltic.

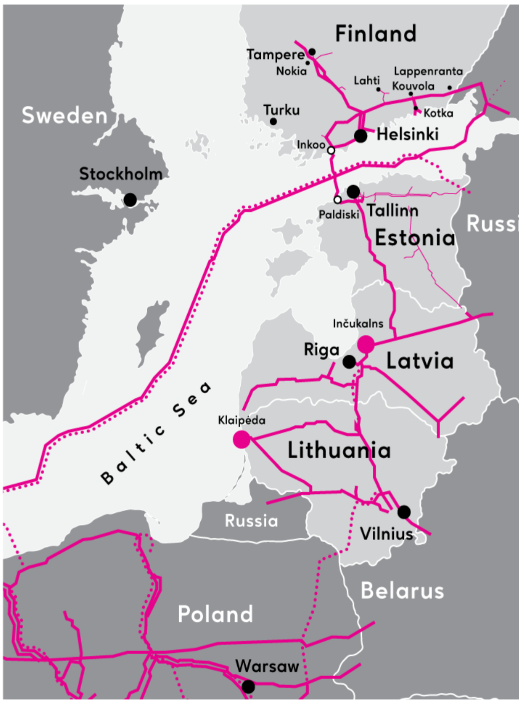

Figure 2. Natural gas network in Finland and Baltic (Gasgrid Finland Oy).

Previously, Finland and the Baltic have been isolated from the European network due to the difficult location and non-existing network and thus being depended on the Russian natural gas. Open market increases the reliability and security of the system. Of course, opening the gas markets still does not help with the problems of self-sufficiency, because natural gas is not available in Finland. In the future, when biogas is produced in larger amounts, the larger utilization of the existing gas networks comes easier.

In the recent couple of years, the European gas markets have been in an upturn. While the negative image of nuclear power spreads and the shutdown of more polluting coal power-plants increase, natural gas has been slowly confirming its place in the current energy markets. Biogas and other synthetic gasses emerge to the market and utilize the existing gas networks enhancing the overall appeal of gas use. Main transfer projects in the making, that have an effect to the European gas markets, are the Nord Stream 2, the Baltic Pipe Project and the Gas Interconnection between Poland and Lithuania (GIPL). The Nord Stream 2 is a pipeline connecting Germany and Russia via the Baltic Sea said to be ready in 2021 (Musariri, 2020). The Baltic Pipe Project connects Norway to Denmark and Poland also through the Baltic Sea. This pipeline is said to be ready in 2022 and the GIPL is said to be ready in 2021 (Baltic Pipe Project) (Amber Grid). These improvements to the gas infrastructure aim to open new corridors to the European Gas Market and make Finland and the Baltic fully connected to the Central Europe.

An article published by Eser et al. in the Applied Energy Magazine (2019) studied the effects of the Nord Stream 2 and LNG trade to the security of the European gas network. The calculations indicated that the gas transit trough Poland would decrease 23 % and 13 % through Ukraine by 2030 due to the Nord Stream 2. Completely cutting off Ukraine is found to be a detrimental strategy for Russia, due to the high percentage that can be re-routed from Ukraine over a short timeframe via Nord Stream 2. If the gas flow through Ukraine is disrupted entirely, only 40 % can be rerouted through other pipelines to Europe, and 60 % needs to be delivered from other sources. Several studies find that eastern European countries are most adversely affected by the supply disruptions from Russia and this makes the Baltic Pipeline project as well as the LNG trade significantly involved in the security question of the short-term supply outages. (Eser et al. 2019)

It is estimated that by 2030 European’s own gas production will increase by 12 % due to the increase of biogas production and utilization of existing gas reservoirs and storage. Increase would happen also with LNG imports and this would require 17 % of European gas pipelines to be bidirectional, which would mean investments into the gas infrastructure. LNG is more affected by the fluctuation of the market prices than natural gas. In the publication by Eser et al. simulation shows that short-term disruption of LNG would increase gas prices in southern Europe by up to 40 %. Even though LNG has its own security and economic issues, LNG imports are estimated to be cost-intensive replacement of disrupted gas flows from Russia. (Eser et al. 2019)

Security issues are addressed in a government level as well. A report by Finnish Energy Authority (2019) state that all possible disruptions of natural gas supply will be able to be replaced with alternative energy sources and fuels. The background of the targets set by the Finnish government for the supply security is to secure the basic functions that serve the people and the economy. To meet the possible requirements in a supply disruption, there are storages representing average of five months normal consumption. For natural gas, these are both storages owned by energy companies and government owned storages. In case of a shortage of gas transmission system operator can limit the use of non-ordered gas by raising the prices of balancing gas. If this is not sufficient, transmission system operator can also cut the reserved gas from the consumers and the gas exchange markets take care of the after markets. (Energiavirasto, 2019) Finland has alternative energy production methods and fuels in which to rely on if needed. For example, biomass is domestically produced fuel and oil storages are also in stand-by ready to be used in case of the gas supply fails. Finnish homes rarely heat up with only gas, which makes the households more secure in this matter compared to Central Europe for example. It is noticeable that in the long history of natural gas infrastructure in Finland, there has not been a single significant disruption in the gas supply from Russia.

2.2 Market model

According to the European Union ‘s legislation, in an open gas market the same company cannot be both the gas supplier and the transmission system operator. Therefore, a new company needed to be formed to be responsible for the gas transmission in Finland. The transmission network operations were unbundled from the previous company, Gasum Oy, to a separate company, Gasgrid Finland Oy. The transmission system operator (TSO) is responsible for selling the transmission capacity into the system and other market participants are responsible for selling the gas energy. Transmission capacity stands for the right to transmit the gas energy in the transmission network. (Gasgrid Finland Oy)

Trading in gas can take place either in gas exchange or over the counter (OTC). This means, that one market participant can be both the seller and the user of the gas. Gas energy sold and transmitted is measured in a higher heating value (HHV) in kWh energy or kWh/h in transmission capacity. In the gas markets, balancing time is currently 24 hours. This means that hourly values are not charged separately but the balance is calculated based on the total use in the 24 hours. Gas is also sold and reserved for 24-hour time periods. The 24 hours is not a regular day, but referred to as a gas day, which is from 7 a.m. to the next day's 7 a.m EET. (Gasgrid Finland Oy)

The pipelines carrying the gas are divided into transmission network and distribution networks. Main technical difference between these two is the pressure in which the gas is transferred. Transmission network carries the gas in high pressure and is operated by the TSO. Distribution network carries the gas in low pressure to the end users and is connected to the transmission network. There are multiple companies distributing the gas to consumers and industry in each operating area and these are all working as a distribution system operator 's market role. (Gasgrid Finland Oy) Figure 3 shows the transmission network in Finland.

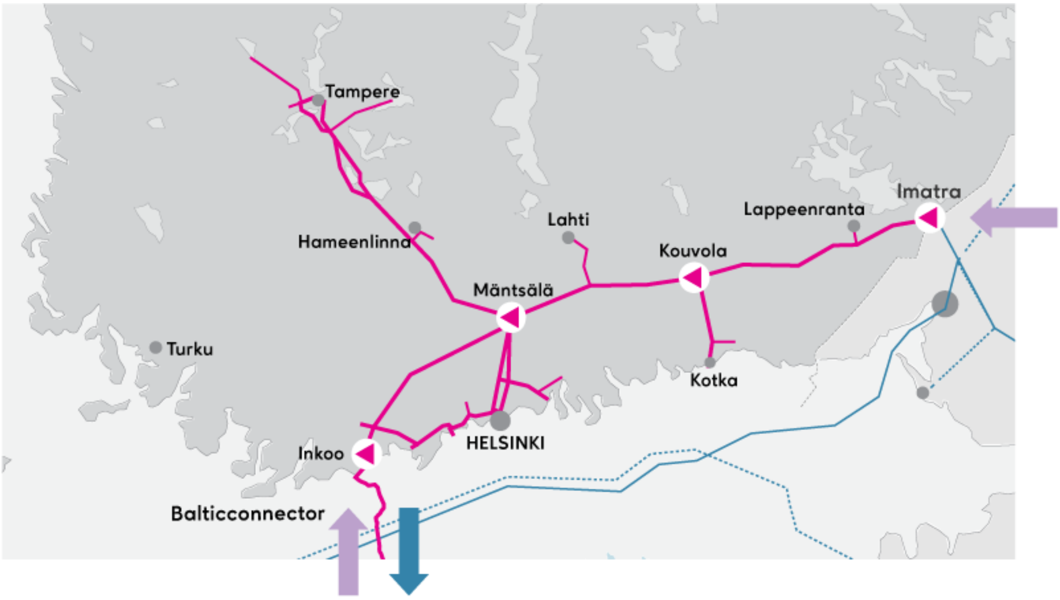

Figure 3. Transmission network in Finland (Gasgrid Finland Oy).

The gas transmission system can be divided into several points, where gas flows in and where it flows out. The concept of entries and exits can be seen as physical concept or aggregated virtual points. The points can be metered or non-metered points. Gas comes to the system through entry points, which in concerning the natural gas are located either in Imatra or Inkoo. Entry point in Imatra imports the gas from Russia and the point in Inkoo from Estonia using the Balticconnector. In addition to the physical entry points for natural gas, LNG and biogas can be injected to the system through their own points. Virtual points contain all the injection points regardless of which network they are physically connected to. (Gasgrid Finland Oy)

Exit points are the places, where gas exits the system. Gas can be either exported from Finland via Balticconnector or used by the end user. Both entry and exit points require capacity bookings, so that enough gas energy can be transmitted physically in the transmission system. (Gasgrid Finland Oy) Figure 4 demonstrates the gas flows from the possible entry points to the exit point. All the wholesale market gas trading happens in Virtual Trading Point (VTP), which is a non-physical hub for trading. VTP represents all entry and exit points in the market area.

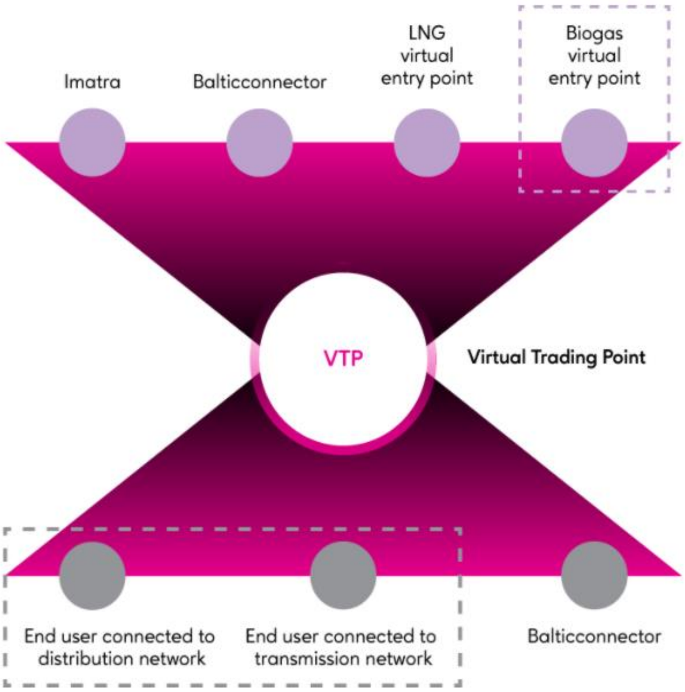

Figure 4. Market model (Gasgrid Finland Oy).

2.3 Market parties

There are a total of eight different market roles for marker parties and a company can have multiple roles simultaneously if the company fulfills the demands for that role. Market parties can be divided into wholesale market participants and retail market participants. Wholesale market participants are called shipper, trader and end user of the transmission network. Retail market participants are retailer, distribution system operator (DSO) and end user of distribution network. Depending on whether the production plant is connected to the distribution or transmission network, biogas injecting parties and LNG injecting parties can be either on the wholesale markets or on the retail markets. (Gasgrid Finland Oy). Figure 5 categories the market participants and shows the responsibilities of the transmission system operator.

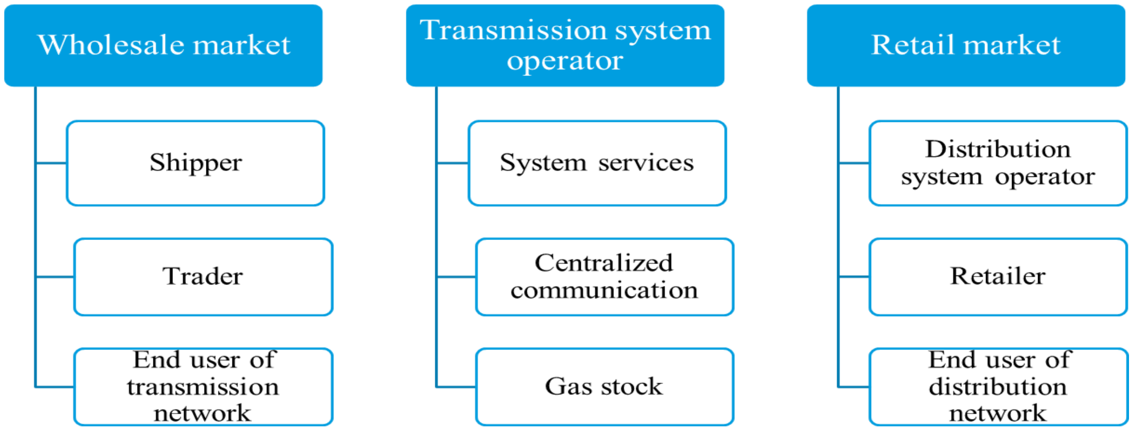

Figure 5. Market participants.

Each market role grants specific permissions but also include responsibilities. These responsibilities and permissions are stated in the general agreement for each market role and in some cases in the Natural Gas Market Act (587/2017). The Natural Gas Market Act ensures efficient, secure and sustainable supply of natural gas and aims to create ideal conditions for European Union ‘s internal markets. Companies operating in the natural gas markets should take care of their customer’s natural gas procurement services and promote efficient and economical use of natural gas in their own and their customer’s operations. (Natural gas Market Act 587/2017) Table 1 shows the current number of each market roles in Finland and the following chapters give detailed descriptions of the most significant market roles.

Table 1. Market participants in Finland 6/2020 (Lehtinen, 2020).

Market role	Number
Shipper	24
Trader	16
Retailer	22
Distribution system operator	18
End user of transmission network	37
Biogas injecting party	1
Total	**118**

2.3.1 Shipper and trader

Shipper is the most visible market role in wholesale markets as it works with gas trading, capacity bookings and gas transmission. System operator transmits quantities of gas in the transmission network to the shipper in accordance with capacity agreements and gas transmission rules. A shipper may also act as a retailer, biogas injecting party, transmission network or distribution network end user. If a market participant is acting as a shipper, it is automatically righted to act as a trader at the same time, because a trader may be classified as a subcategory of a shipper. Out of the market roles, trader carries out only wholesale trading and does not enter into capacity agreements with the TSO or trade capacity on the secondary market. Trader makes the trades only on paper or in the virtual trading point and never physically transmit the gas. The responsibility of a trader is to trade gas energy on a wholesale markets according to the gas transmission regulations.

Both a shipper or a trader may act as a balance responsible party or be a part of a balance group. They are both bound by the Natural Gas Market Act (587/2017) section 42. The wholesale market operator with the most market force over the transmission network has the obligation to supply equally and with un-discriminatory terms the imported gas to the retailers. To do so, wholesale operator must have public prices and supply terms with reasonable conditions. (Natural Gas Market Act 587/2017)

Shipper makes delivery contracts with the retailers and end users of the transmission network. Shipper can either buy the gas from another shipper, trader or from the gas exchange and one of the rights as a shipper is to import the gas through the Finland’s entry points. Trader can also buy and sell the gas to another trader or a shipper or trade at the gas exchange. After fulfilling the role specific framework agreement, which includes collateral demands and rules for capacity agreement, one can register as a market participant. (Gasgrid Finland Oy)

2.3.2 Retailer

Retailer works at the retail markets directly with the end users via a DSO’s distribution network. Retailer has a delivery agreement with a shipper and a sales agreement with a distribution network end user. (Gasgrid Finland Oy)

In the Natural Gas Market Act (587/2017) section 44 retailer’s delivery obligations are stated. Retailer must deliver natural gas in its operating area in reasonable price to the end consumers, who use gas mainly to heat up the residence buildings in the area and to the end users whose power when joining to the network is maximum of 250 kW. This obligation to deliver gas with reasonable price is applied to the retailer with significant market power in the operating area. If there is no such retailer, the retailer whose quantity of the natural gas delivered compared to the gas acquired by end users is highest, is the one with the delivery obligations stated in the Natural Gas Market Act. (Natural Gas Market Act 587/2017)

2.3.3 Distribution system operator and end users

Distribution system operator carries out the distribution and is responsible for ensuring the maintenance of the network and operating the network. If necessary, DSO develops the distribution network in each area and its interconnections with other systems. DSO is responsible for ensuring a long-term ability of the system to meet its reasonable demands for the gas distribution. (Gasgrid Finland Oy) Distribution system operator is a natural monopoly since it is not profitable for multiple networks to transfer the gas to the end users in two separate pipelines simultaneously.

Distribution system operators are the ones transferring the gas to end users via low pressure pipelines. There are currently 18 DSO’s operating in Finland, who have listed their company’s market role as public. The transmission system operator transfers the gas in high pressure pipelines to the DSO’s who then distribute it to the end users. Compared to the old closed markets in Finland, now the DSO and a retailer working in the same operating area can be different companies. (Gasgrid Finland Oy) In figure 6, there are the transmission network in purple and the distribution network in orange in Tampere area for an example of the physical differences between the TSO and the DSO. The information in the figure comes from 2020 data and is a rough estimate from the Tampereen Sähkölaitos website. Distribution network changes as new customers join the network and additional pipelines are built.

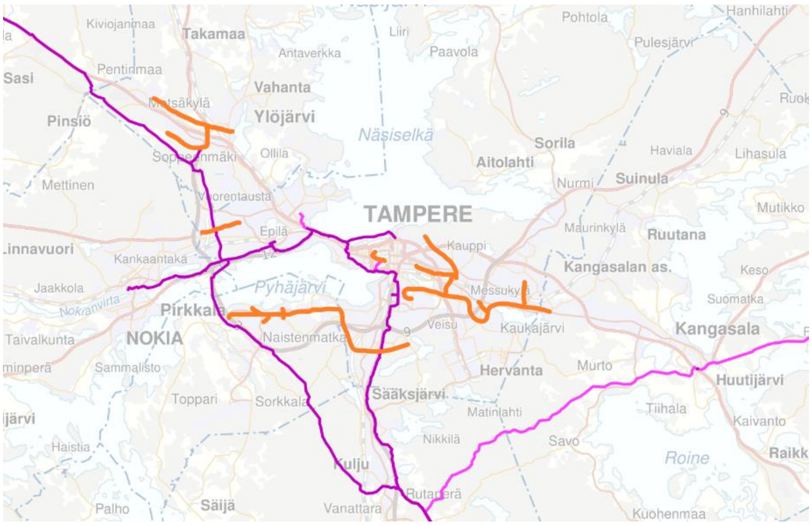

Figure 6. Gas network in Pirkanmaa.

End users consume the gas. In transmission network end user is assumed to be the one who consumes the natural gas at the metering site connected to the transmission network. Distribution network end user is the customer who buys gas for its own use and is connected to the distribution network's metering point. End user of the distribution network can use the gas by consuming it for energy production or any other need such as industrial needs. Transmission network end user can be at the same time a shipper, trader, biogas injecting party, retailer or even a distribution network end user. (Gasgrid Finland Oy)

2.3.4 Balancing responsible parties

The balance of the whole Finnish gas network relies on the TSO. TSO oversees the market's financial and physical balancing, and it neutralizes the imbalance of the balance responsible parties at the end of each gas day. Imbalance is simply calculated by taking entries and subtracting exits from the system. Entries are the dyadic trades and the trades made in the gas exchange as well as the injecting points and imports trough the Balticconnector or Imatra. Exits in this concept are consumptions, export trough the Balticconnector and sells in the gas exchange or between two market parties. TSO announces the imbalance of the systems in the Gasgrid portal using the traffic light color system. If the balance is green, the systems imbalance can be handled using only the storage in the pipelines. If the color turns yellow, TSO needs to affect the market by buying gas from the GET Baltic and thus the balancing prices are tied to the weighted average price of the gas exchange spot prices.

As a shipper or a trader, one can either be a balancing responsible operator or join a balancing group held by a shipper or a trader. It is mandatory to be a part of some balancing group or to be one alone. TSO makes preliminary balance for the measuring points and biogas and LNG injecting points. This is done daily for the day before yesterday before 15:00 UTC wintertime and 14:00 UTC summertime. The final balance reports are done for the whole month on the fifth day of the next month. In the balance reports, also the network losses are taken into account by comparing the measuring points and the consumption points. If a market participant is not a balancing party itself, the balancing responsibilities are outsourced to the balancing responsible, who then charges for the balancing services and reports to TSO.

The applications used for monitoring and data transfer between the market parties are Gasgrid portal and Datahub. All the wholesale market action happens in the Gasgrid portal, for example nominations and virtual trading. Retail markets use the datahub, which contains information from the measuring points. Also, distribution network balance can be calculated there for the DSO. Measured values imported by the TSO to the Datahub are the amount of natural gas and biogas used in a measuring area and the heating values in that area. Imported values by the DSO are the amounts and the heating values in a DSO’s measuring points. Information that can be received from the Datahub is based on the market role. For example, the TSO get the measuring point values from the DSO’s, and retailers get the market area’s total consumption on hourly and daily resolution. (Gasgrid Finland Oy)

3 NATURAL GAS PRICE

The price of natural gas as well as the price of derivates is a significant economic interest for various stakeholders. Looking both from a macro and firm-specific perspective, understanding the drivers of natural gas prices is relevant for making market analysis. Unforeseen political effects and disruptions in the gas supply may induce a significant repercussion in these markets. However, the price formation at liberalized gas market is complex since the markets are faced with different fundamental demands and supply influences. (Nick & Thoenes, 2014)

Many studies have proved how natural gas and crude oil prices in the United States are closely tied together. This cointegration has been, however, also questioned since there seems to be decoupling of gas and oil prices, partly due to the increasing production of shale gas. The gas price dependence on oil prices seems not to be stable over time in the Unites States and this has caused studies to argue whether the oil price has only weak explanatory power for short-term gas price fluctuations or whether the power is more dominant. Other drivers for gas price formation are the weather conditions that affect the consumption, storage possibilities, business cycles, international trade flows and substitution effects among energy commodities. (Nick & Thoenes, 2014) Before the market liberalization, Finland’s gas pricing has been traditionally made based on both oil and coal price as well as domestic price index for energy markets, including electricity and heating. The pricing method has been as follows.

$$40\ \% * \frac{BRENT_6}{BRENT_0} + 30\ \% * \frac{API2_6}{API2_0} + 30\ \% * \frac{D35_6}{D35_0} \tag{1}$$

where	$BRENT_6$	six-month average price for crude oil published by the Platts,
	$BRENT_0$	reference price for crude oil published by the Platts,
	$API2_6$	Northwest European six-month average price for coal,
	$API2_0$	Northwest European reference price for coal,
	$D35_6$	six-month average for basic energy price index publish by Statistics Finland,
	$D35_0$	reference for basic energy price index publish by Statistics Finland. (Suomen Kaasuenergia, 2020)

In addition to crude oil price, affecting factors for natural gas price can be divided into supply- and demand-side factors. Supply-side factors are amount of natural gas production, level of natural gas in storage and volumes of imports and export. Demand-side factors are weather variations, level of economic growth and availability and prices of other fuels. Especially during wintertime, short-term increases in demand or reductions in supply may cause large fluctuations in natural gas prices due to natural gas supply infrastructure constraints and limitations to switch fuels quickly by gas consumers. Generally, increases in supply or decrease in demand result in lower prices and decreasing supply or increasing demand tend to lead to higher prices. (U.S. Energy Information Administration, 2020)

A paper by Bastianin et al. (2019) shows that natural gas prices in Europe are closely related and when analyzing the gas price in liberalized markets in Central European countries as well as in Nordic countries, the price curves seem to be correlating. While gas trading in Continental Europe is still largely based on long-term contracts indexed to the price of crude oil, there is evidence that gas-specific factors are becoming more relevant. There are differences between mature and poor gas hubs and how the prices are converged. Mature and liquid markets allow more efficient balancing, managing of hedging price risk and overall adjustable imbalances of the system. The higher the market liquidity, the more rapid convergence to the market equilibrium. Converging prices in European countries correlate with the regulator characteristics of each country. The Energy, Transport and Communications Regulation (ETCR) index for the natural gas markets indicates the restrictions for competition. The index takes values between zero and six, and the lower the value is, the fewer restrictions the country has for competition and the more affected it is by the market fluctuations.

(Bastianin et al. 2019) For example in 2013, ETCR natural gas score for the Great Britain was 0,0, for Germany it was 1,2 and for Finland it was 4,2 (OECD.Stat).

Since Finland has only recently opened its gas market, natural gas converging pace to European standard price can be conducted from the results from a study by Bastianin et al. (2019). The study focused on 14 European countries that are working in a liberalized gas markets and have interconnections to at least one other country. The calculation was made based on σ-convergence that indicates that cross-section variation of natural gas prices decreases over time. Results are showed in figure 7.

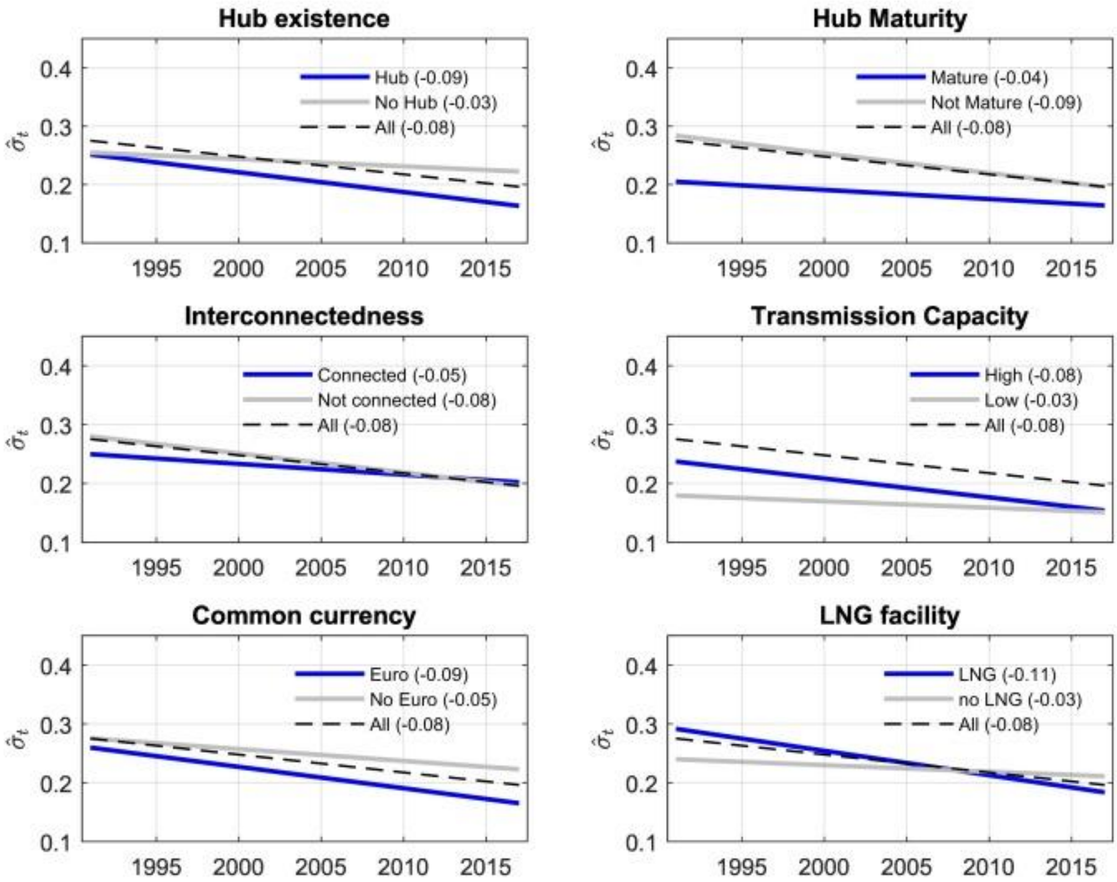

Figure 7. Convergence of price differentials (Bastianin et al. 2019).

To summarize, the standard deviation of prices is lower in countries with a mature gas hub, LNG facilities, or have Euro as common currency. Steeper negative trends, meaning faster converge, are associated with countries that operate LNG terminals, have high transmission capacity, have trading hubs or share a common currency. (Bastianin et al. 2019) Finland, being isolated with only one transmission pipe to European Union Member State and new at the liberalized markets, is probably not as fast converging prices compared to Central Europe for example. But Finland shares the common currency, has a gas hub, and operates couple LNG terminals, which are all drivers for more converged gas prices.

3.1 Price trends

Natural gas hub is a central pricing point for the network's natural gas. There are several hubs all over the world and they tend to be at the heart of gas infrastructure, such as pipelines and LNG terminals. In some cases, a financial derivative contract is priced off gas delivered at this point and the hub price is used to price the LNG exports as well. The world's biggest hub is in Louisiana, United States, and called the Henry Hub. Gas delivered at Henry Hub sets the basis for the U.S 's natural gas features. In Europe, the main natural gas hubs are Britain's National Balancing Point (NBP), which was the first active gas hub in Europe, and the Dutch Title Transfer Facility (TTF). NBP is positively affected by the high consumption and significant domestic production. TTF takes benefit from Groningen onshore gas field and high LNG import capacity. Recently, TTF has taken the lead in Europe for natural gas pricing. In Asia, there are not yet any one dominant gas hub for all Asia because they prefer long-term oil-indexed contracts, but one benchmark price used is the LNG price in Japan. (Reuters, 2017)

Natural gas price compared to the oil price is showed in the figure 8 from 2006 to 2017. It is noticeable that all the hub-prices follow the lead of oil price, LNG price in Japan most clearly (Atradius, 2017). The global financial crisis in 2008-2009 is seen in the fast increase of the prices followed by a sudden crash. This drop was almost entirely the result of the sudden oil demand crash, which also caused the price drop in gas. The second decline of the prices in 2015 was caused by a mixture of demand decrease and at the same time, supply increase from shale gas. (Rogoff, 2016) Looking closer to the figures, some smaller spikes come from weather conditions, such as cold winters or storms and some of the low prices are due to the high shale gas production in the U.S, reduction of industrial gas use or exceptionally warm winters (Willing, 2020).

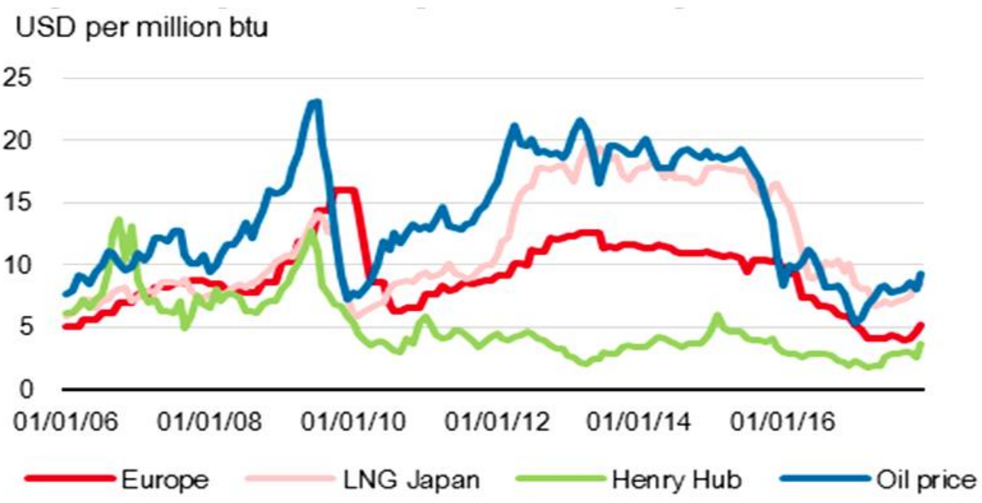

Figure 8. Gas price development across regional markets (Atradius, 2017).

Most recently, gas prices have hit their all-time lows. For example, on 16th of June in 2020, the Henry Hub price was lower than in 20 years, settling at $1,38/MMBtu. Part of the reason was warm winter and thus surplus supply in the storage. Global pandemic reduced industrial and commercial demand and recent Saudi-Russian oil price affected the natural gas prices as well. Short-term forecast predicts that gas prices are likely to continue the rise from the lows reached in the summer due to the seasonal trend for higher prices as temperatures fall and due to an economic recovering from the COVID-19. (Willing, 2020)

Looking long-term, one of the main effecting factors to the gas prices in Europe, is the changes in the local gas fields. In Norway, a new gas field in the Arctic Ocean started its operation at the end of 2020. The Askeladd field is producing approximately 21 billion cubic meters of natural gas. Additional development to the Great Snohvit area, in which the Askeladd field is a part of, is also on planning. (NS Energy, b) One of the biggest gas fields in Norway, the Troll Oil and Gas Field will finish its repairs by spring 2021. The constructions will increase the gas production as well as the lifetime of the field. (NS Energy, c) For a long time, the largest European gas field has been the Dutch Groningen gas field, but it is estimated to phase-out its operation in 2022 (NS Energy, a). There are also changes to come in Russia regarding the operating gas fields. It is estimated that by 2030, Russia has halved its current gas production from the 2020 level due ending operating periods. New field is established in Nadym-Pur-Taz Region and some existing ones are further exploited, such as in Yamal, in Eastern Siberia and in the Russia Far East, making the overall production increase by 2030. (Locatelli, 2017)

The main uncertainties for the long-term price forecasting for 2021 and forward are the spread of a global pandemic and its effects on the economy, gas storage changes as well as the Saudi Arabia-Russia price war. The utilization rate of renewable energy sources will also affect the gas prices as it will affect the supply and demand. The average price forecasts indicate that the prices both in Europe and in the United States will increase by 2030. The rate of the increase is different depending on the forecast. The increase in prices from 2020 to 2025 is estimated to be less steep than from 2025 to 2030. Average price for 2025 is about 6 $/million Btu, so around 17 €/MWh. By 2030, the average European price would be little over 7 $/million Btu, so about the same level as in 2018. This would mean roughly 21 €/MWh. In the U.S., the increase would be more stable and lower than in Europe. European average price is estimated to fluctuate more than the U.S. 's due to current investments and changing targets and legislations in the European Union. (Tiseo, 2020) (Knoema, 2020) (Enerdata, 2018) Three different forecasts are shown for Europe and the United States in figure 9. Blue color indicates European prices and red the U.S. prices.

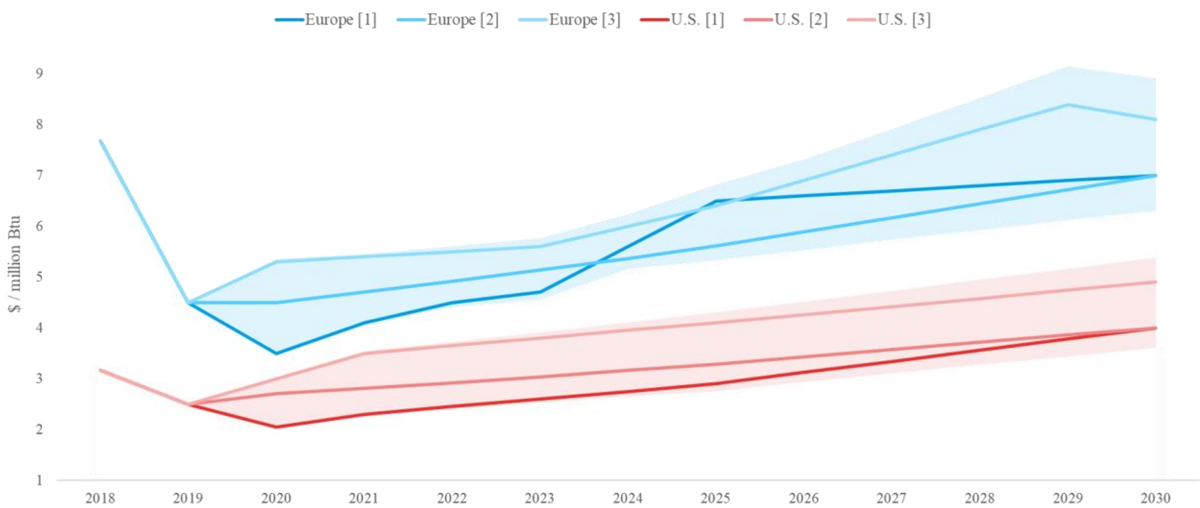

Figure 9. Natural gas price forecasts with 5 % margin of error. [1] Statista forecast, [2] World Bank forecast, [3] Enerdata forecast. (Tiseo, 2020) (Knoema, 2020) (Enerdata, 2018)

3.2 European gas hubs affecting Finnish gas prices

Mature hubs in Europe are the earlier mentioned Britain's National Balancing Point (NBP) and the Dutch Title Transfer Facility (TTF). The criteria for depth, liquidity and transparency of the hubs determine whether the hub is mature or just active one. The key elements are number of active market participants, traded products and volumes, liquidity and the ratio of traded volume to actual physical throughput. In 2019, there were four active hubs in Europe: German NGG (Nahrung-Genuss-Gaststätten) and GPL (Gaspool), Austrian CEGH (Central European Gas Hub) and Italian PSV (the Punto di Scambio Virtuale). Other hubs in European countries or areas were categorized as poor or inactive hubs in 2019. The highest traded volume and the range of traded products in 2019 was in TTF (Heather, 2020)

A trading platform called GET Baltic, which operates within the Baltic Region, is used in Finland. The trading in GET Baltic Finnish-Baltic market from January to September in 2020 was 3,9 TWh, so 0,4 % of the trades in the fourth biggest European hub Gaspool, where the volume was 1051 TWh during the same time. (GET Baltic) (Gaspool) Gaspool or TTF monthly index is used often as a benchmark for Finnish wholesale market pricing and thus also for retail market pricing due to on-going wholesale contracts. GPL and TTF are both liquid markets and do not differ greatly in price. Both also use euros as currency, unlike the British NBP, and trade the same products. (Powernext) In Finland, GPL is often used as a benchmark over TTF partly due to the Nord Stream 2, which will increase the importance of German energy markets significantly. Oil and coal indexed pricing became uncommon in Europe as the European Commission imposed binding obligations on Gazprom to ensure competitive prices. The obligations were that new Gazprom prices must reflect competitive Continental Western European price benchmarks, including prices at liquid hubs. (European Commission, 2018) This concluded into Gazprom making contracts with the Baltic using Gaspool as a benchmark.

Predominant natural gas prices in GET Baltic are referenced as BGSI's (Baltic Gas Spot Index) or by other name, neutral gas price in GET Baltic. The price is calculated as volume weighted average from all the trades in one gas day. Figure 10 shows the lowest and highest prices as well as BGSI from the beginning of 2020 to the end of December. Highest BGSI was 16,2 €/MWh in January, and lowest 5,0 €/MWh in July. The prices have clear seasonal relationship and in the beginning of the year, the price deviation from the BGSI was higher than during the summer and the fall. (GET Baltic)

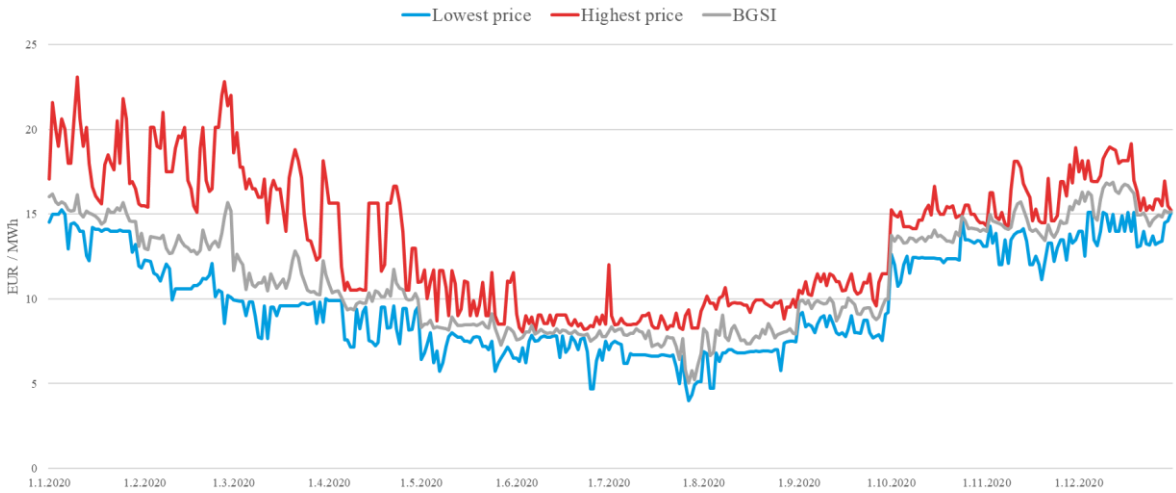

Figure 10. Fulfilled trades in Baltic-Finnish market in €/MWh (GET Baltic).

3.3 Wholesale and retail prices

Typically, the contracts between shippers or traders and between a wholesale market operator and a retailer are fixed-term contracts, where the company would not benefit from the excess gas and extra use would be charged differently. The prices would be tied to a gas hub price, typically the Gaspool or the TTF, which will make the contracts secure for both the supplier and the end user as the price is not as vulnerable for short-term market changes and the consumption is in the beforehand set limits. Sales contracts can vary on the timespan in which supply takes place, whether there is minimum or maximum order rates and whether the price is fixed or index related. The possible pricing methods and the hedging needed for the gas market operations are discussed in the following two chapters.

3.3.1 Pricing methods

There are several pricing strategies that can be applied to gas trade in the retail markets. One is pricing to competition. If there are several companies operating in a same market, investigating their prices and pricing to the average or about the same as the lowest market price is a good method to stay competitive in the field, when there are no specific features to distinguish the companies. Another strategy is a cost-plus pricing. This strategy focuses solely on how much profit a company wants to gain. In a cost-plus method, a fixed percentage of the products cost is added to the price. An opposite of the cost-plus method is break-even strategy, where the pricing is made to only meet the product cost. Benefits of this could be penetration to the market or gaining customer base to increase the prices later or gain profits from supplementary products. (Decker, 2020)

One of the examples on flexible pricing strategy is dynamic pricing, which is also known as surge pricing or demand pricing. It is a flexible pricing strategy where prices fluctuate based on market and customer demand. Algorithms are used as a tool for dynamic pricing and they consider factors such as demand and competition. One way to add up value to the product is to form a same price for two or more complementary products and use a strategy called bundle pricing. (Decker, 2020) Considering gas trade, this could be used for example with gas energy, transmission and balancing services or anything related to environmental actions and services, such as biogas trading and manufacturing. A pricing method related to transmission of gas is pricing to positioning. As the network being a natural monopoly, prices can be set without a competition and only focusing on the profit, reputation and regulations (Decker, 2020). A risk from high pricing is that gas consumers could move from gas use to alternative fuel. For example, in heating, customers moving to a wood-based product or electric heating would diminish the revenue. The strategies stated above are not necessarily meant to stand alone but to use as mixture of different methods needed.

Gas pricing can be made with similar mindset as electricity pricing. Gas is consumed in an energy unit, typically in mega- or kilowatthours and it needs the network for the distribution. Like in electricity use, gas use follows seasonal demand and is dependent on both the temperature and the consumer's end use sector's consumption profile. For example, industrial use may follow the cycle of workdays and weekdays and heat production follows the temperature changes. Examples of the pricing methods are index-related pricing, where the pricing is being made in correlation with some Gashub price, or constant pricing for the whole year or season, which could interest the small consumers. Gas pricing can be also made to fit a certain consumption. For example, peak load consumption is widely used in the industry as well as seasonal consumption. Some yet unused, but possible pricing methods for the future could be gas exchange pricing or time-related pricing, where the consumption takes place only at night for example.

3.3.2 Risk management

Energy company 's risk management can be described as systematic actions to identifying risks and their possible outcomes, management and control. Risks management guides decision making and operative actions, and it aims to control company's profitability. Currently, market participants must consider possible risks in the demand side, operative and strategic risks, political risks, risks in credit as well as the risks in prices. Compared to financial assets, such as bonds and currencies, energy commodity prices have different risk characteristics. The physical aspect of energy commodity makes the prices vulnerable to frictions in demand and supply. Standard risk models from financial markets are not adaptable to energy commodities as the distributions change over time in accordance with the changing market regimes, commodity-specific business cycles and seasons. (Dahlen et al. 2015)

Strategic risks come from changes in the competitor's actions or under- or over scaled investments. Political risks are mainly regulatory actions like changes in the laws, commandments, taxation, emission control systems or geopolitical situations. Political risks extent to national, European and global level. (Partanen et al. 2020) As gas is highly bound to geographical locations, it faces similar political risks as for example the oil. Finland cannot be yet self-sufficient in gas as the main consumption is imported fossil natural gas and this is a risk every energy provider must consider. Natural gas is a polluting fossil fuel and thus energy companies using it are about to face even more political pressure to cut the use. These risks are not easy to hedge from financially and as they usually have a long-term market effects, that are more relevant to the wholesale markets.

Demand risks are characteristic for open markets. Due to consumers being able to choose their retailer, the risks regarding changes in the customers are present. (Partanen et al. 2020) Gas is often used in industry, in which the consumption amounts can be high, thus one industrial client can make significant changes in the overall demand. If one client is lost to the competitor unexpectedly, procurement contracts can be over scaled. Volume risks are similar to demand risks because they are actualized when there is a difference between the procurement and the sales. Sales side volume risk comes from lost profits as customers change the retailer and procurement side volume risk is often actualized as price risk as the gas exchange can be used to balance the supply if needed (Partanen et al. 2020).

When looking at sales and procurement, main risks are gas price, volume risk and demand risk. Price risk is an outcome of a high price volatility. High volatility is an outcome of the temperature dependency that is associated with the consumption changes and the characteristic of the storage options. (Partanen et al. 2020) The optimization of the sales and procurement has become more complicated when the markets opened as there are more factors to take into consideration. In addition to price and volume risks, there are also significant operative risks related to the optimization of the procurement and the sales. For example, if the consumption is underrated or the supply overrated there is a need for gas trading in the gas exchange or a need for a balance gas after the consumption day. This creates price risks as the price could be higher than purchased beforehand. This works another way around as well, and in that case, there could be losses in the too low sales prices for the excess gas.

A requirement for operating successfully on the gas market is an identification and control of the risks. Risk management allows the market participant to be functional in all circumstances. The tools for risk control at the wholesale markets are derivates and purchasing contacts and, at the retailer markets, suitable pricing methods. The derivates are for example forwards, futures and options, and they aim to decentralizing the profit, not to improve it. (Partanen et al. 2020) Price risks are covered by making procurement hedging and transferring some risks to the client with strategic pricing.

Forward contracts are common and functional way to be protected from the price fluctuation related risks. Forward contracts are widely used especially in the fixed-period contracts to protect both the supplier and the consumer from the price risk. Forward contract is an agreement between two market participants to transact the asset at a future date. This includes an agreement to buy or sell on a certain date for a certain price. Similar derivate to forwards is futures. Futures is an agreement to trade the assets in the determined future date at certain price. One of the main differences between futures and forwards is the time of the cashflow.

Futures are daily marked-to-market with cashflows passing between long and short position to reflect the daily futures price change, whereas forwards are settled once relevant For gas trade, futures are used in the gas exchange and forwards are a private contract between two parties. (Clewlow & Stricklan, 2000)

Options contracts are, in addition to futures and forwards, a cornerstone to the derivates market. Using options as a part of everyday risk management is beneficial for both price risk protection as well as the volume risk protection. Especially, when there are changes between the sales estimate and the actual consumption, options are proven to be practical risk management method. There are two types of options, a call or a put. A call option gives the holder the right to buy and a put the right to sell the asset at a certain price before a predetermined date. This is a right, not an obligation and thus option differs from futures and forwards. Like in forwards, options have two sides of the contract, a vendor and a buyer. (Clewlow & Stricklan, 2000)

Options allow the company to avoid over- or underhedged situation and futures or forwards binds the buyer to buy as promised at certain price an agreed amount. It is not unambiguous what derivate is most profitable to which situation. If there is significant price fluctuations and the price estimates have been significantly wrong, futures or forwards can be profitable. Options then help with the volume risks as they are more flexible with the amount of gas. By making different contract types and agreeing with the price in the contract the risks are divided between the buyer and the vendor. The company must have real-time information from the consumption estimates, on-going sales contracts, on-going purchase contracts and derivates to manage the risks successfully. If the actions are not monitored, the company is exposed to operative risks and loss of profit.

3.4 Transmission and balance control prices

When gas is transmitted to Finland, transmission system operator will charge transmission tariff for the gas delivered. The amount depends on the point used: Imatra, Balticconnector, biogas injecting point or LNG entry point. In addition, based on the transferred gas quantity, a commodity charge is added to the transmission price. When a shipper is booking transfer capacities, it needs to book both entry and exit capacity and pay for both, which will add up to the total amount paid for the capacity. The prices for capacity depend on the capacity type, which is divided into different short-term products such as monthly or daily products. Shipper can then sell the transmission forward. (Gasgrid Finland Oy)

TSO is also doing daily imbalance charging. If a shipper has surplus gas, it will be bought by the transmission system operator with system responsibility after the gas day has ended. Currently, the price is 0,9 times the neutral gas price of that day. If shipper must buy extra gas to balance a certain gas day, the gas will be bought as balance gas for 1,1 times the neutral gas price of that day. Balancing responsible shippers are the ones doing the balancing operations and invoicing accordingly from the customers. In case of a state of emergency or abnormality, the balancing prices can be different depending on the gravity of the situation. (Gasgrid Finland Oy)

3.5 Taxation

Excise taxes are commonly charged based on monthly use starting from midnight. Gas taxation follows different time as the gas balancing and trading happens in gas-time 07:00-07:00. Trading happens in the higher heating value, but excise taxes are calculated based on the lower heating value (vero.fi, b). The difference between higher and lower heating value comes from whether the water evaporation is considered or not. Higher heating value is calculated with the moisture being in liquid form in the product and lower heating value with moisture being in vapor form.

Gas tributaries are the stated taxpayers in the Exercise Law, the TSO, registered users and nominated storage holders. If the TSO transfers the gas directly to a registered user, the transferred gas is taxless. If the transferred gas is not for registered user, TSO pays the exercise taxes and can then charge them from the users, like from the DSO, who then charges the taxes again from the distribution network end users. Registered user is the one consuming the gas directly from the transmission network and who uses the gas for electricity production or in electricity plant’s starts, shutdowns or to maintain production preparedness.

The applied taxes can be divided into energy content tax, carbon dioxide tax and supply security tax. The amount of the tax depends on the end use. In 2021, carbon dioxide tax is 12,94 €/MWh and supply security tax 0,084 €/MWh. If the gas is used for electricity, the energy content tax is 10,33 €/MWh and if in CHP, the tax is 2,7 €/MWh. Compared to 2020, the energy content taxes were raised for 2021. (vero.fi, b)

4 PROSPECTS

Natural gas has many same risks as other fossil fuels when it comes to the resources, availability, legislation, and policy related issues. But compared to coal or oil, some risks concern only gas. These issues relate to the infrastructure needed for transferring gas or injecting LNG to the network, so some of the problems are strictly tied to current investments on the infrastructure. Another gas specific risk can relate to the political uncertainties. Especially in Finland, some risk come from the fact that most of the gas is imported from Russia and this raises concerns about the continuity of the supply. Technologies affecting the future of gases are for example biogas, Power-to-Gas, hydrogen, synthetic gases, and synthetic liquefied gases as well as gas fueled transportation vehicles. Some of these technologies and their impact are addressed in the following sections.

The fundamental uncertainties about the future of gas in Europe can be categorized to three groups: ambience, energy markets and infrastructure. Main questions regarding the ambience are in what the future value system and ideology in the society is. This leads to the question on which direction the energy and environmental politics are heading and what possible new legislations these politics bring. The values guide the economic growth and thus also the possible competitiveness of the energy-intense industry. Questions related to the markets are what the governmental relations are, especially to Russia, and how the gas markets are unifying in Europe. Market development will be affected by the gas sources and demand as well as the technology development of new sources, such as biogas and synthetic gases. The uncertainties related to infrastructure are the possible use of it in the future, meaning do the possible new gases need a pipeline network and injecting points or how does the transfer operate in the future. (Gasgrid, 2020)

There are several questions that need to be answered to determine the significance of gas in the future. Finding absolute answers to the questions is impossible, but possible scenarios can be examined to find the main risks and possibilities, and this is done in the upcoming chapters. Table 2 contains some of the main concerns about the future trajectory of gas.

Table 2. The main questions on determining the future significance of gas (Gasgrid, 2020).

	Fundamental concerns for the future role of gas
Political	· What are the relationships between the Member States and how much power does the EU hold? · Can the gap between the gas supply and the demand be balanced by EU's inner energy markets? · What the focus is for environmental political guidance in Finland, and what is the taxation and legislation? · Is gas used as a power-tool?
Economical	· In what direction is the economy developing? · Which country is the industrial production transferring or is that kind of change happening? · How energy-intense industry is being treaded from incentives point of view? · How is the market unifying in Europe?
Ideological	· What factors are considered in the decisions making as a company or a consumer? · What effects the global warming have on attitudes? · How strongly consumers seek for carbon-neutrality? · How gas' imago develops?
Technical	· Are new pipelines being build? If so, where? · What is the utilization rate of the existing infrastructure? · How the gas transfer operates? · What type of gas is produced and imported? · How other energy production forms threaten the competitiveness of gas?

Based on the study by Gasgrid Finland (2020), the highest possible impacts on the future role of gas are environmental politics, development of the infrastructure, demand changes, hydrogen economy, taxation and changes on the energy markets. Highest uncertainties then are related to the energy form changes used by the industry, competition about natural resources, new technologies and public opinion about global warming. High uncertainty as well as high impact is with small modular nuclear reactors. These would change the structure of energy production and gas demand on peak loads. Mediocre impact and uncertainty are with the role of Russia and Poland, gas security, CO_2 taxes, role of global technology companies and CHP as well as electrification of the industry and transportation. (Gasgrid, 2020) The impacts are shown as a function of uncertainty in appendix 1 and the ones with highest possible impact based on the Gasgrid Finland 's research are displayed in figure 11.

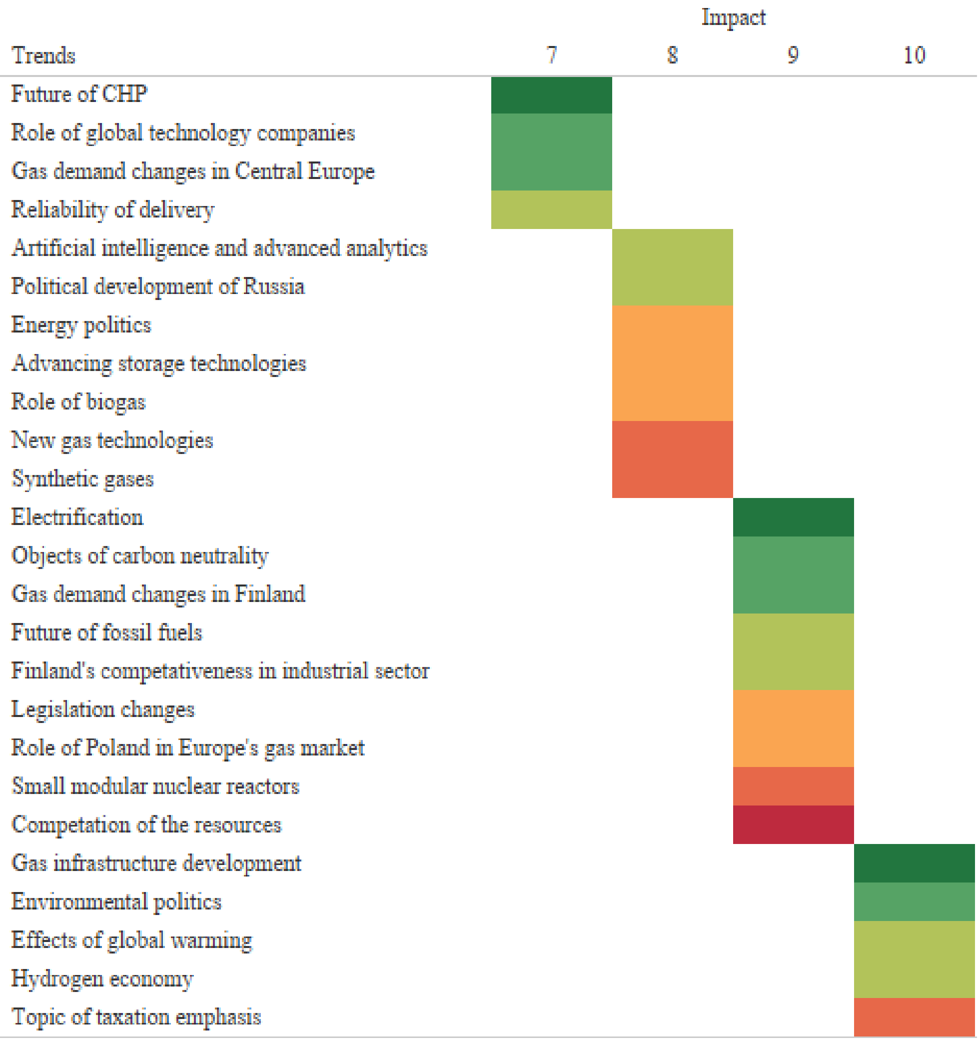

Figure 9. Trends impacting the role of natural gas on scale of 1 to 10. Green color indicates low uncertainty and red high uncertainty. (Gasgrid, 2020)

Even with many of the questions regarding the role of gas are not easy to answer, some of the affecting market changes can already been seen. The role of peat in energy production is changing and will have an impact on the use of gas by reducing the overall supply and diversity of fuels. Urbanization and the changes in work methods and industry affect the electricity as well as heat demand and thus affect the energy production and peak load demands. Emission trading has been around from the last decade and the price trends guide the use of fossil fuels. Overall, the renewable energy has had a significant impact on gas use and will continue to do so, as the production continues to increase. Increasing use of renewable energy will on one hand reduce the need for fossil fuels, but on the other hand increase the need for secure, steady and well-known energy production methods in high demands. (Gasgrid, 2020)

4.1 Alternative gases

Natural gas will unlikely keep its position looking longer into the future for it being a fossil fuel and emitting energy option. The way of making the use of gas more appealing, secure and environmentally friendly, is to make the gas using other methods than drilling to the ground. One of the main possibilities and already widely used gas is biogas. Other innovations addressed in the following chapters are hydrogen use as a fuel and Power-to-X technology, which is the method used to produce hydrogen and synthetic natural gases.

4.1.1 Biogas

Biogas is created in natural degradation of organic material by microorganisms under anaerobic conditions. Biogas can be produced from waste, agricultural or industrial residues, sewage sludge and manure, to name a few. Biogas has become one of the most attractive renewable energy pathways as it promotes circular economy and has various economic benefits. Fuel sources for the biogas production can be traditionally used as fertilizers in the agriculture, but that can cause water contamination and pollution. By using the manure first as a source material for biogas and then the byproduct digestate as a fertilizer, harmful pathogens are not led to the ground. Biogas production at farms or waste treatment facilities also reduce the odors and methane emissions from the storage. Biogases possess various support schemes and can be used in generating both heat and electricity as well as in the transportation sector. (Scarlat et al. 2018)

In 2018, total production of biogas in Finland was 931 GWh, of which 788 GWh was used in energy production. This meant that biogas used in energy sector was 3,6 % of the total gas used. During the same year 60 % of the gas fueled vehicles consumed biogas. The production was mainly done in combined facilities, which is a traditional biogas plant utilizing multiple source materials. Other production methods were landfill gas, sewage facilities and farms. (Kaasuyhdistys) In developed countries, biogas production focuses mainly on larger scale, farm-based and commercial plants producing the product for electricity and heat use. Biogas production has seen a significant growth in the last years in Europe driven by the favorable support schemes happening in some Member States. (Scarlat et al. 2018)

For biogas to enhance its technical features, it can be upgraded into biomethane and this will open new opportunities to utilize it for example in the transportation sector. Utilizing the existing grid in the distribution, biomethane can be stored at lower cost and used easier at the places where it is needed. Europe is currently the world's leading producer of biomethane and some estimations of the future potential of biogas in Europe can be made based on data on various feedstocks. Compared to the existing production of 18 billion m^3, by 2030 the utilization could be 48-50 billion m^3 out of the total technical potential of 151 billion m^3. This shows that there is significant potential for the European biogas production to contribute more to the climate actions, especially since about half of biogas is produced in Germany and the potential in other countries is only marginally used. (Scarlat et al. 2018)

In the long term, biogas will have an important role in the EU and in Finland as the potential is still largely unexploited. The potential of using biogas will greatly be affected by the level of the price of emission allowances, what requirements will be set for the sustainability of bioenergy production and whether it will retain its carbon-neutral status in emission trading. Biogas is a part of a bio-based economy and has been favored in several countries by positive policy framework conditions. This is because biogas can significantly contribute to the development of rural areas and encourage creating new supply chains for circular economy. Biogas is a flexible in use and storable and thus important future energy carrier. But for biogas to become highly competitive fuel, there is still technological improvements to be made.

4.1.2 Hydrogen

Hydrogen has quite recently overtaken its status in all European long-term energy plans, like in the European Green Deal program and the 2050 roadmap as well as in many national renewable energy action plans that address the years 2030 to 2050. For a long time, hydrogen was considered a utopia; too expensive and far from actual working technologies. In 2020, as the European Green Deal announced ambitious hydrogen goals, a movement towards national hydrogen plans commenced. In the publication by the Ministry of Economic Affairs and Employment of Finland (2017) hydrogen is seen as one of the options for renewable transportation, but nothing is said about it being used also in other energy sectors in 2030. The publication states, that hydrogen is the only energy carrier that enables completely carbon free transportation. While in the upcoming decades, biofuels are the most important fuels to replace fossil fuels in Finland, hydrogen will also gain a foothold over the long term. (Ministry of Economic Affairs and Employment, 2017) Even with great potential to being the solution to solve numerous problems, current estimates represent hydrogen as only a modest fraction of the energy mix in Europe and it would require extensive investments, so the shift to hydrogen economy will not happen instantly.

Hydrogen suits for many purposes. It is currently used in industrial processes and in some gas vehicles. In the future it could be utilized in numerous industrial purposes, fuel heavy vehicles, like trucks or even airplanes, and used as an energy carrier to balance the renewable electricity grid. One of its challenges is that it is currently produced from fossil fuels and producing it without them would require investments to new infrastructure and significant amounts of renewable electricity. Therefore, the prioritization on which the investments are targeted should be made collectively. In Finland, fossil-free hydrogen, also known as green hydrogen, could be targeted for industrial purposes, like fertilizer or steel production and oil refineries, where fossil fuels could be replaced with hydrogen. Hydrogen could also make significant changes to the transportation sector ‘s emissions and help with the problems regarding electric vehicles range and energy needs. (Nordic West Office, 2020)

Hydrogen has relatively low heating value compared to other gases, so utilizing it as a substitute for natural gas would also require energy efficiency improvements in the applied technology to get the needed energy output. In the heating sector for example, hydrogen can potentially be blended with natural gas and thus contribute to decarbonizing of heating, but with adequate fuel properties. In transportation sector, the properties could be enhanced by further manipulating hydrogen to hydrogen-delivered synthetic fuel. Figure 12 shows the higher heating values of different gasses. The technical method for producing hydrogen is explained in chapter 4.1.3.

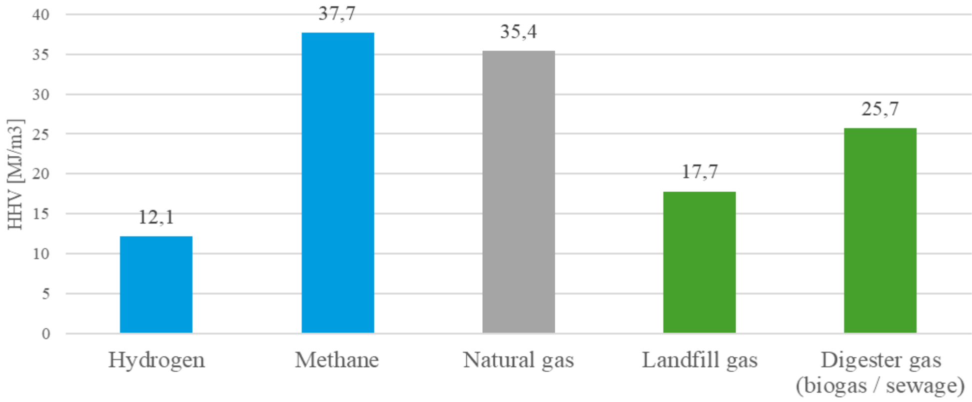

Figure 10. Higher heating values of different gases (Engineering ToolBox).

Specific hydrogen production goals are missing from Finland's own renewable energy plans, but the European Green Deal program suggest a goal of at least 40 GW production of hydrogen by 2030 (European Commission, 2019). As a comparison, this would be 0,01 % of EU's energy production in 2018 (IEA). There are some challenges to tackle before hydrogen can be fully utilized. For example, hydrogen is highly flammable, and therefore its safety issues need to be estimated and infrastructure build correspondingly. Its production needs to be made economically feasible and its utilization technically possible. Also, the share of renewable electricity needs to be increased for hydrogen to be produced from green sources. For these issues to be solved, national input is needed as well as key players to join the hydrogen alliance. The next steps for Finland would be setting up specific hydrogen goals covering all sectors, making incentives for hydrogen marketplace, setting up blending requirements for synthetic fuels and supporting industrial scale hydrogen production as well as large multi-company projects. (Nordic West Office, 2020) A traditional SWOT analysis was made by the Business Finland in 2020 regarding the production and the use of low-carbon hydrogen in Finland. The results are displayed in figure 13.

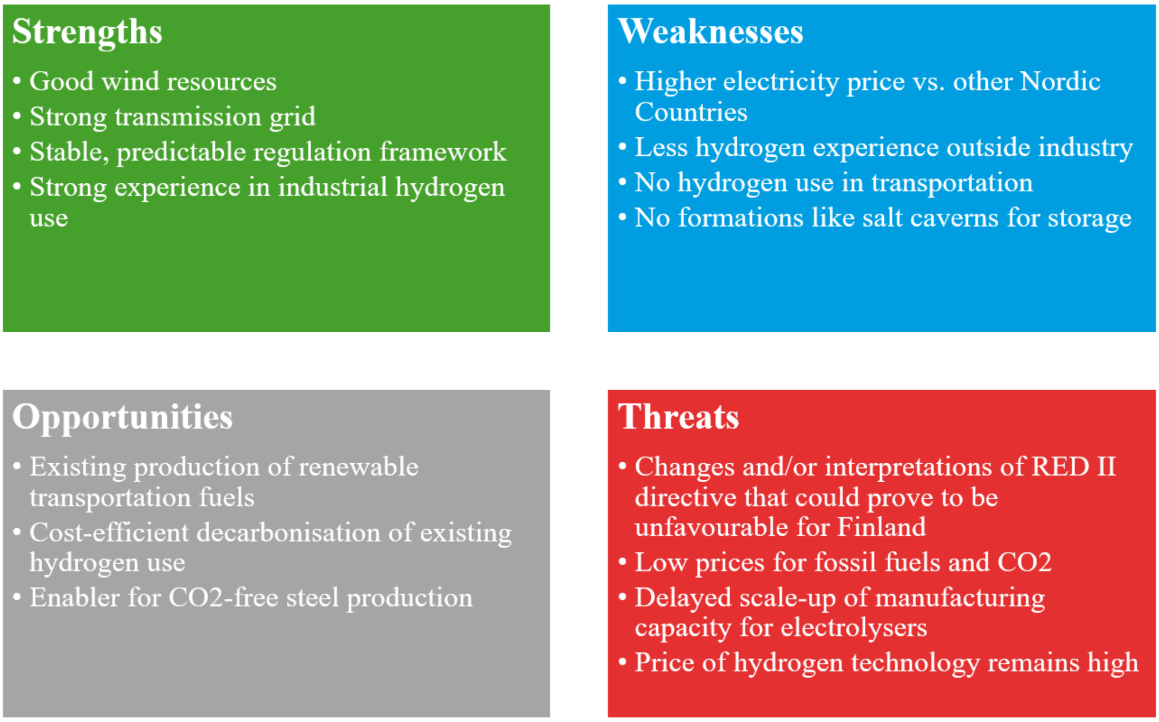

Figure 11. SWOT analysis for Finland's hydrogen production and use (Laurikko et al. 2020).

The future cost of hydrogen from renewable sources is yet unclear, but it is estimated to have gone down already by 60% in the past ten years and is expected to halve in 2030 compared to today. Today's fossil-based hydrogen is around 1,5 €/kg and renewable hydrogen around 2,5-5,5 €/kg, with the price of renewable electricity driving the prices. As a comparison, natural gas was about 1,33 €/kg and biogas about 1,45 €/kg in Finland for transportation in 2018 (Kestävä Energiatalous, 2018). In some regions, where renewable electricity is cheap, green hydrogen is estimated to become competitive to fossil-based one in 2030. (Nordic West Office, 2020) However, the cost of renewable hydrogen can go down quickly, and different estimates come up with different solutions for the years of the cost decline, all around 2030 to 2050.

4.1.3 Power-to-Gas

Power-to-X (PtX) is a technology for reforming electricity into something storable. Electricity can be used to make liquids, gasses or solids. PtX has been conceptualized in the late 2000s, but the idea of using renewable electricity to produce other energy carriers is not new. The first period of pioneering activity was from 2000 to 2010, when the knowledge was enhanced. From 2011 to 2018, the vision of an energy system based primarily on renewable energy has put emphasis on the challenge of balancing demand and supply, and this coincided with the development of first pilot plants. Most recently, technology providers and selectors increasingly turned their focus from asking project-specific resources to advocating for regulation change at European and national level. (Decourt, 2019) PtX is estimated to be the system balancing solution for seasonally variant and uncontrollable energy production. The end product of the PtX can be utilized for example to fuel vehicles, produce heat in boilers or even as a food source. The source molecules could be captured from industry or power sector's emissions or even from the air. PtX contributes significantly to the change into the circular economy, but it still faces difficulties for being economically feasible.

Using PtX to create gas is referred to as Power-to-Gas (PtG). In the process, electricity flows into the water splitting its components into two, creating hydrogen as an end product and excess oxygen to be released into the atmosphere. If there is also input carbon dioxide, the product is methane. The product can be then either further manipulated into liquids, chemicals and other synthetic gases, or stored as it is for energy production. PtG enables controllable electricity grid with renewable production methods via flexible demand and supply exploitation. (Wulf et al. 2018) Figure 14 clarifies the process in PtG.

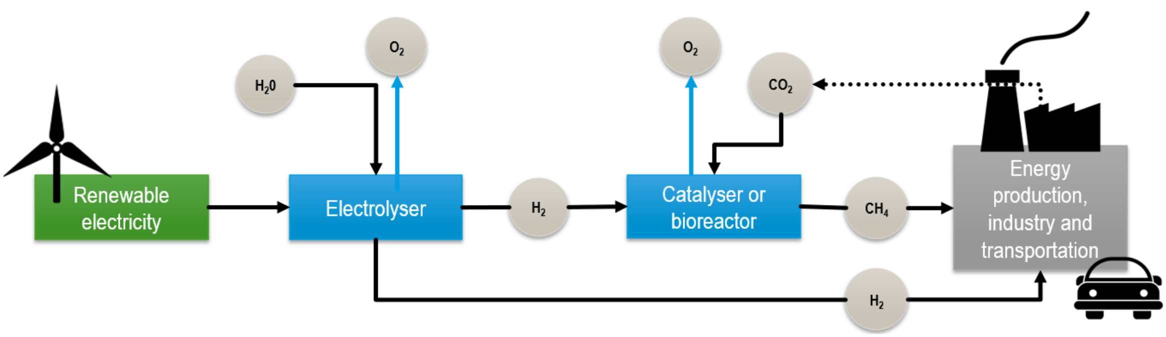

Figure 12. Power-to-Gas process flow (Wulf et al. 2018).

A study by Benoit Decourt (2019) investigated the drivers for Power-to-X diffusion in Europe. The paper finds that the European technological innovation system in PtX is growing and shows early signs of system building motor of innovation. However, the lack of market formation and conflicts of interest might be in a way of future development in Europe. The analysis suggests that the major contributing country to facilitate the PtX technology would be Germany. Based on the data collected for the research in 2018, there are 970 actors in the technological innovation system. The main actors are either knowledge organizations, enactors, electrolysis providers or industrial gas players. Over 70 % of the actors are directly involved with the PtX-related research and development projects and out of the actors, about 46 % are from Germany. Second largest contributing country would be, based on the number of actors, France. The main organizations affecting the PtX technological innovation system are the Hydrogenics GmbH, the Fuel Cells & Hydrogen Joint Undertaking, the European Commission and the French Alternative Energies and Atomic Energy Commission. (Decourt, 2019)

The research identified three main divers for PtX: large enactors and selector base, positive feedback loops, and success in regulatory framework adjustments. To expand the production from small-scale pilot plants to large scale utilization, technology providers with significant resources are needed. Along with the first movers like Hydrogenics and NEL Hydrogen, Siemens and ThyssenKrupp are now deeply involved in expanding the production, strengthening the advocacy coalition and limiting the resistance to change. The positive feedback loop is formed, when more and more events are discussing the PtX, more resources are available, regulation evolves, and entrepreneurial activities are buoyant with a growing number of projects announced. Lastly, shaping of a positive regulatory environment is important driver for the full utilization of PtX technology. (Decourt, 2019)

Finland is estimated to be 11th biggest country to contributing European PtX research and development (Decourt, 2019). Finland being distinguished country in many low-carbon technology projects, in PtX Finland is not as significant actor due to missing large enactors, although some research is being made. Finland is traditionally focused on bio-based energy system and thus the focus in gas-related research has been somewhat more on that. In 2020, Wärtsilä announced that they started a new project regarding PtX in Finland with 1 m€

investment from the Business Finland, so in the near future the technology development also in Finland could make significant leaps forward as there are also other companies joining the innovation development (Leiwo, 2020). If the PtX follows a learning curve like many innovations, it would be now on stage 2. The technology learning curve has five stages; research and development, demonstration, pre-commercial, supported commercial and fully commercial. If the PtX follows the traditional learning curve, it is estimated that the technology would be supported commercial roughly in 2035-2040 and fully commercial by 2040-2045 (Gasgrid, 2020).

4.2 Significance of gas in the future

The future path of gas is yet uncertain and varies greatly depending on the country and its policies. The future can only be estimated based on different scenarios. For Finland, Gasgrid Finland has conducted four main scenarios for the period 2020-2040 that are used in this thesis as a base for the future timeline in addition to EU's 2050 Roadmap and the European Green Deal program, which are both discussed after the introduction to Gasgrid Finland 's scenarios. The scenarios consider possible legislation and policy changes as well as demand and supply changes due to public opinions, technology development and infrastructure changes.

First of the scenarios looks Finland as an environmental leader. Finland focuses on the green and sustainable energy policies and thus aims for exemplary leader for Europe. In addition to government taking significant steps for renewable and sustainably society, companies have made their own additional efforts for cutting emissions and enhancing efficiency. These efforts stem from the new generation taking the lead in decision making and aiming for sustainable economic growth. The society is strongly electrifying, and traditional gas is losing its status. As Europe is still relying on natural gas to balance the electricity production, Finland has shifted to hydrogen economy, where traditional gas infrastructure does not have significant role in the energy systems sector integration. (Gasgrid, 2020)

Where the first scenario focuses on Finland's lead in hydrogen and electricity, the second scenario sees all Europe taking extensive methods to cut off natural gas. In second scenario, advanced fuels take the lead. Strong co-operation in EU allows significant improvements in gas technologies to be made, such as Power-to-Gas. The energy system is based on zero-emission technologies, which require storage capacity. Gas infrastructure is utilized in this balancing as it is developed to be more flexible and to contain biogas and hydrogen. Political decision-making guides the investments to the utilization of new technologies and extensive sector coupling in Finland brings Finland to the head of hydrogen and Power-to-Gas development. Gases in transportation also become more popular and hydrogen is used in heavy delivery, at sea and at local transportation solutions. Even though, both scenarios see the future in Finland as sustainable, they differ in the EU's attitudes. First scenario estimates Finland to set much higher goals for sustainability and environmental goals than EU. In the second scenario EU and Finland have the same high goals set and this enables faster technological development, which is required, for example, for PtX to become competitive new technology. (Gasgrid, 2020)

Third and fourth scenarios are not as optimistic in decarbonization and emission control as the first two scenarios. Third scenario sees still Europe as the global environmental leader, but Finland struggles with the weak economy and is lacking behind on the development. Central Europe starts to shift to hydrogen economy, but the same improvements are still not possible in Finland as industry does not have the same desires to invest. Natural gas is used to bring reliability to the system as the wind power capacity increases, which also lowers the electricity prices. The increasing use of renewable energy lowers the need for CHP gas production and gas is used mainly for back-up or peak demand production. Due to fiscal reasons energy and fuel taxes are constantly increasing and financial supports for energy technology solutions are cut. (Gasgrid, 2020)

The last scenario estimates gas to continue to keep its traditional status in Europe. As the era of globalization is over and Russia's interests towards Europe gets stronger, Finland wants to guarantee its energy security with storable and controllable energy production method and LNG is used to substitute more emitting coal. The protectionism will take the focus off global warming and environmental investments and shift the focus on security of supply. EU loses its advocacy and shared environmental goals dry out. Alternative gas technologies are studied in Finland, but they will not lead to implementation due to lack of investments from the industrial sector and lack of financial support from the government. When carbon capture becomes feasible, natural gas will strengthen its status as an energy production method. (Gasgrid, 2020)

When estimating, what scenario or mix of scenarios will be the course for the future of gas for 2040, the questions stated in table 2 need to be answered, but that might be difficult or even impossible task. Looking at the recent governmental and regional decision-making, most probable scenarios in my own opinion could be the more optimistic and sustainable scenarios. But if Finland faces significant economic and financial problems, investments and policies to stall the global warming are left to the background. The scenarios were conducted to reach the year 2040, but it is uncertain, are these changes too fast and thus, would the more pessimistic scenarios be more probable for the near future. A summary of the scenarios is displayed in the following table.

Table 3. Summaries of the future scenarios in Finland (Gasgrid, 2020).

	Political	Economical	Ideological	Technical
Scenario 1	Finland makes more ambitious goals than EU regarding climate change prevention.	Alongside of GDP other economic indicators are examined, like sustainability.	Environmentally responsible and sustainable mindset cuts through all sectors and education.	Focuses on electrification. Gas production is local, hydrogen takes the lead in renewable gases.
Scenario 2	EU is unified and takes ambitious goals towards renewable society.	Positive economic growth is strong, and Finland aims to be the leading country in renewable technology.	Environmental values characterize national and regional policies, education, investments and research.	Gas mix is versatile: biogas, LNG and hydrogen. Power-to-Gas technologies are developed. Gas system balances electricity system.
Scenario 3	EU remains at the current path in environmental politics. EU is unified, but Finnish politics are described to be in conflict.	Economic growth is weak, and the change is slow. Asia operates globally as a driver of growth.	In Finland, environmental questions are left on hold. Nationalism starts to be emphasized. EU struggles to maintain binding goals for cutting emissions.	Gas use decreases. No significant new technologies. Wind energy, utilization of heat waste and heat pumps are the main investment points.
Scenario 4	Strong geopolitical tension in the Artic Region, Russia and Asia. Protectionism becomes more popular.	Economic regression starts.	Global initiatives are put to side for finance and security issues.	Technology development is slow. Gas is used to replace coal, and LNG injecting points are growing to decrease the need for natural gas imported from Russia.

Energy Roadmap made for 2050 sees the future as secure, competitive and decarbonized. In 2050 the energy system would be transformed. The production pallet is decarbonized and fuel costs are lower, but capital expenditures are higher. Electricity plays an increasing role and in short-term the electricity prices will increase, but after 2030 the prices would start to decline. Energy savings throughout the system are crucial to cut the emissions and renewable use rises substantially. The Roadmap estimates Carbon Capture and Storage (CCS) to play a pivotal role in the system transformation and nuclear to remain as base load provided. In the households, the expenditures increase and decentralized production becomes more popular. For the system transformation to be possible, energy savings must be made, demand managed, smart technology and storage improved, and the energy mix change started right way. The Roadmap identifies also gas as one of the key players in the transition. (European Union, 2012)

In the 2050 Roadmap, gas is used as a substitute for coal and oil in short to medium term and this would help to reduce emissions with the existing technologies until 2030 or 2035. In 2050, gas used is estimated to be slightly higher in the energy sector than in 2012 due to evolving new technologies for sustainable gas. For this to be possible, gas market in the EU needs more integration, liquidity and diversity of supply sources. Storage capacity also needs improvements for gas to be competitive fuel in heat and electricity sector. Long-term gas supply contracts may continue to be necessary to underwrite investments. Utilizing more shale gas, LNG, biogas and hydrogen would remove concerns about gas' import dependency, but it is yet uncertain, when the unconventional sources become significant. Without CCS, long-term utilization of gas might be limited to flexible backup and balancing capacity. The CCS technology would need to be applied in 2030 to reach the decarbonation targets in power sector. (European Union, 2012)

Most recent EU's climate communication is the European Green Deal (COM/2019/640). As it is the most recent plan for decarbonized 2050 and coming from highly influencing organization, the European Commission, its actions can be treated with the most gravity. The ground for the energy production 's future image is the 2012 made roadmap, but with even more ambitious goals. The Green Deal focuses widely on all aspects of environmentally friendly society. It is estimated that current policies reduce GHG emission only by 60 % by

2050 compared to the 1990 level, so more actions need to be taken to achieve decarbonized future. In the Green Deal, the level of emissions reduction is set to at least 50 % reduction by 2030 in responsible way. By the June of 2021, the Commission will review and propose to revise all the relevant climate-related policy instruments. The instruments will comprise the Emission Trading System with possible extensions of emissions trading to new sectors, emission control outside the trading system and regulation for example to land use and forestry. The goal is to amend the Climate Law and the Energy Taxation Directive accordingly. (European Commission, 2019)

The European Green Deal focuses, like the 2050 Roadmap, to renewable energy sources in consumer beneficial and involving strategy. The decarbonization of the gas sector will be facilitated via addressing the issues related to gas' methane emission, via forward-looking for competitive gas market and via enhancing support to new gas technology development. To maintain affordable price in the energy transition, increased cross-border and regional cooperation are needed. The new regulatory framework should foster the deployment of innovative technologies and infrastructure, such as hydrogen network. The European Green Deal sees hydrogen as the main sustainable gas to implement to meet the emission control goals. Sectors that are hard to decarbonize, like heavy transport, are the ones where low-carbon fuels, such as hydrogen, are needed. The path towards European hydrogen eco-system started from the European Clean Hydrogen Alliance formed in 2020. By 2024, there would need to be at least 6 GW of renewable hydrogen electrolysers in the EU. By 2030, hydrogen would be an intrinsic part of the integrated energy system with at least 40 GW electrolysers. And by 2050, hydrogen would be deployed at a large scale across all sectors that face difficulties in electrification. (European Commission, 2019)

Upcoming actions stated in the European Green Deal indicates that modifications to the Climate Law, Energy Taxation Directive, Energy Efficiency Directive and Renewable Energy Directive would be made in the near future to make the EU's Member States obligated to follow the climate actions at adequate level (European Commission, 2019). The European Green Deal launched new growth strategy for the EU and in the December of 2020, European Council endorsed the Green Deal and gave their full weight to the measures it contains (European Council, 2020).

4.2.1 Short-term possible market changes

The short-term direction of the path for natural gas is determined by the effects of global pandemic and the economic effects it might cause. If economic growth is possible in the upcoming years, the development of renewable and sustainable gas is feasible and environmental goals are likely to be met in the EU. There are also technical improvements that will affect the markets as finished soon. For example, the on-going pipeline projects will make difference in the price trends and security of the supply. As the European Green Deal was recently endorsed by the European Council, possible amendments to the directives and legislation may be relevant in the upcoming years as well. The timelines for the gas markets in Finland proposed in the following chapters are conducted from the most sustainable scenarios stated in chapter 4.2 and technical prospects in chapter 2.1 concerning the pipeline projects. The specific years of each action are based on the estimates of the writer and indicate only the relations of the actions, not the absolute truth, and this timeline should be used only to evaluate the possible market trends.

Finland's 2035 carbon-neutrality goal indicate that in the period of 2020-2035, significant investments are being made, most likely first to existing commercial technologies and then to more advanced technologies once they have been tested and developed further. If the European Green Deal 's suggestions for the directives are assumed to be approved, the timeline includes the legislation changes like the EU's Emission Trading System (ETS) expansion, taxation incentives for renewable gas, compulsory five-year reviews on the actions taken to reach EU's carbon neutrality by 2050 and regulations to emissions and land use. Market changes could be made also to unify the European gas markets. These action focus on setting the practical policies convergent, for example regarding the regulatory framework. The possible timeline for 2020 to 2030 is seen in figure 15.

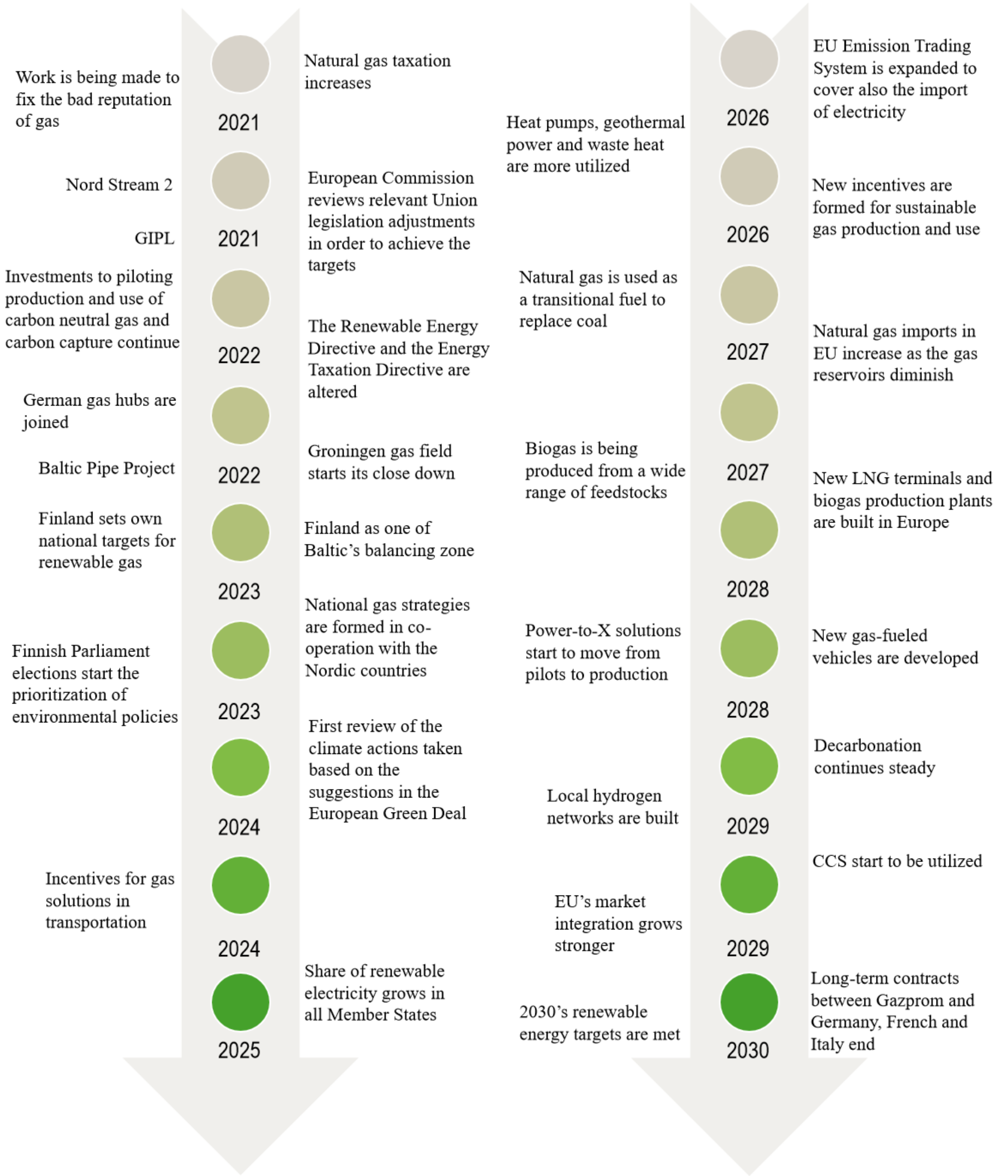

Figure 13. Possible timelines for 2020-2025 and 2025-2030.

4.2.2 Long-term possible market changes

Looking to the year 2050, European Union targets to be carbon neutral and Finland targets to be carbon negative, meaning that the forests would bind more carbon than the country is emitting. The actions towards these targets are not yet defined but some upper-level trends can be estimated for the period of 2030 to 2050 and are displayed in figure 16. In addition to the trends in the timeline below, there is a possibility for similar market changes as in electricity markets, like changes in the balancing zones, balancing resolutions, measuring regulations and more co-operations with the neighboring countries.

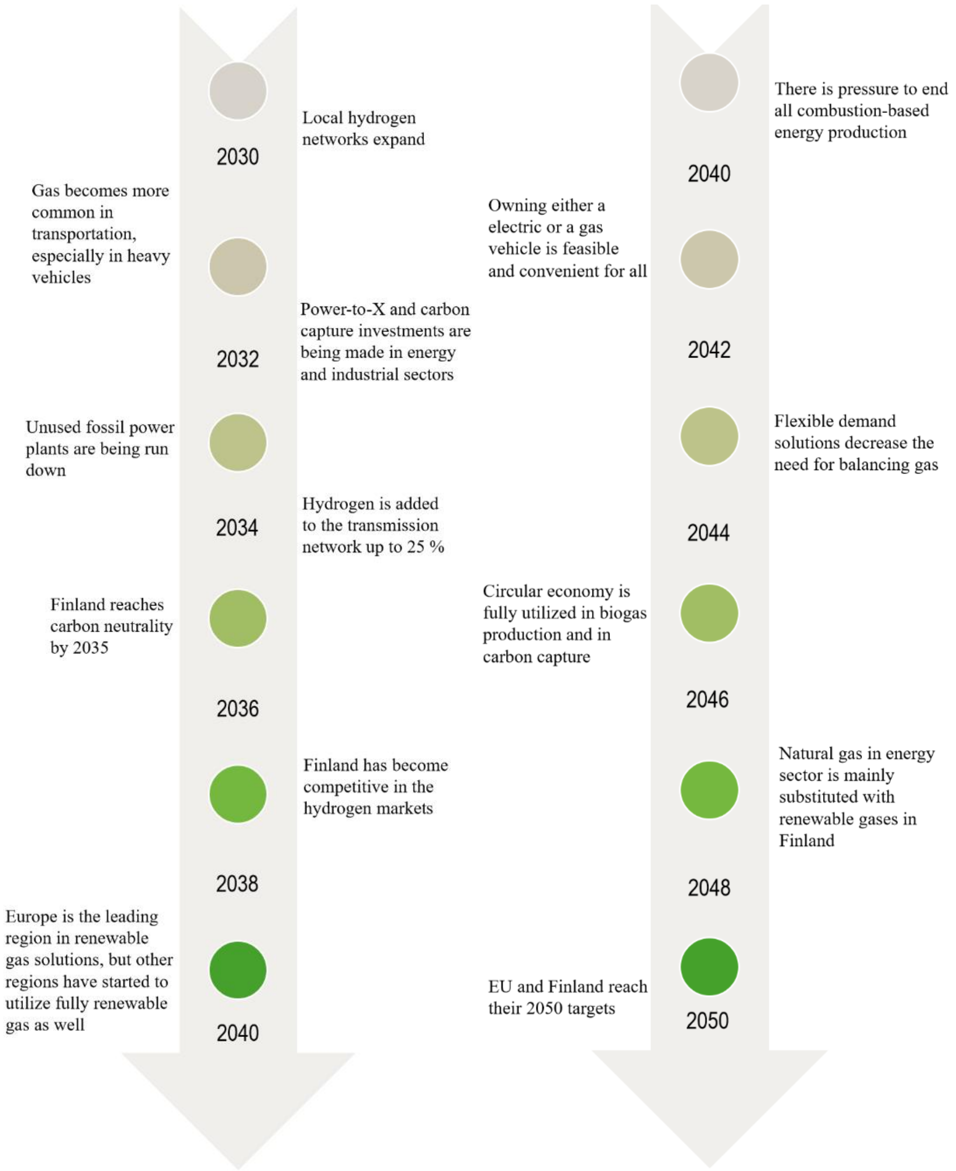

Figure 14. Possible timelines for 2030-2040 and 2040-2050.

5 GAS TRADE IN TAMPEREEN SÄHKÖLAITOS IN 2020

In 1888, first municipal electric company in Finland was established. Since then, it has only increased its energy production from the first electric lights to comprehensive district heating network, and most recently, district cooling. Energy mix in Tampereen Sähkölaitos is quite complex; biomass, peat, gas, municipal waste, hydro, wind, pellets and woodchips. Maximum electricity power is 235 MW and maximum heating power is 320 MW from the CHP plants and over 800 MW from the heat boilers. Out of these powerplants, Naistenlahti 2 burns biomass and peat in maximum of 120 MW_{th}, Lielahti burns natural gas in maximum of 160 MW_{th} and the waste-to-energy powerplant in Tarastenjärvi burns municipal waste in maximum of 40 MW_{th}. In addition, Tampereen Sähkölaitos operates a reserve power plant for Fingrid, the electricity transmission system operator in Finland. The power reserve, Naistenlahti 1, burns natural gas as a primary fuel. (Tampereen Sähkölaitos)

Tampereen Sähkölaitos, shortly known as TKS, operates as the area’s distribution network operator. It works as a gas retailer at the local retail market and as a trader for the wholesale market. TKS has currently the shipper position available but does not exercise its operations and thus is now only referred to as a trader. TKS also uses gas from both its own distribution network and from the transmission network. Currently, TKS is a part of a balancing group, not a balancing responsible party itself. Figure 17 subtracts the gas procedure currently in the TKS.

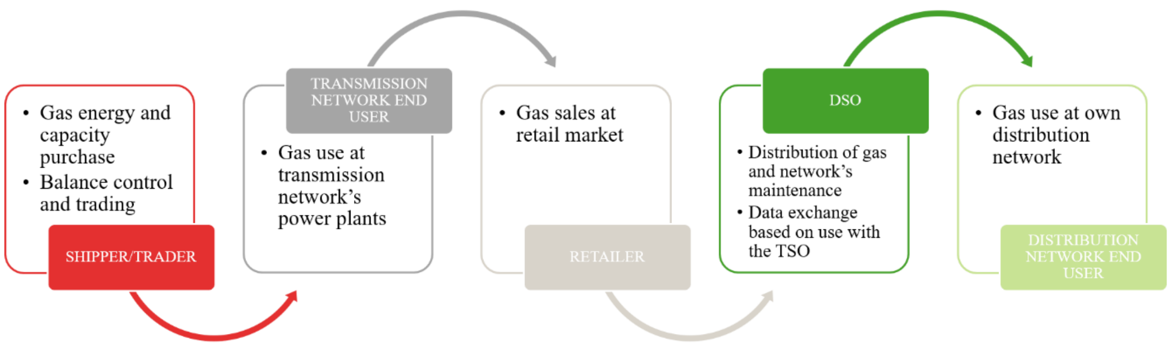

Figure 15. Gas business unit in Tampereen Sähkölaitos in 2020.

5.1 Gas flows

Gas consumption in Tampere follows greatly seasonal demand and gas is a crucial part of the area's district heating network. When the district heating demand gets higher, gas consumption also increases as the peak demand heat is produced in boilers and in gas turbines. Gas turbines operate mainly in sub-zero temperatures and boilers are used to balance the heat supply in quick demand peaks, such as cold nights. Other distribution network end users than heat producers use the gas mainly for industrial purposes, which also follow somewhat the season. In the summertime, industrial use is lower due to the low temperatures and possibly due to seasonal production changes. Residential gas use in the district is low, like in all Finland. As seen in chart 18, significantly over half of the TKS's gas use is being used in gas turbines, which produce both heat and electricity.

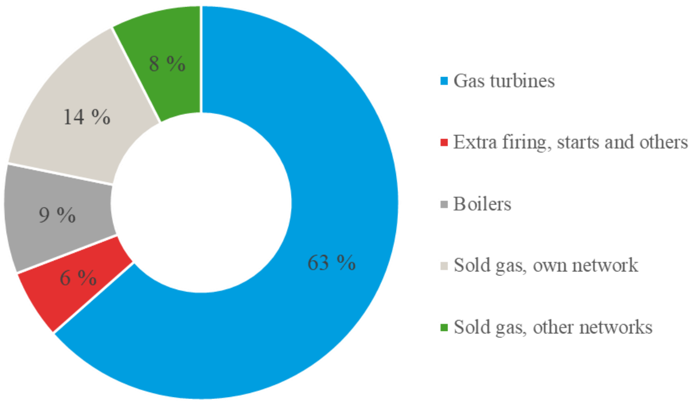

Figure 16. Percentual use of natural gas in different sectors in Tampereen Sähkölaitos in 2020.

As the gas use follows seasonal demand in the TKS, the gas is purchased based on the district heating demand forecasts. In 2020, the gas contracts were mainly fixed-term contracts such as monthly and quartal contracts. Because there is also retail market's gas consumption, some yearly contracts were also made as the consumption is somewhat constant. Fixed-term contracts used the Gaspool front month index as the base for the pricing. Some purchasing was made also in the GET Baltic gas exchange, which allows more variation to the use as there are no mandatory minimum purchase amounts. In addition, some daily and intraday orders were made. Figure 19 demonstrates the contracts and the consumption. There can be seen that more predictable use is purchased mainly as a fixed-term orders and less predictable use mainly from the gas exchange and short-term orders from shippers.

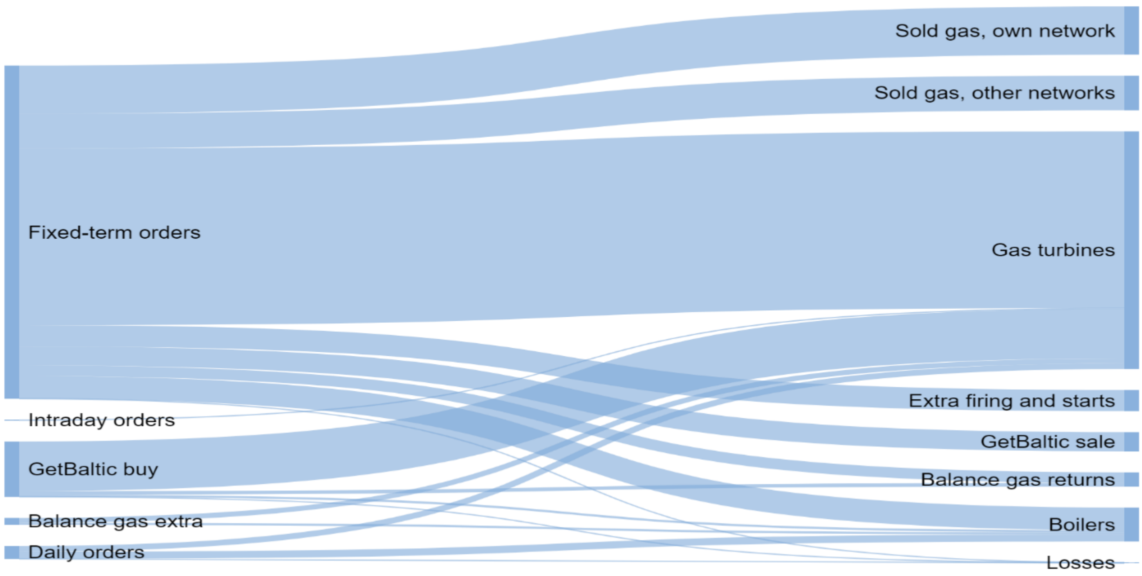

Figure 17. Gas flows based on procurement contracts in Tampereen Sähkölaitos from January to September in 2020.

Over the years, gas consumption in the TKS has been decreasing (figure 20). The reason for this is a combination of multiple things. Firstly, as the gas use is highly dependent on the district heating demand, high winter temperatures make the consumption lower. This is of course a fluctuating variable and cannot be strictly used as a concluding evidence of the gas use trend. Another, and more comprehensive factor, is the changes in the district heating production. In 2013, the boiler using pellets started its operation. In 2015, the gas-powered turbine plant, Naistenlahti 1, was transferred into a power reserve. In the same year, the waste-to-energy power plant as well as the wood-chip-fueled boiler started their operation, and a scrubber was added to Naistenlahti 2. (Tampereen Sähkölaitos) All these new investments moved TKS closer to more sustainable district heating and significantly reduced the need for natural gas in the energy production. The trend in sustainable investments remains ascending, partly due to hard taxation facing natural gas. For example, the new biomass-based power plant, Naistenlahti 3, is estimated to start its operation in 2022 (Tampereen Sähkölaitos).

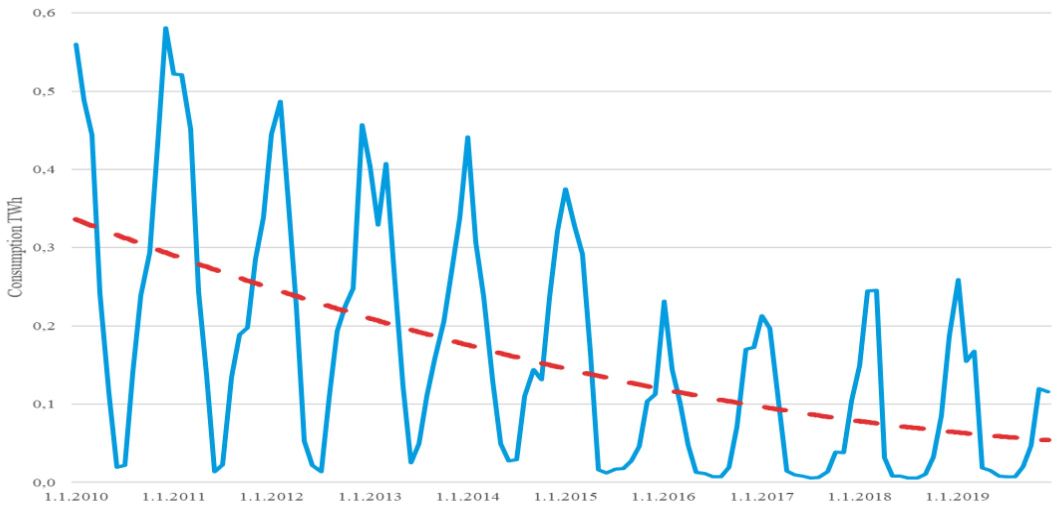

Figure 18. Gas use in Tampereen Sähkölaitos from 2010 to 2019.

5.2 Characteristics of distributed gas in Tampereen Sähkölaitos

The characteristics of distributed gas is important knowledge for the evaluation of the retail sales contracts and possible new market operations. In this paper, the gas consumed by the end users who purchase the gas from TKS is addressed as the distributed gas. There are also distribution network end users, who purchase the gas from other retailers, but those are not used in the evaluation as there is not enough available information. Distributed gas was 15 % of the total use in 2020. From this point forward, some exact consumption and price values are covered for confidentiality purposes.

The distributed gas has a distinctive yearly, weekly and hourly profile as seen in the figure 21. During the summertime, distributed gas is 50 to 90 % of the total gas use in TKS and during the winter, the percentage is only about 5 %. This indicates that the energy use in Tampereen Sähkölaitos focuses heavily on the heating period and distributed gas is not as temperature depended as TKS’s own use. In the distribution network, currently about 70 % are TKS’s customers in the retailer point of view. Some gas is also sold to other networks. In 2020, about 30% was sold to other networks and 60 % to own network from the retailed gas.

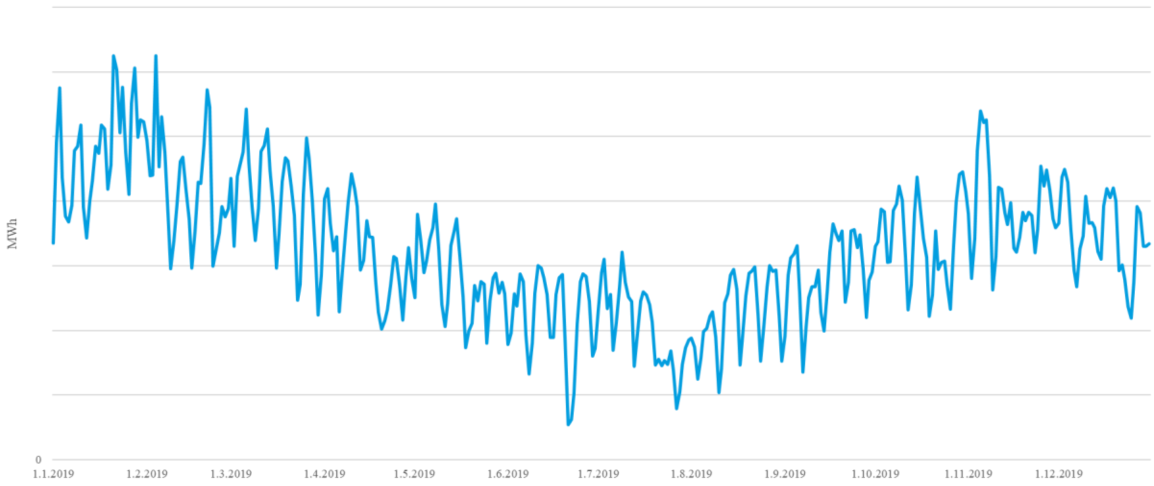

Figure 19. Total amount of distributed gas in retail market in Tampereen Sähkölaitos in 2019.

5.2.1 Consumption profile

The gas consumption profile is highly dependent on the end use sector. Energy use follows the heating demand and thus is more temperature dependent than industrial use and more constant as there is always some kind of heating demand present. Due to higher demand in residential, industrial heating and industrial production during workdays, weekends show usually lower gas demand. Industrial use tends to have high peak demands and unpredictable gas consumption as the use follows the production needs. There are also seen differences depending on the time of the day. During the day, industrial use is higher as the gas is used in machinery and production. Then, during the night, some customers start the use as the night temperatures get lower. During the winter, the use is higher on the nights than days due to more significant heat demands at lower temperatures. During the summer, day-use is higher as the industrial use and water heating is higher than the space heating. Currently, the hourly profile is not as significant as the balancing is being made in 24 hours resolution in gas day, which is from 07:00 to 07:00 the next day.

Figure 22 is a snapshot of the consumption from couple customers in one week in July. In the graph, the first day is Monday, so a clear difference is seen between the weekend and the workdays. The gas demand during the nights is also seen to be lower than during the day, which is characteristic for the summer. The temperature is shown on the secondary axis. The distribution network customers use the gas for different purposes, so there are differences in the profile of each customer. As a comparison, the figure 23 shows a snapshot of the distributed gas during one week in February. There can be seen, that consumption is higher than in the summer. The overall number of customers is also higher during the heating period. The differences between night and day and between the workdays and the weekdays is not that clear, but the temperature dependence is visible. The gas use is not easy to forecast as the overall distribution is dependent on multiple factors: season, temperature, time of the week, time of the day and most importantly the end use sector.

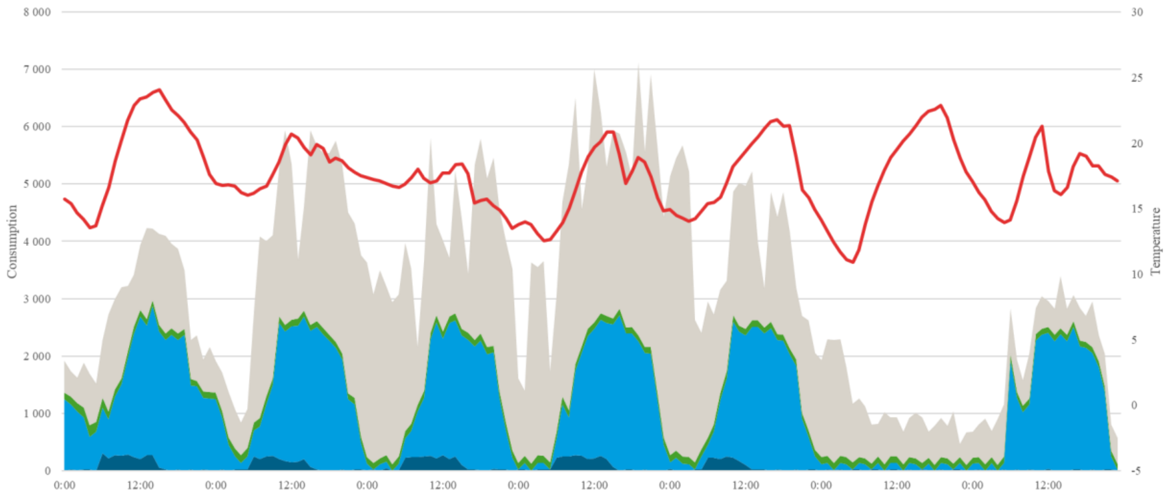

Figure 20. Consumption from 5 customers and temperature during week 31 in 2020.

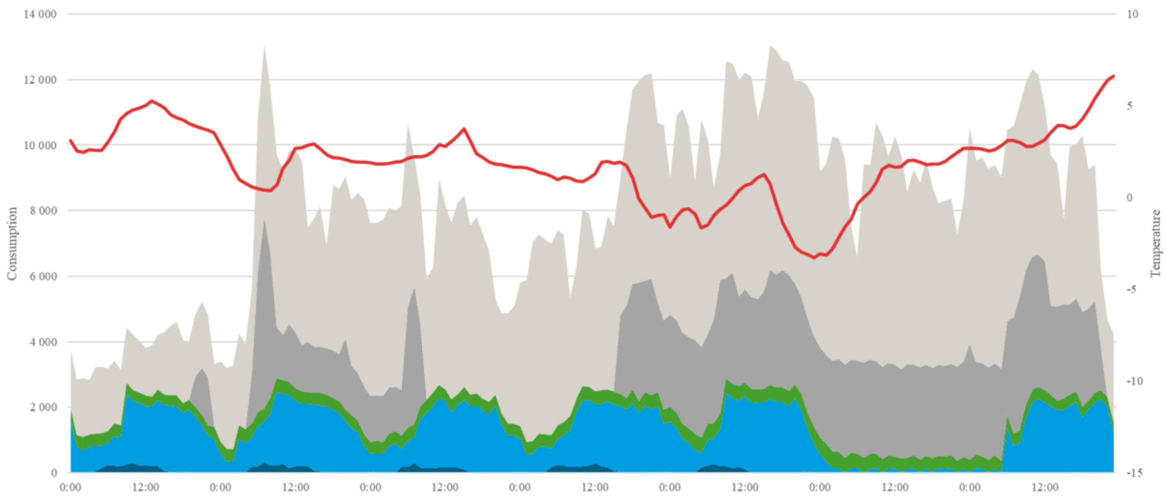

Figure 21. Consumption from 5 customers and temperature during week 7 in 2020.

5.2.2 Temperature dependency

The temperature dependency of the gas depends on the customers end use sector, but when evaluating the overall consumption, a relation with the temperature and the daily consumption is visible as most of the distributed gas is used at least partly in heating purposes, especially during the winter. Temperature dependency is shown in graph 24. There can be seen that the relation is polynomial, but there is a lot of incoherence. For example, at zero temperature Celsius, the consumption is from 16 to 40 MW per hour. The data becomes more coherent in warmer temperatures. The transition temperature seems to be about 12 degrees, in which the trend line turns from descending to a horizontal line. The data could be looked at also based on the heating demand values. Heating demand values are calculated based on the difference between the indoor and the outdoor temperatures. In the spring, the heating demand value is lower compared to the temperature than in the fall, because there is more sunlight, which will be stored in the buildings structure and thus reduce the need for extra heating. But it is also noticeable, that in the early fall, the ground is warm, which will also have an effect to the overall demand and temperature relationship.

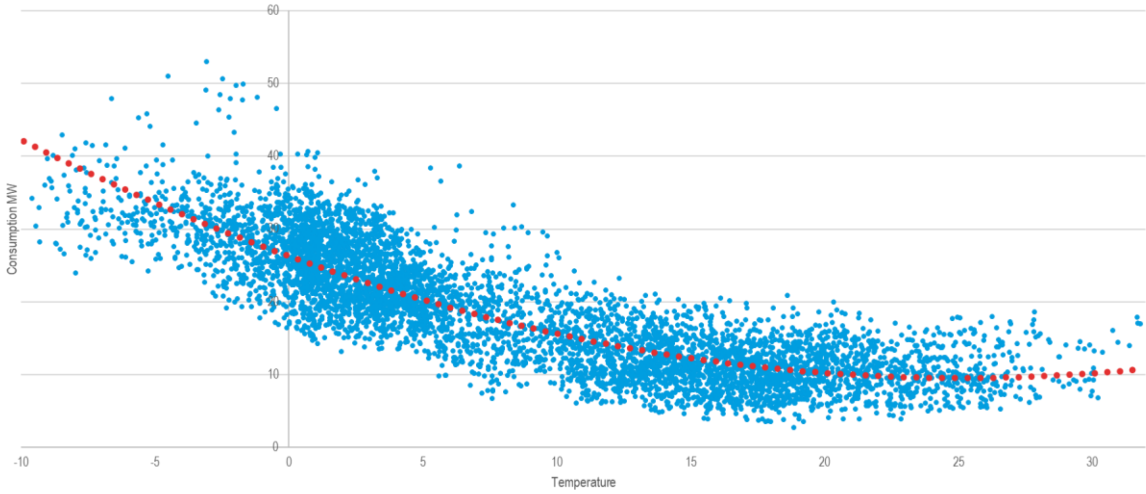

Figure 22. Gas use relation with the temperature in 2020.

5.3 Existing procedures

In TKS, the gas trade is divided between two operations: wholesale and retail markets. In the wholesale market operations, gas is bought currently as a trader, imbalance is monitored, and necessary legal issues are taken care of. The process starts with long-term focus. Firstly, the consumption is estimated mainly based on the TKS's own use estimations that come from historical data and weather forecasting. Long-term contracts in TKS are contracts between traders or shippers, mostly fixed-term index-related contracts. After the long-term operations, short-term consumption is forecasted in TKS's control room. This means consumption estimates for the next gas day for TKS's own use as well as for the retail market sales. Balancing is being made in the control room by doing gas exchange operations. Figure 25 is the wholesale market process flow broadly.

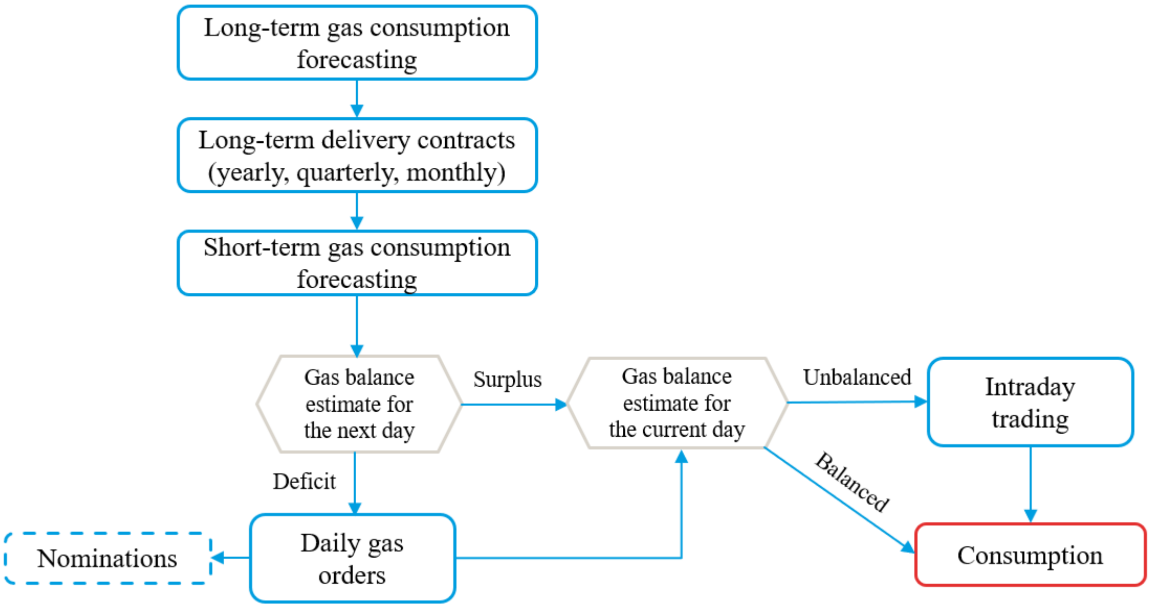

Figure 23. Wholesale market's gas procedure in 2020.

Retail market operations are currently a separate market operation in the TKS, but some co-operation is being made. When the customers' consumption is estimated for the contracts, data is exchanged between the wholesale and the retail market operations on the long-term contracts and current market trends. Currently there are no biogas injectors in the distribution network and therefore the biogas consumption is handled only via biogas certificates. Figure 26 shows the retail market process.

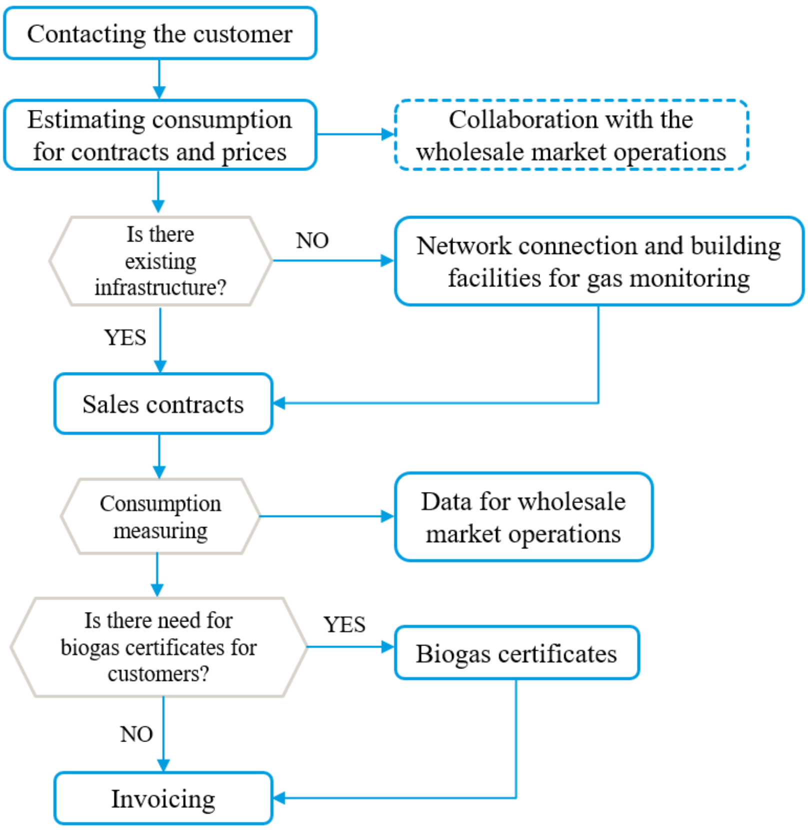

Figure 24. Retail market's gas procedure in 2020.

The relations between Tampereen Sähkölaitos and other market participants are visualized in the figure 27. The colors indicate the role in which the relations are connected. As a DSO, Tampereen Sähkölaitos must have a network agreement with the distribution network end users, a sales agreement with retailers operating in that network area and a connection and a collaboration agreement with the TSO. TKS must have a purchase agreement with another shipper or a trader, if gas is being traded, and a capacity agreement with the TSO, if capacity is being traded directly with a TSO and not with another shipper. Currently TKS operates only as a trader and thus does not need a capacity agreement with the TSO. As a retailer, TKS has sales agreements with the end users and a purchase agreement with a shipper or a trader. The dashed lines in the figure below indicate that there are currently no other market participants in that role.

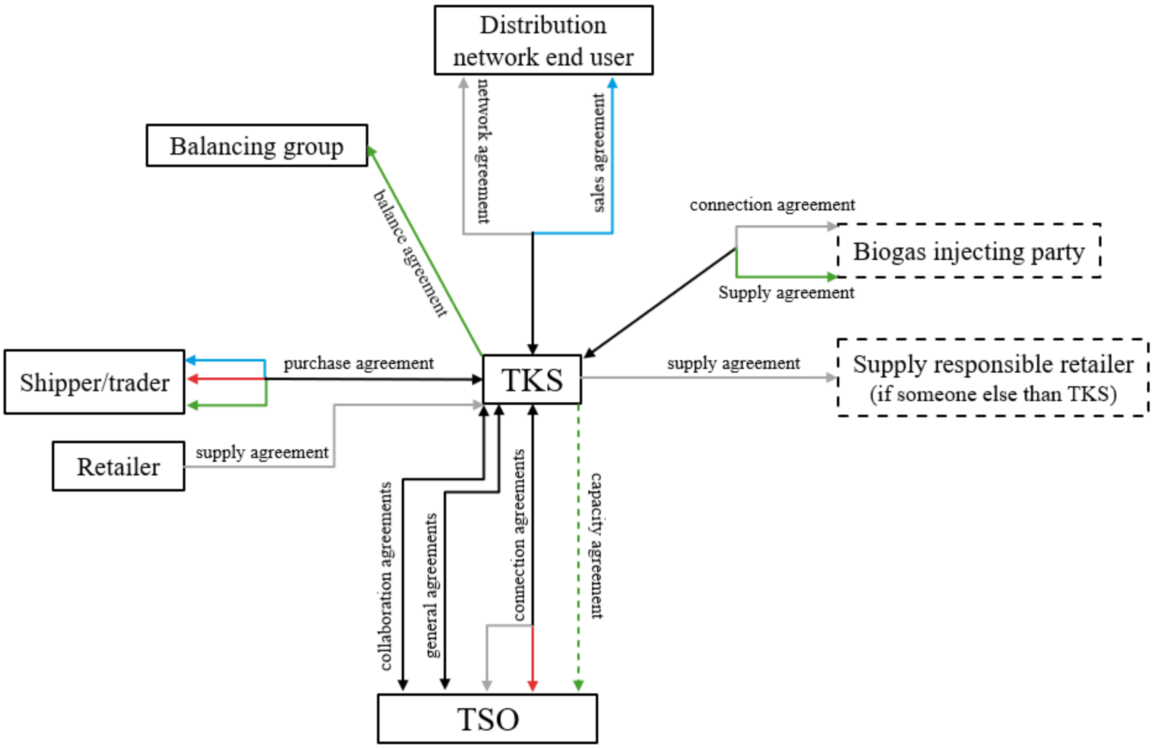

Figure 25. Relations between other market roles and Tampereen Sähkölaitos (TKS). Green indicates relations for the TKS's trader or shipper role, blue relations for the retailer role, grey relations for the DSO and red relations for the end user role.

5.4 Development scope

Roughly divided, TKS has five market operations where optimization can be made. There is the monopoly in the distribution network, which does not require actions currently as the distribution network is a reliable source of income if there are gas users in the network. Another market operations are the wholesale and the retail market operations, which both contain potentials for improvements. Roughly, the operations in most potential for development are either gas sales or gas procurement due to their high volumes. Fourth market operation with possible potential for improvements is the balancing operations; whether to be a balancing responsible or a part of a balancing group. Fifth operation can be said to be the gas consumption in the TKS, but the technical aspect of gas consumption is not in the scope of this thesis. Overall, the wholesale and the retail markets should not be considered separate functions in TKS but as a part of the overall gas business unit. Thus, one of the development aspects should be the unification of the operations in order to have the potential to fully optimize the gas trade and to keep more sufficient track of the cash flows.

When doing rough market research, it is noticeable that the gas prices stated in the retailer's websites for small scale users is one of the lowest in TKS in 2020. The industrial users' prices cannot be compared as the contracts are usually made individually and in private. TKS offers Gaspool front month indexed price and other Finnish retailers mainly either constant prices, index-related prices or the traditional oil and coal related pricing method for small consumers. Biogas is sold currently only via certificates and when hydrogen or other synthetic fuels start to become competitive, new operations regarding them can be evaluated.

Development on the wholesale market operations should focus on the optimal market roles and on the preparations for possible market changes, like taxation and legislation changes. Examples of the upcoming market changes are regulatory changes from the European Green Deal as well as the changes in the infrastructure, like new pipeline projects and LNG terminals finished in 2021-2022. These affect the gas transmission and energy prices due to changes in the supply routes, border crossing transmission tariffs and changes in the gas quality. It is clear from the total consumption that own use is the most vital gas related operation in the TKS, which means that most efforts and developments should be made to that. The market role optimization needs to be done keeping in mind, which operations are crucial, not only looking the gas business, but the total TKS's total operations and scope.

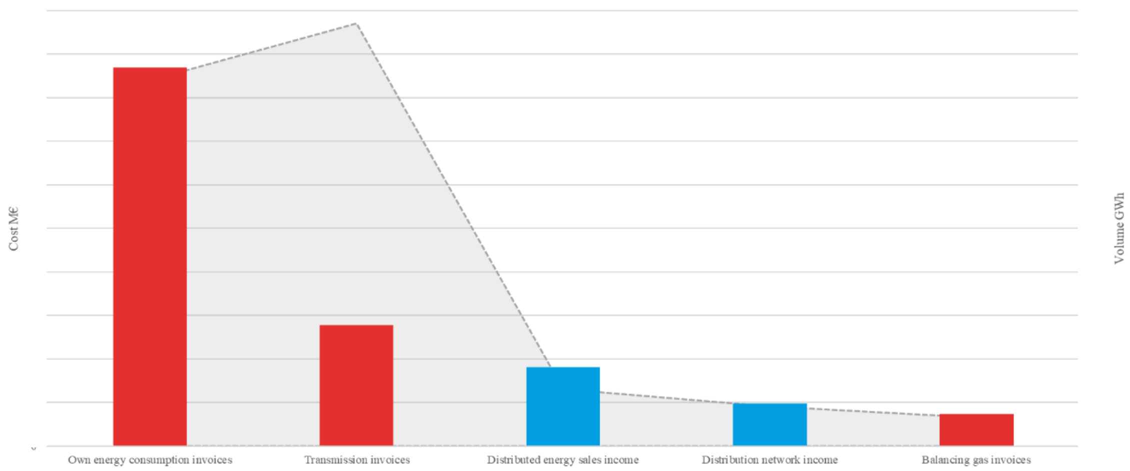

Figure 26. Incomes (blue) and expenditures (red) in different gas operations in 2020. Volumes are on secondary axis in gray.

As seen in figure 28, TKS's gas use is high on volume and thus it is a significant expenditure. There is not much to do about the transmission and distribution pricing currently and therefore they can be left aside on this development process. Concerning the TKS's own use, the 2020 contracts were made successfully and, like supposed to, this is the operation with the most inputs. The TKS's average purchasing price for gas was lower than the GET Baltic neutral gas price and especially the contracts in the spring were adequate in volume as well as low in prices. If all the consumption would have bought as a balancing gas priced as the TSO, the expenditure would have been 12 % higher, and if the gas would have bought in the Gaspool front month indexed price, the expenditure would have been 17 % lower. This indicates that the development process is not currently as urgent for the own gas procurement, even with its significance in high volumes.

The cost of balancing gas in the figure 28 is calculated using the 2020 balancing gas prices set in the balancing group's contract. If TKS continues to be a part of a balancing group, there is a possibility to be charged either the same as the balancing prices from the TSO or by another price specified in the balancing group's contracts. This contains risks, if the separate balancing prices are significantly different than the gas exchange price, which is used in the TSO's pricing. As seen in the graph, balancing expenditure is the lowest in expenditures, but because its volume is also low, the cost per energy is high and thus it is important to examine as well.

Because clear evaluation of the gas processes has not been made since the market was opened in Finland, it is useful to look at the gas trade, even if no specific improvements are found. The finding of this short evaluation of the gas trade operations and their financial significance is that the biggest potential for development is on the gas sales, market roles and the balancing gas. This does not mean that they are the most crucial business operations related to gas, but an estimation should be made to find the full potential or to ensure that the current operations are optimal.

6 FUTURE OF THE GAS BUSINESS UNIT

There are multiple aspects to start to tackle the optimization problems related to the gas trade. The focus points stated and explained in chapter 5.4 were gas sales pricing, market roles and gas balancing. Looking into the future, also the potential of sustainable gas solutions and gas market trends need to be considered, even if they do not cause currently relevant actions. The following chapters evaluate the effects of different actions related to the gas busines unit, like market roles, sales contracts and long-term market trends. After the estimation, the possible actions being taken, or actions left undone, are summarized to three possible strategies for TKS's gas business unit.

6.1 Market roles

TKS possess currently numerous gas trade related market roles, but none of those are essential. There is a possibility to stop the distribution business and retail sales, and the consumed gas in the power plants could be purchased as either a trader, a shipper or an end user. It is important to evaluate, does the market role contribute more than it requires. This is not simple to calculate as also the work put into it is a contributing margin, not only the incomes. It is clear, that the distribution business is something to hold on to as it is easily profitable. The most important question relies on whether to be a trader, a shipper or a retailer, or some combination of those.

As a trader, TKS can trade the gas and control daily imbalance as well as negotiate contracts to fit its use effectively, and thus a trader is currently an important market role. In 2020, TKS purchased most of the gas from shippers, but it could also buy all straight from the gas exchange or other traders or shippers and make the capacity bookings accordingly, which would mean exercising a shipper role. There is also a possibility to purchase the gas outside of Finland as a shipper and make the transfer payments for it, but that is not currently estimated here as the prices are not easily accessible. Figure 29 shows couple example cases for the roles based on the 2020 consumption. The figure contains simplifications and estimations and thus is not the absolute truth.

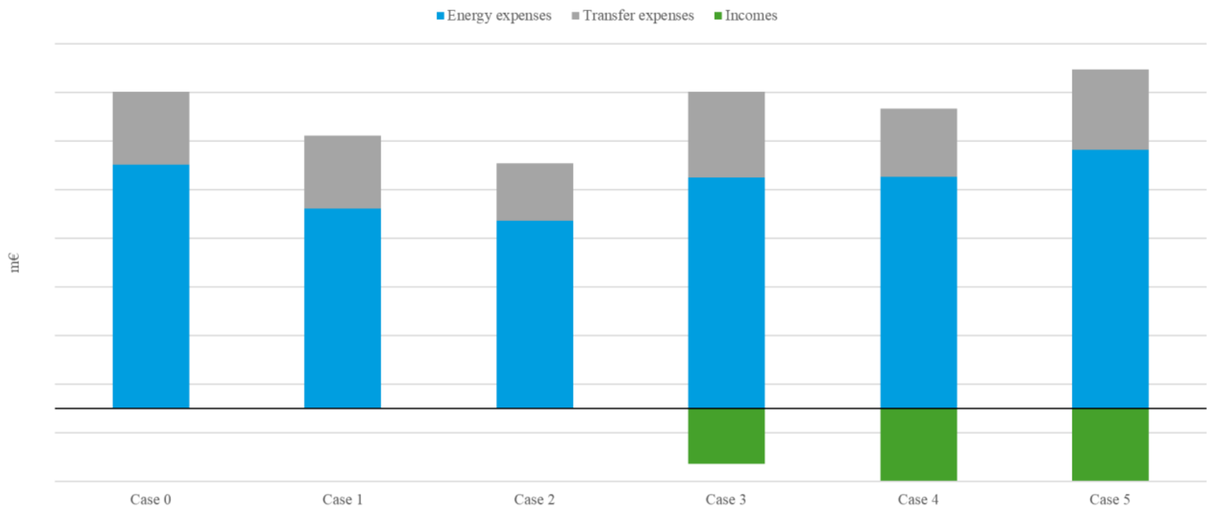

Figure 27. Expenses and incomes in five different market strategy cases in 2020.

In the figure above, blue indicates the energy expenditure and grey the transit expenditure. Green indicates possible incomes, not the profit. The cases do not include balancing gas, so the purchasing is estimated to have made with the exact consumption estimations. Balancing is looked at in more detail in chapter 6.3. The cases examined are as follows.

- Case 0: TKS is an end user only purchasing the gas for own consumption.
- Case 1: TKS is a trader, who purchases the gas as in 2020, but with no retail market sales.
- Case 2: TKS is a trader, who purchases the gas in the most optimal way for 2020, but with no retail market sales.
- Case 3: TKS is a trader, who purchases the gas as in 2020 and with the same retail sales as in 2020.
- Case 4: TKS is a trader, who purchases the gas in the most optimal way for 2020 and with the same retail sales, also including sales in the VTP.
- Case 5: TKS is a shipper, who purchases the gas from the gas exchange and makes capacity booking accordingly with no intermediary and has retail and VTP sales.

The most optimal purchasing way used in the cases 2 and 4 is using the cheapest contracts made in 2020 with the suitable amounts. The capacity prices are estimated based on the prices from the TSO using the quartal product for the whole year. There would be multiple products used in reality to fit the yearly consumption profile better.

As seen in figure 29, clearly the most expensive one is case 0, which is TKS operating only as an end user and thus this can be left out of further examination for its absurdity. In cases 1 and 2, the market roles are the same, but they are used differently. If the consumption and contracts are like in 2020, the case 2 is more affordable, but the consumption prediction is sometimes difficult and thus reaching the optimal contracts is not feasible. Case 3 can be used as the baseline, as it is closest to the reality in 2020. Taking the incomes into account, case 4 is the most profitable one, but case 2 is not far from it. These two were the cases with the most optimal utilization of the current role and thus it makes sense that they are the most profitable ones, but the reality of succeeding in this needs to be kept in mind. Cases 1, 3 and 5 are all close together, when looking at the net costs. In the case 5, where TKS would operate as a shipper making capacity agreements, it is noticeable that there is also an assumption of retail sales. If there would be no sales, this case would be the most expensive one, after the case 0.

The case 5 creates extra workload and case 1 reduces it. The overall output needs to be put to perspective according to the inputs, like manhours used. It is also noticeable that the gas retail markets are diminishing as the total gas consumption is most likely to reduce, thus the growth potential is not endless. The most promising market strategies currently based on the figure 29 are a trader, who buys from shippers and does not sell to end users at the retail market, or a trader who buys from shippers and sells to the end users. But the difference between these two cases is not massive. All these possibilities are more examined as a part of the whole gas business unit in the chapters 6.5 to 6.7.

6.2 Retail market operations

One of the main difficulties in retail market pricing in a company, which consumes the gas also itself, is how to divide the costs of the operations to the retail market end users and to the company’s own use. For example, if there are multiple contracts being made for a certain month, is the cheapest one for own consumption or to the retail sales, or is the prices divided somehow as a weighted average for both operations. This is one of the subjects for further development and essential contributing margin for the retail pricing. To allow competitive pricing of the retailed gas, the cheapest contracts could be guided to the distribution networks use. But then the most volumes are, especially during winter, in TKS's own use and thus having the cheapest prices for that is sensible. On one hand, as TKS's own use can be said to be the main gas operation in TKS, the contracts are made only to fit that and all the retail sales are, so to say, add-ons and thus not a part of the long-term contracts. On the other hand, the retailed gas is quite predictable as the industrial gas use can be estimated based on the previous year, so a long-term purchase contacts are possible to be directed to the retail use. This area needs further development and is discussed in chapter 6.9 regarding the next steps.

Another difficulty in the pricing is related to the multiple retailers working in the same area. For example, if a company wants to sell gas for the same price to TKS and TKS's customers, how would TKS be able to compete with the prices, unless pricing without any fees for TKS. One of the possibilities to compete would be not with the pricing, but for example with additional services and locality. TKS is a local producer and large companies might not want to do the additional work to gain a customer base including only multiple small users. If wanting to compete with the pricing, the procurement needs to be cheaper than the competitor to be able to add the fees for TKS. This would mean having multiple contracts, for example procuring the gas as longer-term contract than selling it at the retail market. This is one of the actions also in need of a further development.

If the retail market revenue is something TKS wants to expand, it is desirable that the offers to the customers can be made effectively, and therefore the main products should be evaluated and pricing methods composed. Retail market products can be drawn from other retailers in the market, from the consumption profile and from the characteristics of gas use. For instance, a common product used by other retailers is the constant pricing method for small scale users in heating. For small scale users, who use the gas for space heating and heating water, consumption does not have high peaks and it is relatively constant. Residential users can also want the constant priced product for its easiness, even though it might not be the cheapest. Then with constant pricing, it is noticeable that as the purchased gas price varies price risks need to be taken into consideration. Some of the most feasible gas energy products are compared in the table 4.

Table 4. Gas energy pricing methods for TKS.

Method	Description	Advantages	Risk management
Index-pricing	Some front month indexed price is used, most likely TTF or GPL. The retailer price is front month price + fee per kWh.	Usually same as the pricing in the wholesale market. Follows market trends but does not fluctuate daily.	Containing take-or-pay offers or minimum or maximum consumptions. Priced similar as in the wholesale market, thus both sells and purchase are influenced with the same market trends.
Standard pricing per consumption	Price is constant all year around per kWh.	Predictable. Can allow higher profits for either way. Usually set quite high to manage risks, which could create high profits.	Volume risk managed by setting consumption limits. Must have clear market view to set the prices to fit the yearly profiles. Set price needs to contain a risk factor.
Standard pricing per month	Price is constant all year around per month. Usually contains limits in use.	Predictable. Usually set quite high to manage risks, which could create high profits.	Seasonal changes in both volume and prices can be minimized with low maximum consumption limits. Set price needs to contain a risk factor.
Constant consumption pricing	Price is some of the above, but the consumption is set to a certain monthly, quartal or yearly value.	Predictable in volume. Allows contracts made to fit a specific fixed-term consumption.	No returns for profit to reduce extra bookings.
Seasonal pricing	Price is some of the above, but the consumption takes place only part of the year.	Allows contracts made to fit a specific fixed-term consumption.	Volume risk managed by setting consumption limits. Must have clear market view to set the prices to fit the seasonal profiles.

In addition to the gas energy sold, transmission and biogas certificates are being sold in the retail market. To expand the revenue, the products could be also bundled together to compose desirable packages for the customers. All the pricing methods contain risks and hedging methods are also important aspect of each retail market operation. When sustainable gases emerge to the markets, new products are probably formed. For example, hydrogen certificates, synthetic gas from PtX and possibly even carbon capture utilization possibilities from gas consumption.

When considering, which retail market strategy to implement, it is noticeable, that in addition to gas energy sales and transfer, attributing factor is the existing infrastructure. The pipeline network, metering points, facilities, existing data transfer and information systems and their investments all contribute to the calculated expenses of the retail market operations. The fast electrification of the heating sector could move smaller gas consumers from the gas use and high sustainability goals could move the industrial users from natural gas to alternative products such as hydrogen. This would mean exercising current methods in the retail market operations could prove to be either too extensive or not sufficient enough, depending on the direction the gas markets.

6.3 Balancing strategies

In 2020, TKS was a part of a balancing group with specified prices set for extra gas and excess gas. For 2021, these prices are changed to the TSO’s neutral gas pricing method and TKS is remaining in the balancing group. There are four possible strategies to handle the balancing gas, which are all examined and compared in the next chapters. The possibilities are (1) being in a balancing group that prices gas like in 2020, (2) being in a balancing group that prices like the TSO, (3) being a balance responsible party and (4) forming a balancing group. For 2020, the balance was done like in strategy 1 and for 2021, the balance is done like in strategy 2. The four different balancing strategies are compared in table 5.

Table 5. Comparison of different balancing strategies.

Strategy	Advantages	Disadvantages	Responsibilities	Cost
1	No collaterals, no extra responsibilities towards TSO, predictable expenses as the prices are in before set limits. Easy.	Expensive. No possibility to gain profits from the load variations.	Own imbalance monitoring for the balancing responsible. Payments to the balance responsible.	Set gas price in €/kWh for the balancing gas.
2	No collaterals, no extra responsibilities towards TSO, yet the same energy costs as being a responsible party oneself. Easy.	Prices not as predictable and thus riskier. No possibility to gain profits from the load variations.	Own balancing monitoring for the balancing responsible. Payments to the balance responsible.	TSO's gas price in €/kWh for the balancing gas.
3	No responsibilities to any balancing group, prices are up to the TSO, possibility to profit from the balancing activities.	Collaterals, extra work with the balancing activities with the TSO.	Balancing monitoring and payments accordingly to the TSO, registrations to the datahub, collaterals.	TSO's gas price in €/kWh for the balancing gas + collaterals.
4	Pricing the balancing to others, possibility to make bundled products. Possibility to gain profit form the load variations.	Collaterals, extra work with the balancing activities with the TSO and with monitoring the balance of others and invoicing accordingly.	Balancing monitoring and payments accordingly to the TSO, registrations to the datahub, collaterals, contracts with other balancing group participants and their invoicing.	TSO's gas price in €/kWh for the balancing gas + collaterals. Possible incomes from the balancing group participants.

If the expenses remain like in the current contracts, strategy 2 is by far the easiest and most profitable. If the strategy for all gas trade in TKS is to expand the revenue, adding new products could possibly help with the sales as they could be used to gain coverage and to form a package deals with the customers. If own balance group would be formed with other participants, TKS would gain benefits from the load variations. For example, if one customer has surplus and at the same time another customer has deficit, they will balance each other and thus there is less need for expensive balancing actions. Due to TKS's own use being so high, collaterals are a noticeable expenditure. If the measuring happens in real-time for TKS's own use as well as for the retailed gas, the balancing strategy loses some of its significance as the balancing can be made up to date in the gas exchange. Of course, balancing contracts should be made keeping in mind of the possible measuring failures, as the volumes can be at the inconvenient times significant.

6.4 Sustainable gas use

In the upcoming years, gas is bound to become more sustainable as well as less consumed fuel in the energy sector, if the European Green Deal manages to start the extensive shift to sustainable gases. The changes to low-carbon economy are not fast, but inevitable. TKS can either contribute to the low-carbon society by renewable gas investments or by some other methods, like renewable electricity and bioenergy production. The changes in the fuel properties in the transmission network will also affect TKS through gas pricing and the possible energy outputs from the gas. This could happen for example, if hydrogen is added to the transmission network up to a certain percentage. Sustainable gas is either sold by certificates, injected to the network to make a fuel mix or used directly from the production plant. The following chapters discuss profitability and future trends of the sustainable gas at retailer markets in Tampere area, as well as TKS's own sustainable gas consumption in the future. It is also noticeable, that if CCS becomes cost-effective, traditional gas might not be fully replaced in the future by sustainable alternatives, but still some exploitation is most likely being made.

6.4.1 Biogas

Currently, biogas can be bought via certificates. This means that the gas is consumed from the network and it is converted into biogas by buying a biogas certificate. Biogas certificate is a way of showing that the consumed gas is zero emission gas and thus possibly not affected by the taxation. The price of a biogas certificate is the tax benefits it possesses added to a certain fee. Biogas use cannot be directed to a certain use, but it is divided in the relation of the end uses at a certain measuring point. (vero.fi, a)

As the sustainable mindset penetrates to the markets, consumers start to even more demand environmentally friendly products. This is seen in the electricity markets, where one of the factors affecting the purchase decision is whether the production is sustainable or not. In some time, it might not be adequate that the district heating is mainly produced with carbon neutral biomass or municipal waste, but the total production also at peak loads should be low emission as well. This is when the biogas certificates become handy as they can be sold to the consumer to transfer the gas to carbon neutral solution.

It is estimated that only 4 % of biogas production's potential is currently utilized in Finland. As the production increases, the prices are likely to reduce. Sweden is one of the trailblazers in biogas use and if the Finnish production follows its neighbor's path, the biogas is mainly targeted to transportation. But if the use follows the path of Denmark, the biogas utilization will focus on the CHP production. (Gasum) As natural gas plays significant role in the district heating in TKS, biogas would help with the security issues related to natural gas as well as make the production less emitting. The main issue with biogas is currently a large-scale production, but the potential is there and the full utilization also in TKS's own gas consumption, not just in the retail sales, might be sensible in the upcoming years.

The cost of biogas for transportation was 0,97 €/l in January 2020 with no taxes and the cost of natural gas from the same provider was 0,84 €/l. The cost difference between natural gas and biogas is not that large, but still currently relevant. Biogas most probably will not enjoy tax-free status forever, and thus with the descending prices, the overall cost of biogas might not drop that much due to the taxes being added. In the governmental program of 2019, the methods for enhancing the status of biogas were coming up with new incentives for biogas production, making biogas as a part of the obligatory distribution and rationalizing the regulatory framework of biogas production. (Mutikainen, 2020) If biogas is added as an obligatory distributed fuel, this would force TKS to make changes to the current distribution network.

One of the possibilities for TKS could be utilizing more landfill gas. Landfill gas is a biogas formed from an anaerobic condition of a landfill waste. It contains mainly methane. In Tarastenjärvi landfill, landfill gas collected since 2016 is mainly turned into electricity at the landfill. An estimation of the methane emissions in Pirkanmaa region ’s landfills in 2019 was total of 4955 tonnes, so about 40 GWh. Out of this, 15 % was captured and from the captured gas 90 % was utilized somehow. (Pirkanmaan Jätehuolto) If the current extraction would be used as a biogas, this would mean 210 000 €/year in the form of sold biogas certificates with the biogas certificate price being 35 €/MWh. The landfills are located far from the current distribution network, and thus the necessary infrastructure is costly. As the landfills get older, their methane production decreases, and it gets harder to maintain them financially and thus the payback time for the needed infrastructure is hard to obtain.

6.4.2 Hydrogen

Hydrogen trade or utilization in TKS has more long-term prospects than biogas. Biogas is more likely being utilized in the upcoming years, but hydrogen needs 10, even 20 years to become profitable. Hydrogen could be used as a retail market product or as a part of energy production. To meet the Finnish 2035 target of being carbon neutral, also TKS needs to make additional investments to sustainable solutions. In the upcoming years, this means most likely investments to biogas and renewable electricity, rather than hydrogen, but if the technological improvement is fast when it comes to Power-to-Gas, hydrogen could also be one of the possibilities. Investments to hydrogen could mean selling its certificates at the retail market or distributing it via the distribution network.

Hydrogen has lower heating value than other gasses, like seen in figure 12. But if hydrogen is mixed with natural gas in the pipelines, the low properties of hydrogen are compensated with the better qualities of the secondary fuels. Adding hydrogen to the network will probably increase the cost of gas as it is expensive to produce. In addition to hydrogen, also changes in the taxation, geopolitical changes, new infrastructure investments and demand change could increase the cost of gas. But then, low emissions will affect the carbon dioxide costs and thus help to make sustainable gases more attainable. If hydrogen becomes widely produced, it will balance the electricity prices between days and nights and between low and high renewable electricity supplies, so it would have also implicit effects to the TKS's operations.

6.5 STRATEGY 1: Low investment

Like stated in chapter 4, there is a possibility that the gas markets will diminish as sustainable focus points move the consumption to another direction. Multiple forecasts estimate the gas energy prices to increase and the current national taxation strategy seems to be constantly increasing the carbon taxes as well as energy commodity taxes for natural gas. Sustainable innovations like PtX and CCS are still in need for a development to become affordable, and it is unlikely from them to become feasible in the next five to ten years in Tampere. If these estimations come true, moving away from gas consumption, would be a reasonable strategic decision. If TKS wishes to maintain only the most necessary operations in the gas business for the next years, this would mean slowly diminishing only the retail operations. The wholesale market operations allow savings in the gas energy contracts and thus it is a market role to keep in the upcoming years while slowly investing to other production methods.

Like seen in chapter 6.1, the difference between having and not having retail market sales is not that significant and taking into the manhours put to it, the profits are not extensive using the current sales strategies. Looking at the figure 29, the cases 1 and 2 would be used in the low investment strategy, meaning exercising the trader role and not having any retail business operations. This allows low expenses, but also no incomes. In the low investment strategy, extensive methods are not used to shift the gas use to more sustainable direction. It is also noticeable that if the low investment strategy is implemented, there could be also decrease in the distribution network incomes as some consumers could move from gas use to for example biomass as the gas procurement would be made more arduous.

Low investment strategy would mean utilizing the current procedures in the wholesale markets and pricing the retail markets to gradually diminish the current customer base. There would be no competing with other retailers with the low prices, on the contrary, pricing could be higher than other retailers to reduce the sales gradually. Other possibility to handle the retail markets could be selling the customer base and this would create profit in the beginning of the strategy implementation. TKS's own gas use would remain as it is and when the time comes to end the gas use as it becomes un-economical, the use would be replaced with a sustainable technology available at that time on the market.

It is noticeable that if the low investment strategy is implemented, TKS might lose the future possibilities to operate successfully in the renewable gas system. For example, if hydrogen and biogas become widely used in the area and they contain high possibilities to gain profits, or CCS helps gas to keep its status, entering the market with lost customer base becomes challenging.

6.6 STRATEGY 2: Mediocre investment

Mediocre investment strategy would be considered "business-as-usual"-strategy. In the upcoming five to ten years, the gas use might remain quite constant as it is used to replace more emitting options. As renewable electricity production increase, it is profitable to maintain gas production as an energy balancing method. In the scenarios in chapter 4.2, one of the possibilities was stated to be electricity grid balancing via versatile gas mix; biogas, LNG and hydrogen. If this estimation is the reality, as the European Green Deal suggests, not adopting the low investment methods could prove to be more reasonable.

In the mediocre investment strategy, retail market operations would remain to be a part of the gas business unit, but with some advanced inputs. Looking at the current trends regarding the retail market's gas consumption, it is possible that the consumption will decrease as customers move to electrification. Then, technical improvements are being made to sustainable gas and thus gas can be seen to remain as one of the fuels in the energy mix in the next decade. Some low input improvements could be made in the next couple of years, if feasible with the current manpower. These could mean adding some new pricing methods and offering sustainable gas via certificates. Also, balancing role decisions could be altered with the current procedures easily.

Mediocre investment strategy would require centralized gas purchase, as it is now, but also more co-operation between the retail and the wholesale market units in TKS to allow efficient retail pricing. This would be possible with low efforts and thus should be included in the mediocre investment strategy. Comparing the market role strategies in the figure 29, the most profitable with the set assumptions is the case 4, which meant trader buying the gas and selling at the retail markets to other end users like in the year 2020 and possibly also in the VTP. If some small improvements are being made with no significant extra input, the profits also concerning the manhours is explicit.

6.7 STRATEGY 3: High investment

With high investment, TKS's gas revenue would be expanded to cover also additional services and increasing sales. The new operations could be, exercising the shipper role in capacity bookings and forming own balancing group with the neighboring energy producers, as well as offering comprehensive selection of different pricing methods and sustainable gas products. The sustainable products would firstly focus on biogas, but later also to hydrogen. High inputs to decarbonization could fasten the development of CCS and this would make the gas use zero-emission and thus removing all the emission related problems regarding the traditional gas use. But it is possible that even with high inputs, some consumption reduces as the ambitious goals drive the fast electrification of the society.

High investment strategy would require investments to additional manpower and changes in the TKS's gas business unit organization. There would be a need for both market analysis on the gas supply and consumption as well as the price trends, and new inputs to the retail sales. Finland has traditionally focused on more in the electrification of the society, renewable electricity production and biomass solutions rather than sustainable gas technologies. But these focus points could move also in Finland following the recent European Green Deal program. Given the required fast improvements to meet the ambitious national targets, it might be possible that currently adding high investments into new gas solutions might be proven to be too costly in short-timespan and unnecessarily extensive for long-term in the area as the consumption in both retail markets and in TKS would decrease following new renewable investments. Given these estimations, high investment in this context would mean inputs to short-term retail sales and market role optimizations, like utilizing the shipper role's actions to remain as part of the operators in the Finnish gas sector.

6.8 Discussion

As natural gas is increasingly reducing in both residential and in energy sector, the sales are bound to become somewhat smaller eventually in the TKS, even without any specific strategies implemented. This is due to new investments being made in TKS to alternative heating methods, like the biomass power plant Naistenlahti 3, and electrification of the society. Following the market trends evaluated in the chapter 4, the residential and the industrial sector will reduce its natural gas use in Finland partly due to current incentives, sustainable attitudes and taxation. As stated in the chapter 3.1, the gas price is increasing, which will mean increasing total expenses from the gas energy consumption.

This thesis gives three possible strategies for the gas unit in TKS: low, mediocre and high investment. In all the strategies, distribution network is not included in the estimates for simplification. Three strategies are chosen for their feasibility and a combination of the strategies is also a possible solution. The strategies are seen to be valid for the next five to ten years. After that, new sustainable technologies are most likely to have developed so that they should be included further in the estimates. Also, legislations and taxation changes are probable and not taken into account in other aspects than pricing in the following figure.

In the low investment strategy, the two options were either slowly diminish the retail market operations or sell them. Selling the operation would mean profits from the sales in the beginning of the strategy implementation. If the possibility to slowly diminish the operations is chosen, consumption first stays constant as at the same time prices are increased and then customers are moving to other producers. In couple of years, the customer base diminishes to so small that the incomes are significantly reduced. At the same time, TKS's own consumption decreases and thus the overall cost of the gas business is in downwards trajectory. TKS's own production is decreasing as the focus is moved towards other energy commodities.

In the mediocre investment strategy, incomes remain quite constant but with small inputs advancement can be seen. In the high investment strategy, incomes are significantly increased as the business is enhanced. In both operations, TKS's own gas consumption is not reducing as significantly as in the low investment strategy. Figure 30 shows the estimated income and net cost relations between the three strategies, ignoring the transmission and the distribution. The figure includes multiple simplification and assumptions and does not indicate the absolute truth.

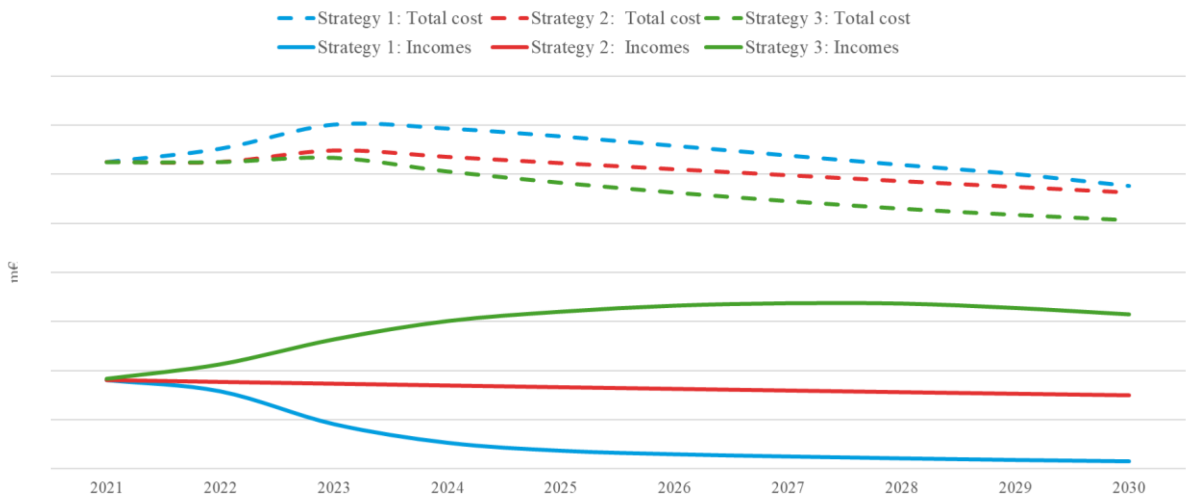

Figure 28. Comparison of the net costs and incomes from different strategies.

If TKS wishes to make better profits from the gas business, the only options are either mediocre or high investment strategy. There is also a possibility to use multiple strategies, for example for the next five years, the mediocre investment strategy and then moving to some other investment strategy. Having some retail sales contributes to also making the contracts for the wholesale market operations more affordable as the volumes increase. Looking only the numbers from the estimation above, high investment strategy is the most profitable one, but this requires additional workload and investments to the infrastructure which are not taken into the calculations. The possible legislation changes are also not included in the strategy calculations and thus if Finland chooses to make the gas use exponentially more expensive, mediocre and high investment strategy could be not as profitable as predicted.

Given the gas markets are facing significant changes in the upcoming 10 years or so, low investment strategy could limit the future market roles from TKS's reach. Being a distribution network operator goes hand in hand with the retail sales and for being able to also contribute at the local energy production overall, holding on to that market role helps. But like said previously, the difference between having and not having retail market operations with the current methods is not that extensive and thus to make the most of the current market role, some operational improvements should be made. It is also noticeable, that current investments to the distribution network, information systems and monitoring should be considered to provide comprehensive results for the effects of the low investment strategy. The possible payback periods of the current investments have not been taken into account when estimating the price of the low investment strategy.

A recommendation for the upcoming couple years, based on the evaluation of the chapters 6.1 to 6.7, is the utilization of the mediocre investment strategy. Successful operations would require operational changes in the business unit, meaning unification of the procurement and sales to some extent, to achieve competitive retail pricing. Balancing would be made as in 2021, meaning being a part of a balancing group that charges based on the TSO's balancing pricing, due to it being the cheapest solution with low workload. The wholesale market role would be a trader, due to it being an adequate role with current consumption and supply. Biogas would be further utilized, if economically feasible, and TKS's own natural gas consumption would reduce as an outcome of sustainable investments. The sustainable solutions and market changes would be a part of constant market analysis in TKS and the strategy is then altered, when seen appropriate. This recommendation allows TKS to gain profit with reasonable inputs. As the retail market operations do not hold a significant share of TKS's revenue, the labor inputs need to be kept in mind.

6.9 Next steps

To estimate the overall effects of the retail market operations as well as possible new products concerning either sales or balancing, more data should be collected to be sure of the factual costs. Effective and reliable estimation requires the knowledge of the actual input hours in TKS as well as up-to-date contracts between the end users and TKS and between TKS and shippers. Doing this thesis, some of that information was not fully available. This caused the need for simplifications and estimations in the calculations. Also, market trends are still somewhat uncertain, and they need to be monitored due to the upcoming possible changes stated in the European Green Deal and new national regulatory framework for sustainable gases.

Based on the evaluation of the gas business unit in Tampereen Sähkölaitos made in this thesis, one of the simple improvements would be improving the co-operation and data exchange between the wholesale and the retail market operations. This would reduce the risks from the pricing, which is not currently being made in accordance with the up-to-date purchases. Having more fluent data exchange between the operations would allow faster and more flexible offers being made to the consumers as well as help with the wholesale purchase operation as the consumption would be easier to estimate. One of the main difficulties in the retail market pricing is the division of the procurement price between wholesale and retail market operations. There needs to be a policy made to answer to this issue and to conduct that effectively, some operational improvements in TKS are in order. Having correct and real-time consumption measuring is also a key element of successful balancing, whether being a part of a balancing group or a balancing responsible party oneself.

7 SUMMARY

The objective of this thesis was to come up with solutions to make the gas trade in Tampereen Sähkölaitos more profitable with reasonable inputs and to analyze the prospects of the gas market. Tampereen Sähkölaitos uses gas for both heating and electricity production as well as distributes it at the retail markets, thus Tampereen Sähkölaitos possess numerous market roles, like trader, retailer and distribution systems operator. The market roles were formed as the Finnish gas markets were opened for competition in the beginning of 2020 making the retailing and gas exchange possible for all market participants. In 2020, over 60 % of the consumed gas in Tampereen Sähkölaitos was used for gas turbines and mainly it was bought using fixed-term contracts from couple providers, but also the GET Baltic trading platform was utilized making the purchasing versatile.

Gas plays a crucial role in Tampereen Sähkölaitos ’s energy production, but its retail market operations have remained scarce. The gas business operations are divided into wholesale and retail operations, which cause problems with the efficient consumption estimations, sales contracts and overall performance analysis. When new heating methods are added to the mix, gas will reduce its significance in Tampere’s heating sector, and this long-term prospect is also taken into consideration when estimating the optimal solutions for the gas business unit.

The distribution networks hold easy potential as it is a natural monopoly and thus the distribution network operator role is reasonable to keep. As currently the consumed volumes are high, a trader role allows flexible and cost-effective procurement and is thus a vital role. These two market operations can be said to be the main operations in Tampereen Sähkölaitos in addition to being an end user. The most unexploited potential is seen to be in the retail sales as the current inputs have been low and the incomes are estimated to grow with additional investments to the retail operations. The retail market operations could be enhanced also by making the offers more flexible and fast by adding co-operation with the wholesale operations. Current balancing strategy is seen suitable as it is cost-effective and requires minimum inputs.

This thesis came up with three different possible strategies for the gas business unit. The first being a low investment strategy, where the gas market operations would be slowly abolished. The mediocre investment strategy would give improvements with low additional inputs and high investment strategy gives the highest profits, but also requires significant investments to the operations and workload. Even with high inputs to gas operations, it is possible that the current sustainable development trends in Finland turns the focus to other new technologies and gas is slowly being put to side as it is a polluting fuel and producing it sustainably is still costly. Then, if the market trend is the opposite, having low investment strategy could block Tampereen Sähkölaitos from having profits from the gas market. Considering the consumption trends and current pricing, the mediocre strategy could be the most optimal to implement for the upcoming couple of years as it allows profits with reasonable inputs.

The future trajectory of gas is yet undecided, but hints of the possible path of gas is seen as the EU published their new targets for 2030 including strategies for sustainable gas. In the rest of the Europe, hydrogen is seen as one of the main contributing technologies to reach a zero-emission society. But in Finland, the focus has widely been on bio-based solutions, like biogas. In conclusion, there are multiple ways of tackling the optimization problem that is the gas market operations. One could focus on the wholesale market operations, as it is the one with highest volatility, or expand the revenue and improve the retail markets. The gas markets are, like any other energy sector's operations, highly affected by the policy changes, geopolitical changes and technology improvements and thus analyzing the procedures should be one of the on-going operations to make the reactions to the possible market changes effective.

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APPENDIX I

Uncertainties and impacts on the future role of gas.