MEASURES TO IMPROVE RISK HEDGING OPPORTUNITIES ON THE ELECTRICITY MARKET IN SWEDEN

A REPORT TO THE SWEDISH ENERGY MARKETS INSPECTORATE

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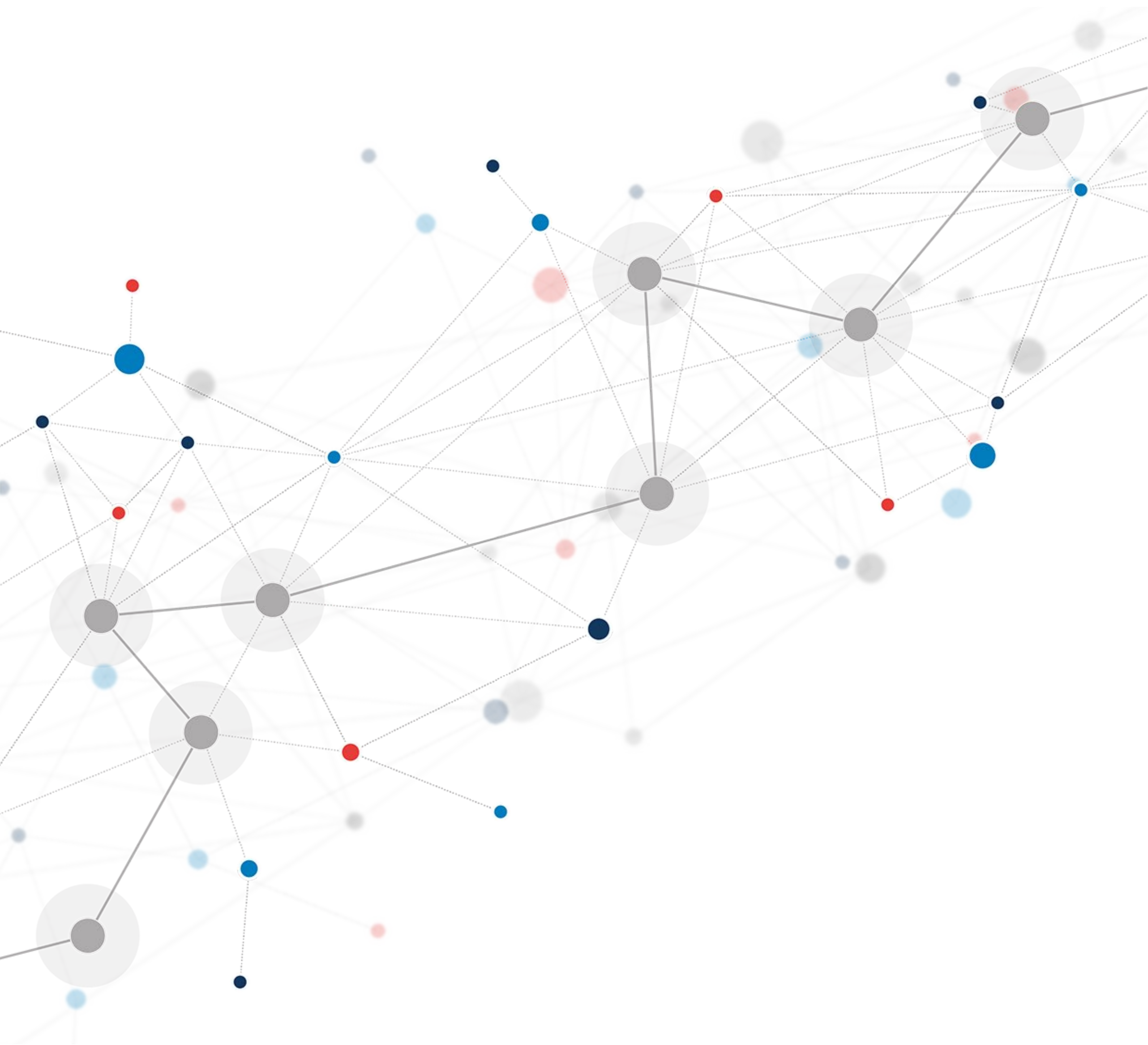

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EXECUTIVE SUMMARY

This report is written for the Swedish Energy Markets Inspectorate (Ei). Ei is seeking knowledge about different hedging instruments on the electricity market and possible measures that can be taken to improve the hedging opportunities in the current system with Nordic system price futures and EPADs. Costs, benefits, and implementation time of possible measures to strengthen hedging opportunities should be evaluated in comparison to the alternative of introducing long-term transmission rights (LTTRs). Such knowledge is needed so that Ei along with other NRAs in the Nordic countries and the EU can be able to make coordinated decisions on risk hedging opportunities in accordance with Article 30 of the Forward Capacity Allocation Guideline (FCA GL).

The study has been conducted in collaboration between the consultancy firms Merlin & Metis and Compass Lexecon. The work consists of three main parts. The first part aims to identify three relevant measures to improve hedging opportunities in the current system with Nordic system price futures and EPADs in Sweden. The identification and evaluation of alternative measures is based on a literature review and interviews with market participants. The three measures that have been selected for further analysis are: TSO auctioning EPADs, introduction of regional EPADs, and improved market making.

- **TSO auctioning EPADs**, selling in bidding zones (BZs) with a larger buying then selling interest, typically BZs with more consumption than production and vice versa, could to some extent correct market asymmetry and add EPAD volumes to the market. This measure wouldn't require an introduction of new hedging products. The implementation process would be fast relative to many other measures. Auctions could also be accessible to smaller and larger market participants alike. Having a predetermined, transparent method for specifying auction times, contract types and volumes would be essential.
- **Regional EPADs** are financial products covering more than one BZ. For example, SE3 and SE4 could be pooled into a regional SE3/SE4 EPAD. This is a measure that directly addresses a potential source of low liquidity in the EPAD market, namely small and asymmetric BZs. The implementation time of this measure is an issue, as it would be beneficial to implement first after the ongoing BZ reconfiguration process to avoid having to update the regional EPADs structure to match new BZs, in case BZs are revised.
- **Improved market making** could be implemented relatively quickly and it could improve liquidity in the market. The TSO would finance this measure at a cost dependant on the requirements set in a market making agreement. With a well-functioning market making in place, market participants will always be able to buy or sell a contract and exit positions. It can also potentially attract speculative market participants and lead to tighter bid-ask spreads. It is, however, not able to address the underlying structural issues such as asymmetry between buyers and sellers but could be a complement to another measure.

The alternative measures that were identified but not selected for further analysis were the following: forcing (large) vertically integrated companies to trade, formulating the system price based on a weighted average of price areas, and BZ reconfiguration.

The second part of the study consisted of a cost-benefit analysis of the suggested measures and comparing the results to the alternative of introducing LTTRs. Market data was provided by Nasdaq

OMX Commodities enabling a quantitative analysis of futures markets based on historical prices and volumes for the period of 2017-2021. The analysis includes assessment of added volumes (open interest) resulting from the introduction of each measure as well as estimating the impact of these added volumes on transaction costs (bid-ask spreads). Other information, such as costs estimates, were collected from written sources as well as from interviews. The alternatives were then compared arriving to the following conclusions:

- TSO involvement by auctioning of EPADs is the measure that delivers the highest societal net benefit, much driven by its ability to lower bid-ask spreads. Overall, this measure has a good potential to improve the current market that the market participants have been relying on, are familiar with, and are asking for its improvement rather than its overhaul.
- While the congestion rents and auction revenues for the TSO-auctioned FTRs as well as its implementation costs were assessed in this study, all societal benefits of FTRs were not covered in the analysis. The potential benefits of FTR auctions for hedging may come from indirect effects of increased liquidity in other hedging products, such as Nordic system price. However, these benefits are expected to be small.
- If the main policy objective is to improve the hedging possibilities of market participants in Swedish electricity market, we would tend to recommend measures improving the existing EPAD market. If the liquidity can be improved and transaction costs reduced for reasonable costs, EPADs can already now and have always been able to deliver the same function as FTRs, if the market participants demand it.

Table 1: Summary of annual benefits and costs of the alternative measures

	Measure 1: Improved market making	Measure 2: Regional EPADs	Measure 3: TSO-auctioned EPADs	Measure 4: TSO-auctioned FTRs
Volume impact: increased liquidity (TWh)	6.1	9.4	17.5	35.1
Benefit from added volume: Lower bid-ask spread, (€m)	6.3	14.7	51.0	N/A
Costs (€m)	5.4	~ 0	0.45	0.45
Net benefit	**0.9**	**14.7**	**50.5**	

Source: Compass Lexecon analysis

The third and final part of the study was to propose a roadmap for the implementation of the selected measures, focusing on TSO auctioning EPADs. The implementation plan is based on existing legal guidelines, key aspects of each measure as well as interviews with relevant actors. The roadmap includes the identification of the most relevant steps along the implementation process, key activities related to each of them as well as an estimation of the required timeline.

Ei can proceed with the suggested measures within Sweden directly, while it is required to agree with other NRAs regarding cross-border BZs. If two NRAs can't agree, the case is passed on to ACER which then has six months to decide. The next step in the process will be for the Swedish TSO, Svenska Kraftnät (Svk), to start preparing for the process, for example to agree on the means of financing, develop a transparent methodology for auctioning specifications and arrange a public consultation process. Following Svk submitting its proposal to Ei, it is subject to approval. Once approved, Svk has 6 (possibly 12) months for implementation. The implementation includes procuring an auctioning platform and related services, putting in place internal routines and an organisation for the required activities, preparing to continuously evaluate the market with the purpose of following its methodology and providing relevant information to market participants. Overall, the time estimate for the process is between 12 and 24 months.

SAMMANFATTNING

Denna rapport är skriven till Energimarknadsinspektionen (Ei). Ei söker kunskap om olika risksäkringsinstrument på elmarknaden och tänkbara åtgärder som kan förbättra risksäkringsmöjligheterna under befintlig marknadsstruktur med nordiska systempris-terminer och EPAD-kontrakt. Kunskapsinhämtningen innefattar kostnader, nyttor och implementeringstid för olika tänkbara åtgärder avsedda att förbättra risksäkringsmöjligheterna, samt att jämföra dessa åtgärder med ett tänkbart införande av långsiktiga transmissionsrättigheter (LTTR). Ei söker denna kunskap för att tillsammans med andra nationella tillsynsmyndigheter (NRA) i Norden och EU fatta koordinerade beslut utifrån artikel 30 i *Forward Capacity Allocation Guideline* (FCA GL).

Studien är genomförd av konsultbolagen Merlin & Metis och Compass Lexecon. Den är indelad i tre delar. Den första delen syftar till att identifiera relevanta åtgärder för att förbättra risksäkringsmöjligheterna på elmarknaden och välja ut tre av dessa för fördjupad analys. Denna del baseras på en kombination av litteraturstudier och intervjuer. De tre åtgärder som valts för fördjupad analys är: TSO auktionerar EPADs, regionala EPADs introduceras och *market making* förbättras.

- **TSO auktionerar EPADs** genom sälj i budområden med större köp- än säljintresse, typiskt sett elområden med mer konsumtion än produktion av el och vice versa, vilket till viss del skulle kompensera för en underliggande marknadsasymmetri och samtidigt tillföra nya handelsvolymer. Denna åtgärd skulle inte kräva att nya finansiella produkter introducerades. Auktioner skulle också kunna vara lättillgängliga för såväl små-, medelstora som stora aktörer på likartade villkor. Att ha en transparent modell för hur auktionsvolymer sätts, vilka kontrakt som ska auktioneras ut och tydligt och med god framförhållning annonsera såväl detta som när auktionerna kommer att hållas, är av stor vikt.

- **Regionala EPADs** är finansiella produkter som täcker mer än ett budområde. Till exempel skulle SE3 och SE4 tillsammans kunna utgöra basen för ett EPAD-kontrakt avseende ett volymviktat medel av de båda elområdena. Den här åtgärden skulle direkt adressera en potentiell källa till bristande risksäkringsmöjligheter, nämligen små och asymmetriska (mellan köp- och säljintresse) elområden. Implementeringstiden för den här åtgärden är ett problem, då en ny elområdesindelning väntas beslutas 2023 och vara på plats tidigast 2025, dessförinnan vore det inte lämpligt att införa nya finansiella produkter syftandes till den gamla elområdesindelningen ifall utfallet blir en ny elområdesindelning.

- **Förbättrad market making** är en åtgärd som skulle kunna implementeras snabbt för att förbättra likviditeten på EPAD-marknaden. TSOn skulle kunna finansiera denna åtgärd och kostnaden skulle bero av vilka krav som sattes på *market making*-funktionen. Med en välfungerande *market making* på plats, skulle marknadsaktörer alltid kunna köpa och sälja kontrakt och på så sätt komma ur finansiella positioner. Mindre *spreadar* mellan köp- och säljsidan, samt ett förbättrat orderdjup skulle potentiellt också bidra till att attrahera nya marknadsaktörer och på så sätt trigga en positiv spiral avseende likviditetsutvecklingen. *Market making* adresserar dock ej de underliggande strukturella problemen på EPAD-marknaden, så som skillnader i köp- och säljintresse i elområden med markant större elproduktion än elanvändning eller vice versa, men kan vara ett bra komplement till andra åtgärder.

De tre andra åtgärder som identifierats i studien, men inte valts ut för fördjupad analys är; att få vertikalt integrerade energibolag att handla mer volymer på den öppna marknaden, omformulera hur systempriset beräknas och en ny elområdesindelning.

Den andra delen av studien består i en kostnads-nyttoanalys avseende de analyserade förslagen för förbättrad risksäkringsmöjlighet, samt en jämförelse av dessa i förhållande till en introduktion av LTTR:er. Analysen bygger på data från Nasdaq OMX Commodities avseende priser och volymer för perioden 2017-2021. Analysen innefattar antaganden om tillkommande volymer (*open interest*) till följd av respektive av de analyserade åtgärderna och en estimering av hur dessa tillkommande volymer påverkar transaktionskostnaderna (*bid-ask spread*). Annan information avseende exempelvis kostnadsestimat har baserats på litteraturstudier och intervjuer. Åtgärdernas kostnader och nyttor jämfördes och följande slutsatser kan dras från analysen:

- TSO auktionerar EPADs är den åtgärden som medför störst samhällsekonomisk nytta, till stor del drivet av dess förmåga att tillföra lägre *spreadar* mellan köp- och säljsidan. Denna åtgärd har över lag god potential att förbättra marknaden med befintliga finansiella produkter.
- Flaskhals- och auktionsintäkter avseende LTTR:er, liksom implementeringskostnader har estimerats i denna studie, dock ej alla samhällsekonomiska nyttor. Potentiella samhällsnyttorna med LTTR-auktionering kan komma från indirekta effekter av förbättrad likviditet i andra risksäkringsprodukter, så som nordiska systemprisprodukter. Dessa samhällsnyttor bedöms dock som små.
- Om det huvudsakliga policy-syftet är att förbättra risksäkringsmöjligheterna för marknadsaktörerna på den svenska elmarknaden, rekommenderar vi att införa åtgärder som fokuserar på befintliga finansiella produkter. EPADs leverera redan nu samma funktion som LTTR:er och med föreslagna åtgärder kan likviditeten förbättras och transaktionskostnaderna minskas till rimliga kostnader.

Tabell 2: Summering över årliga kostnader och nyttor med analyserade åtgärder för förbättrade risksäkringsmöjligheter

	Åtgärd 1: Förbättrad *market making*	Åtgärd 2: Regionala EPADs	Åtgärd 3: TSO-auktionering av EPADs	Åtgärd 4: TSO-auktionering av FTRer
Volympåverkan: förbättrad likviditet (TWh)	6,1	9,4	17,5	35,1
Nyttor med adderad volym: Lägre *bid-ask spread*, (€m)	6,3	14,7	51,0	N/A
Kostnader (€m)	5,4	~ 0	0,45	0,45
Nettonytta	**0,9**	**14,7**	**50,5**	

Källa: Compass Lexecon analysis

Den tredje och sista delen av studien avser att föreslå en *roadmap* för implementering av föreslagna åtgärder, med primärt fokus på TSO-auktionering av EPADs. *Den sista delen av studien* innefattar även en identifiering av de mest relevanta stegen i implementeringsprocessen, nyckelaktiviteter i varje steg och tidsestimeringar.

Ei kan fortskrida med föreslagna åtgärder inom Sverige utan fördröjning, medan det krävs överenskommelser med angränsande länders NRAs för åtgärder som spänner över nationsgränser. Om två NRAs inte kan komma överens, skickas fallet vidare till ACER, som då har sex månader på sig att fatta beslut i frågan. Nästa steg i processen blir för den svenska TSOn, Svenska Kraftnät (Svk), att påbörja förberedelserna för implementering genom att exempelvis analysera finansiering av åtgärderna, metod för auktioneringsförfarandet och arrangera minst en publik konsultation. När Svk har färdigställt sitt förslag, ska det godkännas av Ei. När det godkänts (efter eventuell omarbetning), har Svk sex månader (anstånd för ytterligare sex månader kan eventuellt beviljas) på sig att implementera åtgärderna. Implementeringen innefattar bland annat att upphandla en auktionsplattform och tillhörande tjänster, implementera interna rutiner och en organisation för erforderliga aktiviteter, förbereda sig på att kontinuerligt utvärdera marknaden och hur den påverkas av införda åtgärder. Sammantaget är tidsuppskattningen för processen mellan 12 och 24 månader.

GLOSSARY OF ABBREVIATIONS AND TERMS

ACER	EU Agency for the Cooperation of Energy Regulators
Bid-ask spread	The difference between the lowest buying price and the highest selling price. It is a direct measure of transaction costs for a specific instrument and should remain low.
BZ	Bidding Zone
Congestion rent	Ignoring losses, congestion rents are the difference between payments made by loads and exports and the revenues received by generators and imports.
Ei	Swedish NRA, Energy Markets Inspectorate, Energimarknadsinspektionen.
EMIR	European Market Infrastructure Regulation that lays down rules on OTC derivatives, central counterparties and trade repositories. EMIR has been effective since August 2012.
EPAD	Electricity Price Area Differential. A futures contract that references the price difference between the day-ahead price in a specific BZ and the Nordic system price in the same period.
EPAD Combo	A combination of two EPAD contracts that hedges the price difference between two BZs.
EPAD, Regional	A regional EPAD contract is an EPAD contract covering a larger region than a single BZ.
FCA GL	Forward Capacity Allocation Guideline. It addresses the allocation of long-term transmission rights, necessary for the operation of long-term forward markets.
Future contract	A standardised financial contract that allows to lock-in a price for electricity delivered in future periods.
Liquidity	Refers to the speed and easiness by which assets can be bought or sold without drastically impacting market price.
LTTR	Long-term Transmission Right. A contract issued by TSO, that provides the holder with a right (option) or obligation to flow electricity in a specific direction between connected BZs during a specified time period.
FTR	Financial Transmission Right. A type of LTTR.
PTR	Physical Transmission Right. A type of LTTR.
Market maker	Refers to a market participant that provides both bids and offers (asks) as well as volumes to the market, increasing liquidity and market depth.

MiFID II	Markets in Financial Instruments Directive. MiFID II refers to the legislative framework as it has been effective since January 2018.
NRA	National Regulatory Authority
Open interest	The total number of pending (not yet settled) trades on a forward exchange. Numerous unclosed positions indicate a high willingness to participate.
OTC	Over-the-counter. Refers to financial contracts being traded between two parties and without a central exchange or broker.
PPA	Power Purchase Agreements. Bilateral agreements regarding financial or physical sales of power (cash settlement or provision of power).
Svk	Swedish TSO, Svenska Kraftnät
System price	The price that would be obtained if the entire Nordic was region was cleared as a single BZ, hence ignoring all transmission constraints. Calculated by Nord Pool.
TSO	Transmission System Operator

INTRODUCTION

This report is written for the Swedish Energy Markets Inspectorate (Ei) by a consortium of two consultancy firms, Merlin & Metis and Compass Lexecon. Ei wants to gain an increased knowledge and understanding of various instruments for risk hedging of electricity. Further, Ei wants to get an idea of what it means, in terms of time and cost, to introduce long-term transmission rights (LTTRs) in Sweden, compared with strengthening the risk hedging opportunities in current system with Nordic system price futures and EPADs. Such knowledge is needed to allow Ei, along with other NRAs in the Nordic countries and in the EU, to make coordinated decisions on risk hedging opportunities in accordance with Article 30 of the Forward Capacity Allocation Guideline (FCA GL).

The report shall bring insight into what concrete possible measures can be taken to achieve better risk hedging opportunities in the Swedish bidding zones (BZs) or in a BZ connected to the Swedish BZs. The report shall also provide a roadmap towards a cost-efficient improvement of risk hedging opportunities.

Background and motivation

European regulation and more precisely, FCA GL, seeks to ensure that market participants have sufficient opportunities to hedge electricity price risk across bidding zones. Article 30 of FCA GL establishes the principle that LTTRs by default should be issued by the TSOs on all BZ borders unless the competent regulatory authorities of the BZ border have adopted coordinated decisions not to issue LTTRs on the BZ border. LTTRs offer a mechanism by which market participants can hedge the cross-zonal price spread. If the electricity forward market is assessed not to provide sufficient hedging opportunities in the concerned BZ, the competent regulatory authorities shall request the relevant TSOs:

- to issue long-term transmission rights; or
- to make sure that other long-term cross-zonal hedging products are made available to support the functioning of wholesale electricity markets.

It is required that National Regulatory Authorities (NRAs) review cross-border hedging opportunities at least every four years. In 2021 the Swedish NRA, Ei, concluded that hedging opportunities are sufficient but there is potential for improvement of the risk hedging opportunities for electricity in Sweden.[1] In this context Ei wants to analyse potential measures to improve risk hedging opportunities in the electricity market in Sweden. This report seeks to analyse what it means, in terms of implementation time and cost-effectiveness in a societal perspective, to introduce a trading system with LTTRs in Sweden compared to reinforcing the risk hedging possibilities in the existing system (derivatives on system price and EPADs). The report also presents a roadmap of the implementation of the suggested measure(s).

Report structure

The report is structured as follows:

[1] Ei (2021): Utvärdering av risksäkringsmöjligheter på den svenska elmarknaden – för samråd enligt FCA-förordningen

Chapter 1 – Introduction

A brief overview of the context that this report is based upon. This chapter explains relevant hedging instruments that we have today and that we consider implementing, what type of market participants there are, and why they hedge. This chapter also explains the current market structure with its asymmetries regarding volume differences between consumption and production in each BZ, as well the historical price developments.

Chapter 2 - Literature review

A short summary of relevant findings for this study in academic literature and technical reports. The literature review includes public reports, public consultations regarding electricity price risk hedging on the Nordic electricity market, and TSO studies over the last 10 years, as well as academic literature regarding relevant market design issues and hedging instruments. Appendix 1 summarises some of the key literature, report-by-report.

Chapter 3 - Measures to strengthen the current risk hedging system

Chapter 3 describes six measures to strengthen the current risk hedging system that has been considered in this study, including pros and cons related to each measure. The measures are analysed based a literature review, interviews with market participants such as Nasdaq, TSOs, interest groups representing generators as well as consumers (see appendix A for a list of interviewed market actors), as well as our own expert view. In this chapter, three measures are chosen for further analyses in chapter 4.

Chapter 4 – Analyses of measures strengthening hedging opportunities in Sweden

This chapter qualitatively and quantitatively first assesses the status quo of hedging in Sweden with Nordic system price and EPAD contracts. Then, the chapter presents an assessment of benefits and costs of the three measures chosen in chapter 3 as well as an introduction of LTTRs.

Chapter 5 – Roadmap towards a cost-efficient improvement of risk hedging opportunities

A road map of how to implement the chosen measure(s), including implementation time and required activities.

Chapter 6 – Study limitations and future work

A short note on limitations that stem from the predefined scope of work as well as the methodology applied. In addition, some suggestions for future work and next steps are provided.

Hedging instruments

Market participants have different needs and strategies for hedging, which may lead to different preferences regarding hedging instruments. However, most market participants have the common objective of liquid hedging products that cover their relevant risk exposures. In this section, we outline the main tools used by market participants for hedging electricity prices in Sweden and EU.

System price electricity futures

Future contracts are the most common risk hedging instrument on the electricity market in Sweden today. Future contracts are standardised financial contracts that allow market participants to lock in a price for electricity delivered in future periods (e.g., weeks, months, quarters, years) often for a fixed volume over the entire hedging period (e.g., 1 MW). Settlement structures are offered with settlement either daily (mark-to-market valuation for the financial contract), or in the delivery period (DS Futures).

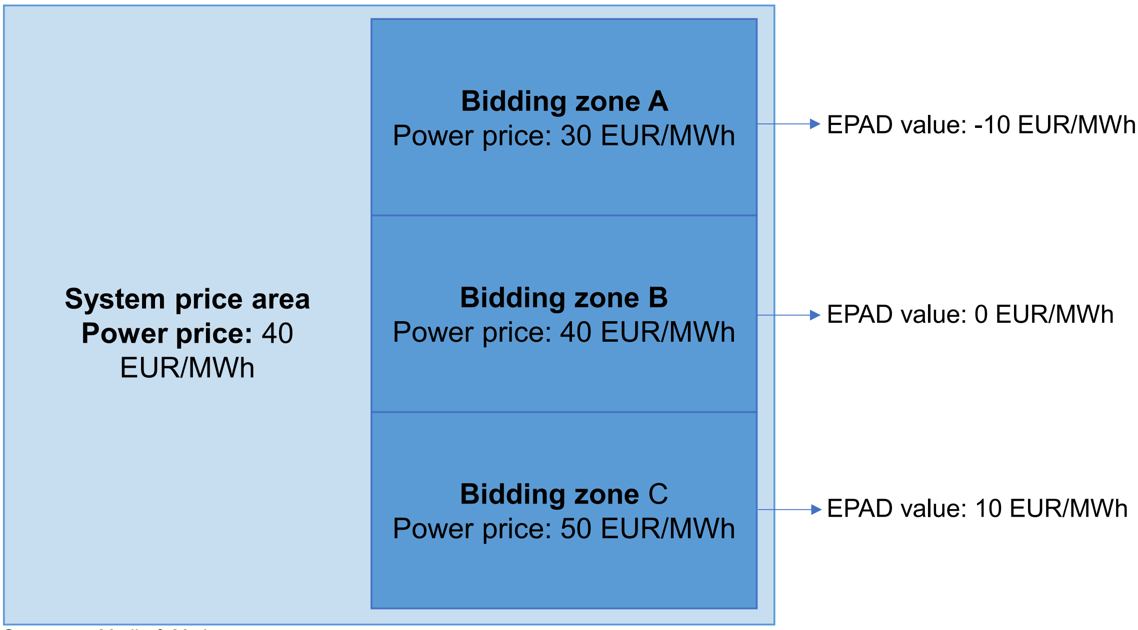
The main trading platform for futures trading of electricity in the Nordics is Nasdaq. Nasdaq offers both trading and clearing.

In most Continental European electricity markets, electricity futures are referenced against the spot price of a specific BZ. In the Nordic market, most electricity futures are referenced against the Nordic system price, rather than the price of a specific BZ. The system price is calculated by Nord Pool as the price that would be obtained if the entire Nordic was region cleared as a single BZ, hence ignoring all transmission constraints between the Nordic BZs.

Electricity Price Area Differential (EPADs)

To be able to hedge the electricity price in a specific BZ, the Nordic system price futures are completed with EPADs, a futures contract that references the price difference between the day-ahead price in a specific BZ and the Nordic system price in the same period. EPAD prices can thus be positive or negative, depending on the market participants' expectations of the price difference during the delivery period. A Nordic system price future and an EPAD future can jointly form a hedge for a specific BZ. EPADs are traded both on Nasdaq and over-the-counter (OTC). Figure 1 illustrates how the EPAD value is calculated as the difference between the Nordic system price and the BZ that the EPAD refers to.

Figure 1: EPAD illustration

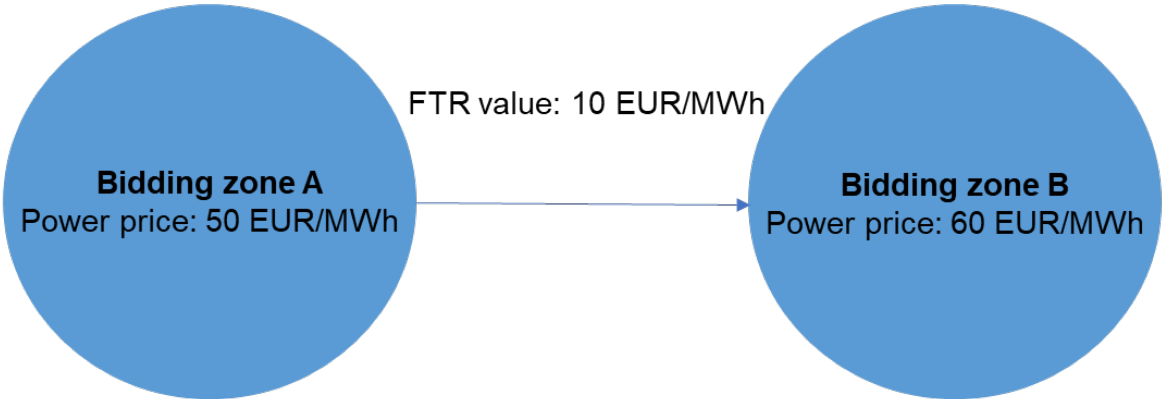


Source: Merlin & Metis

Long-Term Transmission Rights (LTTRs)

Long-Term Transmission Rights (LTTRs) are contracts issued by TSO's, that provide the holder with a right (option) or obligation to flow electricity in a specific direction between connected BZs during a specified time period. Currently on the electricity markets in Continental Europe such rights are typically issued as Financial Transmission Rights (FTRs), while Physical Transmission rights (PTRs) were more common in the past. FTRs are cash-settled, based on the price spread between the relevant BZs. An FTR option provides the holder with the price spread only where this spread is positive. An FTR obligation will result in a payment between the holder and the issuer of the obligation that reflects the direction of the relevant price spread. Figure 2 illustrates the value of a FTR between to differently priced BZs.

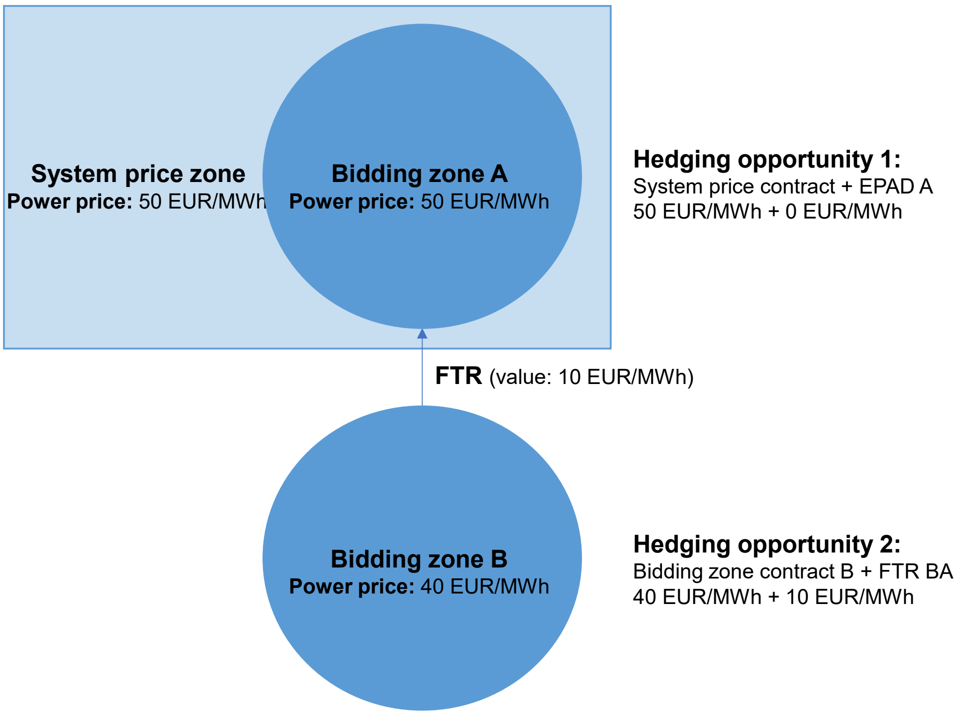
Figure 2: FTR illustration



Source: Merlin & Metis

FTRs can be used by market participants that want to hedge the price spread between connected BZs. FTRs can also be used by market participants to hedge the electricity price in a BZ by buying a future for a connected BZ and an FTR. Figure 3 illustrates how the electricity price for BZ A can be hedged both under the current system with a system price contract and an EPAD for BZ A, or with an alternative set up with a BZ contract referring to B and a FTR referring to the price difference between B and A.

Figure 3: Hedging with FTR or EPAD in bidding zone A



Source: Merlin & Metis

As LTTRs can be used as a complement to a financial contract for a more liquid BZ, to hedge the electricity price in a less liquid BZ, LTTRs are sometimes said to provide a “bridge to liquidity”.

Power Purchase Agreements (PPAs)

PPAs are bilateral agreements regarding the sales of power, financial or physical (cash settlement or provision of power). The PPA prices are often linked to the prices of futures and EPADs. PPAs are bespoke contracts, although efforts are made to standardise PPAs. The PPAs include specifications of delivery point, agreed price, time period, etc. Sometimes they can include a fixed volume and profile, while other times they may be under terms such as pay-as-produced. They typically cover a period of 5-15 years in the Nordics, although both shorter and longer contract periods exist. PPAs may also include solutions to handle counterparty risks, for example by a third party (e.g., a bank) taking on the counterparty risk. PPAs may be sold by specific generation projects or by utilities.

Liquidity on the financial hedging instruments for electricity in Sweden

The economic benefits of access to liquid, transparent hedging instruments

Market participants hedge to manage price risks. Most market participants prefer a predictable and stable financial result. Extreme market outcomes can cause economic costs for market participants that are not sufficiently hedged, i.e., higher costs of capital or the cost of having to liquidate a bankrupt firm. With an effective risk management, economic costs of extreme situations can be avoided. Access to liquid and transparent hedging products are in most cases essential for an effective risk management.

Illiquid hedging instruments tend to increase the direct costs associated with hedging and they make it more difficult for holders of these instruments to get out of their positions quickly and cost effectively. In an illiquid market bid-ask-spreads for example tend to be larger, making it more costly to get in/out of a financial position.

A lack of transparent hedging instruments may lead to less informed decision making among investors and thus increased economic costs. It may also increase the time needed to find a trading counterparty and to settle a transaction.

Briefly about the liquidity development on hedging instruments for electricity in Sweden

Today Swedish market participants mainly use the futures for the Nordic system price and EPAD’s for their hedging purposes. PPAs have gained volumes in the last couple of years, largely driven by a new type of investors looking for long-term financing of large investments in renewable electricity production. PPAs may contribute to reduce liquidity on the future markets, as market participants choose PPAs as a substitute to futures. If one of the PPA parties is a utility, it is common that the utility partially offsets the risk associated with the PPA by buying/selling futures. If the PPA triggers future trading, the effect on the liquidity on the future market will be low.

Nordic system price contracts are mainly traded at the Nasdaq exchange. The traded volumes and open interest in the Nordic system price contract have been declining gradually over a long period of time. After the introduction of MiFID II, EMIR, and the removal of bank guarantees (a cost-efficient collateral) in March 2016, traded and cleared volumes decreased substantially due to increased costs for collaterals and increased administration. Nasdaq has reported a large loss of clearing members since 2016, mainly small/medium sized market participants.

EPADs are mainly traded OTC through brokers such as SKM, but also traded over the Nasdaq exchange. The brokers often report trades to Nasdaq so that prices and traded volumes can be compiled, although it is challenging to compile complete information regarding order depth and bid-ask spreads on the EPAD market. Traded volumes on the EPAD contracts for the Swedish BZs have generally decreased over the period 2015-2020. As price differences between the Nordic system price and the Swedish BZs increased substantially 2020, traded volumes increased somewhat, until autumn 2021.

Why market participants hedge?

Different market participants have different hedging needs. The hedging needs and objectives are often largely defined by the market participant's role as a supplier, generator, or consumer.

Suppliers

Suppliers' risk exposure generally arises from entering supply contracts with fixed, or partly fixed prices. Today between 25-50% of the Swedish households have an electricity contract with fixed, or partly fixed price[2]. Many businesses also have fixed price or partially fixed price contracts with suppliers. These contracts expose the supplier to electricity price risk due to the need to purchase electricity to meet these supply obligations. As the risk exposure connected to these contracts is generally large in comparison to the contract margins, suppliers often practice the so-called back-to-back hedging. Back-to-back hedging is where any open position is immediately closed, meaning that fixed-price supply commitments are hedged (buying system price and if needed EPAD contracts) as soon as possible. Liquid hedging products are essential to hedgers using a back-to-back hedging strategy, providing an opportunity to quickly close new open positions. Conversely, a lack of a liquid hedging products may reduce suppliers' willingness to offer fixed-price contracts and/or increase the price of such contracts to the end consumer.

Generators

Some generators have a portfolio of assets, often with an active short term trading strategy. Other generators are more project-oriented investors, often investing in renewable resources, with a strategy to lock in a safe but low margin long-term profit. The latter category is in the literature often referred to as investors. The investors are typically looking for a long-term hedge, often 10 years or more, to lock in a profit and being able to secure favourable financing. The more traditional generators typically have a few years hedging horizon for most of their forecasted production. Hedging activity will often be influenced significantly by the generator's expectations of future electricity price developments relative to the market, i.e., a larger share of the forecasted future production may be hedged (sold) if future prices are assessed as high relative to their price expectation.

Consumers

Consumers are a very heterogenous group in hedging terms, both with differences between consumer categories, but also large individual differences. Many energy-intensive industries, as consumers often operate at low margins and with electricity contributing to a large share of their total operative costs. With the electricity spot prices being volatile, many energy-intensive consumers prefer a high degree of hedging including long-term. Like generators, hedging behaviour will also be influenced by expectations of future electricity price developments relative to the market, i.e., a larger share of the forecasted future consumption may be hedged (bought) if future prices are assessed as low relative to their price expectation. However, energy intensive consumers' hedging decisions will also be significantly influenced by considerations related to their end market.

[2] Statistics Sweden (SCB)

In particular, the desired hedging time horizon will reflect the business' certainty over future orders and activity.

An increasing number of consumers are looking for long-term hedging opportunities directly connected to a new renewable electricity production. These consumers often seek to contribute to new renewable energy being built by offering the investor an opportunity to lock in a long-term revenue needed to secure sufficient financing for the project. At the same time many of these consumers may have an interest in long-term price hedging.

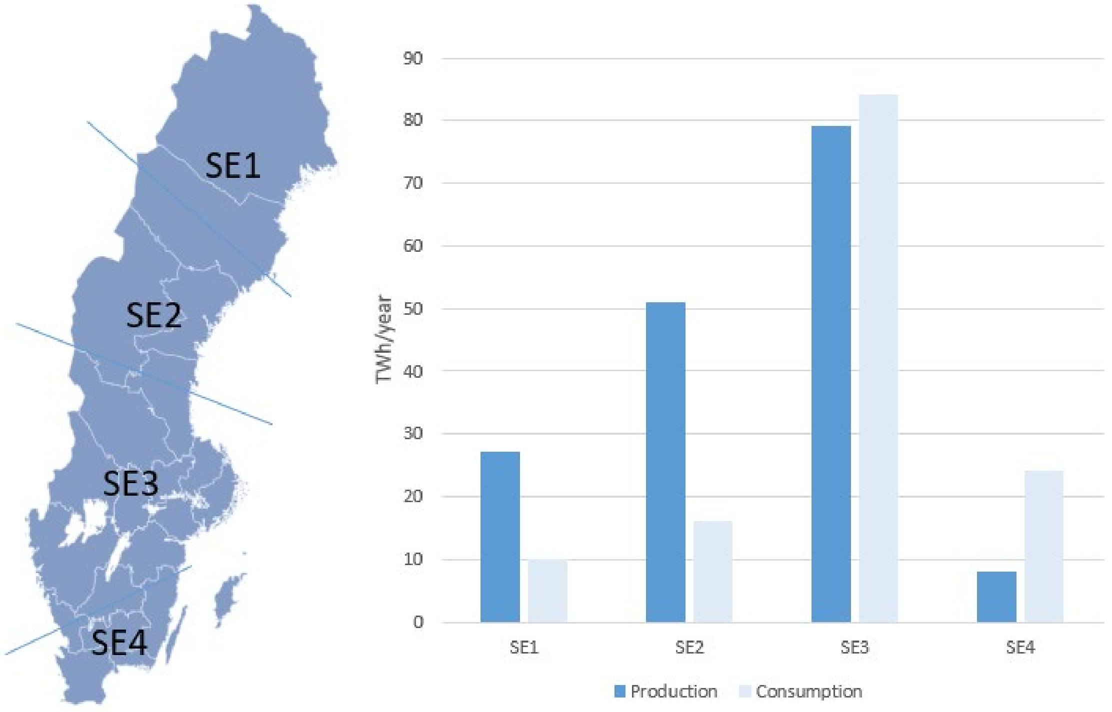
How does the market participants size affect its hedging activities?

Larger market participants do typically have more resources/market knowledge and are able to be direct exchange members[3], while smaller market participants often contract a larger market participant for market access. With the introduction of new financial regulation, the last couple of years (particularly in 2016), smaller and medium sized market participants have been seen abandoning their direct exchange memberships, and instead entering a bilateral agreement with one of the larger market participants. In addition to market access, a larger market participant can also offer a smaller market participant credit, physical trading/balancing services, etc.

The Swedish bidding zones

Figure 4 illustrates the balance between annual electricity production and consumption and shows how BZs SE1 and SE2 have a large electricity surplus, SE3 is mostly balanced, and SE4 has an electricity deficit. The imbalance between consumption and production in SE1, SE2 and SE4 contributes to an asymmetry between buying and selling EPADs in these BZs. The figure also illustrates how the volumes in SE3 are substantially higher than in the other BZs.

Figure 4: Illustration of the Swedish bidding zones and production/consumption 2021



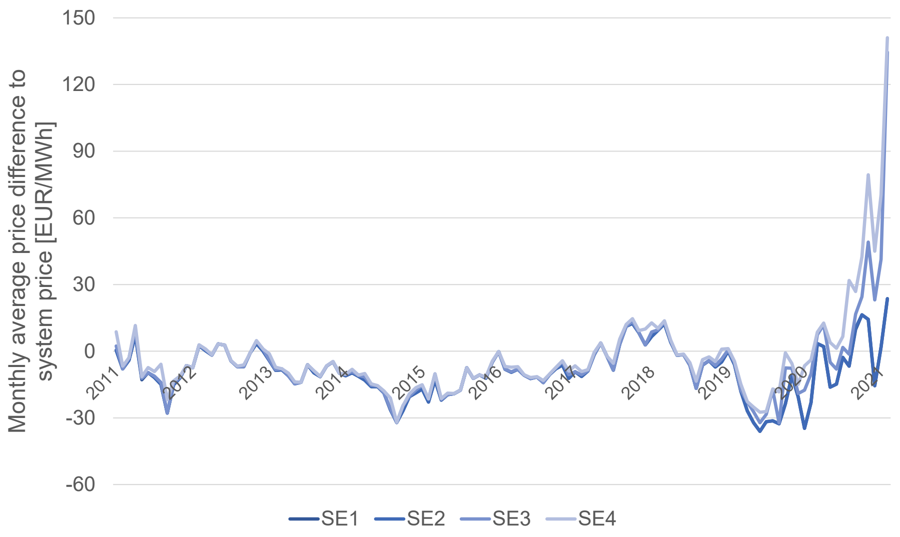
Source: Merlin & Metis with data from Nordpool

[3] Members on Nasdaq trading exchange

Market development

Figure 5 illustrates how the price differences between the Swedish BZs and the system price were rather modest since Sweden was split into four BZs in November 2011 until 2020. During 2020 and 2021 prices in SE3 and SE4 have been substantially higher compared to the system price and also compared to SE1 and SE2. When the price difference between the Nordic system price and the BZs was relatively low, many market participants chose to bare the price area risk and settled with hedging only the system price. Larger absolute price differences between the system price and the BZ prices have increased the interest for EPADs in these BZs.

Figure 5: Price differences between the Swedish price areas and the system price



Source: Merlin & Metis with data from Nordpool

LITERATURE REVIEW

As a part of this study, we have identified several relevant written sources. This chapter summarizes their main findings with focus on three parts. The first part presents metrics for evaluation of forward markets' efficiency and liquidity. These metrics are similar to those used in the analysis of this study. The second part brings about market participants' views on the hedging opportunities and the functioning of the markets. The third part focuses on alternative measures for improving hedging opportunities that have been discussed in previous literature, including TSO involvement, re-defining markets for improved symmetry, actions that can be taken by market actors as well as introducing LTTRs. Summaries of the key literature report-by-report can be found in appendix B.

Measuring efficiency and liquidity on forward markets

The report "European Electricity Forward Markets and Hedging Products – State of Play and Elements for Monitoring" from Economic Consulting Associates (2015) aims to provide insights regarding the functioning of forward markets and the availability of hedging products in the EU. The report lists the following features that characterize a well-functioning forward market:

- It provides effective hedging opportunities and is sufficiently liquid;
- It facilitates price discovery;
- It allows market access at a reasonable cost;
- It supports contestability in the wholesale and retail electricity markets; and
- It is characterised by effective competition.

The report points to the following metrics and monitoring methods that have been used to assess the efficiency of forward electricity markets.

Table 3: Metrics for the measurement of forward electricity market efficiency

Metric	Definition
Liquidity	Volume/value turnover, number of transactions, 'open interest', churn rates, bid-ask-spread, volume of bid and sell offers (MW), futures volumes, by timeframe.
Product availability	Share of long-term hedging products in total open interest.
Product transparency	Demand and supply transparency, reporting of all trades.
Low transaction and entry costs	Percentage of OTC contracts with force majeure and/or suspension clauses, entry/exit activity as a % of the number of suppliers/market participants
Level of granularity	Standard product clip size, diversity of products.
Diversity of counterparties	Number of market players/ new entrants per year, number of active traders, volume by trader type:

Table 3: Metrics for the measurement of forward electricity market efficiency

	retailer, financial, market maker, percentage of FTRs held by financial entities versus physical entities.
Low market concentration	Minimum number of companies that are needed to reach 50% of the market volume, Herfindahl–Hirschman Index (HHI), the combined share of the five leading producers of total buy volume and total sell volume, concentration ratios (CR3).

Source: Economic Consulting Associates (2015): European Electricity Forward Markets and Hedging Products – State of Play and Elements for Monitoring.

Based on the evaluation of these metrics, the report recommends the following to be monitored in forward electricity markets to ensure their functioning and capture deviations there of; turnover, churn rates, bid-ask spreads, reporting of trades, minimum number of companies needed to reach 50% market share and the Herfindahl-Hirschman Index (HHI).

The report also finds that there is a limited amount of literature with respect to market monitoring methodologies for the efficiency of forward capacity allocation. It provides an approach to determining market efficiency in EPADs. The methodology is based on Spodniak et al. (2014) and seeks to determine if EPADs provide a correctly priced hedge against cross zonal price differences in the Nordic market.

Table 4: Evaluation methodology for EPAD market efficiency

Evaluation against criteria	Calculation methodology	Interpretation of results
The proposed measure looks at market efficiency defined as the extent to which EPAD prices equate to expected congestion rents. This is the case if parties are seeking a hedge against congestion affecting prices.	Calculate the value of the EPAD as the difference between the traded price and the average price spread in the market over a year. The residual value represents risk premium. A Nordic benchmark can be derived from the same data; this should be used to adjust the EPAD value for each area to remove any year-on-year variation affecting the whole market.	A net EPAD value per MWh should be close to zero once adjusted by subtracting the regional benchmark value from the area value. There is no specific target range, and it is difficult to be certain how to quantify inefficiencies. Trends over time in area EPAD values can then be assessed with changes investigated. Issues such as hydrology can affect the year-on-year values and so results are only a prima facie assessment.

Source: Table based on Economic Consulting Associates (2015): European Electricity Forward Markets and Hedging Products – State of Play and Elements for Monitoring.

With respect to the Nordic market, the report finds that the market surveillance unit at Nasdaq OMX Commodities as well as NordREG in its role have been successful in monitoring the efficiency of the market and conduct of market participants, providing confidence in the pricing mechanisms, the transparency of price relevant information and integrity of the market.

The paper, "Forward risk premia in long-term transmission rights: The case of electricity price area differentials (EPAD) in the Nordic electricity market" by Spodniak and Collan (2018) has analysed the price discovery process, in particular hedging behaviour in derivatives markets that are explained by forward risk premia that is determined by market participants' expectations and risk preferences. As noted above, it is defined as the systematic difference between trading prices of electricity as reflected in forward contracts and the spot prices observed on the date of delivery (revealed ex-post) and can be seen as a mark-up charged either by suppliers or consumers for bearing the demand and price risk for the underlying commodity. The authors explore the forward risk premia dynamics on EPADs by investigating the significance, direction and magnitude of forward risk premia in individual bidding areas and contract maturities during the period of 2001-2013.

The authors find that the difference between the current forward price and the expected future spot price is negative. Negative risk premium could imply systematic hedging pressure effects. The relative (buyer vs seller) risk aversion regarding cross-border price differences will be affected by congestion-based transmission risk in an export or import oriented area. Generators may be more risk-averse in an export-oriented area with area prices very close to, or below the system price. This may lead to negative risk premia, due to greater hedging pressure of the buyers over sellers. With the increasing risk of area price hikes, retailers and large electricity users may become more risk-averse and their risk aversion may change. In this case, sellers could exert greater hedging pressure over buyers in commanding positive risk premia in EPAD contracts.

However, the empirical findings from analyses where risk premia are regressed on their respective remaining time to delivery support only partially the hypothesis of a negative relationship between forward risk premia and time-to-maturity. The authors emphasize that this finding presents the need for further research on forward risk premia by expanding the considered factors beyond market power and market price of risk to consider supply risks. With increasing share of intermittent generation, the security and reliability of supply will be increasingly relevant in the derivatives markets.

The authors point to churn rates, bid-ask spreads and open interest (contracts that have not yet been liquidated) as relevant measures of liquidity. They note that they are not able to identify whether liquidity problems are a supply or demand problem but conclude that the solutions to improve EPAD liquidity reside in the market participants knowledge about the product’s benefits, and reduction of transaction costs, fees, and market complexity. In particular, they find that the regulatory burden of e.g. EMIR and MIFID, has become an entry barrier for market newcomers that could impact liquidity.

As liquidity is a key measure and referred to frequently in the context, its definition is important to highlight. The EU ASSET study by Tractebel Impact (2021) provides the following definition of liquidity: “*Market liquidity may refer to the speed and easiness by which assets can be bought or sold without drastically impacting the underlying market price. Concretely, for energy traders, this translates into several requirements such as having volumetric markets with many counterparties, sufficient product variety, adequate price discovery, low transaction fees and execution complexity*.”

In addition, the report specifies parameters that are relevant for measuring liquidity that are presented in the table below.

Table 5: Metrics for the measurement of market liquidity

Metric	Definition
Turnover	The total traded volume or value generated over a specific timeframe, reflects global trend in market activity.
Open interests	The total number of pending (not yet settled) trades on a forward exchange or for a specific product. Numerous unclosed positions indicate a high willingness to participate.
Churn rates	The total traded volume divided by its targeted physical demand. Although there is no agreement, many stakeholders believe a churn of at least 300% is

Table 5: Metrics for the measurement of market liquidity

	required for a market to be considered liquid (Economic Consulting Associates, 2015).
Market depth	The ability of the market to absorb orders without them drastically affecting prices (measured graphically or using Kyle's Lambda in practice.
Bid-ask spread	The difference between the lowest buying price and the highest selling price (both in-the-money). It is a direct measure of transaction costs for a specific instrument and should remain low (EFET, 2016)). [4]
Time to maturity	Time to maturity in a forward market defines the time between the execution of the forward trade and the target delivery period. Longer maturities (3+ years) indicate liquid products and better price discovery.
Risk premiums	The difference between the forward price and the spot price of the underlying period (DNV-GL, 2020). A positive risk premium may indicate a scarce market or a high risk-aversion from buyers. Meanwhile, negative premiums (discounts) can point to a high risk-aversion from producers or an oversupplied market.

Source: EU ASSET study (2021) by Tractebel Impact.

A study that has evaluated liquidity in the Nordic and Baltic markets is "Analysis of Electricity Forward Market Hedging Opportunities in Finnish, Estonian, Latvian and Lithuanian BZs´ Borders" by Thema Consulting Group (2021). The report examines possible measures for increased sufficiency of hedging opportunities in the Finnish, Estonian, Latvian and Lithuanian BZs, as well as the bordering BZs in Sweden (SE1, SE3, SE4) and Norway (NO4). This work follows the calculation of the measures specified in the NordREG Methodology[5], including open interest, trading horizon, traded volumes, bid-ask spreads, churn rates, ex-post risk premia, correlation coefficients, and the Amihud illiquidity ratio.

The report notes decreasing liquidity in the system price contract, while liquidity in the EPAD markets has increased slightly from 2020, in line with what has been seen in other studies. The EPAD contracts for Stockholm and Helsinki are found to be far more liquid than for example Luleå, Malmö and Trondheim. The open interest in the EPAD contract for Tallinn and Riga is less than 1% of the corresponding figure for Helsinki or Stockholm. The system price contracts show relatively tight bid-ask spreads for the longer contracts (year, month and quarter), at around 0.5 EUR/MWh, but higher spreads for the near-term contracts, in the order of 1–2 EUR/MWh.

The bid-ask-spreads are analysed as a proxy for transaction costs, as they represent direct transaction costs for market participants. The report concludes that high bid-ask spreads may both cause and be caused by low liquidity. High transaction costs discourage active trading and therefore harm liquidity. While illiquidity increases the inventory management costs that traders must bear and results in them requiring a larger bid-ask spread to be encouraged to trade.

No clear trend in the development of bid-ask spreads for system price products is found. The system price contracts show tight bid/ask spreads for the longer contracts (year, month, quarter), but higher spreads for the near-term contracts, indicating a relative illiquid near-term market. The report also finds that the bid-ask spreads for many of the studied EPADs, including Helsinki, Malmö and Sundsvall, increased early 2020, and are relatively high. Further the report concludes that there is a relatively high degree of correlation between the spot prices in Finland and the Baltic states, indicating that the more liquid Helsinki EPAD may be used as a hedging proxy for market participants in the Baltic countries.

[4] EFET. (2016). ENTSO-E survey on market efficiency with regard to bidding zone

[5] NordREG (2020): Methodology for assessment of the Nordic forward market

Market participants' perceptions on liquidity and hedging opportunities on forward markets

A Thema study, "Power Price Risk Hedging Opportunities in the Norwegian Market" (2021), discusses whether power price risk hedging opportunities for Norwegian market participants need to be strengthened and examines options to improve risk hedging opportunities in the Nordic power market. It points out that in theoretical terms, a lack of liquidity and transparency in hedging markets imposes a variety of economic costs, some directly such as larger bid-ask spreads, some indirectly such as needs for bilateral contracting. The report also concludes that liquidity of the financial power market has been in decline since the 2008 financial crisis and lately open interest in system price contracts appears to have fallen. The report lists factors that stakeholders in the Norwegian market view as affecting liquidity on the exchange in general. These include increased collateral costs and more burdensome reporting requirements as well as the attractiveness of PPAs and vertical integration among some market participants. In addition, the following factors affecting liquidity on EPAD markets are listed; small number of market actors, market power, asymmetry in local supply and demand as well as the regulatory risk related to bidding zone redefinition.

The advantages and disadvantages of several possible interventions to support liquidity are considered in the report. These include, among others, redesign of BZs, the creation of regional EPADs, TSO requirements to supply either transmission rights or EPADs, and enhanced market-making. As noted, the effectiveness of these options depends on the underlying cause of low liquidity and conclude that the choice of option should ideally reflect an explicit diagnosis of the relevant cause or causes.

Also surveys and interviews with market participants suggest that there is widespread concern about a lack of liquidity for the financial derivatives used for power price hedging, especially EPADs. Another study that reports this is Thema's report (2021) titled "Investigation of bilateral hedging and hedging strategies". The report summarized the market participants' views of the sufficiency of current hedging opportunities, as well as how these opportunities might be improved. The report includes an online questionnaire analysis combined with in-depth interviews. In total 61 respondents provided their input to the study, representing different stakeholders.

Majority of the respondents viewed hedging opportunities as insufficient. EPAD liquidity was thought to be undermined in particular by the small number of actors present in each BZ, as well as – in some zones – the asymmetry between generation and consumption volumes and the presence of market power. There were, however, also some groups of respondents that considered the hedging opportunities to be sufficient. These included:

- Large generator or trader organisations with trading desks and relatively sophisticated hedging operations (although there is not a consensus among such actors);
- Large consumers that have found success using PPAs; and
- Small retailers that are satisfied with the hedging solutions provided by brokers or hedging services providers.

Less than 5% of the respondents hedged exclusively via the exchange. The remainder conducted at least some hedging activity bilaterally and a significant share (42%) hedged exclusively using bilateral arrangements or Power Purchasing Agreements (PPAs).

Motivations for bilateral trade varied somewhat among participants. Smaller actors meant that the administrative costs associated with direct exchange participation may be prohibitive and therefore bilateral trade, for example supported by a broker or a hedging services provider, is a preferable approach to hedge exposures. For those wishing to hedge long-term, a lack of market depth in longer-dated exchange contracts encourages the use of PPAs. Larger consumers with relatively stable consumption may also be attracted to PPAs because they imply lower administrative costs over their lifetime, while also dealing with area price risk and the regulatory risk of BZ redefinition. Large scale generators are more likely to combine exchange-based and bilateral trade and to explicitly contrast the option of trade via the exchange with OTC trades or the use of PPAs. Where the perceived depth or liquidity of the exchange is lacking, they may opt to hedge bilaterally.

Possible measures for improving hedging opportunities by TSO involvement

A study by Thema/Hagman Energy (2015), “Measures to support the functioning of the financial electricity market” compares six different models for TSO involvement in the EPAD market in case such involvement would become necessary. The background for the report was that while system price contracts had been relatively liquid to that point, the same had not been true for all EPADs. The authors point out that there have been different challenges in different BZs; some BZs have been without listed EPAD contracts, some with listed EPAD contracts but with a skewed supply-demand balance while other BZs have had listed EPAD contracts and a market maker. They also emphasize that low liquidity is not a problem if there is sufficiently high correlation between the system price and the area price, or if market participants are hedged via bilateral contracts. The report therefore concludes that there is a need for NRAs to assess whether lacking or low liquidity indeed implies a market failure in the form of lacking hedging opportunities before a TSO is instructed to intervene in the market. If this is not the case, a market intervention can imply an efficiency loss. Market participants feedback has been that they do not wish to replace basic hedging in the system price with basic hedging in area prices.

Two of the measures that have been studied in the report relate to TSO supporting the **market making function**, either by financing a sufficiently tight bid-ask spread and minimum volume or taking on itself the market maker function by guaranteeing minimum spreads. They find the second of the two to be similar to the first one but more costly for the TSO, therefore focusing on the first alternative. In terms of costs, supporting market making would imply a fixed cost to be paid by the TSO. The report finds that it could be sufficient to support one market maker rather than two or more in each BZ. Supporting market making would not change the TSOs price risk, nor its volume risk that depends on the relationship between traded volumes and contract volumes. TSOs are normally exposed to volume risks related to available transmission capacity, but face no firmness risk, as congestion revenues accrue from the actual trades generated by differences in spot prices between BZs[6].

Another report supporting improved market making, “Hedging possibilities and the Forward Capacity Allocation Network Code” from EC Group in 2015 investigated the consequences that introduction of LTTRs could have on the Nordic market. This report finds that instead of LTTRs, one should create better hedging opportunities by supporting current markets by means such as letting the TSO support a market maker service to increase liquidity.

Two other measures in the 2015 Thema/Hagman Energy study relate to **TSO involvement by auctioning EPADs or EPAD combos.** In the case of EPADs, the TSO would sell contracts if the cause is missing supply, and buy contracts if the cause is missing demand. In the case of EPAD Combos, the TSO would sell EPADs in one BZ and buy the corresponding volume in another BZ. EPAD auctions should be performed in cooperation with an exchange listing EPAD contracts. This would imply some costs, as well as any settlement of positions that the TSO would be required to do. In a later (2021) Thema report, “Power Price Risk Hedging Opportunities in the Norwegian

[6] The report defines price risk as the risk that price differences are smaller than expected, volume risk as the risk that the traded volumes are smaller than expected, and firmness risk as the risk related to whether the volumes defined in the contracts are fixed up-front (firm).

Market", it is noted that auctioning could provide an additional benefit in comparison to adding volumes to continuous trading, namely that a well-functioning auction can help provide credible and robust reference prices to secondary trading and provide easier market access to smaller players.

The Thema/Hagman Energy (2015) study also points out that auctioning of individual EPAD contracts would introduce a new price risk for the TSO in terms of contract losses. However, contract losses due to changes in area price differentials will often be associated with increases in the associated congestion rent. The study concludes that the change in the TSO's risk exposure depends on the correlation between the system price and the relevant area price. Normally the total risk exposure is reduced. Auctioning of EPAD Combos is likely to further reduce the risk of contract losses as it implies selling in one area and buying in another, and hence to reduce the total price risk exposure of the TSO. In well-functioning financial markets, the price of financial contracts should reflect expected market values. However, if the auction does not manage to realize the expected values, the TSO cost will be higher.

The study also points out that EPAD auction volumes should be based on an assessment of the volume needed to achieve the desired liquidity in the concerned BZ, and not on the exchange capacity between BZs. Even if EPAD contracts are strictly firm, the volume risk associated with EPADs will vary between different BZs.

The authors conclude that liquidity and hedging opportunities are likely to be improved by models that support the EPAD market by means of increased liquidity. However, in a BZ with a skewed supply-demand balance, a market maker function may not be as efficient as auctioning of EPADs directly which increases traded volumes. It is also noted that liquidity will depend on secondary trading opportunities.

Another benefit of TSO involvement in supporting the EPAD market is that it will not split liquidity by introducing new financial products, nor reduce trading in system price contracts. This is found to be positive since existing financial markets for system price contracts have been particularly liquid in the Nordic market. As EPAD contracts are combined with hedging in the system price, this alternative would support the current market structure. Still, the authors find that if needed, EPAD trading could potentially be split between platforms depending on the TSO's procurement process for the auction platform or support for market making. Looking into these alternatives, the study found no strategic behaviours that would give arise to either, concluding that no such concerns appear relevant.

With respect to market participants' costs, they would be very limited. As the TSO would support market making the reimbursement cost would go to the TSO not to other market participants. Also, the costs from EPAD auctions would be insignificant to market participants if they are not required to register on a different exchange or clearing house.

The study by Thema/Hagman Energy (2015) went on to compare these measures to FTR auctions, finding that implementing FTRs would be an inferior alternative to measures that support EPAD trading in the Nordic market, since the measures of supported market making and auctioning of EPADs are linked to and strengthen the trading of system price contracts, in contrary to FTRs. The authors therefore prefer the measures that support EPAD trading to introduction of FTRs.

According to the authors, the preferred option between supporting market maker function or EPAD auctioning depends on the situation in the BZ. In a BZ with a skewed balance between supply and demand, support to a market maker function may be insufficient. Auctioning of individual EPAD contracts directly increases the traded volume. However, this may expose the TSO to risks for contract losses. Auctioning of EPAD Combos has the advantage that the magnitude of possible contract losses is smaller for the TSO since an EPAD Combo combines a buy in one area with a sell in another area. The report summarized the findings in a table (see Table 6). More details on the FTR alternatives are presented in the chapter below.

Table 6: Comparison of market impacts of the different measures

Criteria	Support market maker function	Auction EPAD contracts	Auction EPAD Combos	Auction FTR options	Auction FTR obligations
Liquidity and hedging	++	++	++	0	+
Existing markets	++	++	++	-	-
Strategic behaviour	0	0	0	0	0
Market participants' direct costs	0	0	0	-	-
Overall ranking	1	1	1	3	2

Source: Thema/Hagman Energy (2015): Measures to support the functioning of the financial electricity market.

Characteristics of EPADs, EPAD Combos and FTRs

A paper by Spodniak, Collan and Makkonen (2017) titled "On long-term transmission rights in the Nordic electricity markets" has evaluated the contract types for hedging the risks connected to LTTRs; the financial transmission right (FTR) and the electricity price area differentials (EPADs), including the possibility to replicate the FTR contracts with a combination of EPAD contracts. The paper notes that these alternatives differ in many dimensions. EPAD contracts are used to build a hedge for a bidding area price in relation to the system price, while an FTR contract hedges the price difference directly between two adjacent bidding areas. This also means that to hedge the price difference between two adjacent bidding areas with EPADs, one must use a combination of two EPAD contracts (one long and one short). These are referred to as EPAD combos.

As an FTR contract price is directly dependent on the price difference between the two bidding areas in question while an EPAD Combo price is also dependent on the joint relationship between the two areas prices vis-a-vis the system price, there are consequently more possible states that can occur, when an FTR is constructed with two EPAD contracts, than are possible with a pure FTR. The authors point further that dramatic changes in the relationship between the area prices and the system price may occur during the maturity of EPAD contracts, which may cause difficulty in being able to judge the best combination of EPAD contracts (from the four possible contracts between two areas and the system price) to be is used to replicate an FTR. That is, it may be more difficult to forecast two rather than one price difference.

Further, EPADs and EPAD combos are securitized purely financial contracts traded in a securities exchange, without a direct link to the transmission capacity of the interconnectors and thus also without volume caps, while the FTR contracts are connected to the physical transmission routes and capacities. EPADs and EPAD combos are put on market by the Nasdaq, while the FTR contracts are typically auctioned by the TSOs in a single allocation platform at European level. This means that the market mechanism of the hedging products in the Nordic market and the proposed FTR market is different; also, the efficiency of the marketplaces in which these contracts are traded will play a role. The paper provides a summary of the underlying characteristics of each contract type in a table (see Table 7).

Table 7: Main characteristics of FTRs, EPADs and EPAD Combos

Attributes	Long-term Transmission Rights (LTTRs) Financial Transmission Rights (FTRs)	Electricity Price Area Differentials (EPADs)	Combinations of electricity price area differentials (EPAD Combos)
Underlying	Hourly spot price difference between two bidding area prices.	Hourly spot price difference between bidding area price and the system price.	Hourly spot price difference between two bidding area prices.
Specification	Position dependent on the chosen route and direction.	Requirement for the system price calculation.	Combination of two EPAD contracts; requirement for the system price calculation.
Hedging	Provides a complete hedge if market participants have a physical position in both markets. Option or obligation type.	Provides a complete single area hedge, if market participants have a financial position for system price and physical position in the market. Obligation type.	Provides a complete hedge, if market participants have a financial position for system price and physical positions in both markets. Obligation type.
Volume limits	Financial contract limited by the volume of physical transmission capacity, with the possible netting (selling higher volume due to counterflows).	Independent financial contract unrestricted by transmission capacity volumes.	Independent financial contract unrestricted by transmission capacity volumes.
Auctioneer/ marketplace	Auctioned by transmission system operator (TSO) or “allocating company”.	Sold and cleared by an exchange.	Sold and cleared by an exchange.
Risks	Firmness and counterparty risks, revenue adequacy, impacts on bottleneck income.	Counterparty risks borne by the exchange; firmness ensured (OTC and bilateral trade risks separately).	Counterparty risks borne by the exchange; firmness ensured (OTC and bilateral trade risks separately).
Trading	Liquidity for longer timeframes supported by additional contracts, e.g., Auction Revenue Rights (ARR), liquidity dependent on secondary market place efficiency.	Electronic trading system (ETS), OTC and bilateral trading; liquidity dependent on marketplace efficiency.	Electronic trading system (ETS), OTC and bilateral trading; liquidity dependent on marketplace efficiency.

Source: Spodniak, Collan and Makkonen (2017): On long-term transmission rights in the Nordic electricity markets.

Notwithstanding the observed differences between the construct of the three LTR vehicles, what remains is that the obligation type (future) FTR contract and EPAD Combo are theoretically equivalent in terms of the protection they offer. The authors point out, however, that this theoretical equivalence is a simplification of reality since it omits firmness, counterparty, and revenue adequacy risks, among others. Also, the reliance on exchange quoted EPAD closing prices represents a risk due to potential market inefficiencies in contract pricing in Nordic EPAD markets.

Possible measures for improving hedging opportunities by re-defining markets for improved symmetry

Considering the underlying structural asymmetries in the EPAD markets, the question arises on bidding zone reconfiguration. The EU Asset Study by Tractebel Impact (2021), “Smaller bidding zones in European power markets: liquidity considerations", provides a view on potential adverse effects on liquidity and market functioning if smaller BZs are introduced in European wholesale electricity markets. It takes its point of departure in the current zonal approach to pricing electricity in European wholesale electricity markets where congestion is assumed to be negligible within BZs and electricity thereby uniformly priced. Prices between BZs vary when there is scarcity in the cross-zonal transmission capacity. With integration of intermittent generation, zonal pricing may result in higher levels of structural congestion that trigger the need for smaller BZs that can improve both the allocative efficiency (price signals to consumers and dispatch) as well as the dynamic market efficiency (where, how much, and what technology to invest in). Smaller BZs also offer more transmission capacity to the market, foster market integration and improve competition. There are, however, concerns related to liquidity and market functioning as BZs are reduced in size.

The study suggests that smaller BZs may result in lower liquidity by increasing price volatility and fragmenting the market. Illiquidity complicates risk mitigation practices resulting in higher costs to final consumers. The analysis in the study, based on quantitative measures as well as a literature review, concludes that the fundamental issue might not be related to the size of the BZs as such, but rather to the current design of risk mitigation instruments that are not well adapted to new BZ configurations. The report also emphasizes the importance of the physical (spot) markets pricing the transmission externality to improve allocative and dynamic market efficiency. Higher price volatility in smaller BZs should therefore be considered as a price signal to the market, not as a problem, to better reflect locational scarcity in the network as well as to signal the need for more flexibility. The search for the optimal BZ configuration should aim to make spot prices right first.

A study "Power Price Risk Hedging Opportunities in the Norwegian Market" by Thema (2021) discusses, in addition to the measures discussed above, also BZ redesign and the creation of regional EPADs as two possible options that could be addressed to correct for local asymmetry in the supply and demand of EPADs and thereby lead to improved market liquidity.

The study concludes that **BZ reconfiguration** could address potential structural causes of low liquidity in the EPAD market in an impactful way. However, BZs not reflecting the grid congestions may impose additional economic costs, for example in terms of more costly congestion management. Further the study mentions the possibility of a less dramatic version of this option, amending the objectives used in the BZ review process, to place a greater emphasis on the potential hedging liquidity impacts.

The same study also suggests creating EPAD like financial products that cover larger areas than individual BZs, **regional EPADs**, as a possible measure that could tackle market asymmetry. Each region would need to have a reference price defined to be used as a proxy for the combined BZs, and a financial product, regional EPAD, be created for the spread between this reference price and the system price. The reference price would need to be highly correlated with the underlying prices in BZs. Since the correlation will not be perfect, however, the report points out that the use of regional EPADs would leave a residual basis risk between the regional EPAD and the BZ price.

Actions from market actors

Another alternative for approaching the structural issues in the market could be to adjust the system price definition from its current form (being based on a theoretical calculation of what the Nordic system electricity price would have been without any constrains within the system price area), to a **system price that is based on a weighted average.**

As it is pointed out in the paper "On long-term transmission rights in the Nordic electricity markets" by Spodniak, Collan and Makkonen (2017) there are differences between the Nordic and the

Continental European electricity markets, one such difference being that in the Nordic markets a system price is quoted and acts as a benchmark price for the markets.

As mentioned above, the study by Thema/Hagman Energy (2015), “Measures to support the functioning of the financial electricity market”, finds that measures to support the EPAD market are preferred also because they do not split liquidity between products, nor reduce trading in the system price contracts. This is particularly important since existing financial markets for system price contracts have been relatively liquid in the Nordic market.

The NRA could also make a market intervention by **forcing vertically integrated companies to trade**. This measure is mentioned in the study “Power Price Risk Hedging Opportunities in the Norwegian Market” by Thema (2021). The study notes that this could add volumes to the market and thereby liquidity. However, this measure does not address the structural causes of illiquidity and may reduce or eliminate genuine efficiencies from vertical integration.

Introducing LTTRs to the market

A paper by Spodniak and Collan (2018), “Forward risk premia in long-term transmission rights: The case of electricity price area differentials (EPAD) in the Nordic electricity market” makes a note on a fundamental difference between the EPAD market and markets for FTRs. In EPAD markets, generators and retailers are each other’s counterparties, which contrasts with FTRs where TSO is the counterparty. This could potentially reduce forward premia. There are two key differences between the EPADs and FTRs; (1) EPADs have no connection to the congestion rent collected by the TSO during cross-border congestion, whereas FTRs are issued directly by TSO, which redistributes the collected congestion rent, and (2) FTRs hedge the price difference between BZs, whereas an EPAD hedges the price difference between a BZ and the reference system price.

A study titled “Hedging possibilities and the Forward Capacity Allocation Network Code” from EC Group in 2015 investigates consequences that introducing LTTRs could have on the Nordic market. It emphasizes that any market intervention, including the requirement of a TSO to offer LTTRs, should be designed to correct a market failure and be based on a cost-benefit analysis. Also, the introduction of LTTRs would likely entail significant costs. It is noted that there could be many reasons for missing markets beyond market failure, such as insufficient demand for the products, or lower willingness to pay for hedging than the costs involved.

One argument for introducing LTTRs was that missing markets for cross zonal hedging products would hamper competition in the wholesale market, and tradable LTTRs could provide a solution for this problem. However, the report finds that there are in fact more direct and efficient measures mitigating the abuse of dominant positions in the physical electricity markets - improved competition cannot be expected by contract opportunities only.

The EC Group (2015) report also notes that Nordic TSOs are regulated to act independently of short-term profit or loss from congestion rent and therefore also the sale of LTTRs. This means that requiring TSOs to sell LTTRs is not likely to change their practices when it comes to setting cross-border transmission capacities. Auctioning LTTRs would require market participants to perform hedging activities on two platforms with two types of contracts that are not fully compatible. Overall, the report finds that LTTRs are not very compatible with a system price that is without geographical reference. It therefore concludes that introducing LTTRs could risk significant loss of liquidity and lead to increased hedging costs in the Nordics. What the report suggests instead is to create better hedging opportunities by supporting current markets, e.g., by letting the TSO support a market maker service to increase liquidity.

Thema/Hagman Energy study "Measures to support the functioning of the financial electricity market" compares the models for support market making and TSO involvement with two alternatives where TSO would auction FTRs, as mentioned above. The first option was auctioning of FTR options related to the interconnection between two BZs according to the expected net transmission capacity between the BZs. As the FTR option entitles the holder to the congestion rent in one direction for each hour when it is positive, the price for an FTR option will reflect the expected sum for all hours with positive price differentials. The second alternative was for the TSO to auction FTR obligations that oblige the owner to also pay the price differential for all hours when it is negative. Hence, the settlement of an FTR obligation equals, and will reflect, the average price differential for the period.

Relative to risks, the study finds that auctioning of FTR options in both directions on an interconnector removes the price risk for the TSO as it effectively sells the right to the congestion rent. The second alternative, auctioning of FTR obligations in both directions does not change the risk exposure of the TSO. Overall, auctioning of EPADs or FTR obligations exposes a TSO to lower auction risk than auctioning of FTR options because the former instruments are more suitable for fundamental hedging. If congestions in both directions are possible, an FTR option will be less useful for fundamental hedging than an FTR obligation. An FTR obligation can be suitable for fundamental hedging of the day-ahead price in a specific BZ if it can be combined with a liquid area price contract for the other BZ, forming a 'bridge to liquidity'.

The study concludes that auctioning of FTR contracts would mean that a new product is introduced that could risk reducing liquidity in the existing EPAD contracts as well as system price contracts. Also, from the market participants perspective, participation in FTR auctions implies costs as they are required to register at the single allocation platform and provide collaterals to it as well, or in the case of FTR obligations to the clearing house chosen by the single allocation platform. In addition, the Thema report from 2021, "Power Price Risk Hedging Opportunities in the Norwegian Market", notes that the product set and market design would be significantly complicated by an introduction of FTRs.

In 2016, a report was published by the Swedish Energy Markets Inspectorate, "Area price hedging and the Nordic market model", that describes the advantages and disadvantages of the various price hedging instruments in relation to the Nordic market model and the impact the instruments have on overall competition and consumer benefit. In addition to describing the instruments in the Nordic market context, the report summarizes relevant findings from interviews with market participants.

The Nordic market participants at the time expressed no need for additional price hedging products and found that the instruments available were sufficient to meet the needs of securing both the underlying price risk and the specific area price risk associated with the respective BZ. The report points out that EPADs and LTTRs are not necessarily mutually exclusive however introducing LTTRs would mean splitting of liquidity between instruments and therefore risk weakening the current market structure. Even if adding instruments could provide more options in risk management, they could also add complexity and potentially result in smaller actors choosing to withdraw from the market deteriorating competition in the long-term. However, if more sellers and buyers could move across BZ boundaries, competition could also increase and lead to reduced spreads. Consequently, prices for end-users could marginally be reduced. This customer benefit is, however, likely to be limited. Also, trade in transmission rights could risk undermining the system price as a reference price on the market.

The report from Ei concludes that the overall benefits associated with the TSO auctioning of transmission rights are too small to motivate such obligation considering the risks. Most interviewed market participants were also of the opinion that maintaining and developing the current market already set up is the preferred option.

A study by NVE and Thema (2021), “Evaluating Hedging Possibilities on NordLink, NorNed and North Sea Link” was intended to support NVE-RME’s considerations of whether long-term transmission rights should be issued and what would be the implications of issuing LTTRs on the NordLink, NorNed and North Sea Link interconnectors from Norway, hence to all of Norway’s connections to non-Nordic bidding zones. The report includes a data analysis that shows a trend towards decreased open interest in the Nordic system price contracts since 2017. Meanwhile, the open interest in EPAD contracts have increased since mid-2018, which may be explained by a higher perceptions of area price risk. It should be noticed that the data only cover hedging conducted using exchange traded products but excludes, for example, the use of OTC trading and PPAs.

Responses from a survey indicate that whereas respondents with the Nordics prefer the current market set up, respondents outside of the Nordics were in favour issuing LTTRs. The report lists the following potential benefits of issuing LTTRs:

- LTTRs could potentially add to the transparency of market price expectations by providing publicly accessible pricing information on the LTTR product.
- LTTRs could, at least in theory, help to reduce order processing costs, inventory holding costs and adverse selection costs by improving liquidity indirectly by e.g. acting as a bridge-to-liquidity, or directly by e.g. increasing speculative activity and therefore stimulating liquidity in complementary products.
- LTTRs could reduce barriers to entry into other markets, as well as support cross-border competition in the electricity retail sector.

The key costs and distributional impacts that are mentioned are the following:

- Administrative costs related to the implementation and operation of systems to issue and settle LTTRs.
- Potential firmness costs where the settlement of LTTRs is not strictly tied to the congestion income.
- A difference between LTTR revenues and payments may have distributional impacts for market participants.

The report concludes that LTTRs have the potential to improve hedging opportunities and increase the liquidity of futures in associated markets, however without mitigating measures, they could also impact cable revenues and therefore consumer tariffs.

MEASURES TO STRENGTHEN THE CURRENT RISK HEDGING SYSTEM

This chapter describes six possible measures to strengthen the current risk hedging system, their pros and cons, and acknowledges legal challenges and opportunities/threats of the measures. The most relevant measures will then be compared with an introduction of LTTRs in the next chapter.

Table 8: Summary of measures to strengthen the current risk hedging system

Measure	Pros	Cons
Improved EPAD market making function – Funding of an improved market maker function to reduce bid-ask-spreads and/or order depth.	Reduced bid-ask spreads. Increased price transparency. May help to break a cycle of illiquidity. Relatively simple to implement.	Doesn't handle the structural causes of illiquidity, e.g., market asymmetry. Funding required for the market-making role. May have legal challenges.
TSOs buying/selling EPADs or EPAD Combos – The TSO gets involved in the EPAD market to reduce underlying structural problems with asymmetry between consumers and producers.	Could contribute to solving the underlying structural problem with asymmetry between consumers and producers in some bidding zones. Could add substantial trading volumes. Could help creating a credible price reference.	May affect the TSO's credibility as an independent actor, especially if the TSO involvement is through continuous trading rather than auctioning. If the TSO involvement is done by continuous trading by one procured market participant, this may concentrate much market power to that market participant. A theoretical risk that EPADs will be bought/sold at unfavourable prices for the TSO, redistributing value from transmission-tariff payers to participants in the EPAD markets.
Bidding zone reconfiguration – Bidding zone reconfiguration towards larger and more balanced (between consumption and production) bidding zones.	Larger and more balanced bidding zones would directly address some of the structural causes of low liquidity in EPADs.	If the bidding zone design isn't based on physical structural bottlenecks in the grid, economic costs will rise, including congestion management and less efficient location of new electricity consumption/production.
Regional EPADs – Financial price areas covering more than one bidding zone are created to increase liquidity in the financial products.	Could address structural issues (small bidding zones and asymmetry between consumers and producers in some bidding zones).	Introduces basis risk between the regional EPAD's price and the bidding zone price. Some market participants may have policies that prohibit them from taking on basis risk.

Table 8: Summary of measures to strengthen the current risk hedging system

	Easier to implement than a bidding zone reconfiguration. Economic costs that may occur from a bidding zone configuration that is not based on physical bottlenecks in the grid can be avoided.	It would not be advisable to implement regional EPADs before the ongoing BZ review is finalised.
System price based on a weighted average of price areas – A new way of calculating the system price that may be easier to understand and be more relevant to some market participants.	The calculation would be easier to understand and more transparent than the current system price calculation.	Would require a long implementation time.
Forcing (large) vertically integrated companies to trade – Increasing the number of financial instruments traded on the exchanges from large vertically integrated companies.	Could offer a mean of promoting higher exchange traded volumes, liquidity, and transparency.	To form and maintain well-functioning obligations to trade and self-supply restrictions can be complicated and administratively demanding

Improved EPAD market making function

A market maker is obliged to post bids and offers for a financial product with specified requirements regarding bid-offer spreads and order depth, thereby ensuring the presence of a counterparty and a price. Official market-makers generally have an agreement with the exchange that stipulates a minimum volume to be offered, a maximum permissible bid-ask spread, and the products and time windows to be covered. Establishing a market-maker is often essential to establish a price and initial liquidity when launching new exchange-traded financial products. Market makers are generally compensated for taking on these obligations in the form of lower trading fees or direct payments.

The compensation a market participant will demand for taking on the market making function will depend on several factors, including how the obligations are set and how fast-moving the market is. In a fast-moving market an ill-informed market-maker that fails to react quickly to market developments will make losses because of trades with better-informed, fast-acting counterparties. Near term markets are often moving faster, as sudden changes in weather forecasts, outages etc can have large price consequences. E.g., a sudden network outage can have a large impact on a near-term EPAD contract. A market-maker that fails to react quickly to such a sudden event will risk large losses.

On the EPAD markets the trading fees are low in comparison to the bid-ask-spreads and lower or no trading fees may not be enough to incentivise a market making function providing tight bid-offer spreads and large order depth. In 2021 the market maker for EPADs in Sweden announced that it would resign from its role due to an increased perceived risk. Currently there aren’t any market makers for the Swedish EPADs.

In addition to a financial compensation, market participants may have a variety of strategic interests to be a market maker. Market participants with a large structural need to either buy or sell, as well trading companies may have an interest in supporting liquidity. Market participants with a dominant position may see the creation of a liquid market as a mean to avoid regulatory intervention.

A market-making function could be achieved by tendering for the market-making role. In some cases, market-making obligations have been enhanced by regulation. Improved market-making would include either tightening the conditions imposed on market-makers, increasing the number of market-makers or both. Tighter conditions imposed on market-makers could reduce the maximum bid-ask spread and thereby reduce trading costs. Increasing volume requirements would make it easier to conduct larger trades and quickly exit a large position. An increased possibility to quick exit financial positions may reduce the perceived liquidity risk, thereby encouraging new market participants to enter the market. Multiple market-makers can distribute the risks of market-making and reduce the risk faced by any individual organisation, potentially lowering costs for all.

Pros

Improved market-making can reduce trading costs by reducing the bid-ask spread, ensure price transparency, and may help market participants to find a counterpart. Market-making may also help to break a cycle of illiquidity and uses current financial products. Market-making is relatively easy to implement and can easily be combined with other measures.

Cons

Improved market-making doesn't handle the structural causes of illiquidity, such as market asymmetry between consumers and producers. With a structural market asymmetry, the market maker may place its mid-spread higher/lower than the fundamentally expected price in line with the market asymmetry, to avoid building a large net-position. In this case the excess demand/supply will not be handled. A recent NordREG study concluded that a market maker function will not be effective if there is a skewed market structure within the BZ.[7]

Improved market-making implies an additional cost to the market-maker. If the procurement is to be handled by an authority, there may be legal challenges with restricting the procurement to a specific exchange. The process may thus render in the additional liquidity being split between different exchanges or end up at a different exchange than where most liquidity currently is.

Effects on the TSO and market participants

Someone will need to bear the cost for the procurement of the market-making function. FCA-GL article 30 section 5 and 6 indicate that the TSO would be a candidate and the TSO is also mentioned in previous studies as a potential barer of these costs. In the interviews that have been part of this project, it has been suggested that the TSO could use congestion revenues to finance a market-making function. The legal possibilities to do so are not part of the scope for this report but should be analysed further.

Tight bid-ask-spreads may be of extra high importance to suppliers that adjust their hedges often, while an increased volume may be more important for speculative market participants that may value the possibility to quickly get out of a large position. A tight bid-ask-spread may also have positive technical effects in reducing the risk-based margin requirements for each counterparty account.

TSOs buying/selling EPADs or EPAD Combos

This measure would require TSOs to buy or sell EPADs or EPAD combos through auctioning or continuous trading (executed by procured market participant(s)). Combining the purchase of an EPAD for one BZ with the offsetting sale of an EPAD in another BZ produces a so called EPAD Combo that hedges the price between the two BZs. An EPAD Combo is effectively a contract for the price difference between the two areas and is similar to an LTTR (FTR obligation) in this respect.

[7] Thema/Hagman Energy (2015): Measures to support the functioning of the Nordic financial electricity market

While an EPAD together with a system price contract constitutes a price area hedge in itself, an EPAD combo only offers a hedge for the price difference between BZs.

The TSO owns cross-zonal transmission capacity and is therefore exposed to the price spread between the relevant BZs in terms of congestion revenue. As an alternative to receiving a congestion revenue as the actual price difference between two BZs multiplied with the transmitted volume on the day-ahead market, the TSO could hedge its cross-zonal transmission with EPADs or EPAD combos. Congestion revenues are either used to ease price area differences by counter trading or adding transmission capacity, or passed through to consumer network tariffs, so it is ultimately the consumers that are exposed to this.

The TSO would, in contrast to market-making, take a net-position. For instance, as electricity is net-transmitted by the TSO from BZ A to BZ B, the TSO would be expected to take a net-position by, for example, buying EPADs for BZ A and selling EPADs for BZ B. The size of the TSOs EPAD position should be predictable and not exceed the TSOs natural exposure based on the expected transmission between BZs. The TSO could either do this through auctioning or by procuring one or many market participants to trade continuously for the TSO, or a mix of the two.

Auctions can reduce trading costs by effectively eliminating the bid-ask spread and attract smaller market participants that lack the resources to actively trade. With auctions the TSO would avoid taking any role in the EPAD market. Auctions are often held in the beginning of a trading day or at end of business but can also be held at other times and with high or low frequency. An auction in the beginning of the day could serve as an early price reference and thereby reduce uncertainty and otherwise often high bid-ask-spreads early in the day, which is the case on the EPAD markets today. An auction at the end of the day could help creating a credible closing price. Too frequent auctions could constitute a problem for small market participants with less resources.

TSO involvement on the current EPAD market for continuous trading would tackle the lack of liquidity on the continuous markets and address market asymmetry, while auctions could possibly cannibalise on the liquidity on the continuous markets. Continuous trading would offer market participants a better opportunity to get in/out of positions when they want, not only when auctions are held.

While auctions would provide a credible price reference when they are held, they would not add credibility to the prices on the continuous markets in between the auctions. Both auctions and continuous trading through a market participant would add some implementation and administration cost.

TSO involvement on the EPAD market would add some administration to the TSO, with financial reporting under EMIR. It would also add some costs for either market participation on the current continuous trading markets or setting up and operating an auctioning platform.

The current exchange (Nasdaq) and JAO provide auctioning platforms that could possibly be used. A benefit with using Nasdaq's platform would be that the auctioned EPADs could be cleared simultaneously with the auction. A benefit with using JAO's platform would be that many market participants already use it for FTR auctions.

Pros

TSO involvement in the EPAD markets could contribute to solving the underlying structural problem with asymmetry between consumers and producers in some BZs. The TSO would primarily buy EPADs in BZs with an excess of producers that naturally want to sell EPADs in the relevant BZ, and vice versa.

If the TSO would use continuous trading with current EPAD products, this could add substantial trading volumes, and thereby increase liquidity.

If the TSO would use auctioning with current EPAD products, this would help to create credible price references.

Cons

May affect the TSO's credibility as an independent actor, especially if the TSO involvement is through continuous trading rather than auctioning.

If the TSO involvement is done by continuous trading by one procured market participant, this may concentrate much market power to that market participant.

A theoretical risk that EPADs will be bought/sold at unfavourable prices for the TSO, redistributing value from transmission-tariff payers to participants in the EPAD markets.

Effects on the TSO and market participants

The TSO will earn an EPAD spread income from selling EPAD in the cheaper BZ and buying an EPAD in the neighbouring more expensive BZ. The level of the TSO's earnings should, over time, correspond to the expected congestion income of the same volume on its cross-zonal transmission, if the market is well functioning.

Bidding zone reconfigurations

This measure involves reconfiguring BZs and could be used to create BZs that are larger and more balanced between producers and consumers of electricity. Larger BZs would increase the number of market participants in each BZ and thus increase liquidity. A better balance between producers and consumers of electricity would decrease market asymmetry and would help to avoid a situation in which one side of the market cannot find a counterparty.

On the other hand, larger BZs would have a negative impact on congestion management. This argument may become more valid ahead as more new electricity production/consumption are expected to be added over the next decades, than what has been the case over the past decades, making it more important to have a price signal incentivising a location that has a positive effect on congestion. Further, integration of more intermittent electricity generation may yield higher levels of structural congestion, that may trigger the need for smaller BZs. A recent study[8] for the EU commission suggests that BZ configuration should aim to make (spot) prices right first. Larger BZs may also decrease transparency on where electricity is produced/consumed.

The ongoing BZ review in Sweden is conducted under the EU regulation and is part of the implementation of EU's internal market for electricity. This process is in a rather late stage and the European TSOs handed in a common proposal regarding methodology, assumptions, and scenarios for the BZ review in February 2020. However, this proposal could not be unanimously accepted by the concerned NRAs and consequently the case was handed over to ACER. ACER decided upon what methodology should be used for the review in November 2020 and is expected to announce its decision on what alternative BZ reconfigurations should be analysed further during 2022. ACER's decision is dependent on the requested nodal price simulations from the TSO. After that the TSO has one year to finalize the BZ review and hand in a proposal to the concerned states or their NRAs. If a new BZ reconfiguration is decided upon, the Swedish TSO (Svk) has estimated that the new BZs can be implemented the earliest in 2025.

[8] EU Asset Study (2020): Smaller bidding zones in European power markets: liquidity considerations by Tractebel Impact

During the process, the TSO shall compare the status quo BZ configuration with the alternative BZ configurations decided by ACER. The comparison should be based on a list of criteria provided by ACER[9]. The list includes “market liquidity and transaction cost” as one of 22 criteria. It is not trivial to state how these 22 criteria should be weighed against each other, and we don’t intend to draw any conclusions on what an optimal BZ configuration would be. We can only note that larger and more balanced (between demand and supply of electricity) BZs would have a positive impact on the improved market liquidity and decreased transaction costs for risk hedging on the electricity markets.

A challenge with larger BZs in Sweden is that under the current EU regulation a minimum of 70 percent of interconnector capacity, respecting operational security limits of internal and cross-zonal critical network elements, taking into account contingencies, must be made available to the market (70 percent rule).[10] Svk does currently have an exception from this rule on many interconnectors, as Svk assesses that there aren’t enough counter-trading resources available to maintain security of supply while coping with the 70 percent rule under existing conditions. ACER allows the national NRAs to grant exceptions from the 70 percent rule up until 2026. Larger BZs would increase the challenge for Svk to cope with the 70 percent rule even further. More transmission grid, available counter-trading resources and technical installations improving the possibility to transport larger quantities of electricity, together with an improved balance between where electricity is produced and consumed would improve the possibilities for larger BZs.

Some actors have also argued for the possibility to create BZs exceeding national borders to enlarge the BZs, while avoiding increased congestion problems.

Pros

Larger and more balanced (between producers and consumers) BZs would directly address some of the structural causes of low liquidity in EPADs.

Cons

The BZs design should be based on a common European method decided by ACER[11]. If the BZ design isn’t based on physical structural bottlenecks in the grid, economic costs will rise, including congestion management and less efficient location of new electricity consumption/production.

Effects on the TSO and market participants

A BZ reconfiguration would cause implementation costs for market participants. However, this is inevitable in the likely event of a change in the BZs in the coming years. This measure only suggests that a higher emphasis should be put on the effects on liquidity on financial products, when reconfiguring the BZs. A BZ reconfiguration would also have potentially high redistributional effects, i.e., if Sweden would be reconfigured to one BZ, electricity consumers/producers in northern Sweden would receive higher electricity prices and vice versa for electricity consumers/producers in southern Sweden.

Regional EPADs

Regional EPADs could be created by pooling BZs into larger zones (Regional EPADs) with more liquid financial products that may work as a proxy hedge for the BZs included. To avoid splitting liquidity between financial products for the regional EPADs and existing EPADs, the new products

[9] Methodology and assumptions that are to be used in the bidding zone review process (2020)

[10] Electricity Market Regulation 2019/943

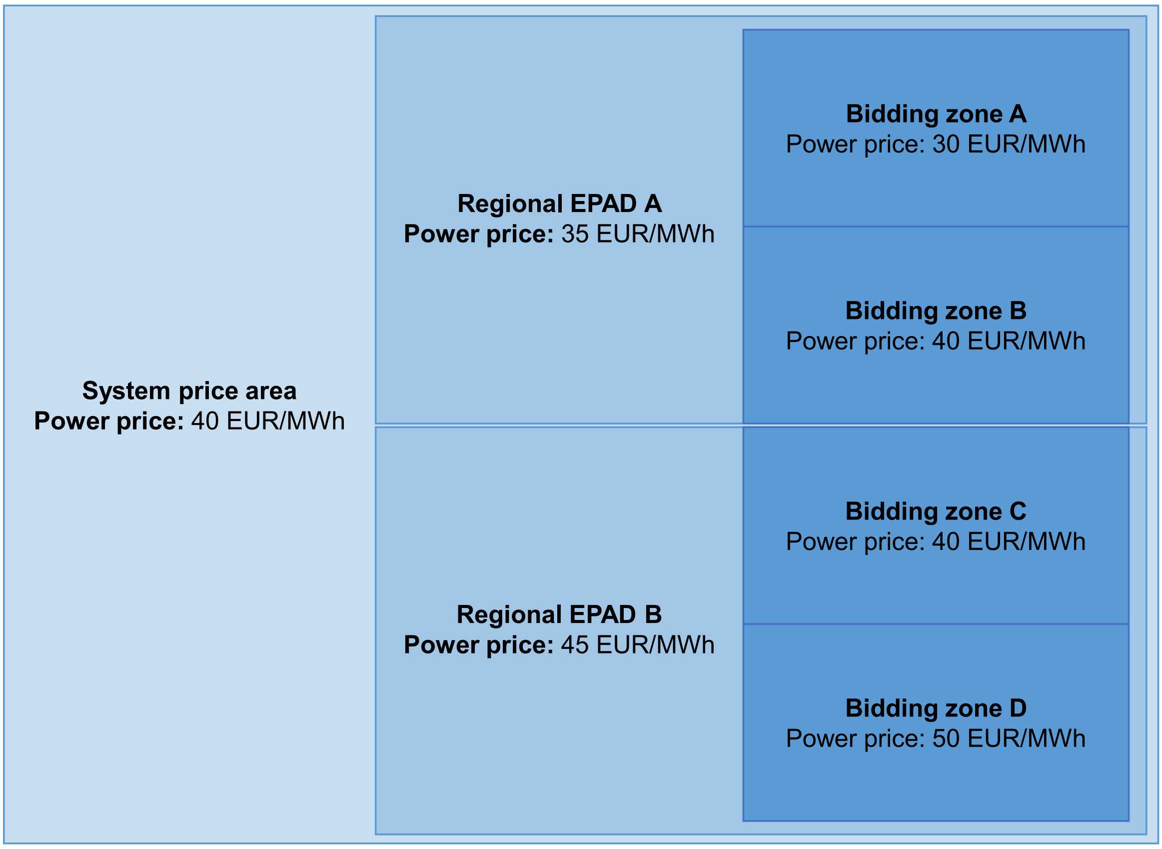
[11] Electricity Market Regulation 2019/943

would presumably need to replace the existing EPADs for the regions in which they are implemented.

The choice of how to pool BZs into regional EPADs would presumably be made to reflect the expected future price correlation between the underlying BZs. There is a trade-off here, like that for the Nordic system price, products for larger areas may lead to a higher liquidity, but on the other hand work as a less perfect hedge for the underlying price exposure.

The new regional EPAD contracts could either refer to the price difference between the system price and the regional EPAD area or replace the system price contracts too and refer directly to the regional EPAD area price. The later alternative, where the current system price contracts are replaced, is a larger and more complicated procedure that would jeopardise the liquidity in today's system price contracts.

Figure 6: Illustration of regional EPADs



Source: Merlin & Metis

Pros

In contrast to BZ reconfiguration, the creation of regional EPADs doesn't affect the actual BZ configuration and therefore avoids economic costs such as congestion management and less efficient location of new electricity consumption/production. It will also be easier to configure the regional EPAD area in the future, than reconfiguring the BZs.

Cons

A hedge with a regional EPAD (in contrast to an actual BZ), will compose a less perfect hedge than the current EPAD's related to the actual BZ, for a market participant. Hedging using a financial contract related to a regional EPAD price would imply accepting a residual basis risk that is not currently present with the use of EPADs. How large this basis risk will depend on the correlation between the regional EPAD price and the BZ prices included in the regional EPADs. Some market participants may have policies that prohibits them from taking on basis risk.

It would not be advisable to implement regional EPADs before the ongoing BZ review is finalised, as the regional EPADs then would risk having to be reconfigured already shortly after being introduced.

Effects on the TSO and market participants

If implemented quickly, it could have a negative effect on market participants possibility to get out of their positions in the current EPAD contracts. However, there are relatively few EPAD contracts with long duration outstanding, limiting this effect.

System price based on a weighted average of price areas

The current system price is based on a theoretical calculation of what the Nordic system electricity price would have been without any constrains within the system price area. This calculation may be considered complex, as bidding strategies with block bids on the day-ahead-market may have a high impact on the system price, while not affecting the BZ prices in the BZs where the bid is conceded. Changes could be made to the system price calculation to improve the reference price's correlation with the actors' underlying price exposure and make it perceived as less complex. An option that could be in that direction would be to reconfigure the system price calculation to instead reflect a volume weighted average of area prices. This would potentially increase the correlation between the system price and high-volume BZs.

Pros

The calculation would be easier to understand than the current system price calculation. A system price based on a weighted average of price areas would also be more relevant for hedging purposes to many market participants.

Cons

A new system price calculation would require a long implementation time, as there are relatively large volumes of outstanding financial instruments connected to the current system price with long duration time. A fast implementation of a new system price would have substantial negative consequences on market participants not being able to get out of positions connected to the current system price. It would also affect the value of EPAD contracts, as these are valued based on the price difference between the price in a BZ and the system price.

Effects on the TSO and market participants

A system price based on a weighted average of price areas may be more relevant for market participants in BZs with large consumption, such as SE3 and SE4, while it may be less relevant for some market participants in BZs where the price currently is close to the current system price, including SE1 and SE2.

Forcing (large) vertically integrated companies to trade

The Nordic energy markets involve many larger vertically integrated companies that have both electricity generation and business units that require electricity. These companies have both buying and selling interest as they have opposing exposures to the electricity price. These interests can be internally netted, or the company can choose to accept a price risk exposure on both sides as it provides a natural hedge. The lack of hedging need in these companies may decrease the market for hedging products.

Forcing these vertically integrated companies to trade hedging products despite their naturally reduced hedging needs would increase liquidity on the hedging product markets. This can be achieved by explicit obligations to trade or restrictions on self-supply. Obligations to trade could require that a vertically integrated company sell a specified volume of hedging products e.g., Nordic system price and EPAD contracts. Self-supply restrictions can limit generation and consumption units within the same business from contracting bilaterally for future supply. A lighter version to self-supply restrictions would be to offer advantageous trading fee structures for companies that handle their hedging needs for both buying and selling on an exchange.

Pros

If vertical trading is reducing exchange traded volumes, obligations to trade and self-supply restrictions could offer a mean of promoting higher exchange traded volumes, liquidity, and transparency.

Cons

To form and maintain well-functioning obligations to trade and self-supply restrictions can be complicated and administratively demanding.

Effects on the TSO and market participants

Obligations and restrictions on market participants' trading behaviour will obviously be perceived as negative by the larger vertically integrated companies affected.

Conclusions

Based on the literature review and interviews with the Swedish TSO, market participants and Nasdaq, three measures (TSOs buying/selling EPADs, improved market making, and regional EPADs) have been chosen to be further analysed in the next chapter.

The effectiveness of the measures depends on the underlying cause of low liquidity and the current market situation, something that may change over time, which needs to be considered. The choice of measure should ideally reflect the cause or causes of the low liquidity. Both the literature study and interviews suggest that asymmetry in some BZs and too small BZs are important causes of the low liquidity on the EPAD markets.

Conclusions regarding measures from the literature review

A study for NordREG by Thema/Hagman Energy (2015) concluded that improved market making and auctioning of EPADs/EPAD combos would have the highest impact on market liquidity. The study recommends improved market making or auctioning EPAD contracts depending on the situation in the concerned BZ. In a BZ with a market asymmetry, improved market making may be insufficient.[12]

A study for Statnett by Thema suggests that relevant options to address asymmetry include BZ reconfiguration, regional EPADs or the introduction of TSO involvement on the EPAD market.[13]

A study for NVE by EC Group discussed improved market making and EPAD auctioning by the TSO as alternative measures to introducing LTTRs, based on a previous interview study. The study concluded that if the fundamental problem is insufficient supply of electricity relative to demand, i.e., that an area is short of supply and/or suppliers, the availability of hedging instruments is not a very precise solution.[14]

Most Nordic market participants and other actors who have been interviewed in various contexts over the past several years have expressed doubt in an introduction of LTTRs in a Nordic context[15]. This overall picture has been confirmed in our interviews.

The three measures we have chosen for further studies – Why we have chosen them, and how we suggest that they should be executed

TSOs buying/selling EPADs – TSO involvement in the EPAD markets is a measure that has been concluded as an interesting measure in previous qualitative studies[16,17] and is often mentioned as one of the most interesting measures to improve the price hedging opportunities in the different Nordic BZs. One benefit of this alternative is that it can tackle the underlying market asymmetry. It has also been mentioned positively in interviews with market participants, Nasdaq, and the Swedish TSO.

TSO buying/selling EPADs has been chosen over EPAD combos, as it would increase liquidity in the currently traded products. Neither the literature review nor the interviews point out to strong benefits of EPAD combos to motivate the introduction of a new financial product. EPAD combos are also similar to LTTRs, which suggests that LTTRs as a well-known financial product on the European electricity markets may be preferable over the similar but less proven EPAD combos. It should also be noticed that EPAD combo is a combination of two EPAD's, a sell for one area and a buy for another area, meaning that it can be replicated by a combination of two EPADs.

While an EPAD together with a system price contract constitutes a hedge for BZ, an EPAD combo only offers a hedge for the price difference between two BZs. This means that EPAD combos would need to be linked to a liquid contract to be a relevant price risk hedge. This may cause a need for a link of many EPAD combos to make up a hedge. For example, a hedge for SE1 could be made by buying a hedge for Germany and adding a chain of EPAD combos all the way up to SE1. This adds complexity and a challenge if the EPAD combos are auctioned at the same time, a market participant may end up receiving two of the four demanded EPAD combos. The EPAD combos would also rely on an ultimate source of liquidity to base a hedge on, i.e., financial contracts for Germany or system price combined with an EPAD for SE3.

The TSO involvement can be done through auctions or continuous trading (executed by one or many procured market participants), both with obvious advantages and disadvantages. An important advantage with continuous trading is that it would add liquidity to the existing markets that

[12] Thema/Hagman Energy (2015): Measures to support the functioning of the Nordic financial electricity market.

[13] Thema (2021): Evaluating Hedging Possibilities on NordLink, NorNed and North Sea Link

[14] EC Group (2015): Hedging possibilities and the Forward Capacity Allocation Network Code.

[15] Ei (2016): Area price hedging and the Nordic market model.

[16] Ibid

[17] Thema/Hagman Energy (2015): Measures to support the functioning of the Nordic financial electricity market.

may trigger involvement of more speculative trading and generate better possibilities to attract market makers as it would improve the possibility to quickly get in or out of a larger position. An important benefit of auctions is that it can reduce trading costs by effectively eliminating the bid-ask spread. It can also attract smaller market participants that lack the resources to actively trade.

A Thema/Hagman Energy study analysed EPAD auctioning in 2015[18], concluding that it is better that the auctioning of EPAD contracts is performed by an exchange, rather than the TSO itself. Further, the study concludes that using exchange platforms (Nasdaq or other) for performing the auctions has been cost-effective for the sellers of auctioned instruments and administratively advantageous for the market participants bidding in the auctions. The auction trades can automatically result in positions towards the clearing house, and settlement and management of collaterals are made with the clearing house. Both this study and interviews with market participants and the TSO supports that auctioning should be done according to a predetermined plan, containing types of contracts, volumes, and timing of auctions. The plan should be announced well in advance and be decided after consultation with market participants.

There are administrative costs for a TSO related to establishing the auctioning plan and for settlement with the clearing house, but these costs are estimated to be small. For the market participants there may be some additional administrative costs if the auctioning is performed on a different trading platform than the continuous trading, but these costs are estimated to be relatively small in this context. There is also a possibility that the exchange will demand a payment for performing the auctioning process, however, the exchange has an interest in performing the auction to increase the trade in concerned EPAD contracts, so the cost is estimated to be rather small.

We have asked both the TSO and a mix of different market participants about which alternative they would prefer if the TSO should get involved in the EPAD market, auctioning or continuous trading. The few that had a clear preference favoured auctioning, and none of the respondents we talked to were negative towards auctioning.

It is a rather a common model to combine continuous trading with auctions. Examples of markets that combine continuous trading and auctions include EU ETS, the electricity intraday market, and Deutsche Börse Group's trading platform XETRA for equities and other financial instruments.

We propose a model of this measure where the TSO auctions EPADs through daily auctioning, in accordance with a transparent auctioning schedule, with a mix of different contract durations. The auctions are to be held in the beginning of a trading day when spreads are relatively high and traded volumes low in comparison with the more trading-intense afternoons. The total auctioned volume for each biding zone and contract durations should not exceed the TSOs net exposure due to available cross-zonal transmission capacity but may be substantially smaller than that.

If TSO involvement on the EPAD market gets implemented, the involvement method (auctioning or continuous trading) and volumes can be adjusted and optimised over time as the actual effects of the involvement can be analysed and market conditions change.

Regional EPADs – Regional EPADs is one of few measures that addresses the underlying structural issues, i.e., asymmetry in some BZs and too small BZs, pointed out as important causes of the low liquidity on the EPAD markets. In our interviews BZ reconfiguration with fewer BZs, possibly cross-national, was often mentioned as one of the most interesting measures, rather than Regional EPADs. This may be partially because regional EPAD is a less familiar measure to many actors in Sweden. None of the interviewed respondents has expressed a negative view about Regional EPADs.

[18] Thema/Hagman Energy (2015): Measures to support the functioning of the Nordic financial electricity market

The BZ reconfiguration is an ongoing process based on a common European methodology developed by ACER. If the BZ design isn't based on physical structural bottlenecks in the grid, economic costs will rise, including congestion management and less efficient location of new electricity consumption/production. In the short term, too small BZs may also make it challenging to cope with the current EU regulation stating that a minimum of 70 percent of interconnector capacity must be made available to the market.[19]

It may also be easier to create cross-border regional EPADs than cross-border BZs. Further, regional EPADs are more flexible and may be easier reconfigured over time compared to reconfiguring the BZs.

With this regard, the measure Regional EPADs have been chosen over BZ reconfiguration for further analysis in the next chapter.

Improved market making – Improved market making can add liquidity to the current market structure. Market making has some obvious benefits that most or none of the other measures offer. It will always be possible for a market participant to buy or to sell a contract with a well-functioning market making. It also gives security for a market participant that it can exit a position if e.g., a stop-loss limit is reached. For improved market making to be able to attract speculative market participants, minimum volumes are important so that they can exit a larger position quickly if, for example, a stop-loss limit is reached. For a fundamental market participant, a tighter bid-ask spread is often more important.

Improved market making was ranked as one of the most relevant measures in a study for NordREG. However, improved market making was not the preferred measure in an asymmetric market since the measure doesn't solve the underlying cause of low liquidity. The same study, however, also concluded that the costs for this measure are relatively high and may exceed the benefits.[20]

Improved market making can be looked upon as an alternative to other measures, a complementing measure or even as a positive consequence of other measures that would improve liquidity and thus make it easier to attract a market maker.

We propose a model of this measure, where the TSO procures a trading platform to guarantee a minimum bid-ask-spread and volume criteria, among others (option details specified in the next chapter). The trading platform in turn may procure one or many market makers to fulfil its commitments to the TSO. A benefit of this structure is that the added market making volume will be concentrated in one trading platform.

Measures that will not be further analysed

Forcing (large) vertically integrated companies to trade could improve liquidity. However, this measure would not handle the underlying structural issues, asymmetry in some BZs and too small BZs. The literature review also mentions the importance of realising that vertical integration may offer efficient means for a firm to manage its electricity price risk exposures, handling this risk while avoiding trading costs and counterparty risk. Further such a force would add compliance and enforcement costs. It may also lead to that the obligated party becomes a distressed buyer/seller, distorting prices and redistributing costs and benefits among the trading parties.[21]

A system price based on a weighted average of price areas (in contrast to today's system price calculation based on a theoretical model without any internal grid constraints)**,** may make the

[19] Electricity Market Regulation 2019/943

[20] Thema/Hagman Energy (2015): Measures to support the functioning of the Nordic financial electricity market.

[21] Thema (2021): Power Price Risk Hedging Opportunities in the Norwegian Market.

system price contracts more relevant as a hedge for some market participants while less relevant for others. Although this measure may make the relatively liquid system price contracts more relevant to some market participants, the system price contract will still need to be complemented with an EPAD to eliminate the price area risk. This measure could be taken without TSO or NRA intervention but has been given limited interest by the market participants. Although this may be a positive measure to be taken in addition to other measures, it seems unlikely that this measure alone will solve the identified need to improve hedging opportunities.

This measure also has a disadvantage that it may require a long implementation time. Many market participants have long-duration financial instruments connected to the current system price and want to have a possibility to get out of these positions. At the same time, having two different system prices parallel would divide the liquidity, and therefore not be desirable.

Bidding zone reconfiguration addresses the underlying structural issues, asymmetry in some BZs and too small BZs. However, it has disadvantages in comparison to regional EPADs that have been discussed above under the headline “Regional EPADs”.

ANALYSIS OF MEASURES IMPROVING RISK HEDGING OPPORTUNITIES

The objective of this section is to shed light on the benefits and costs of introducing different measures improving the risk hedging opportunities on the Swedish electricity market. Specifically, this section presents the analysis of status quo of electricity hedging in Sweden, followed by the analysis of three measures improving the status quo, and an additional measure of introducing LTTRs in Sweden. The chapter begins by describing the methodological setup, which includes an overview of the data used and general boundary definitions of the studied measures. Then the main benefits are assessed in the sections dedicated to volume analysis and bid-ask spread analysis. The costs of implementing each of the measures are then discussed. The section ends with conclusions on the recommended measures with the highest overall benefit from the societal perspective.

Methodology setup

To evaluate the effectiveness of the four considered measures from the socio-economic perspective, we focus on the **key benefit** of **reduced cost of hedging**. The cost of hedging is essentially a proxy for improved liquidity measured by the bid-ask spreads[22]. We evaluate the benefits of reduced cost of hedging by evaluating how much the estimated additional traded volumes stimulated by the implemented measure would reduce the bid-ask spreads and thus improve liquidity.

There are also other socio-economic benefits of the improved hedging measures, such as **facilitated market entry** (into wholesale and retail markets), and **increased price transparency** (for instance from increasing the share of transparent exchange-traded agreements compared to bilateral OTC agreements). While these additional benefits are important, their socio-economic benefits are more nuanced (can be negligible or meaningful) and we rely only on the findings from the studies reviewed in the Literature review section above.

The **costs** associated with the implementation of the proposed measures are mainly **administrative** in nature, namely **set-up and running costs**. We rely on the information from our interviews with market participants (regulators, TSOs, utilities, exchanges) and past studies to derive a range for the implementation costs.

Note that there are also other costs which have **distributional impact** rather than representing a direct socio-economic cost (or benefit). For example, the firmness cost of TSOs selling FTRs for capacity which will later not be available or for prices that are significantly/systematically lower or higher than the ex-post realized price differences. In this study we do estimate the congestion rent costs for the measures of TSO auctioning EPADs and FTRs, but we do not represent this as a direct cost. This is because from socio-economic perspective these costs will be distributed to different market participates, such as to the transmission network users via network charges.

[22] The bid-ask spreads measure the associated costs of hedging, including order processing costs, inventory costs, and adverse selection costs.

To derive the **conclusion** on which measure is expected to deliver the highest socio-economic benefit, we also consider, in addition to the quantified costs and benefits, whether the recommendation is **future proof** and in line with the **proportionality principle**.

Next, we outline the main data used in this analysis, explain some derived indicators, and define several features of the four analysed measures.

Data description

Historical data (2017-2021) for Nordic system price and EPAD future contracts was provided by Nasdaq, including the following:

- **Open interest (OI)**– daily data on open interest (GWh), which refers to the total size of open positions with the clearinghouse (Nasdaq) at a given point in time.
- **Traded volumes** – daily data on bought and sold volumes (GWh), which is a proxy to trading activity and product relevance. Dataset reports only days and products with trading activity.
- **Bid ask spreads** – best, worst, mean and median bid ask spread per day based on a minute granularity of buying and asking quotes. An additional variable of counted minutes per day with available bid ask spread is also included.
- **Market depth** – summed volume of the best four asking and the best four bidding offers from the order book per day.

Additional historical data (2017-2021) from Nord Pool was used in the analysis are:

- **Day-ahead prices** – hourly day-ahead (Elspot) prices for all bidding areas.
- **Day-ahead capacities** – hourly day-ahead trading cross-border (Elspot) capacities.
- **Day-ahead flows** – hourly planned day-ahead cross-border power (Elspot) flows resulting from the day-ahead price calculation.
- **Power consumption** - hourly consumption for all bidding areas.

Indicators

We used several indicators providing further insight into the hedging markets, specifically:

- **Ratio of traded volume to physical consumption** – also referred to as churn rate, refers to the number of times each MWh is traded before it is delivered.
- **Average traded volumes** – represents the average volume of hedging products traded in a market over a period.
- **Volume turnover** – represents the sum of the volume of hedging products traded in a market over a period.

Definitions of measures

Below we outline further details of several definitions and key design features of the status quo situation and the four analysed measures improving the hedging opportunities in the Swedish electricity market.

Status quo (current EPADs and Nordic system price derivatives)

- **Nordic system price contract** – Financial contract for the Nordic (Elspot) system price, which is an unconstrained market clearing reference price for the Nordic region. It is calculated without any congestion restrictions by setting capacities to infinity.
- **EPAD product** – Electricity Price Area Differential (EPAD) financial contract hedging the area price and system price differential, as described in the Introduction section above.

Measure 1: Improved market making

Below we list several design features for the measure of improved market making:

- **Type of products and maturities** – focus on EPAD products and monthly, quarterly, and yearly maturities.
- **Bid-ask spreads** - maximum quotable net spread for bids and offers. Stricter demands on bid-ask spreads may increase liquidity.
- **Minimum volume criteria** – minimum contract volume to be quoted by a market maker at any time or at agreed time intervals.
- **Quoting time** – time interval when Market Makers are required to quote orders. Reliable end of day prices have a positive impact on margin cost.
- **Compensation levels** – compensation should cover the cost of market making (cost of a trader).
- **Number of market makers** – a minimum number of market makers should be appointed.

Measure 2: Regional EPADs

Below we list several design features for the option of regional EPADs:

- **Liquidity pooling** – BZs with high underlying price correlations are pooled together to a larger geographical region which can span national borders.
- **Bidding zones considered in pooling** – which BZs considered for the creation of regional EPADs. In this study we consider only BZs of Sweden and Norway while broader Nordic/Baltic BZs were left outside.
- **Initially proposed pooled areas** – In this study and for the region under assessment, we propose three EPAD regions: North SE/NO (SE1, SE2, NO3, NO4), South NO (NO5, NO1, NO2), and South SE (SE3, SE4). Sweden and Norway were assessed together due to their high interconnectedness and geographical proximity, but also the study needed to stay within its main scope which is Sweden.
- **Contract base reference price –** which price is used for the settlement of the regional EPAD. In this study we work with the pooled region’s (underlying BZs’) consumption-weighted day-ahead price.

Measure 3: TSO auctioning EPADs

Below we list several design features for the option of TSO auctioning EPADs[23]:

- **Neutrality** - TSO maintains neutral position, i.e., it does not oversell available transmission capacity/congestion rent.
- **Netting** – multi-BZ TSO nets positions/congestion rent when auctioning EPADs across BZs under its operation. Capacity netting takes place by both buying and selling in both interconnected BZs.
- **Auctions or continuous trading** – via a procured market participant/s the TSO would buy or/and sell EPADs through regular auctions or/and continuous trading. Detailed design of these mechanisms was out of scope of this study, but their pros and cons are discussed throughout the report.
- **Contract definition** – we assume the TSO-auctioned EPADs are exactly the same as the exchange-traded EPAD contracts. It is beneficial if the secondary market trades are cleared at the same clearing house as the current EPADs.
- **Focus on areas with systematic imbalance and/or (il)liquidity issues** – When defining the auction volumes and BZs where TSOs auction EPADs, the TSO should consider and regularly assess liquidity (transaction costs) measures, or/and underlying fundamental power supply-demand imbalance of the BZs in question. A simplified methodology is proposed here as Option 2 but detailed auction volume methodology should be developed in future work.

Measure 4: TSO auctioning LTTRs

- **TSO auction FTR obligations -** Suitable for fundamental hedging when combined with a liquid area price contract for the other BZ. Based on the literature review above this is not the current market design trend nor there is a demand for this product.
- **TSO auctions FTR options** – Currently the preferred design option in Europe, but less useful for fundamental hedging compared to the FTR obligations.

Next, we proceed with the analysis of EPAD volumes, which includes the view into the status quo and the impact assessment from introducing the four measures.

Volume analysis

Status quo

In this analysis we assess the starting point based on the historical **traded volumes** and **open interest** of EPADs and the Nordic system price contracts. We calculate the aggregated traded volumes and open interest by BZs, and by trading or delivery years. In addition, we calculate churn rates where we relate the traded volumes and open interest to the underlying power consumption in each BZ.

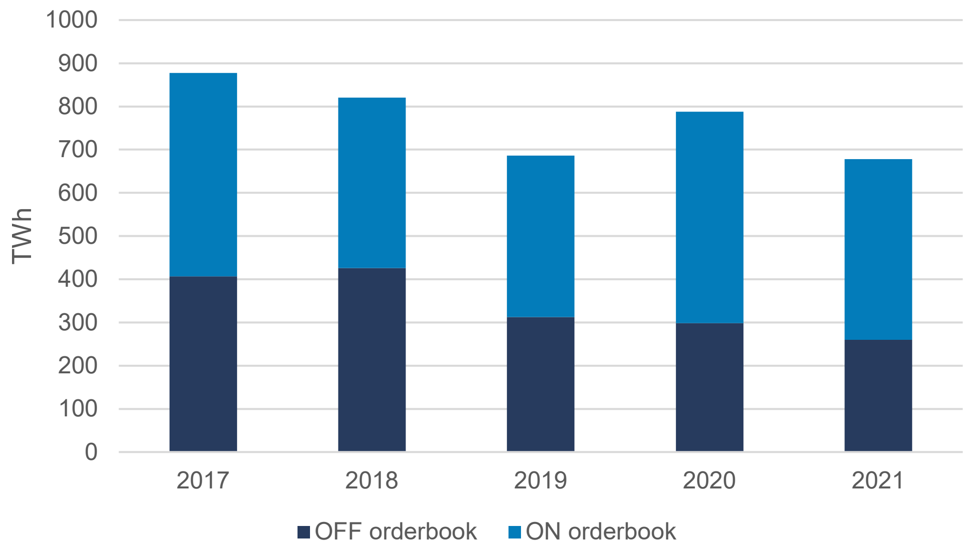
We first focus on volumes summarized by the **trading time**, i.e., summarized by the time when the trades took place rather than when the underlying contracts will be delivered[24]. Figure 7 shows the volume turnover in Nordic system price derivatives split by type of market (on- and off- orderbook) indicating the higher share of on-orderbook traded volumes and overall, a declining trend. The

[23] For simplicity we refer to this measure as TSO auctioning EPADs, but the decision on the concrete selling and buying mechanism (auctions and/or continuous trading) of EPADs is a subject of future work.

[24] This is the typical approach presented in most of the reviewed literature.

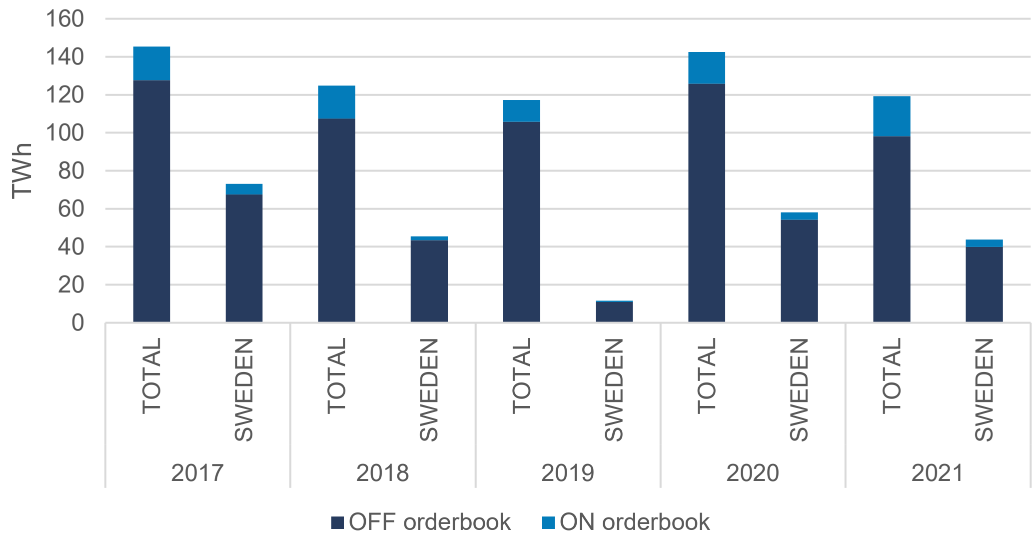
overall declining trend may imply a reduced interest of market participants in the system contract due to the underlying market fundamentals of the last five years. Figure 8 shows volume turnover for all EPADs (Total) and in Sweden, where the share of off-orderbook dominates but the turnover being relatively stable over time. This observation also holds for the individual Swedish BZs. The share of the Nordic EPAD turnover in a total turnover (EPAD + Nordic system price contracts) is approximately 15% (in 2017-2021). EPADs share in total turnover has grown since 2015 (~9%)[25] but this is mainly due to the decline in the trading of Nordic system price contracts.

Figure 7: Volume turnover of Nordic system contracts, TWh



Notes: By trading date
Source: Compass Lexecon analysis based on Nasdaq data

Figure 8: Volume turnover of EPADs overall (Total) and in Sweden, TWh



Notes: By trading date
Source: Compass Lexecon analysis based on Nasdaq data

[25] http://www.nordicenergyregulators.org/wp-content/uploads/2016/04/Nasdaq1.pdf

Figure 9 shows daily average traded volumes in all EPADs (upper left panel) being around ~0.5 TWh/day. Specifically in the Swedish EPADs (upper right panel) the daily average traded volumes are ~0.25 TWh/day. The shown values have been compiled using end of day totals of traded volumes which are then averaged over a rolling time window of 45 days to clearly visualize the trend. The bottom panel displays the same information but specifically for individual Swedish BZs. The figure shows that yearly EPADs represent the largest share of the daily average traded volumes, followed by quarterly and monthly, respectively.

Figure 9: Daily average traded volumes of Nordic and Swedish EPADs, GWh

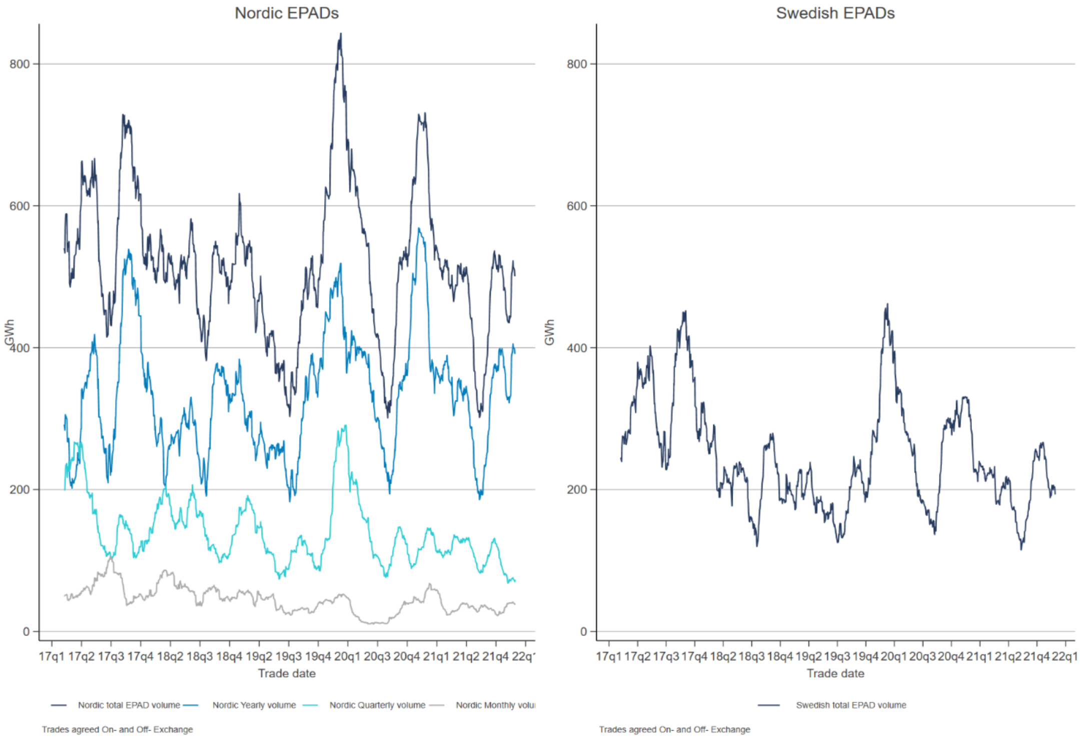
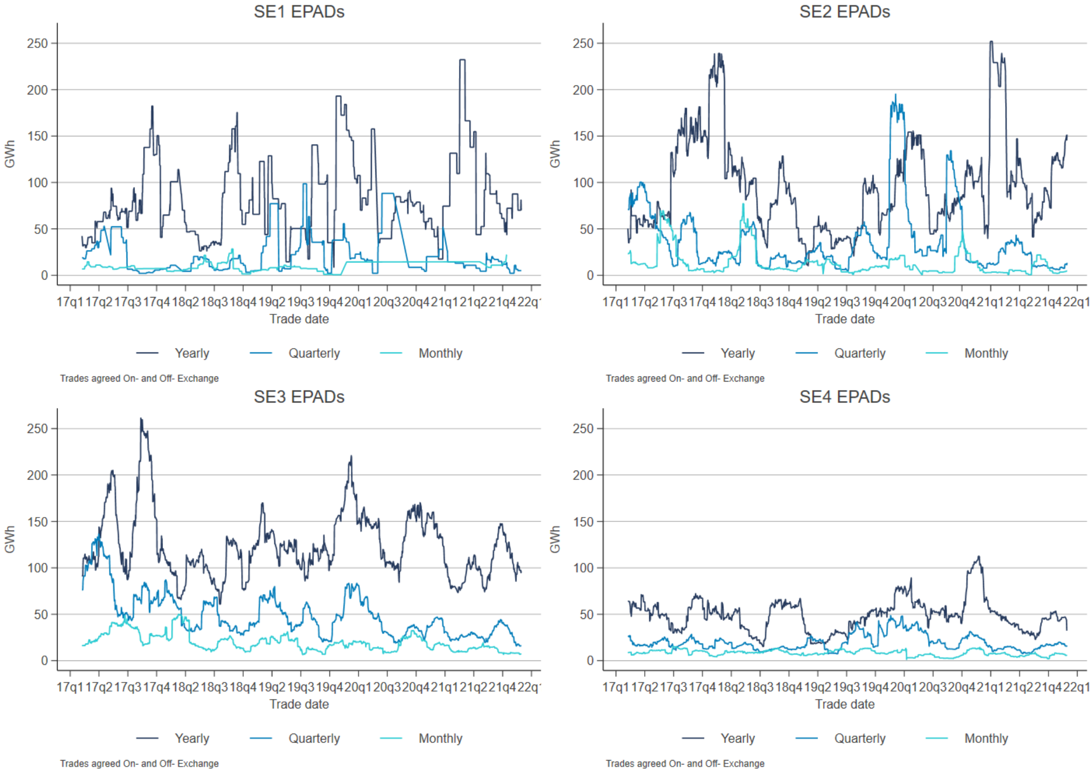


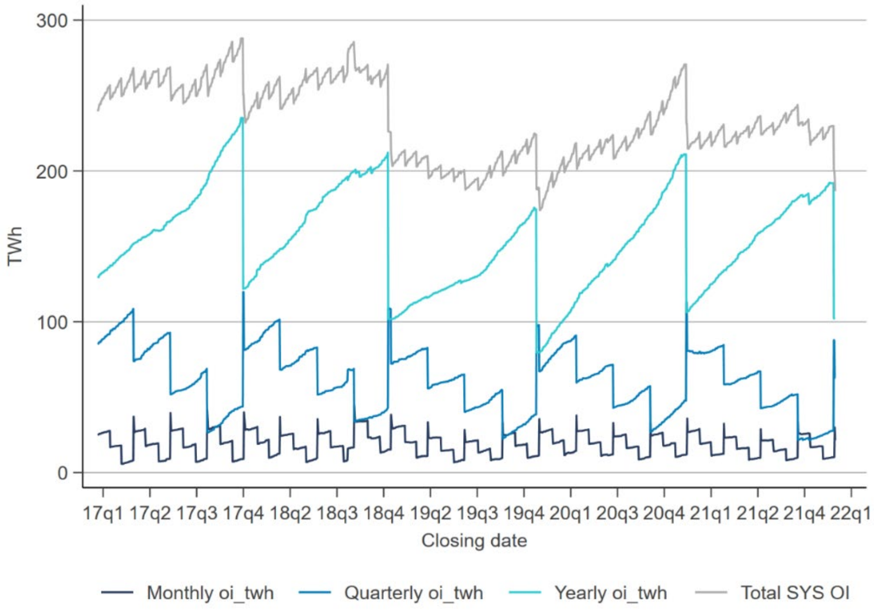
Figure 9: Daily average traded volumes of Nordic and Swedish EPADs, GWh



Notes: Daily by trade date; 45 days rolling window average
Source: Compass Lexecon analysis based on Nasdaq data

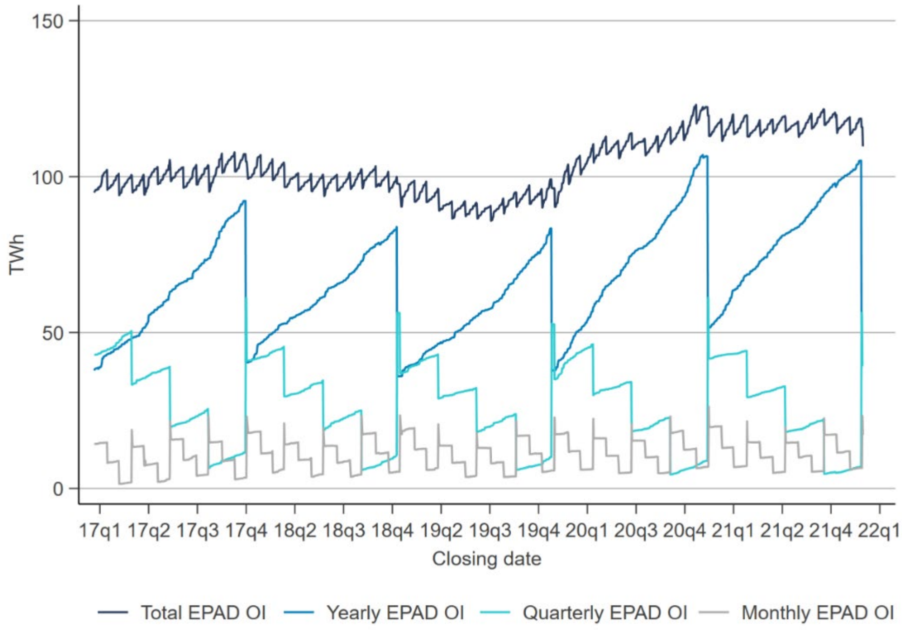
Figure 10 shows the declining open interest in the Nordic system price contracts whereas Figure 11 shows an increasing open interest in EPAD contracts over the same period. The latter implies that hedging the local area price risk with EPADs has become more important to the fundamental market participants. The open interest development in Swedish EPADs across its BZs is illustrated in Figure 12, illustrating a clear dominance of open interest in the Stockholm area SE3 (~40 TWh) followed by SE4 and SE2.

Figure 10: Open interest of Nordic system price contracts, TWh



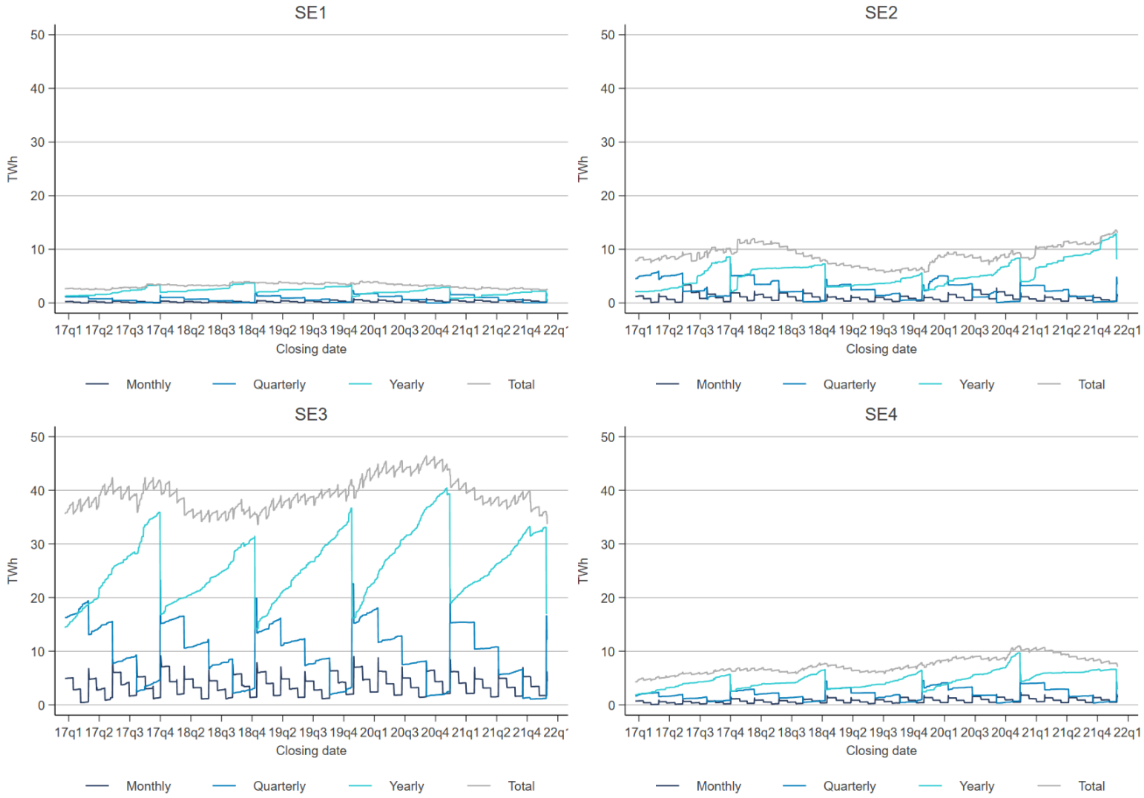
Notes: Daily by closing date
Source: Compass Lexecon analysis based on Nasdaq data

Figure 11: Open interest of EPADs in all bidding zones, TWh



Notes: Daily by closing date
Source: Compass Lexecon analysis based on Nasdaq data

Figure 12: Open interest of EPADs in Swedish bidding zones, TWh



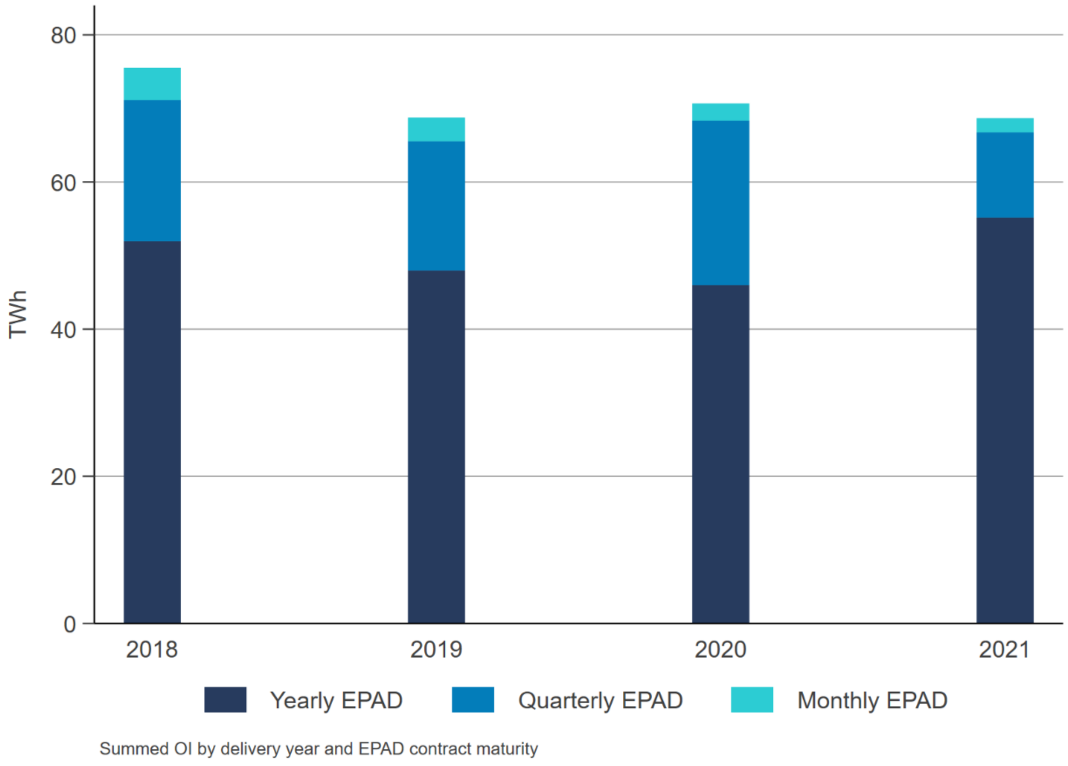
Notes: Daily by closing date
Source: Compass Lexecon analysis based on Nasdaq data

In the following figures, we focus on volumes summarized by the **delivery time**, i.e., summarized by the time when the underlying contracts will be delivered. We leave out the year 2017 because our dataset only begins in 2017 and excludes trades conducted in 2016 but delivered in 2017. We focus on EPADs' open interest held just before expiry, which provides a good approximation of the hedging use of EPADs[26]. Figure 13 illustrates the **open interest of EPADs in energy terms (TWh)** of yearly, quarterly, and monthly EPAD contracts delivered in 2018-2021. The figure shows that approximately 70 TWh of EPADs held until just before expiry are delivered per year, which is the vast majority of the approximately 100 TWh of open interest during the trading time (Figure 11). This confirms the fact that most of the volumes are traded for near-term future.

Figure 14 presents **open interest of EPADs in capacity terms (GW)** by different contract maturity during the delivery year. The figure shows that approximately 8 GW of EPADs of different maturities is delivered per year in the Nordics, of which 6 GW of yearly, 2 GW of quarterly, and 0.3 GW of monthly EPADs for every hour of the delivery year.

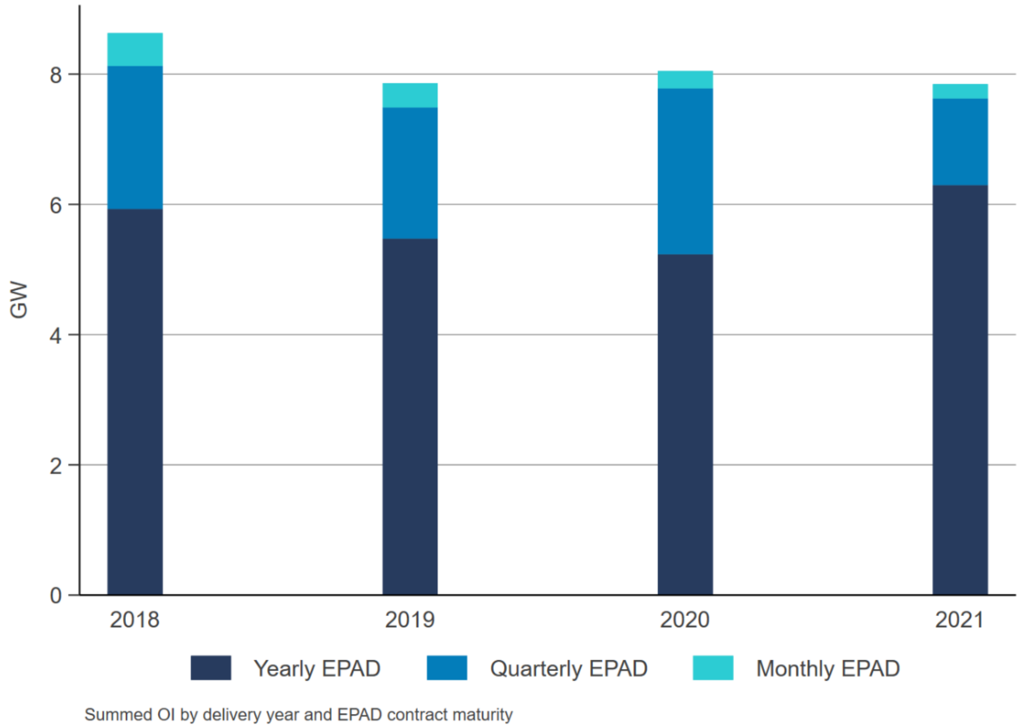
[26] Specifically, we focus on all unique EPAD contracts (2497 delivered in 2018-2021) just before they expire and cascade down into the lower order contracts, i.e., yearly cascading to quarterly and quarterly cascading to monthly. To avoid double counting we net off the yearly volumes from quarterly and quarterly volumes from monthly contracts when stacking the delivery date volumes together. Note that this is an approximation, and the exact delivered volumes should be obtained from the exchange or NRAs.

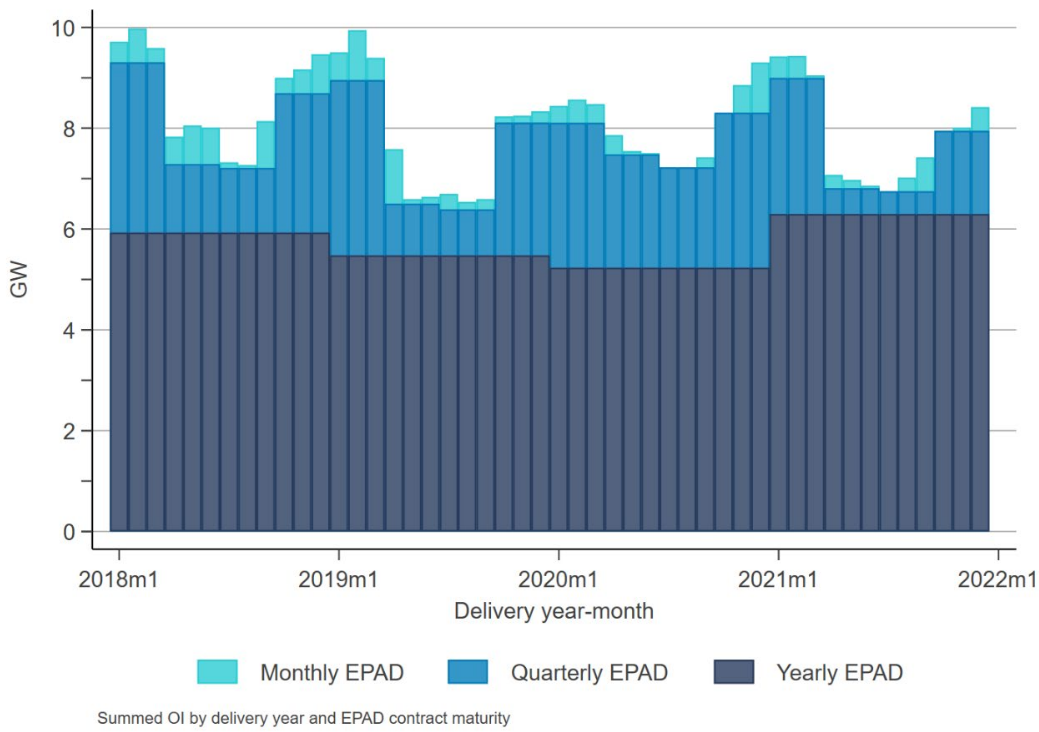
Figure 13: Open interest (energy) of EPADs in all bidding zones by delivery year, TWh



Notes: Yearly by delivery date
Source: Compass Lexecon analysis based on Nasdaq data

Figure 14: Open interest (capacity) of EPADs in all bidding zones by delivery time, GW (yearly and monthly visualization)





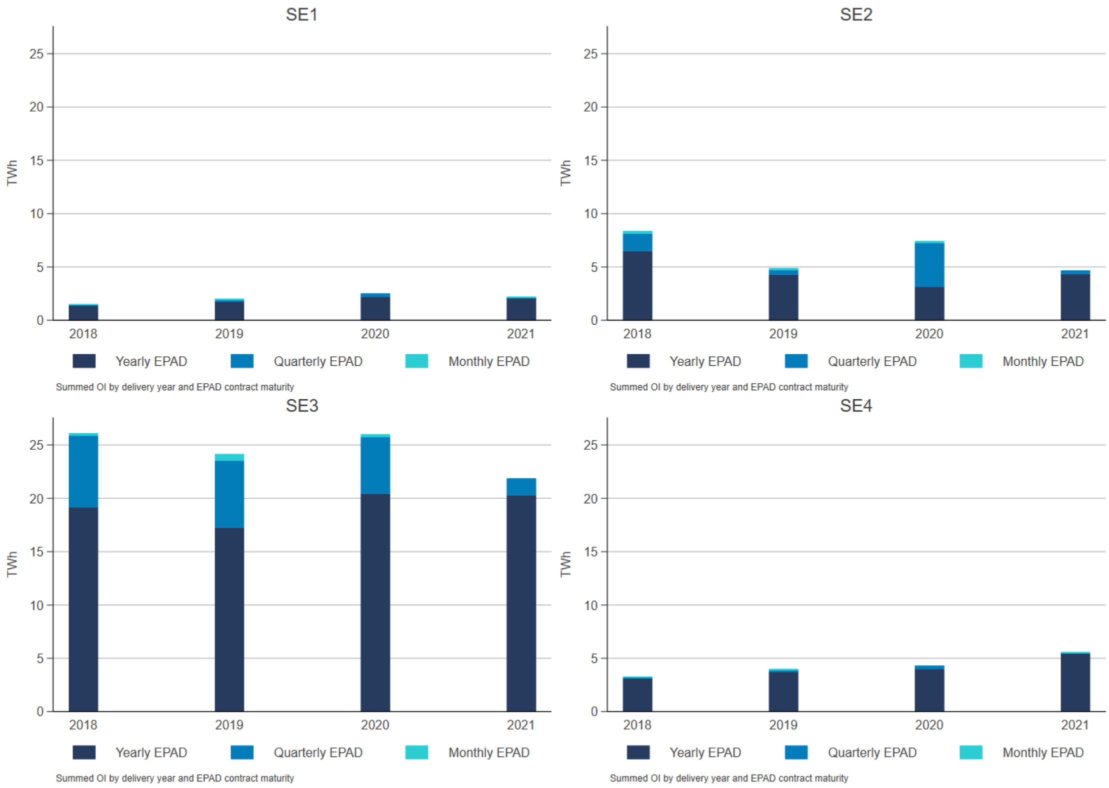
Notes: Yearly by delivery date
Source: Compass Lexecon analysis based on Nasdaq data

Zooming into the **Swedish bidding zones** and EPAD volumes presented by delivery year, Figure 15 presents open interest of EPADs in energy terms (TWh), and Figure 16 open interest of EPADs in capacity terms (GW).

Compared to the trading date data (Figure 12) where we see open interest in SE1, SE2 and SE4 below 10 TWh, the delivery date representation (Figure 15) shows about half of that volume (~5 TWh) is held for hedging in the delivery year. In SE3 (Stockholm) where most of the Swedish EPAD activity takes place, the open interest of about 40 TWh during the trading period is compared to approximately 25 TWh during the delivery year. In capacity terms, the average (2018-2021) **annual EPAD open interest in delivery year** in the individual BZs in Sweden is (total of approximately 4240 MW[27]):

- SE1: 230 MW
- SE2: 720 MW
- SE3: 2800 MW
- SE4: 490 MW

Figure 15: Open interest (energy) of EPADs in Swedish bidding zones by delivery year, TWh



Notes: Yearly by delivery date
Source: Compass Lexecon analysis based on Nasdaq data

[27] The current internal Swedish maximum NTC capacity on the three BZ pairs from North to South, i.e., SE1>SE2 (3300 MW), SE2>SE3 (7300 MW), and SE3>SE4 (6200 MW) totals to 16800 MW. Therefore, the 4240 MW represents about 25% of the current internal Swedish maximum NTC total in the North to South direction.

Figure 16: Open interest (capacity) of EPADs in Swedish bidding zones by delivery year, GW

Notes: Daily by delivery date
Source: Compass Lexecon analysis based on Nasdaq data

Measure 1: Improved market making

In this section we assess how the improved market making (MM) function may impact EPAD volumes by making realistic hypotheses on the underlying impacts.

Below we summarize the proposed approach for assessing the **benefits of improved MM function**:

- On **26.11.2021** Vattenfall AB ceased its market making role for Nordic Electricity Price Area Differential (EPAD) future contracts: **Helsinki**, **Stockholm**, **Luleå**, **Sundsvall** and **Malmö**
- We create daily sums of open interest (OI) and traded volumes by BZ and contract maturity and observe their developments before and after Vattenfall's departure from the MM role in EPADs for Helsinki, Stockholm, Luleå, Sundsvall and Malmö areas. **Specifically**:
  - **Open interest difference:**
    - In the studied period (2017-2021) the Swedish EPADs represent approximately 57% of all EPADs' open interest.
    - Compared to the average historical OI of Swedish EPADs in December months ~60TWh (2017-2020), the December 2021 open interest was **lower by 1.23 TWh**, which is **2% lower** than the historical average.
  - **Traded volume difference:**
    - In the studied period (2017-2021) the Swedish EPADs represent approximately 47% of all EPADs' traded volumes
    - Compared to the average historical traded volume of Swedish EPADs in December months ~284GWh (2017-2020), the December 2021 traded volume was **lower by ~95 GWh**, which is **33.5% lower** than the historical average.

Holding everything else constant, we use the observed change in OI and volume traded after Vattenfall's departure from EPADs' market making as the impact of **1 market maker** on the Swedish EPAD volumes[28]. For simplicity we assume the marginal impact of every additional MM on volumes will stay the same. On the one hand, it could be argued that every additional MM stimulates liquidity less. On the other hand, with every additional MM liquidity may improve more and attract further liquidity, i.e., breaking the liquidity spiral. For simplicity, we assume the marginal liquidity benefit of an additional MM stays the same.

We also acknowledge that the volatile power market conditions at the end of 2021 (due to EU-ETS and gas price increases) led some market participants in the Nordics to leave the power derivatives markets (such as Nordstrom Invest in September 2021, and Shepherd Energy in January 2022). Nonetheless, the market participants that left the market were mainly traders and speculators (trading Nordic system price contracts), which are not the main EPAD market participants (mainly fundamental market players). At the same time, during the period of increased volatility of December 2021 the fundamental market players could have increased their demand for EPADs compared to the previous less volatile Decembers, i.e., damping the effect of the MM's departure. In that case, the 2% and 33.5% estimates above may be considered conservative.

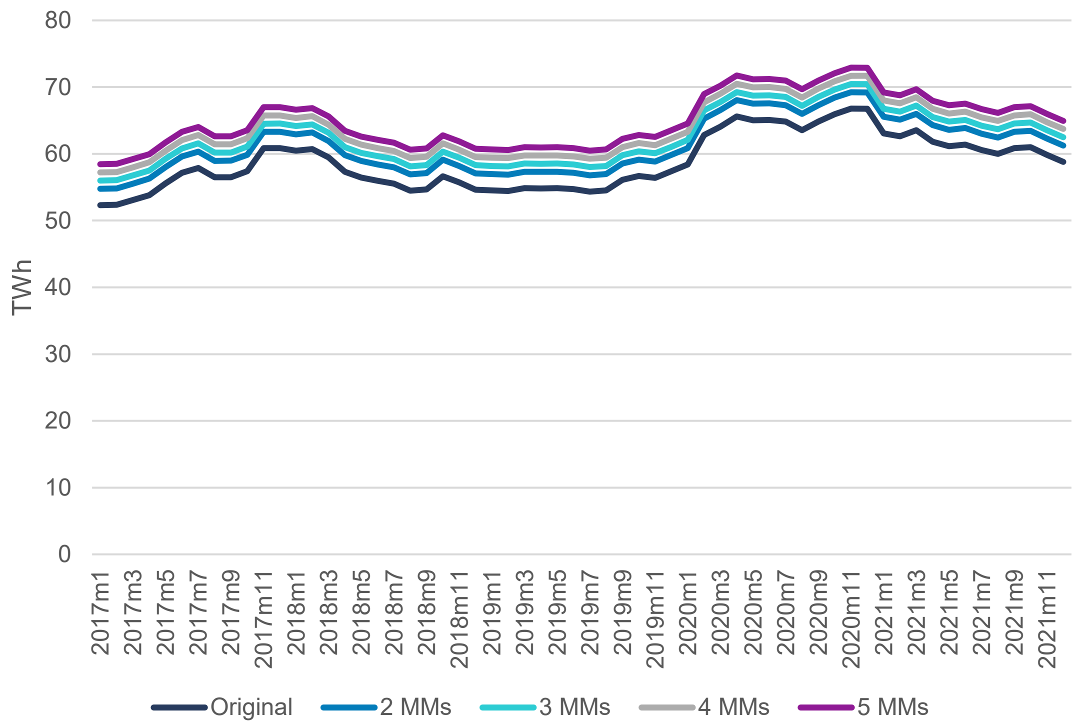
Holding everything else constant and projecting on the historical market data, having 5 MM active in the Swedish EPADs could increase open interest in the Swedish EPADs by 10% (+6 TWh)

[28] The actual volume impact depends on the concreate obligations each market maker has. Nonetheless, we use the actual market data to quantify this impact and therefore refrain from theoretical quantification.

compared to the historical value of ~59 TWh (Figure 17). If the additional Swedish EPAD open interest was pooled into the historical EPADs market where Sweden's share has historically been approximately 57% of all EPADs, the total Nordic EPAD open interest would be approximately 110 TWh or 6% higher than historically (Figure 18). This compares reasonably to the historical average of 230 TWh of open interest in the Nordic system price contracts.

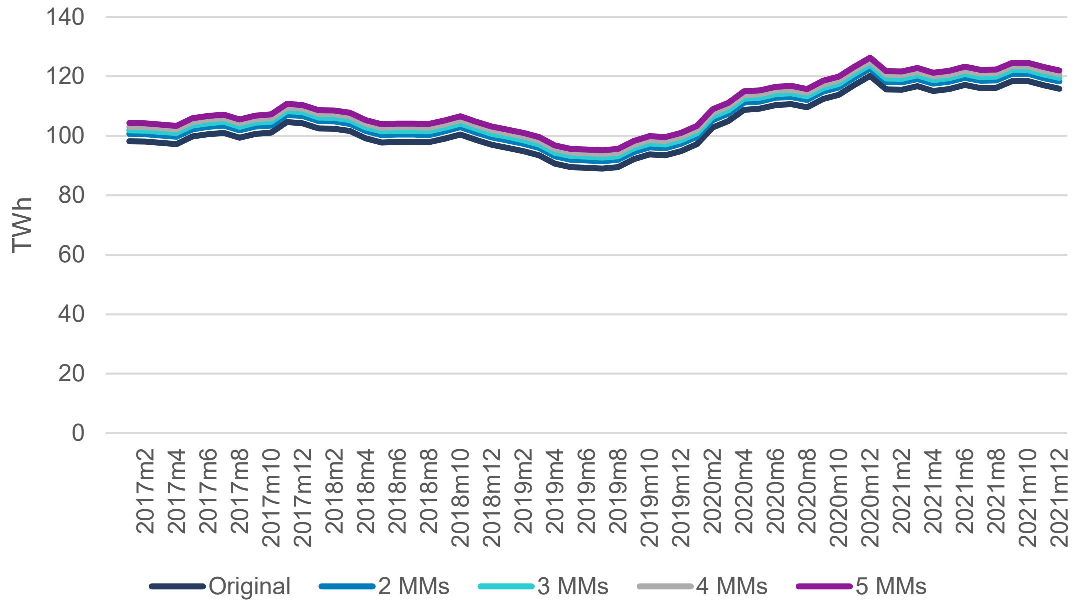
Similarly, holding everything else constant and projecting on the historical market data, having 5 MM active in the Swedish EPADs could almost triple the traded volumes in Swedish EPADs compared to their historical values, from the average of 245 GWh/day to 720 GWh/day (Figure 19). If he additional Swedish EPAD volume was pooled into the historical EPADs market where Sweden's share has historically been approximately 47% of all EPADs, the total Nordic EPAD traded volume would be close 1 TWh (Figure 20). This compares reasonably to the historical average of 3 TWh/day traded volumes for the Nordic system price contracts.

Figure 17: Swedish EPAD open interest by month with Swedish MM impact



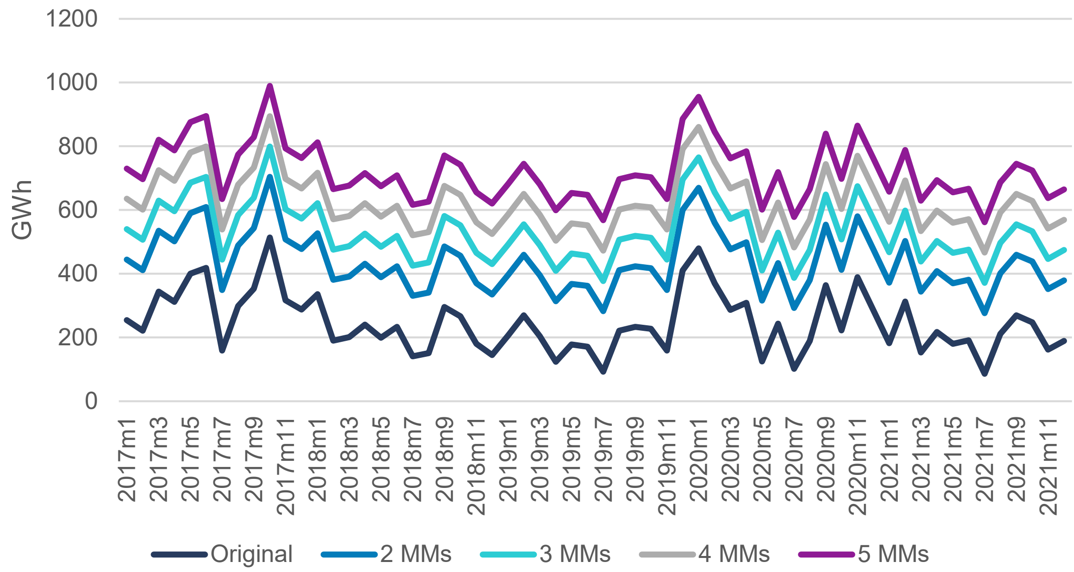
Notes: Volumes by trade date
Source: Compass Lexecon analysis based on Nasdaq data

Figure 18: Nordic EPAD open interest by month with Swedish MM impact



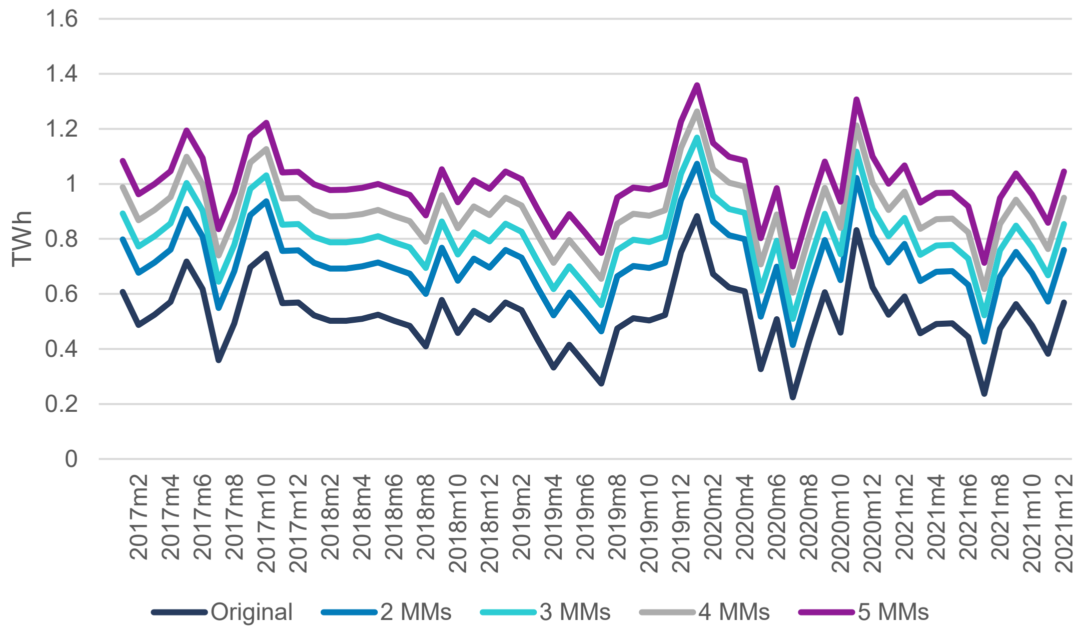
Notes: Volumes by trade date
Source: Compass Lexecon analysis based on Nasdaq data

Figure 19: Swedish EPAD daily average traded volumes by month with Swedish MM impact



Notes: Volumes by trade date
Source: Compass Lexecon analysis based on Nasdaq data

Figure 20: Nordic EPAD daily average traded volumes by month with Swedish MM impact



Notes: Volumes by trade date
Source: Compass Lexecon analysis based on Nasdaq data

Measure 2: Regional EPADs

This analysis focuses on evaluating the volume impacts of the regional EPADs option. We first quantify the historical correlation between day-ahead prices to estimate the pooled/joined areas with high correlations of the BZs included in regional EPADs. Then, we estimate the liquidity impacts of the pooled areas on the trading volumes of EPADs.

Correlation analysis – identifying regions for pooling

Correlation analysis provides insights into the **appropriates** of a hedge. In this analysis, we use historical data for day-ahead prices and power consumption from Nord Pool for the years 2017-2021.

Table 9 presents the correlations of area prices and the Nordic system prices by BZs. The BZs of Norway are marked with stable correlations to the system price except for the last year in NO3 and NO4 when the correlation slightly reduced. The Swedish BZs used to be relatively well correlated to the system price in 2018-2019 but then their correlations started to vary between years and BZs. Finland's and Denmark's BZs have an average correlation to the system price. The Baltic BZs have historically had poor correlation to the Nordic system price but last year it has markedly improved.

Table 9: Day-ahead price correlation of area and system prices

	SE1	SE2	SE3	SE4	FI	DK1	DK2	NO1	NO2	NO5	NO3	NO4	EE	LV	LT
2017	0.78	0.78	0.78	0.77	0.67	0.66	0.69	0.9	0.89	0.89	0.9	0.7	0.67	0.55	0.56
2018	0.95	0.95	0.95	0.86	0.79	0.77	0.78	0.94	0.94	0.91	0.95	0.89	0.79	0.73	0.73
2019	0.93	0.93	0.92	0.85	0.61	0.65	0.67	0.94	0.94	0.94	0.94	0.93	0.49	0.49	0.49
2020	0.7	0.7	0.53	0.45	0.46	0.46	0.42	0.87	0.87	0.88	0.88	0.82	0.37	0.35	0.36
2021	0.64	0.64	0.92	0.88	0.85	0.84	0.86	0.89	0.89	0.89	0.63	0.66	0.84	0.84	0.84
Total	0.75	0.75	0.9	0.86	0.82	0.84	0.84	0.93	0.93	0.93	0.76	0.73	0.81	0.81	0.81

Notes: Based on hourly data, 2017-2021
Source: Compass Lexecon analysis based on data from Nord Pool

Based on the data analysis presented below[29] we propose to pool together several Swedish and Norwegian BZs[30], namely:

- **Northern Sweden and Norway (North SE/NO)** => SE1 + SE2 + NO3 + NO4;
- **Southern Sweden (South SE)** => SE3 + SE4; and
- **Southern Norway (South NO)** => NO1 + NO2 + NO5.

In Table 10 we deep-dive into price correlations between the area prices of the proposed regions to verify the historical price proximity between the pairs of the pooled region. As can be seen from the table, the pairwise correlations in each pooled region are all beyond 0.8 and imply a relatively good fit.

Table 10: Day-ahead price correlation of area prices by proposed regions

	North SE/NO				South SE		South NO		
	SE1	SE2	NO3	NO4	SE3	SE4	NO1	NO2	NO5
SE1	1	1	0.94	0.88	0.64	0.57	0.6	0.59	0.59
SE2		1	0.94	0.88	0.65	0.57	0.6	0.59	0.59
NO3			1	0.95	0.6	0.53	0.63	0.62	0.62
NO4				1	0.57	0.49	0.61	0.59	0.6
SE3					1	0.93	0.83	0.82	0.83
SE4						1	0.82	0.82	0.82
NO1							1	0.99	1
NO2								1	0.99
NO5									1

Notes: Based on hourly data, 2017-2021
Source: Compass Lexecon analysis based on data from Nord Pool

[29] Svk's analysis (2021, p.51) supports our decision and suggests pooling of BZs may be beneficial at least until 2035. Note that SvK study includes simulated future price differences between pairs of internal Swedish BZs and Swedish and Norwegian BZs (among other pairs). This provides insights into the future pairwise price proximity of the BZs included in the regional EPADs proposed in this study but note that the SvK study did not work with regional consumption-weighted prices as suggested here.

https://www.svk.se/siteassets/om-oss/rapporter/2021/langsiktig-marknadsanalys-2021.pdf

[30] Sweden and Norway were assessed together due to their high interconnectedness and geographical proximity, but also the study needed to stay within its main scope which is Sweden.

In Table 11 we further evaluate the price correlations between the **pooled region's consumption-weighted prices** and the **area prices of the bidding zones** included in the respective region. This correlation measures the fit of the regional price (which we propose to be used as the **contract base reference price**) to the underlying BZ price, showing almost perfect average correlation for all the included BZs, i.e., >0.96 in all cases. This means that the basis risk very limited in practice and the upside from increased liquidity should overweight the downside of basis risk.

Table 11: Day-ahead price correlation of area prices and regional consumption-weighted prices

Region	North SE/NO				South NO			South SE	
Zone	SE1	SE2	NO3	NO4	NO1	NO2	NO5	SE3	SE4
2017	0.9	0.9	0.93	0.75	0.99	0.99	0.98	1	0.95
2018	0.98	0.98	0.99	0.96	0.97	0.98	0.95	0.99	0.94
2019	0.95	0.95	0.98	0.97	1	1	1	1	0.96
2020	0.88	0.88	0.88	0.83	1	1	0.98	0.99	0.93
2021	0.98	0.98	0.99	0.94	1	1	1	1	0.95
Total	0.97	0.97	0.99	0.96	1	1	1	1	0.96

Notes: Based on hourly data, 2017-2021
Source: Compass Lexecon analysis based on data from Nord Pool

Volume impact of regional EPADs

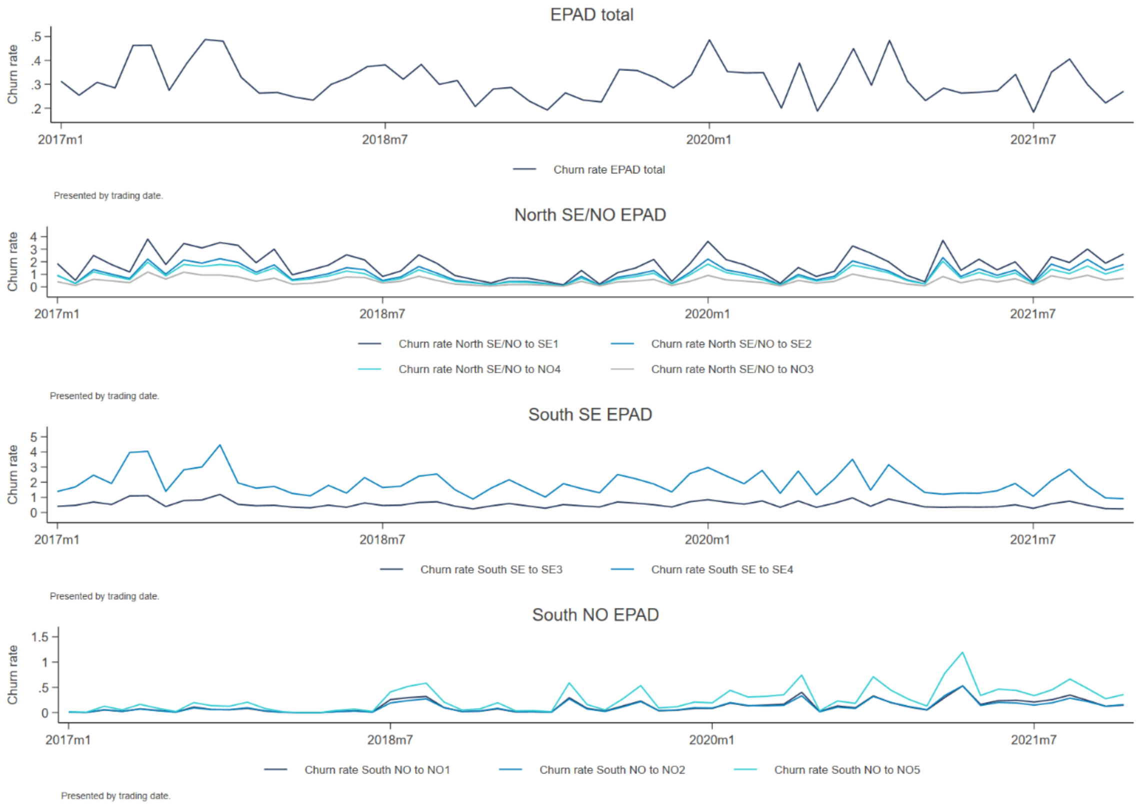
After proposing the pooling of several Swedish and Norwegian BZs into three main regions (**North SE/NO, South SE,** and **South NO**) we combine the EPAD traded volumes of the underlying individual BZs included in each region into the total **regional EPAD volume**.

The pooling of volumes from individual BZs into regional EPAD volumes assumes that the trading interest would stay unchanged. This assumption is justified by the very high correlations shown in Table 11, nonetheless a correction/weighting factor could be applied for bidding areas with imperfect correlations, i.e., below 1. This is because the regional EPAD would not provide a perfect hedge for the zonal price. Possible weighting factor, such as multiplication of the pooled traded volume by the correlation coefficient of the area prices and the regional consumption-weighted prices (Table 11), could be possibly used for correcting the pooled volumes.

Figure 21 shows the impact of the regional EPADs on the churn rates, i.e., relationship between traded volumes and the power consumption, implying how many times a MWh is traded before being consumed. The first panel shows the current churn rates for the entire EPAD market, showing values of ~0.3, i.e., only about 1/3 of power consumed in the Nordics is being traded with EPADs before being delivered. This contrasts with churn rates of 3 and beyond in liquid power markets, e.g., DE or GB, which imply that every MWh consumed is traded 3 and more times before being delivered.

The following three panels in Figure 21 relate the pooled EPAD trading volumes in the proposed regions and the power consumption in each of the underlying BZs. The figure shows that the pooled churn rates increase well beyond 1 in the North SE/NO and South SE regions, while they stay mainly unchanged in the South NO region. This implies that market participants would have access to much more liquid EPAD markets in most of the involved BZs compared to the individual/non-regional EPAD contracts. Based on the historical analysis, this liquidity benefit is achieved without compromising the appropriateness of the hedge against area price fluctuations.

Figure 21: Churn rates of EPADs and the pooled regions



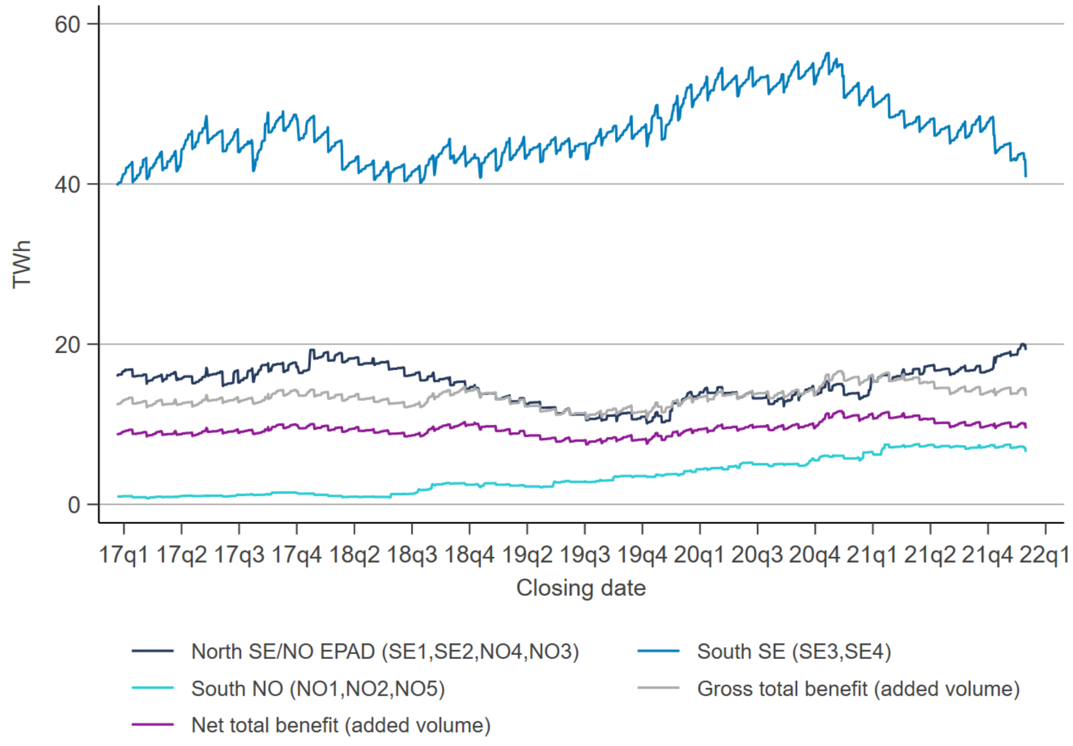
Notes: Churn rates by trade date
Source: Compass Lexecon analysis based on Nasdaq data

We also illustrate the **open interest of the regional EPADs** during the trading time in Figure 22. The figure clearly shows that the South SE EPAD would be the product with largest volumes, followed by the North SE/NO, and South NO.

To illustrate the potential benefits of added open interest by the regional EPADs we first assume the pooled product would increase the **open interest during the trading time** by the value equal to the regional EPAD's open interest net of the open interest volume of the largest underlying BZ[31]. On average, this would increase open interest by approximately 20% or **13 TWh** during the trading time (gross benefit). But as illustrated above, only approximately 70% of open interest held during trading translates into delivered volumes. Therefore, the assumed net benefit during the delivery time (the actual hedging need) would be approximately **9 TWh**.

[31] This means netting SE2's from North SE/NO, SE3 from South SE, and NO1 from South NO in our sample.

Figure 22: Open interest of the regional EPADs



Notes: Total benefit defined as the regional EPAD's open interest net of the open interest volume of the largest underlying bidding zone.
Source: Compass Lexecon analysis based on Nasdaq data

Measure 3: TSO auctioning EPADs

In this option the TSOs would participate in the EPAD market by auctioning EPADs through regular auctions. TSOs are in a unique position as compared to other market participants because the liability of the EPADs they offer can be offset by the congestion rents they collect, resulting from the clearance of the zonal spot markets. More specifically,

- The congestion rent collected by TSO(s) in each hour is equal to the difference between the prices of the neighbouring zones in this hour multiplied by the allocated NTC between the BZs; and
- These congestion rents largely mirror the liability of the EPAD's contract since the pay-out of the EPAD contract defined as the difference between the zonal prices and the system price is determined by the congestion between the zones.

As a result, TSOs can potentially offer a significant volume of EPAD's without carrying material financial risk. On the other hand, TSOs need to maintain their financial neutrality and they should not be offering more EPAD's then they can finance through the congestion rent.

These conditions allow assessing the volume of EPADs that could be offered by TSOs as compared to the current (status quo) situation where TSOs do not offer EPADs. Below we propose and evaluate two options for TSO auctioning EPADs.

Option 1

As a first option, we use a hypothetical estimate[32] of the EPAD volumes per bidding zone that a Swedish TSO could auction to address the current EPAD market limitations especially related to the structural asymmetry between production and consumption in some BZs. The volumes are summarized in Table 12 and separated by buying and selling per internal interconnection, which is colour coded. The table also shows the net EPAD volumes sold (negative) and bought (positive) per bidding area as well as the values of annual energy behind the net volumes. The Swedish TSO would therefore be buying 600 MW (in SE1) and 400 MW (in SE2) and selling 200 MW (in SE3) and 800 MW (in SE4), with the total energy value of approximately 17.5 TWh and 2000 MW[33] in absolute terms.

Table 12: Auctioned EPAD volumes

	SE1	SE2	SE3	SE4
Buy, MW	600	1000	800	
Sell, MW		600	1000	800
Net, MW	**600**	**400**	**-200**	**-800**
Annual energy, TWh	5.26	3.50	1.75	7.01

Note: SE1>SE2; SE2>SE3; SE3>SE4
Source: Compass Lexecon analysis

Using the annual energy volumes auctioned per bidding area and the historical price differences between the area and system prices (the underlying value of EPADs), we estimate the annual congestion rent cost to the TSO from the EPAD auction, as seen in Figure 23.

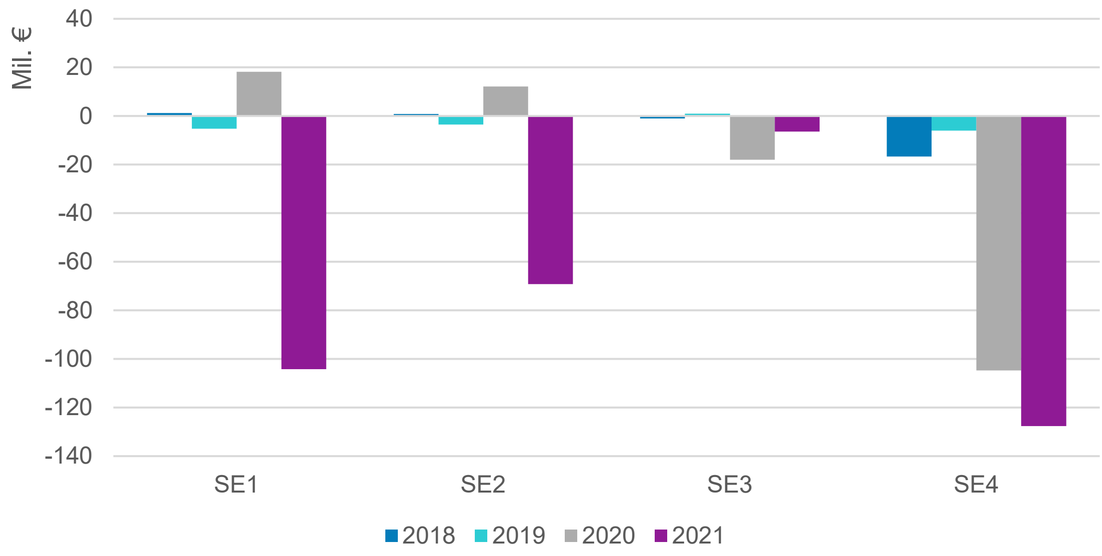
Focusing on the year 2021, the figure shows that the total congestion rent cost would be approximately **€300 million** for the Swedish internal interconnections. This value is approximately **20% of the congestion rent** collected for these lines in 2021[34]. Most of the costs would be allocated to SE4 and SE1 where the largest volumes are auctioned.

[32] The proposed auctioned volumes are inspired by our discussions with the TSO.

[33] Compared to the estimated average (2018-2021) of 4240 MW of annual EPAD open interest in delivery year in the individual BZs in Sweden, the additional 2000 MW would add approximately 50% to the Swedish EPAD market.

[34] Svk, Feb 15 2022, https://www.svk.se/press-och-nyheter/nyheter/allmanna-nyheter/2022/stora-prisskillnader-bakom-rekordhoga-kapacitetsavgifter-2021/

Figure 23: Annual congestion rent cost to TSO auctioning EPADs, Option 1



Notes: Using yearly average price differences between area and system prices as the value of EPAD.
Source: Compass Lexecon analysis based on Nord Pool data

Option 2
In the second option, we attempt to link the bid-ask spread as liquidity measure and the fundamental imbalance between power supply and demand in a BZ together. We do this by following the steps below, with the results summarized in Table 13:

1. Calculate yearly average best bid-ask spread for yearly and quarterly contracts (most liquid) per year and BZ (Panel A);

2. Rank the best bid-ask spreads from worst (highest, rank 4) to best (lowest, rank 1);

3. Assign weights to the ranks of the best bid-ask spreads which will give more weight (auction volume) to the areas with higher bid-ask spreads (Panel C);

4. Define the maximum TSO-auctioned EPAD volumes (Panel D), which can be offset by the congestion rents it collects, specifically:

   – The congestion rent collected by a TSO in each hour is equal to the difference between the prices of the neighbouring zones in this hour multiplied by the allocated NTC between the zones;

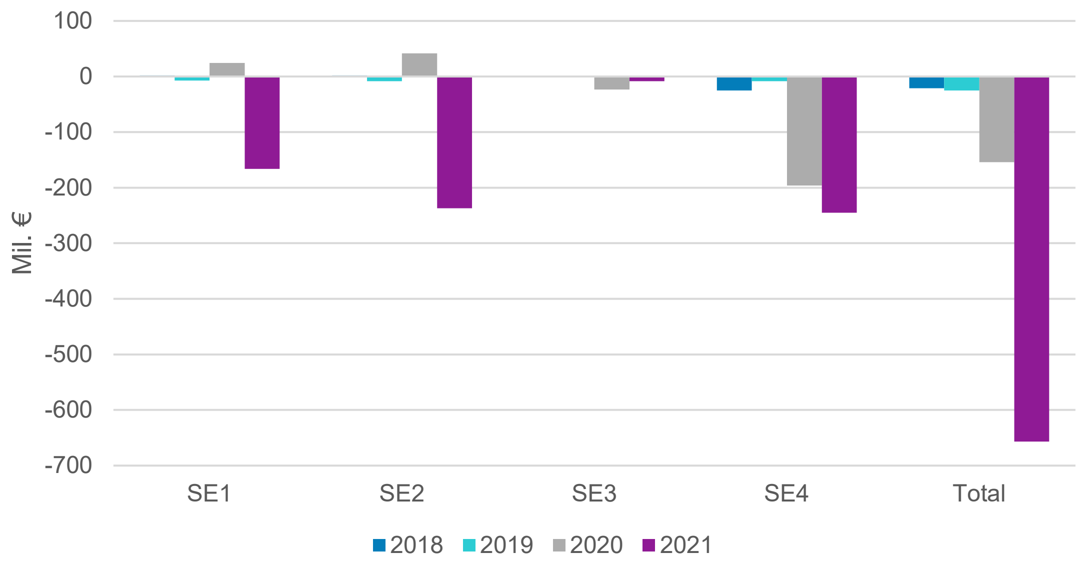
   – These congestion rents largely mirror the liability of the EPAD's contract since the pay-out of the EPAD contract defined as the difference between the zonal prices and the system price is determined by the congestion between the zones; and

   – The maximum TSO-auctioned EPAD volumes are found by finding the maximum volume per BZ which ensures TSO's financial neutrality, i.e., the auctioned volumes do not lead to a systematic additional congestion revenues or costs over the medium-term (here assed over a 5-year period 2017-2021). This implies that on yearly basis minor deviations can occur but over the medium-term the net difference between the collected and distributed congestion rent is zero.

5. Calculate yearly imbalance between power production and consumption in relation to consumption (Panel E) – negative values imply production deficit compared to consumption whereas positive values imply production surplus;
6. Calculate the TSO-auctioned EPAD volumes by multiplying the weights from steps 3 (liquidity weight represented by the bid-ask spreads) and 5 (fundamental asymmetry between production and consumption) with the maximum TSO-auctioned EPAD volumes (step 4) (Panel F);
7. Calculate yearly energy values of the auctioned EPADs (Panel G);
8. Calculate historical price differences between area and system price to determine the underlying value of the auctioned EPADs (Panel H); and
9. Estimate the congestion rent cost for auctioning EPAD volumes as determined in step 7 for the underlying values determined in step 8.

Following the above-described process which links an (il)liquidity measure from the futures market (ranking best-bid ask spreads in Swedish EPADs) with the fundamental asymmetry between power supply and demand in a BZ, would lead to redistributing **€660 million of congestion rent** (Figure 24) and auctioning approximately **4100 MW** (~36 TWh) of EPADs (Figure 25) in 2021. This is approximately **42% of congestion rent** collected in 2021 on the internal Swedish cross-border lines[35].

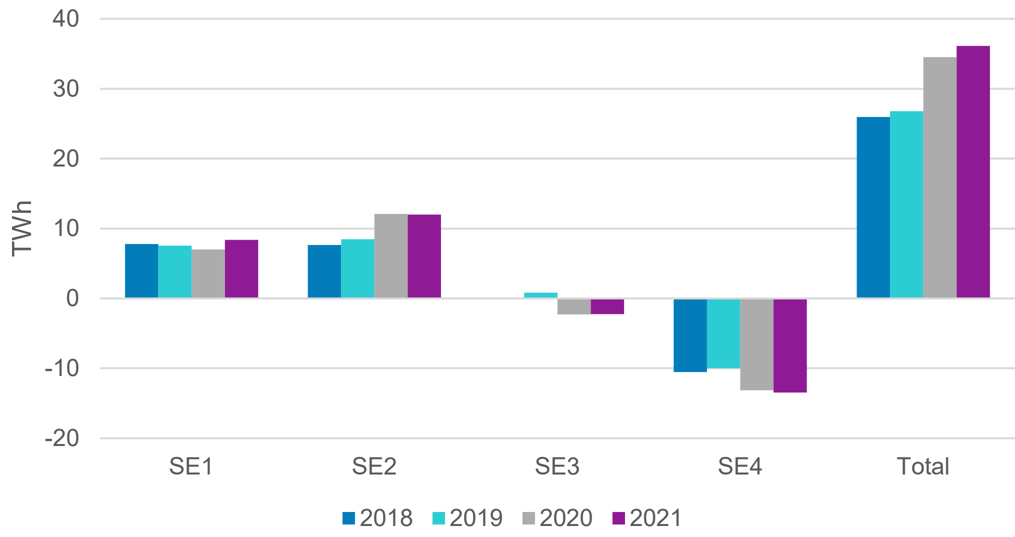
Figure 24: Annual congestion rent cost to TSO auctioning EPADs, Option 2



Notes: Using yearly average price differences between area and system prices as the value of EPAD.
Source: Compass Lexecon analysis based on Nord Pool and Nasdaq data

[35] Svk, Feb 15 2022, https://www.svk.se/press-och-nyheter/nyheter/allmanna-nyheter/2022/stora-prisskillnader-bakom-rekordhoga-kapacitetsavgifter-2021/

Figure 25: Annual TSO-auctioned EPAD volumes, TWh, Option 2



Note: Negative volume implies selling EPADs (mainly SE3, SE4), positive implies buying EPADs (mainly SE1, SE2)
Source: Compass Lexecon analysis based on Nord Pool and Nasdaq data

Table 13: TSO's view on auctioned EPAD volumes, Option 2

Bidding zone	2018	2019	2020	2021
Panel A: Best bid-ask spreads, EUR/MWh				
SE1	0.78	0.89	1.21	1.95
SE2	0.67	0.80	1.19	1.92
SE3	0.49	0.69	0.71	1.31
SE4	0.69	0.81	1.26	2.23
Panel B: Ranking by best bid-ask spreads				
SE1	4	4	3	3
SE2	2	2	2	2
SE3	1	1	1	1
SE4	3	3	4	4
Panel C: Weights of spreads, %				
SE1	80%	80%	60%	60%
SE2	40%	40%	40%	40%
SE3	20%	20%	20%	20%
SE4	60%	60%	80%	80%
Panel D: Maximum EPAD auction volume, MW				
SE1	978	978	978	978

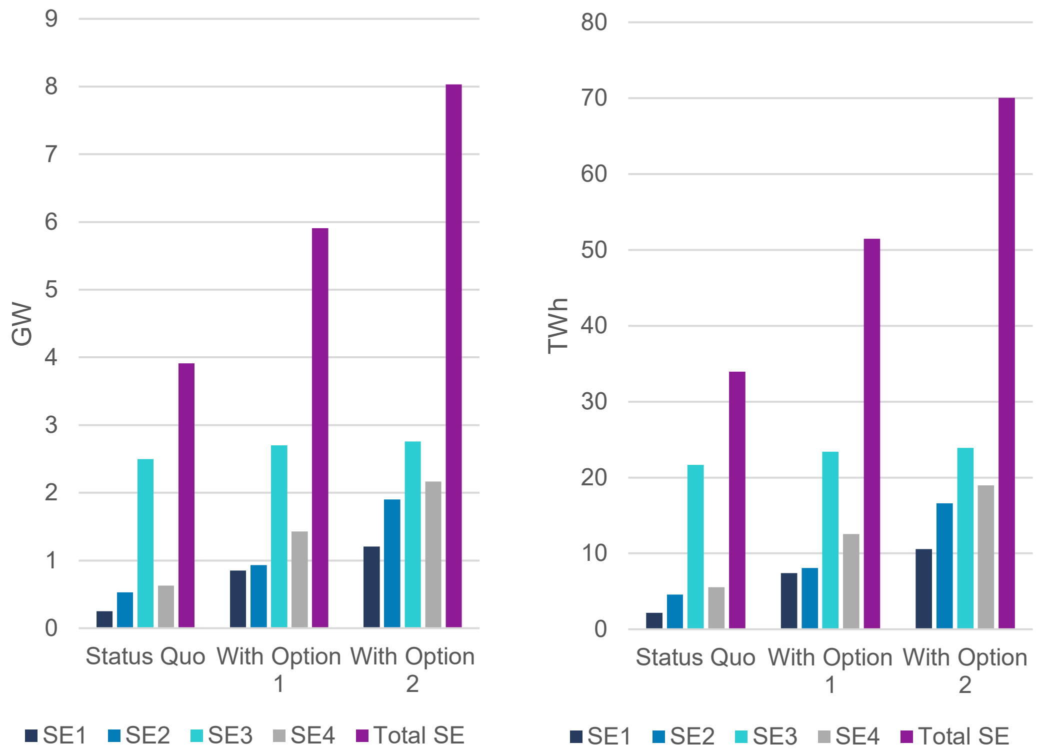
Table 13: TSO’s view on auctioned EPAD volumes, Option 2

SE2	1452	1452	1452	1452
SE3	10750	10750	10750	10750
SE4	2836	2836	2836	2836
Panel E: Weights of production/consumption imbalance, %				
SE1	113%	110%	136%	163%
SE2	150%	166%	237%	236%
SE3	0%	4%	-12%	-12%
SE4	-71%	-67%	-66%	-68%
Panel F: EPAD auctioned volumes, MW				
SE1	888	862	798	958
SE2	872	965	1378	1371
SE3	1	92	-263	-256
SE4	-1202	-1140	-1500	-1536
Panel G: EPAD auctioned volumes, TWh				
SE1	7.78	7.55	6.99	8.39
SE2	7.64	8.45	12.07	12.01
SE3	0.01	0.81	-2.30	-2.25
SE4	-10.53	-9.98	-13.14	-13.46
Total	25.96	26.80	34.51	36.10
Panel H: EPAD payout in EUR per MW				
SE1	0.239	-0.999	3.457	-19.818
SE2	0.239	-0.998	3.458	-19.756
SE3	0.549	-0.579	10.260	3.690
SE4	2.372	0.864	14.935	18.207
Panel I: Congestion rent cost, Mil. €				
SE1	1.86	-7.54	24.17	-166.33
SE2	1.83	-8.44	41.74	-237.30
SE3	0.01	-0.47	-23.62	-8.28
SE4	-24.97	-8.62	-196.31	-244.97
Total	-21.28	-25.07	-154.01	-656.89

Source: Compass Lexecon analysis based on data from Nord Pool and Nasdaq

We summarize the volume comparison of the two options described above against the status quo in Figure 27. Compared to status quo, **Option 1 adds approximately 50% of additional volumes** (+2000 MW/ 17.5 TWh) and **Option 2 doubles** the volumes (+4100 MW/ 36 TWh). These are considerable volume increases which may further attract speculative market participants and trigger a positive liquidity spiral.

Figure 26: Comparison of TSO-auctioning EPADs against status quo in 2021, volumes



Note: The volumes show total absolute values irrespective of buying or selling.
Source: Compass Lexecon analysis based on Nord Pool and Nasdaq data

Measure 4: TSO auctioning LTTRs

In this section we first illustrate the volume impacts of TSO auctioning FTR obligations or FTR options on the **internal Swedish interconnectors,** namely from SE1 to SE2 (SE1>SE2), from SE2 to SE3 (SE2>SE3), and from SE3 to SE4 (SE3>SE4). Then we present estimates of congestion rent redistribution based on the FTR auctions superimposed on the historical period of 2017-2021.

We begin by reintroducing the definitions of FTR obligation and FTR options, as described in the EU Harmonised Allocation rules (HAR) 2022[36]:

- **'Financial Transmission Right Option'** means a right entitling its holder to receive a financial remuneration based on the day-ahead allocation results between two BZs during a specified period of time in a specific direction;
- **'Financial Transmission Right Obligation'** means a right entitling its holder to receive financial remuneration or obliging its holder to provide financial remuneration based on the day-ahead allocation results between two BZs during a specified period of time in a specific direction.

As an FTR option entitles the holder to the congestion rent in one direction for each hour when it is positive, the price for an FTR option will reflect the expected sum for all hours with positive price differentials. The second alternative for the TSO is to auction FTR obligations that oblige the owner

[36] Acer, 29 November 2021, Harmonised allocation rules for long-term transmission rights, https://www.jao.eu/sites/default/files/2021-12/EU%20HAR%202022%20with%20annexes.pdf

to also pay the price differential for all hours when it is negative. Hence, the settlement of an FTR obligation equals, and will reflect, the average price differential for the period.

For traders, FTR obligation entails a higher risk than FTR option, because compared to fundamental actors, traders have no production worth price hedging. In case of unfavourable market outcome (in comparison to expectation) the trader undertakes to pay the area price difference to the issuer of the FTR obligation (the TSO), instead of just paying the cost of FTR option in case their price forecasts prove inaccurate.

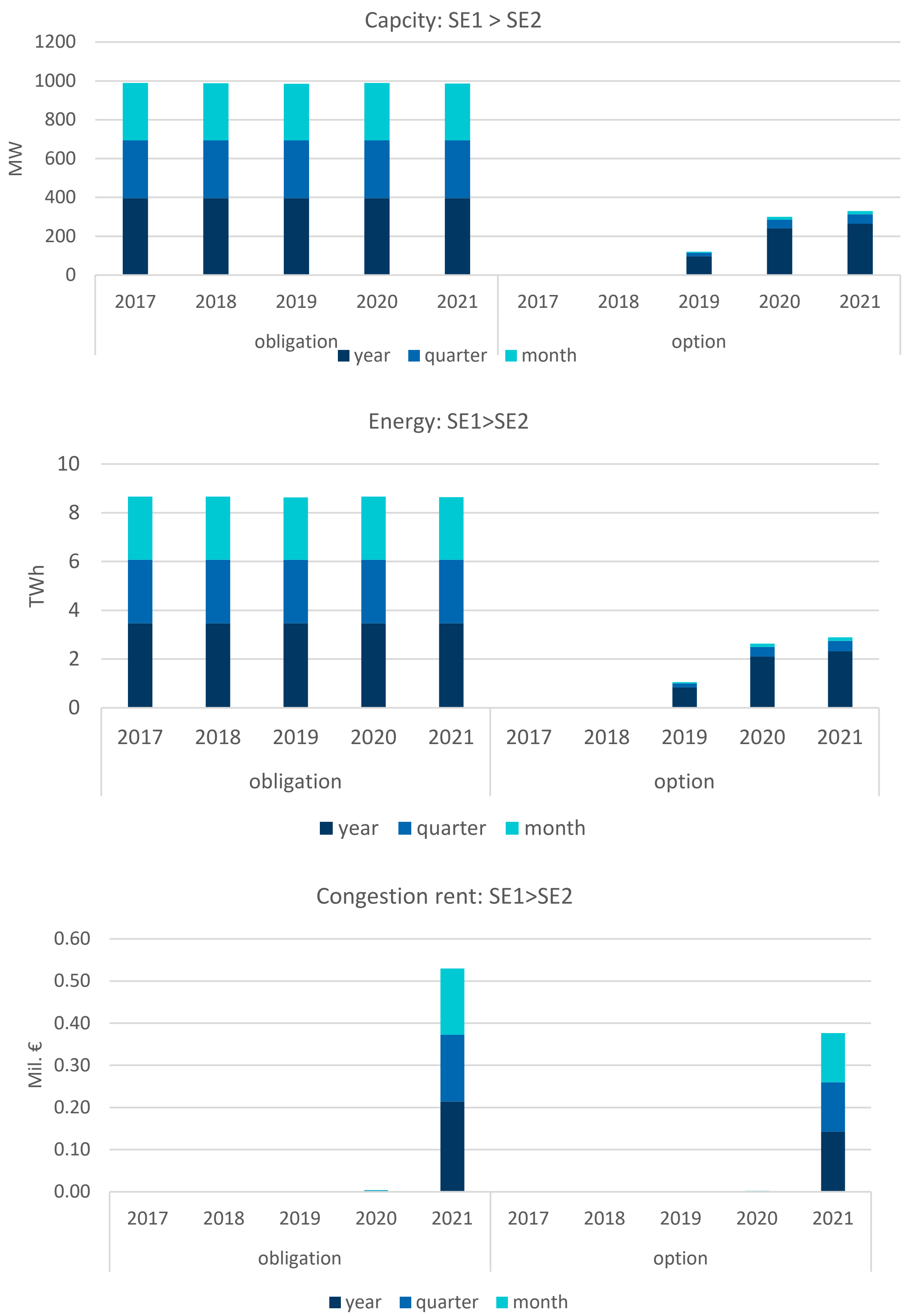
To illustrate the auctioned volumes and congestion rent costs, we follow the following procedure:

1. For each interconnector (direction) of interest, define 30%[37] of the maximum NTC allocated to the day-ahead auction over a full year, each quarter of the year, and each month of the year.
    - For obligations, consider NTC capacities in all considered hours irrespective of price difference on the interconnector (direction);
    - For options, consider only NTC capacities in all considered hours with positive price difference on the interconnector (direction);
2. Assume a split of the defined volumes into the following contracts: 40% yearly, 30% quarterly, and 30% monthly FTRs (HAR requires yearly and monthly contracts, we also include quarterly);
3. Assume FTRs are auctioned for the value equal to the realized price difference between the underlying BZs during the delivery period of the FTR;
4. Calculate the congestion rent underlying the FTR auction.

Following the above outlined approach leads to the volume and congestion rent estimates for SE1>SE2 (Figure 27), SE2>SE3 (Figure 28), and SE3>SE4 (Figure 29). For the north-most interconnector SE1>SE2 the average FTR obligation volume auctioned per year would be approximately 1000 MW, and much less for the FTR option because historically until 2021 there were very little price differences. This is visible on the congestion rent on this interconnector and direction, which shows a meaningful increase only in 2021 with approximately €0.5 million for the obligation.

[37] Based on our interviews with TSOs auctioning LTTRs value of 30% of NTC was chosen as a reasonable starting point to be finetuned over time.

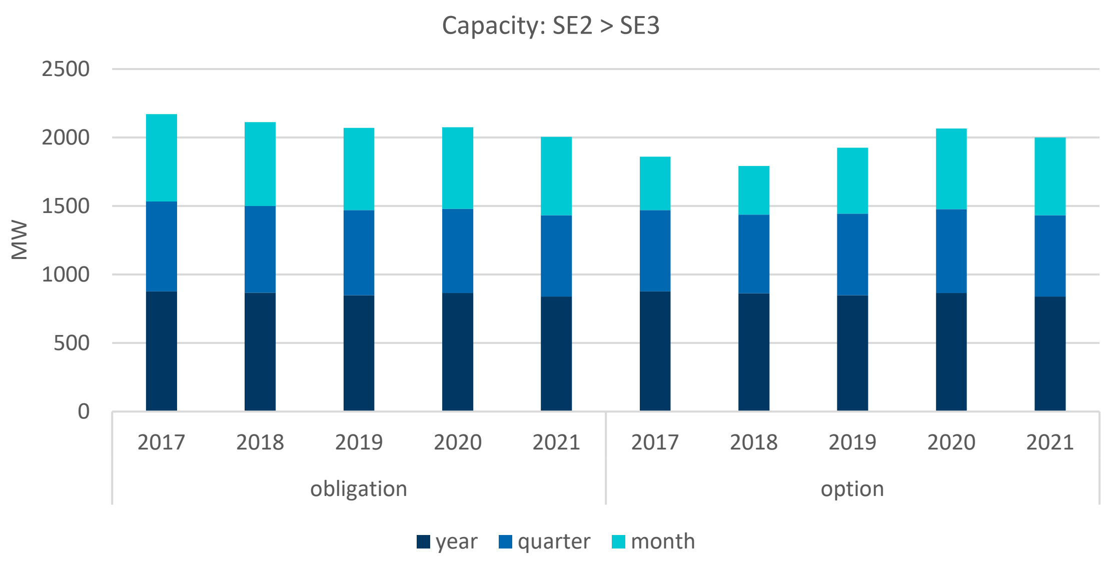
Figure 27: Congestion rent and energy volume distribution for FTR obligation and option in SE1>SE2 direction

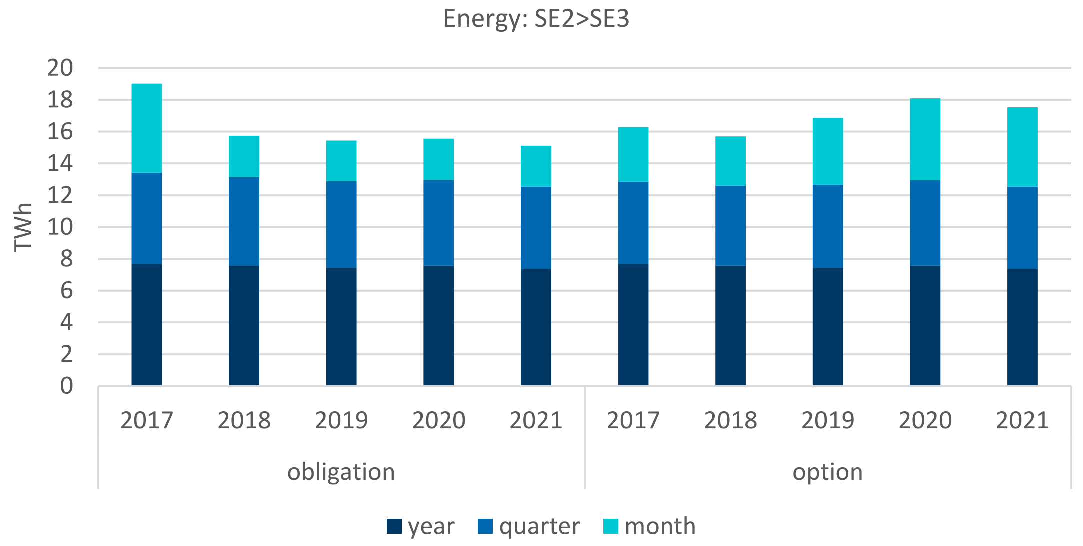


Notes: Volumes in MW represent averages for each contract type over the year; The contract split is: 40% yearly, 30% quarterly, 30% monthly
Source: Compass Lexecon analysis based on Nord Pool data

The interconnector SE2>SE3 (Figure 28) shows a more stable auction volumes of approximately 2000 MW/year for both FTR obligation and option over the studied period. The most radical change is in the past two years when the price spread between the zones strongly increased and would lead to a congestion rent **over €400 million in 2021** for the auctioned FTRs. This would be approximately a third of the congestion rent collected on the internal Swedish interconnectors in 2021[38].

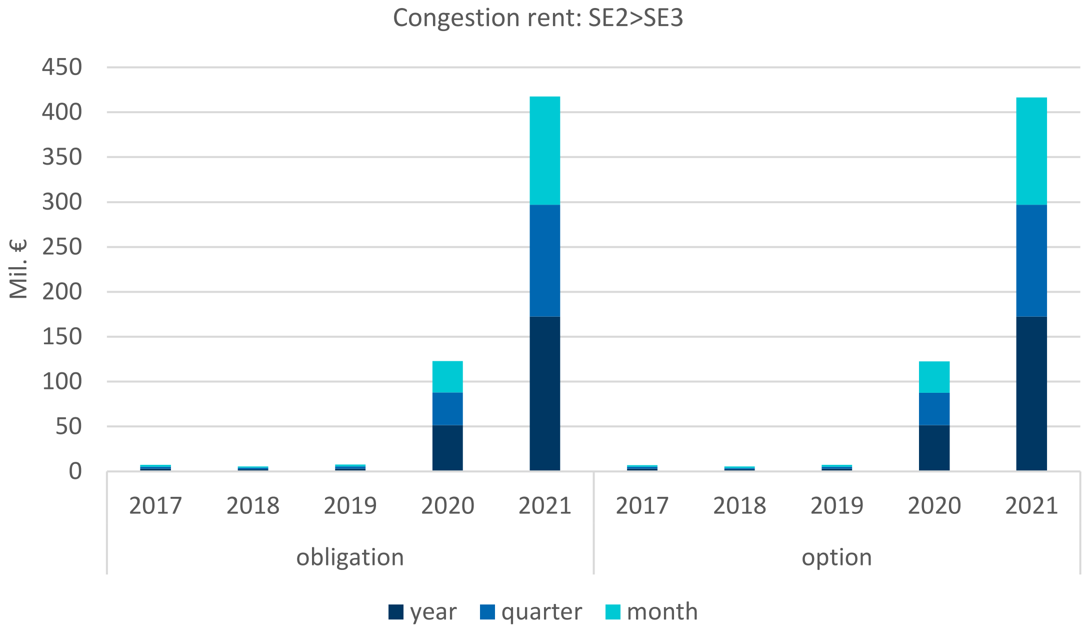
Figure 28: Congestion rent and energy volume distribution for FTR obligation and option in SE2>SE3 direction





[38] Svk, Feb 15 2022, https://www.svk.se/press-och-nyheter/nyheter/allmanna-nyheter/2022/stora-prisskillnader-bakom-rekordhoga-kapacitetsavgifter-2021/

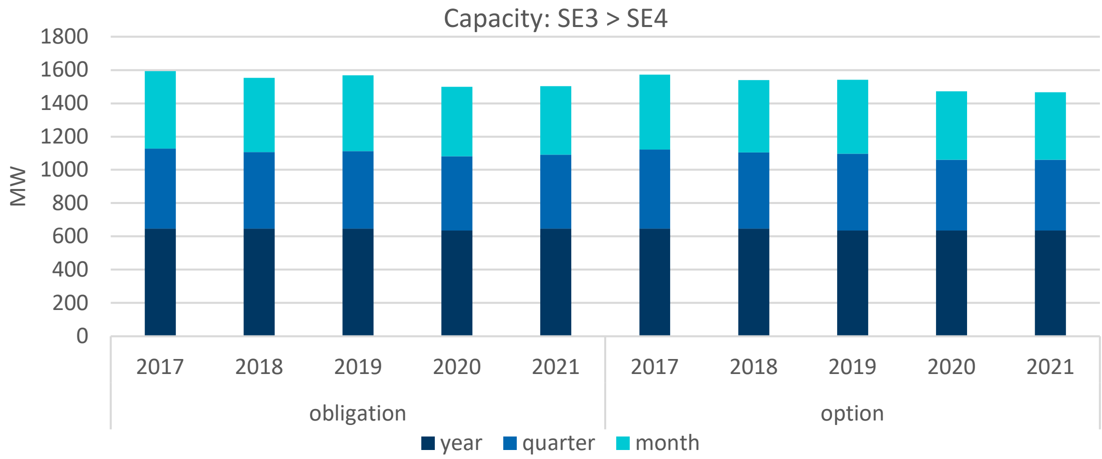
Figure 28: Congestion rent and energy volume distribution for FTR obligation and option in SE2>SE3 direction



Notes: Volumes in MW represent averages for each contract type over the year; The contract split is: 40% yearly, 30% quarterly, 30% monthly
Source: Compass Lexecon analysis based on Nord Pool data

The interconnector SE3>SE4 (Figure 29) shows a stable auction volume of approximately 1000 MW/year for both FTR obligation and option over the studied period. Similarly to the SE2>SE3 interconnector, also SE3>SE4 is characterized by the increased price spreads and therefore the underlying congestion rent hike in 2020 and 2021. The FTR auctions for 2021 on this interconnector and direction would lead to approximately €190 million of congestion rent, which is about 12% of the congestion rent collected on the internal Swedish interconnectors in 2021.

Figure 29: Congestion rent and energy volume distribution for FTR obligation and option in SE3>SE4 direction



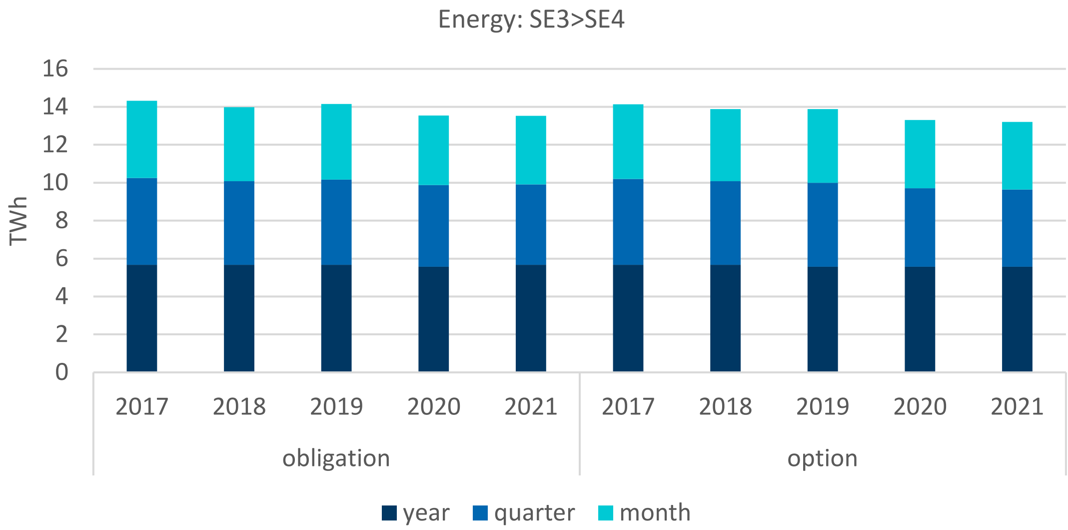
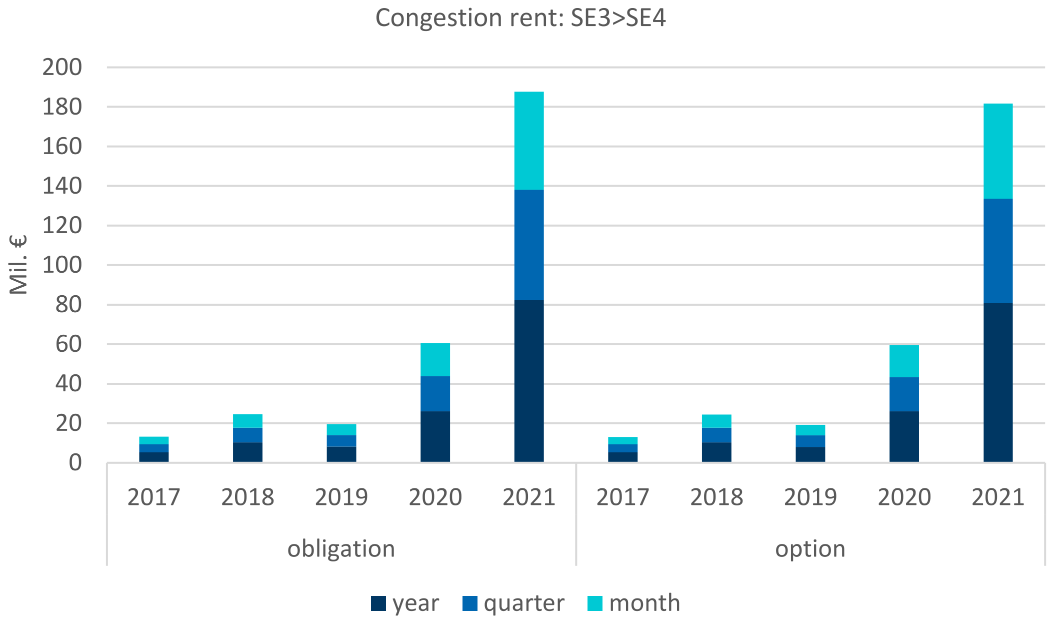


Figure 29: Congestion rent and energy volume distribution for FTR obligation and option in SE3>SE4 direction



Notes: Volumes in MW represent averages for each contract type over the year; The contract split is: 40% yearly, 30% quarterly, 30% monthly
Source: Compass Lexecon analysis based on Nord Pool data

The above illustrated values of FTRs auctioned on the internal Swedish interconnectors would be in line with TSO's revenue adequacy because they are linked to/limited by the allocated NTCs. We could also look at the FTR actioned volumes similarly as the EPAD auctioned volumes in the previous option and consider average net volumes per BZ auctioned in 2021. Table 14 shows that the TSO would auction approximately 4000 MW/year (~35 TWh) for approximately €600 million in 2021. These are similar and slightly lower values as for the Option 2 of EPAD auctions, which were approximately €660 million (~4100 MW/36 TWh). Note that while both EPAD (or synthetic FTR created by EPAD combo) and FTR need physical positions in both markets to have a complete hedge, EPAD (or EPAD combo) needs an additional financial position for the system price contract to obtain a complete hedge.

Table 14: Auctioned FTR volumes for internal interconnectors in Sweden in 2021

	SE1	SE2	SE3	SE4
Buy, MW	986	2004	1503	
Sell, MW		986	2004	1503
Net, MW	**986**	**1018**	**501**	**1503**
Annual energy, TWh	8.64	8.92	4.39	13.16

Note: SE1>SE2; SE2>SE3; SE3>SE4
Source: Compass Lexecon analysis

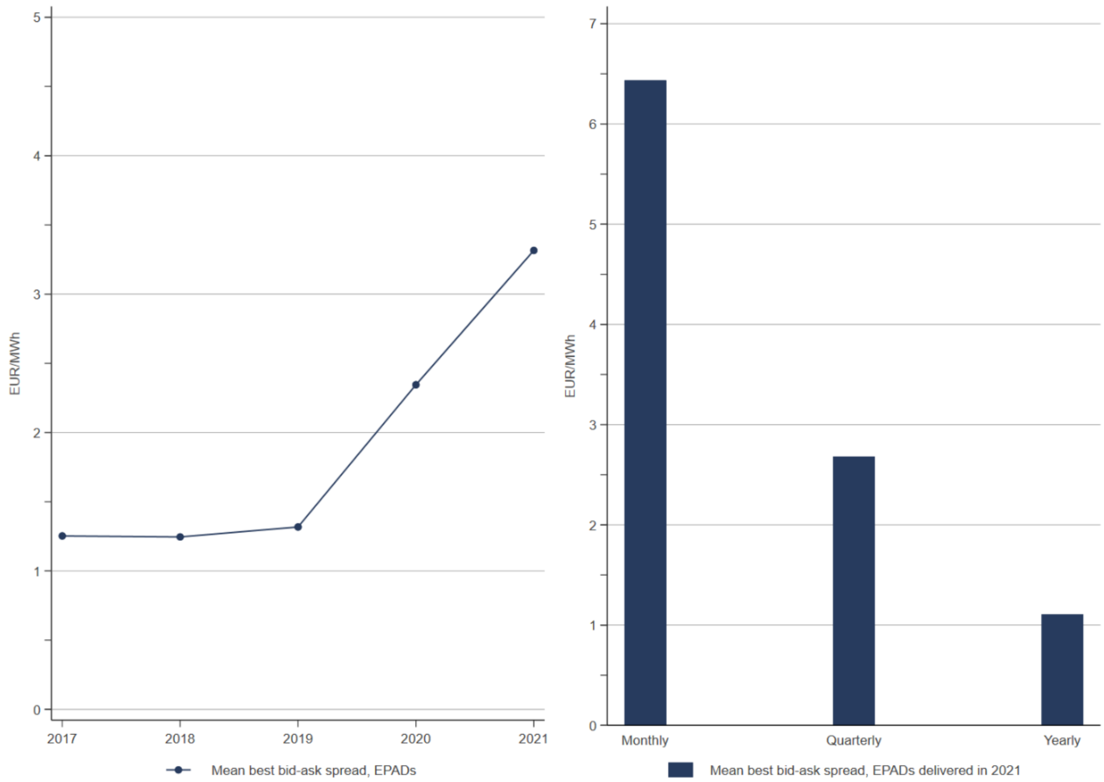
Bid-ask spread analysis

In the section we first briefly assess the status quo of **bid-ask spread**s. We then follow with an estimation of the relationship between the bid-ask spreads and open interest, which we use for the illustration of potential benefits (reduced transaction costs) of added volumes on the reduction of bid-ask spreads of EPADs.

Status quo

Mean daily best bid-ask spreads of EPADs have been increasing especially over the last two years. As shown in Figure 30 in the left panel, EPADs delivered in 2020 had the mean best bid-ask spread almost 2.5 EUR/MWh and in 2021 over 3 EUR/MWh. The right panel of the same figure shows the mean best bid-ask spreads of EPADs delivered in 2021 by contract maturity, implying that the longer the contract the lower the bid-ask spread.

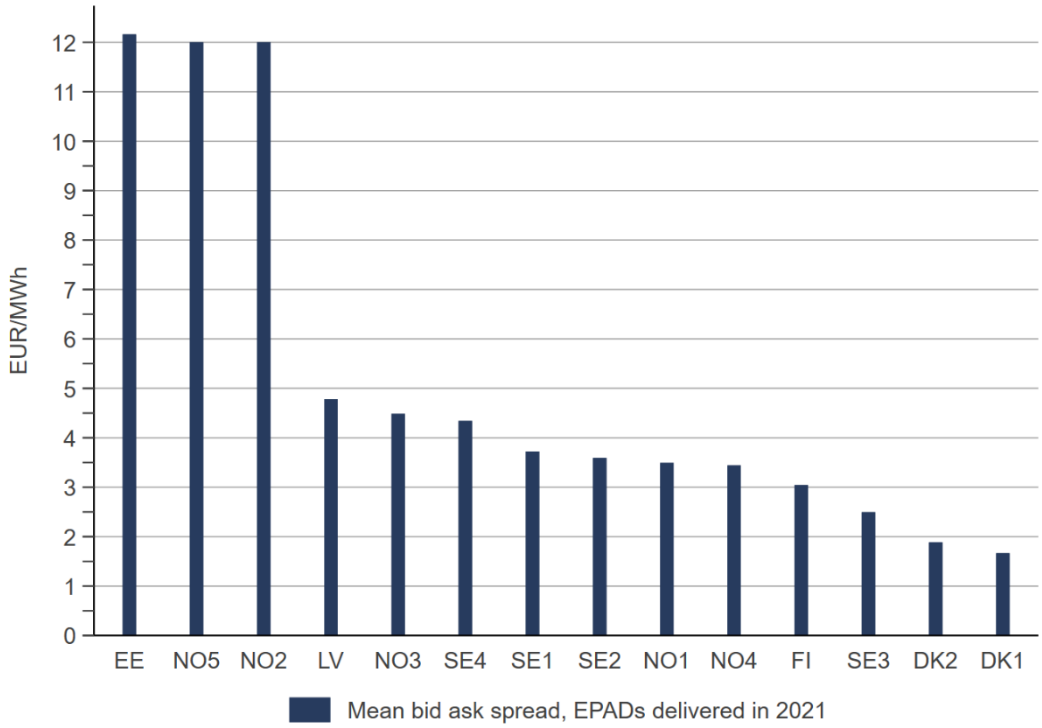
Figure 30: Mean daily best bid-ask spreads for EPADs, by delivery time



Notes: Left panel: includes all EPAD maturities summarized by delivery year; Right panel: EPADs delivery in 2021.
Source: Compass Lexecon analysis based on Nasdaq data

Observing the mean best bid-ask spreads of EPADs delivered in 2021 by BZ in Figure 31, the highest values are in EE, NO2 and NO5 (12 EUR/MWh) and the lowest in DK1 and DK2 (~1.70 EUR/MWh) and SE3 (2.50 EUR/MWh).

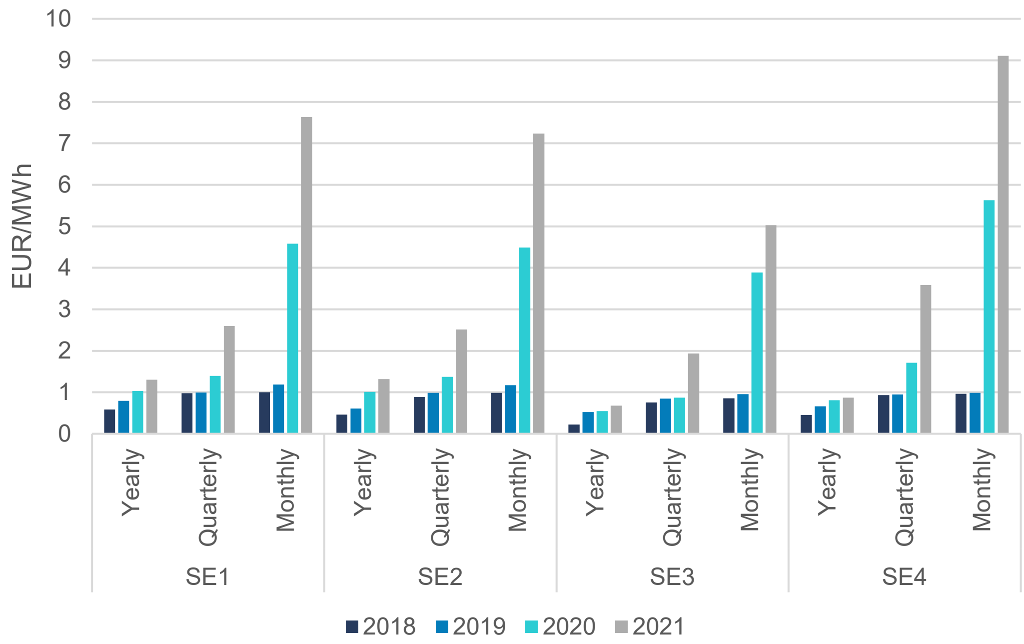
Figure 31: Daily best bid-ask spreads for all EPADs by bidding zones for all maturities delivered in 2021



Notes: Summary by delivery year 2021
Source: Compass Lexecon analysis based on Nasdaq data

Figure 32 zooms into the mean best bid-ask spread for the Swedish BZs EPADs by delivery year. Compared to the large difference of the system price contracts' overall vs. front contract mean bid ask spread, there was a negligible difference between the two for EPAD contracts.

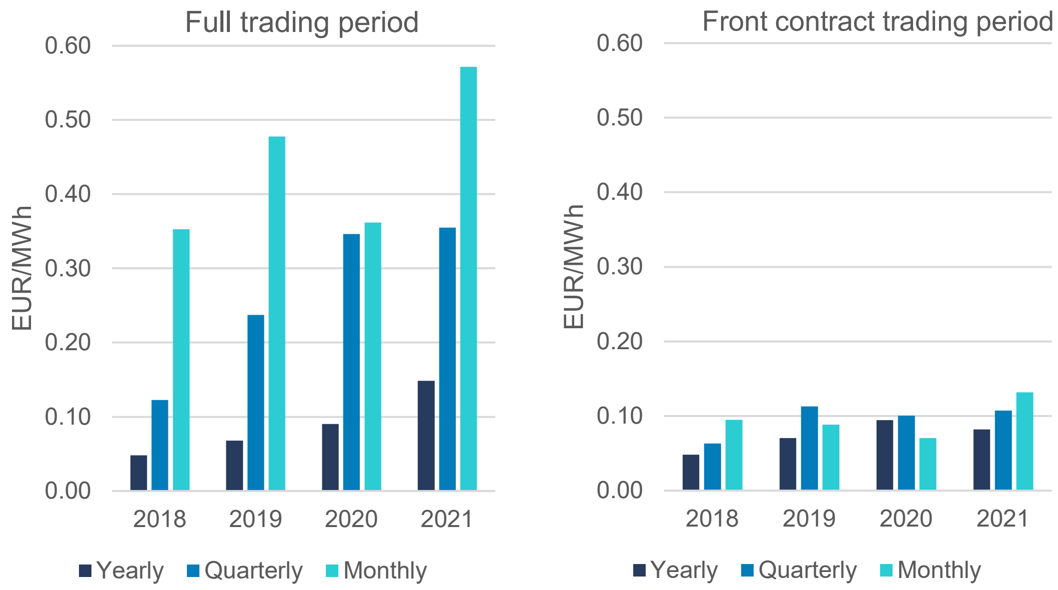
Figure 32: Mean EPAD best bid-ask spreads for Swedish bidding zones by contract maturities and delivery year



Notes: Best bid-ask spreads by delivery year, includes all contracts (not only front-contracts)
Source: Compass Lexecon analysis based on Nasdaq data

For comparison to the more liquid Nordic system price contracts, Figure 33 shows the mean best bid-ask spread for the system price contracts in delivery year. The left panel of the figure includes the contracts' full trading period whereas the right panel includes only the period when they become the front contracts, i.e., 1 month/quarterly/year before monthly/quarterly/yearly contract matures, respectively. The large difference shows that the front contracts are the most liquid with strong impact on the best bid-ask spread.

Figure 33: Mean SYSTEM contract best bid-ask spreads by contract maturities and delivery year



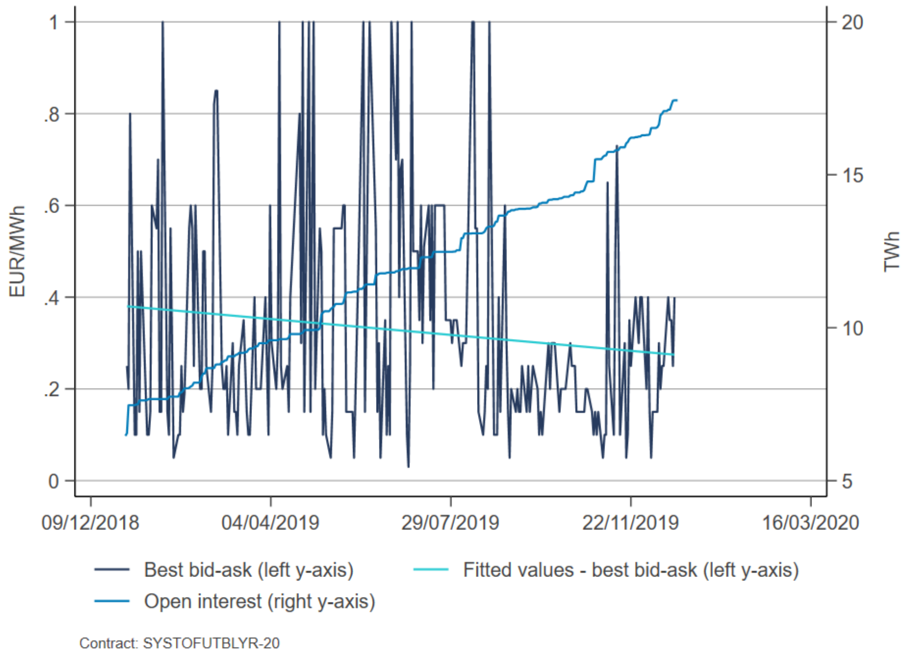
Notes: Best bid-ask spreads by delivery year, all contracts (not only front-contracts)
Source: Compass Lexecon analysis based on Nasdaq data

Impact assessment

Our bid-ask spread data sample includes 1639 unique contracts traded in the period 2017-2021, of which 1163 are EPAD and 476 system price contracts. We merge this dataset with an open interest dataset to observe the quoted best bid-ask spread behaviour in relation to the open interest. The bid-ask spread dataset also includes a variable called "Count" which includes the number of minutes per day with available bid-ask spread. We will also use this variable below to control for the trading opportunity, i.e., when the best bid-ask spread is quoted more frequently during the day market participants have higher opportunity to fill their orders.

Figure 34 shows on a sample yearly EPAD contract for SE3 with delivery in 2020 that the bid-ask spread tends to decline when moving closer to the contract's maturity while the open interest keeps increasing. This implies that as the trading and hedging interest behind a contract increases during its trading time, the best bid-ask spread tends to decrease.

Figure 34: Best bid-ask spread and open interest during the trading time of a yearly futures EPAD contract for Stockholm (SE3) area with delivery in 2020



Source: Compass Lexecon analysis based on Nasdaq data

We use the illustrated relationship between open interest and best bid-ask spread and argue there is a statistically significant negative relationship between the two. We also use the above-described Count variable, which measures the number of minutes per day with available bid-ask spread, representing a proxy to trading opportunity. We also argue that there is a negative relationship between Count and the bid-ask spread, since more frequently updated bids will tend to improve the liquidity and reduce the spreads.

Table 14 presents the results of an estimated regression analysis and the relationship[39] between the best bid-ask spreads (dependent variable) and two explanatory variables - open interest and count. As expected, both variables have negative and statistically significant relationship.

Table 15: Regression results for best bid-ask spread of EPADs in Sweden

VARIABLES	SE EPAD	SE1 EPAD	SE2 EPAD	SE3 EPAD	SE4 EPAD
Open interest, TWh	-0.166***	-0.597***	-0.243***	-0.122***	-0.163***
	(0.00321)	(0.0303)	(0.0179)	(0.00294)	(0.0357)
Count (minutes/day with available bid-ask spread	-0.00810***	-0.00858***	-0.00884***	-0.00460***	-0.0112***

[39] We use an ordinary least squares regression with robust standard errors, which is a first attempt of quantifying relationships between best bid-ask spreads and fundamental variables. This simple model understandably explains only a part of the variation in bid-ask spreads, as shown by the R-squared values of approximately 13%. Nonetheless, this model serves the purpose of the scope of this project and should be further developed in future work.

Table 15: Regression results for best bid-ask spread of EPADs in Sweden

	(9.12e-05)	(0.000173)	(0.000162)	(0.000124)	(0.000261)
Constant	3.660***	3.800***	3.805***	2.589***	4.552***
	(0.0251)	(0.0468)	(0.0467)	(0.0390)	(0.0703)
Observations	56,764	14,063	14,107	14,329	14,265
R-squared	0.124	0.132	0.147	0.136	0.104

Notes: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Compass Lexecon analysis based on data from Nasdaq

We use the coefficients[40] of the open interest variable in Table 14 to assess the mean impacts of the estimated open interest volumes of the three measures improving the risk hedging opportunities in Sweden. Table 16 summarizes the key results, first showing the illustrated open interest volumes added by each option, followed by the mean impact of the estimated volume on best bid-ask spreads, and finally the benefits from the reduced bid-ask spreads.

The table shows results for 5 market makers in Measure 1, the mean added open interest during delivery time by the three regional EPADs in Measure 2, and option 1 of the TSO-auctioned EPADs in Measure 3. Sensitivities and ranges may be added in the future studies, but the results show that **Measure 3** brings **the largest benefits** via the largest added volumes and largest bid-ask spreads reductions.

Table 16: Benefits from added open interest and reduced bid-ask spreads

	Measure 1: Improved market making	Measure 2: Regional EPADs	Measure 3: TSO auctioned EPADs
Open interest volume added, TWh	6.1	9.4	17.5
Mean bid-ask spread impact, EUR/MWh	-1.0	-1.6	-2.9
Benefits from reduced bid-ask spread, M EUR	**6.3**	**14.7**	**51.0**

Note: Measure 1 uses the results for 5 market makers; Measure 2 uses mean added open interest added by the three regional EPADs; Measure 3 is based on the option 1 of auctioned EPADs.
Source: Compass Lexecon analysis based on data from Nasdaq and Nord Pool

Cost analysis

In this section we assess the costs for implementing each of the four considered measures improving the risk hedging opportunities on the Swedish electricity market. We rely on information obtained from interviews with market participants (TSOs, regulators, utilities, exchanges, large end-users) and secondary sources to derive the implementation cost estimates.

[40] Note that there may be a threshold effect after which the impact of open interest on bid-ask spreads may be different. This can be investigated in future work.

Measure 1: Improved market making

The improved market making costs are inherently linked to the detailed design elements and conditions specified in the market making agreement, such as delivering a certain level of liquidity or capping the maximum quoted bid-ask spreads. To nonetheless provide realistic estimates, we use cost estimates from a tendered market making obligation programme implemented in the GB by Ofgem[41] and translate these to the current costs in Sweden.

There are **two main cost components** in introducing the improved market making measure:

1. Cost of operating and designing the tender process; and
2. Running costs for market makers.

With respect to the **cost of operating the tender** for market makers, the study uses an estimate of €600k total annual costs based on a MIBGAS (the Iberian gas exchange) report. With respect to the **running costs for market makers**, the study reports a range of €360k – €840k for the variable costs (includes staff costs, transaction fees, costs of open positions, and costs form managing credit exposures), and €600k for the fixed costs. Both values are based on reported costs by market makers in GB in 2017. The total running costs per market maker are therefore in the range of €960k and €1.44m per year.

Table 17 summarizes the annual costs for individual market maker as well as the **total annual costs** for tendering five market makers, which would be in the range of €5.4m – €7.8m.

Table 17: Annual societal cost of tendered market making

	Number of MMs	Cost of tender (€m)	Cost /MM (€m)		Total cost (€m)	
			Low	High	Low	High
Tendered market maker (MM)	5	0.6	0.96	1.44	**5.4**	**7.8**

Source: Compass Lexecon analysis based on Ofgem report 2019 (see footnote for reference)

Measure 2: Regional EPADs

Based on our interviews with Nasdaq we understand that the introduction of regional EPADs would not lead to any additional costs compared to the current EPAD system. This is because all existing infrastructure is already in place and only the existing EPAD product definition would need adjustment. There would certainly be at minimum labour costs for redefining the existing products (including legal and IT), but we assume the societal cost to be ~ 0 € or negligible, because the measure would heavily rely on the existing resources and knowledge.

Measure 3 and 4: TSO-auctioning EPADs and FTRs

We combine the costs of TSO-auctioning EPADs and FTRs because the related implementation and running costs are similar. We again rely on the information obtained during our interviews with the Nordic TSOs and Nasdaq.

The measure of TSO FTRs auctioned on the Single Allocation Platform JAO would cost approximately €150k /year for 3 products (yearly, quarterly, monthly) per border. If the FTR auction on the given border would involve two TSOs, the annual cost would be €300k /year split by half. However, since this study focuses only on the three internal borders in Sweden operated by a single TSO, the costs per border do not double. This is because some of the costs are shared per TSO

[41] GB Wholesale Power Market Liquidity: Options Assessment, Ofgem by NERA, 2019.

and do not depend on the number of borders or FTR products offered. We therefore estimate that the annual cost to the Swedish TSO for the three internal borders would be approximately €450k (€150k*3). This cost should cover the full administrative fees to JAO running the regular auctions, clearing, and invoicing, among others.

We were also given a high-level cost figure for the exchange organizing and running the EPAD auction on behalf of the TSO. This value was approximately €200k/year or less for the TSO, which would benefit from off-the-shelf auctioning platform, clearing and possibly secondary market trading options available at the exchange. As this number is dependent on specific requirements, this figure is to be treated as a rough estimate. We, however, stay conservative and assume the annual cost of €450k also for the last measure of TSO-auctioned EPADs, because this cost is based on the already implemented platform of very similar nature.

Conclusion

From the three measures improving the existing hedging market in Sweden, the TSO-auctioned EPADs delivers the highest societal net benefit, see Table 18. While the detailed implementation and financing options of this measure is a work-to-be-done, this measure has a good potential to improve the market that the market participants have been relying on, are familiar with, and are asking for its improvement rather than its overhaul.

While the congestion rents and auction revenues for the TSO-auctioned FTRs as well as its implementation costs were assessed in this study, estimation of direct and/or indirect societal benefits of FTRs were left outside of this study (N/A in Table 18). However, recent Nordic studies[42] point out to the limited benefit of FTR options (the current default) for risk hedging purposes. The potential benefits of FTR auctions for hedging may come from indirect effects of increased liquidity in other hedging products, such as Nordic system price. However, these benefits are expected to be small.

If the main policy objective is to improve the hedging possibilities of market participants in the Swedish electricity market, we would tend to recommend measures improving the existing EPAD market. If the liquidity can be improved and transaction costs reduced for reasonable costs, EPADs can already now and have always been able to deliver the same function as FTRs, if the market participants demand it.

[42] Evaluating Hedging Possibilities on NordLink, NorNed and North Sea Link, NVE report by Thema, 2021.
Area price hedging and the Nordic market model, Ei - Swedish Energy Markets Inspectorate, 2016.

Table 18: Summary of annual benefits and costs

	Measure 1: Improved market making	Measure 2: Regional EPADs	Measure 3: TSO-auctioned EPADs	Measure 4: TSO-auctioned FTRs
Volume impact: increased liquidity (TWh)	6.1	9.4	17.5	35.1
Benefit from added volume: Lower bid-ask spread, (€m)	6.3	14.7	51.0	N/A
Costs (€m)	5.4	~ 0	0.45	0.45
Net benefit	**0.9**	**14.7**	**50.5**	

Note: Costs for Measure 1 based on the lower range value; Volume of measure 3 is based on option 1.
Source: Compass Lexecon analysis

ROADMAP TOWARDS COST EFFICIENT IMPROVEMENT OF RISK HEDGING OPPORTUNITIES

Based on the previous chapters, we recommend Ei to enforce a combination of the TSO auctioning EPADs and improved market making as short-term measures to improve risk hedging opportunities in Sweden. In addition to this, larger BZs could be considered as a long-term measure, however, the BZ reconfiguration is a complex matter with many aspects to consider and will most likely not be implemented within less than three years. We also recommend following up on market participants' interest for regional EPADs and/or a review of how the system price is calculated, after knowing the outcome of the ongoing BZ reconfiguration process.

The TSO auctioning EPADs and improved market making can be implemented relatively quickly in comparison to many of the other possible measures improving the hedging opportunities. These measures are also to a large extent in the hands of the NRA/TSO, in contrast to the introduction of new financial products, such as regional EPADs or a new system price calculation that are dependent on private actors. Such measure as an introduction of new financial products replacing the existing products would preferably require several years implementation time to enable market participants to get out of financial positions in the existing products. The market participants' interest in an introduction of new financial products is largely dependent on the outcome of the currently ongoing BZ review. We therefore suggest waiting with such measures until the results of the BZ review are known.

Implementation process overview based on FCA GL Article 30

The first part of the implementation process is to settle on paragraph 5 in FCA GL Article 30. In case the assessment referred to in paragraph 3 shows that there are insufficient hedging opportunities in one or more BZs, the competent regulatory authorities shall request the relevant TSOs (paragraph 5):

a) to issue long-term transmission rights; or

b) to make sure that other long-term cross-zonal hedging products are made available to support the functioning of wholesale electricity markets.

If the involved BZs are in the same country, the NRA for that country can decide solely on paragraph 5 as we interpret it. If the BZs involved are crossing a national border, the NRAs must agree on paragraph 5, or the case will be passed on to ACER. ACER then has six months to decide and to inform the NRAs. After a decision has been taken, either by the NRA(s) or by ACER, the process moves on to paragraph 6.

Paragraph 6 states that in case the competent regulatory authorities (i.e., the NRA) choose to issue a request as referred to in paragraph 5b (ensure that long-term risk hedging products for transmission between BZs are made available), the relevant TSO(s) shall develop the necessary arrangements and submit them to the competent regulatory authorities' approval no later than six months after the request. The NRA then has the following options, upon receiving the TSOs work:

- Approve the TSOs work.
- Ask the TSO for adjustments and completions.
- Adjust the work provided by the TSO.

It is further stated that those necessary arrangements shall be implemented no later than six months after approval by the competent regulatory authorities. The implementation time may be extended upon request from the relevant TSOs by a period of no more than six months. Figure 35 illustrates the maximal timeline for the implementation process according to FCA GL.

Figure 35: Timeline (maximum) for the implementation process according to FCA GL

				Month																							
TASK	ASSIGNED TO	START	END	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Step 1: If involved NRAs can't agree on paragraph 5 in FCA GL Article 30, the question is passed on to ACER	NRA/ACER	1	6																								
Step 2: NRA requests from the TSO to develop the necessary arrangements.	TSO	7	12																								
Step 3: Approval process	NRA	12	12																								
Step 4: Implementation	TSO	13	18																								
Prolonged implementation	TSO	19	24																								

Source: EUR-Lex, illustrated by Merlin & Metis

Roadmap to implementation of suggested short-term measures

We suggest a simultaneous implementation of improved market making and the TSO auctioning EPADs, as soon as possible. Improved market making could possibly be implemented somewhat faster than TSO auctioning of EPADs. However, as the literature review suggests, market making may not be effective if there is a skewed market structure within the BZ. We therefore suggest launching improved market making in parallel with TSO auctioning of EPADs that would tackle some of the prevailing market asymmetries. Below is a roadmap to implement these suggested measures. It is assumed that the suggested measures will only be implemented in Sweden, although the same measures can be implemented in other Nordic/Baltic countries.

If Ei cannot agree on measures to improve the hedging opportunities or an introduction of LTTRs with an NRA of a cross-border BZ where hedging opportunities have been assessed as insufficient in one of the BZs, the case will be passed on to ACER. This may result in a situation where Ei is forced to introduce LTTRs on one or many borders. An introduction of LTTRs on borders to/from one or many Swedish BZs, may change the analysis results somewhat, but we do not see it as likely that it would change our overall conclusions. However, awaiting the results of the cross-border processes may result in substantial delays for the process within Sweden.

Step 1: The NRA can solely and immediately initiate the implementation process of the suggested measures in Sweden. If neighbouring countries decide to implement the same measures, it may be advantageous to coordinate these processes and possibly cooperate regarding, for example, an EPAD auctioning platform and auctioning dates and times.

Step 2: The TSO (Svk) is requested to develop the necessary arrangements, which should involve at least one public consultation. Prior to and/or parallel with the public consultation, there are some issues that need to be addressed:

- Analysing how the TSO procurement can be made in line with Swedish procurement law at the same time as it prevents the added market making liquidity from being spread on many trading platforms.
- Analysing how the suggested measures are to be financed. Could they, for example, be financed by congestion revenues?
- Developing a methodology for calculation of auctioning volumes and determining the frequency of auctions.
- Preparing a procurement procedure for an auctioning platform for EPAD auctions and settlement.
- Forming a model for continuous evaluation of the auction design, to enable adjustments for changes in the underlying market conditions.

A public consultation process is estimated to take at least 2 months. Our interviews with TSOs that have recently implemented or are about to implement LTTRs, i.e., Fingrid, Elering, and Energinet, all suggested that a good dialogue with market participants was crucial to their process with implementing LTTRs. We believe that there will be a similar need for a dialogue with market participants in this case. In our interviews the market participants have pointed out that their knowledge about the suggested measures is limited. This points to the need for information to be provided to market participants prior to the public consultation. Based on this, we suggest that the TSO extends the public consultation process with at least one seminar prior to the public consultation. After the public consultation, the TSO is likely to need about one month to process the received comments.

The public consultation should include questions regarding the market making conditions (maximum bid-ask spread, volume requirements, number of market makers, possible exceptions from market making commitments, etc). Given that a solid public consultation process is emphasised, it is unlikely that step 2 will be completed substantially faster than six months, even if the TSO is prepared when receiving the request. However, we assess that six months should be sufficient for step 2.

Step 3: Once the TSO has finalized step 2, the next step is for the NRA to approve the TSO's submission and give it the task to start implementing it. If the NRA isn't satisfied with the TSO's submission, it can either send it back to the TSO for adjustments and completions or make own adjustments. We assess it as likely that step 3 can be completed in less than 1-2 months.

Step 4: The final step in the process is implementation led by the TSO. The implementation process includes several steps, which most of can be run in parallel. Below are the main steps in the implementation phase:

- Procurement of services for improved market making and an auctioning platform for EPADs.
- Working out internal routines within the TSO and setting up the needed organisation to handle the new tasks.
- Forming a transparent model that provides market participants with relevant information regarding auctioning products and volumes.
- Implementing the model for continuous evaluation of the auction design (initiated in step 2), to enable its adjustment for changes in the underlying market conditions

As these processes can be run parallel to a large extent, we estimate that the implementation can be done in six months or less. A prolonged implementation process would not be needed then.

Figure 36: Detailed implementation process of suggested measures

TASK	Month 1	2	3	4	5	6	7	8	9	10	11	12	Comments
Step 2: NRA requests from the TSO to develop the necessary arrangements.													
Analysing how the TSO procurement can be made in line with Swedish procurement law at the same time as it prevents the added market making liquidity from being spread on many trading platforms.													
Analysing how the suggested measures are to be financed. Could they, for example, be financed by congestion revenues?													
Developing a methodology for calculation of auctioning volumes and determining the frequency of auctions.													*May be revised based on input from public consultation*
Preparing procurement procedure for an auctioning platform for EPAD auctions and settlement.													*May be revised based on input from public consultation*
Forming a model for continuous evaluation of the auction design, to enable its adjustment for changes in the underlying market conditions.													*May be revised based on input from public consultation*
Public consultation													*Including introductionary seminar + public consultation*
Adjustments based on the public consultation process													
Step 3: Approval process													
Step 4: Implementation													
Procurement of services for improved market making and an auctioning platform for EPADs.													*Suppliers can start preparing during step 2*
Working out the internal routines within the TSO and setting up the needed organisation handling the new tasks.													*Can be initiated during step 1*
Forming a transparent model that provides market participants with relevant information regarding auctioning products and volumes.													*Can be initiated during step 2*

Source: Merlin & Metis

In addition to the TSO's implementation process, involved trading platforms and market participants also need to implement necessary measures, including adjustments for IT-systems to cope with the EPAD auctioning platform.

Follow-up on EPAD auctioning and improved market making once implemented

It can be difficult to find the optimal market making requirements or volumes for EPAD auctioning from the start. Even if the optimal settings would be achieved from the start, they are likely to change over time. Therefore, it will be important to have a model to continuously evaluate market liquidity, how the measures affect liquidity as well as the costs that the measures incur.

The evaluation of liquidity may also provide important input to evaluating the relevance of the implemented measures. It may turn out that the market making function procured by the TSO is not needed sometime in the future, or that the TSO involvement in the EPAD market would give better results if it was executed through continuous trading rather than auctioning.

Suggested short-term measures for implementation of LTTRs

The implementation process and implementation time for LTTRs would be similar to the suggested introduction of TSO auctioning EPADs. The introduction of LTTRs may require some more time in step 2, particularly regarding the public consultation. This is because LTTRs are new financial products to many Swedish market participants and would require more knowledge transfer and therefore also time to introduce. LTTRs may also require some more time during step 4 when IT-systems are to be adapted. On the other hand, JAO already offers a proven auctioning platform for

LTTRs. There may be some challenges in setting up an auction platform for EPADs, however, this is assessed as not being a major obstacle.

STUDY LIMITATIONS AND FUTURE WORK

There are several limitations to this study that stem from the predefined scope of work as well as the methodology applied. Below we highlight some limitations that mainly relate to the analytical approach of comparing different transaction costs and benefits of policy measures from a societal perspective. We also provide suggestions for future improvements and next steps.

Limitations to approach and analysis

The scope of this work was to a large extent determined by the project proposal formulated by Ei. The focus was therefore on the Swedish market and the identification of improvement alternatives to the current market set up in comparison to introducing LTTRs. More extensive analysis of the whole Nordic electricity market areas could be conducted and the impacts of cross-border LTTRs developed further.

The time constraints of the project impacted its extent and methodological choices. For example, we had to limit the depth of the literature review and we had to refrain from using a reference group during the project, even though it could have been beneficial to increase the number of market participants' viewpoints.

Similarly, there are limitations in the methodology applied in the analysis which evaluates and compares different transaction costs and benefits of policy measures from a societal perspective. Some of these include:

- The statistical model of the relationship between the bid-ask spread and open interest was purposefully designed simplistically to provide a transparent starting point while ensuring basic statistical properties of a regression model. As a next step, we suggest to further explore and test this relationship theoretically and quantitatively by applying different statistical models, such as time series models. Testing the models' sensitivities to various specifications should also be transparently studied.
- Specific to the measure of TSO auctioning EPADs - When defining the auction volumes and the BZs where TSOs auction EPADs, the TSO should consider and regularly assess liquidity (transaction costs) measures, and/or underlying fundamental power supply-demand imbalance of the BZs in question. We proposed and illustrated the results of a simplified methodology as Option 2, but a detailed auction volume methodology should be developed in future work.
- While we presented ranges and sensitives for some inputs (e.g., costs) and outputs (e.g., different number of market makers) a more thorough sensitivity analysis should be conducted in the future. For example, detailed specification of the market maker agreement may impact both the costs and benefits of this measure (e.g., caps on the quoted maximum bid-ask spreads), and the variation of the auctioned EPAD/FTR volumes by TSO may have different impacts on the market liquidity.

Other future improvements and next steps

Specific to the measure of Regional EPADs, this study focused on pooling BZs of Sweden and Norway only because of their high interconnectedness and geographical proximity, but also to stay within the scope of this study (Sweden). If the option is to be considered further, future work should analyse the entire Nordic region to identify the regions with the highest price correlations beyond Sweden and Norway. This can be done before the BZ review process is finalized as it may result in changes that will not have a significant impact on the outcome. Another step prior to the implementation could be to conduct a study to better understand market participants’ views on the remaining basis risk in any regional EPAD.

Detailed market design with respect to TSO involvement on the EPAD markets should be evaluated on a regular basis and if needed, revised and adjusted accordingly. Although we have suggested that the initial TSO involvement on the EPAD markets should be done through auctioning rather than continuous trading, we suggest that the functioning and impacts of this measure on the market are evaluated after its potential implementation. The evaluation should focus on the liquidity effect of volumes being bought/sold by auctioning in contrast to continuous trading. The TSO’s involvement through continuous trading may have a different impact on liquidity than auctioning EPADs, for example on the order depth. The timing and frequency of the EPAD auctions should also be evaluated.

APPENDIX A – INTERVIEWED MARKET ACTORS

In total 12 interviews were conducted as a part of this study. The interviewed market actors were the following:

- **Nasdaq OMX Commodities** was interviewed two times. The first time to discuss the alternative measures and the data request, the second time to address the implementation process and related costs.
- **Svenska Kraftnät** was also interviewed two times. The first time to discuss the alternative measures, the second time to address the implementation process and related costs.
- **SwedEnergy (Energiföretagen)** represented the viewpoints of electricity generators. It is a special interest organisation for companies that supply, distribute, sell, and store energy.
- **Swedish Forest Industries Federation** (**Skogsindustrierna)** represented the viewpoints of electricity consumers. Thereafter, the alternative measures were presented to SKGS, the special interest organisation for the forest, chemical, mining and metal industries. The industry representatives had the chance to provide comments during as well as after the meeting.
- **Two electricity trading companies** were shortly interviewed, mainly to understand whether TSO involvement in the EPAD markets could take place via auctions or continuous trading. The names of the trading companies are kept confidential, however both of them are established and large market players in the Swedish market.
- **Fingrid**, **Elering** and **Energinet** were interviewed to discuss LTTRs, FTRs in particular, their implementation process as well as related costs.

APPENDIX B – SHORT SUMMARIES OF REVIEWED LITERATURE

As a part of this study literature has been reviewed. In this section, we provide short summaries of the most relevant sources ordered by the year of publication.

European Commission (2021): Smaller bidding zones in European power markets: liquidity considerations. ASSET study written by Tractebel Impact.

The study aims to provide a view on potential adverse effects on liquidity and market functioning if smaller BZs are introduced in European wholesale electricity markets. It addresses concerns related to increasing price volatility and fragmentation of markets in smaller BZs that could contribute to illiquidity, complicating risk mitigation practices and consequently result in higher costs to final consumers. The study provides a definition of liquidity and specifies several parameters that can be used to measure liquidity. The analysis in the study is based on quantitative measures as well as a literature review. With respect to the liquidity in EPAD markets in the Nordics and Baltics, noting that there are several factors that have impacted the market development, e.g. high zone-to-SYS price convergence rate reducing the demand for EPADs in some BZs, and reduced number of market participants and increased costs due to financial regulations.

The study concludes that the fundamental issue might not be related to the size of the BZs as such, but rather to the current design of risk mitigation instruments that are not well adapted to new BZ configurations. BZ configuration should aim to make spot prices right first, as it is essential in pricing the transmission externality and to improve allocative and dynamic market efficiency. The study also concludes that market power appears to be more of a location issue with roots that are independent of the zonal configuration.

Regarding hedging of the transmission externality, the study focuses on LTTRs that provide the opportunity to hedge transmission risk across BZs in continental Europe. It notes that this is important in the presence of increased geographical granularity and price volatility. The study recommends a number of measures to improve these forward hedging, e.g. simultaneous auctioning of FTRs across continental Europe building upon a flow-based calculation of available capacities, improving the ability for market participants to readjust their positions more regularly via longer LTTR maturities and secondary markets and replacing ‘flowgate’ FTRs by a zone-to-zone design to enable transmission hedging between any two distant zones, in which case obligations over options are to prefer.

Thema Consulting Group (2021): Evaluating Hedging Possibilities on NordLink, NorNed and North Sea Link. The Norwegian Energy Regulatory Authority, RME Ekstern Rapport nr. 7/2021.

The report examines the implications of issuing long-term transmission rights (LTTRs) on the NordLink, NorNed and North Sea Link interconnectors from Norway, hence to all of Norway’s connections to non-Nordic bidding zones.

The report includes a data analysis that shows a trend towards decreased open interest in the Nordic system price contracts since 2017. Meanwhile, the open interest in EPAD contracts have increased since mid-2018, which may be explained by a higher perceptions of area price risk. It should be noticed that the data only cover hedging conducted using exchange traded products but excludes, for example, the use of OTC trading and PPAs.

Responses from a survey indicate that whereas respondents with the Nordics prefer the current market set up, respondents outside of the Nordics were in favour of issuing LTTRs. The report lists for following potential benefits of issuing LTTRs:

- LTTRs could potentially add to the transparency of market price expectations by providing publicly accessible pricing information on the LTTR product.
- LTTRs could, at least in theory, help to reduce order processing costs, inventory holding costs and adverse selection costs by improving liquidity indirectly by e.g. acting as a bridge-to-liquidity, or directly by e.g. increasing speculative activity and therefore stimulating liquidity in complementary products.
- LTTRs could reduce barriers to entry into other markets, as well as support cross-border competition in the electricity retail sector.

The key costs and distributional impacts that are mentioned are the following:

- Administrative costs related to the implementation and operation of systems to issue and settle LTTRs.
- Potential firmness costs where the settlement of LTTRs is not strictly tied to the congestion income.
- A difference between LTTR revenues and payments may have distributional impacts for market participants.

The report concludes that LTTRs have the potential to improve hedging opportunities and increase the liquidity of futures in associated markets, however without mitigating measures, they could also impact cable revenues and therefore consumer tariffs.

Thema Consulting Group (2021): Investigation of Bilateral Hedging and Hedging Strategies. Commissioned by Ei, DUR and NVE-RME.

The purpose of the study is threefold; (1) to describe the approaches to power price hedging used by a broad range of market participants in the Swedish, Danish and Norwegian markets, the selection of instruments used and any changes to the approaches used over the past eight years; (2) to describe the scope, prevalence, and efficiency of bilateral power price hedging in the Swedish, Danish and Norwegian markets; and (3) to summarize the market participants' views of the sufficiency of current hedging opportunities, as well as how these opportunities might be improved. The report includes an online questionnaire analysis combined with in-depth interviews, including 61 respondents in total, representing different Nordic stakeholders.

A majority of the respondents viewed the hedging opportunities as insufficient. EPAD liquidity was thought to be undermined due to the small number of actors present in each BZ, the asymmetry between generation and consumption volumes and the presence of market power. Some respondents, however, considered hedging opportunities to be sufficient, e.g. large generator or trader organisations with trading desks and relatively sophisticated hedging operations, large consumers that have found success using PPAs, and small retailers that have been satisfied with the hedging solutions provided by brokers or hedging services providers.

Less than 5% of the respondents hedged exclusively via the exchange. The remainder conducted at least some hedging activity bilaterally and a significant share (42%) hedged exclusively using bilateral arrangements or Power Purchasing Agreements (PPAs).

Motivations for bilateral trading varied somewhat among participants. Smaller actors meant that the administrative costs associated with direct exchange participation may be prohibitive and therefore bilateral trade, for example supported by a broker or a hedging services provider, is a preferable approach to hedge exposures. For those wishing to hedge long-term, a lack of market depth in longer-dated exchange contracts encourages the use of PPAs. Larger consumers with fairly stable consumption may also be attracted to PPAs because they imply lower administrative costs over their lifetime, while also dealing with area price risk and the regulatory risk of BZ redefinition. Large scale generators are more likely to combine exchange-based and bilateral trade and to explicitly contrast the option of trade via the exchange with OTC trades or the use of PPAs. Where the perceived depth or liquidity of the exchange is lacking, they may opt to hedge bilaterally.

Thema Consulting Group (2021): Analysis of Electricity Forward Market Hedging Opportunities in Finnish, Estonian, Latvian and Lithuanian Bidding Zones´ Borders. Commissioned by the Finnish Energy Authority.

The report examines possible measures for increased sufficiency of hedging opportunities in the Finnish, Estonian, Latvian and Lithuanian BZs, as well as the bordering BZs in Sweden (SE1, SE3, SE4) and Norway (NO4). This work follows the calculation of the measures specified in the NordREG Methodology, including open interest, the trading horizon, traded volumes, bid-ask spreads, churn rates, ex-post risk premia, correlation coefficients, and the Amihud illiquidity ratio.

The report notes decreasing liquidity in the system price contract since 2019, while liquidity in the EPAD markets have increased slightly from 2020, in line with what has been seen in other studies. The EPAD contracts for Stockholm and Helsinki are far more liquid than for example Luleå, Malmö and Trondheim. The open interest in the EPAD contract for Tallin and Riga is less than 1% of the corresponding figure for Helsinki or Stockholm. The system price contracts show relatively tight bid-ask spreads for the longer contracts (year, month and quarter), at around 0.5 EUR/MWh, but higher spreads for the near-term contracts, on the order of 1–2 EUR/MWh.

The bid-ask-spreads are analysed as a proxy for the transaction cost, as it represents the direct transaction costs for a market participant. The report concludes that high bid-ask spreads may both cause and be due to low liquidity. High transaction costs discourage active trading and therefore harm liquidity. While illiquidity increases the inventory management costs that traders must bear and results in them requiring a larger bid-ask spread to be encouraged to trade.

No clear trend in the development of bid-ask spreads for system price products can be concluded. The system price contracts show tight bid/ask spreads for the longer contracts (year, month, quarter), but higher spreads for the near-term contracts, indicating a relative illiquid near-term market. The report also finds that the bid-ask spreads for many of the studied EPADs, including Helsinki, Malmö and Sundsvall, increased early 2020, and are relatively high. Further the report concludes that there is a high degree of correlation between the spot prices in Finland and the Baltic states, indicating that the more liquid Helsinki EPAD may be used as a hedging proxy for market participants in the Baltic countries.

Thema Consulting Group (2021): Power Price Risk Hedging Opportunities in the Norwegian market. Commissioned by Statnett.

This report discusses whether power price risk hedging opportunities for Norwegian market participants need to be strengthened and examines options to improve risk hedging opportunities in the Nordic power market.

Theory suggests that a lack of liquidity and transparency in hedging markets imposes a variety of economic costs. Recent surveys and interviews with market participants suggest that there is widespread concern about a lack of liquidity for the financial derivatives used for power price hedging, especially EPADs. These derivatives are not the only means to hedge power price risk. However, the liquidity of the financial power market has been in decline since the 2008 financial crisis and, recently, open interest in system price contracts appears to have fallen.

Possible causes for low liquidity are addressed, including changes to collateral requirements and local asymmetry in the supply and demand of EPADs. The advantages and disadvantages of several possible interventions to support liquidity are also considered. These include, among others, BZ redesign, the creation of regional EPADs, TSO requirements to supply either transmission rights or EPADs, and enhanced market making. The effectiveness of these options depends on the underlying cause of low liquidity and the choice of option should ideally reflect an explicit diagnosis of the relevant cause or causes.

Spodniak, P., Collan, M. (2018): Forward risk premia in long-term transmission rights: The case of electricity price area differentials (EPAD) in the Nordic electricity market. Utilities Policy 50 (2018) 194-206.

Hedging behaviour in derivatives markets are explained by forward risk premia that is determined by market participants' expectations and risk preferences. It is defined as the systematic difference between trading prices of electricity as reflected in forward contracts and the spot prices observed on the date of delivery and can be seen as a mark-up charged either by suppliers or consumers for bearing the demand and price risk for the underlying commodity. The authors explore the forward risk premia dynamics on electricity derivative contracts, namely EPADs, by investigating the significance, direction and magnitude of forward risk premia in individual bidding areas and contract maturities during the period 2001-2013.

The paper finds that the difference between the current forward price and the expected future spot price is negative, hence there being negative risk premia, which could imply systematic hedging pressure effects. The relative (buyer vs seller) risk aversion regarding cross-border prices differences will be affected by congestion-based transmission risk in an export or import oriented area. Generators may be more risk-averse in an export-oriented area with area prices very close to, or below the system price. This may lead to negative risk premia, due to greater hedging pressure of the buyers over sellers. With the increasing risk of area price hikes, retailers and large electricity users may become more risk-averse and their risk aversion may change. In this case, sellers could exert greater hedging pressure over buyers in commanding positive risk premia in EPAD contracts.

The empirical findings from analyses where risk premia are regressed on their respective remaining time to delivery only partially support the hypothesis of a negative relationship between forward risk premia and time-to-maturity. The authors emphasize that this finding presents the need for further research on forward risk premia by expanding the considered factors beyond market power and market price of risk to consider supply risks. With increasing share of intermittent generation, the security and reliability of supply will be increasingly relevant in the derivatives markets.

Spodniak, P., Collan, M., Makkonen M. (2017): On long-term transmission rights in the Nordic electricity markets. Energies 2017, 10, 295; doi:10.3390/en10030295.

This paper evaluates two contract types for hedging the risks connected to long-term transmission rights; the financial transmission right (FTR) and the electricity price area differentials (EPAD), including the possibility to replicate the FTR contracts with a combination of EPAD contracts, so called EPAD Combos. The paper provides a review of the underlying characteristics of each contract type.

The authors point out that notwithstanding the observed differences between the construct of the three LTR vehicles, what remains is that the obligation type (future) FTR contract and EPAD Combo are theoretically equivalent in terms of the protection they offer. This theoretical equivalence is however a simplification of reality since it omits firmness, counterparty, and revenue adequacy risks, among others. Also, the reliance on exchange-quoted EPAD closing prices represents a risk because previous research has shown that the Nordic EPAD markets may not be efficient in terms of contract pricing.

Based on data from ten Nordic interconnector and twenty bidding areas, the study investigates the price accuracy of the replicated FTR contracts by quantifying ex-post forward risk premia. The results show a negative risk premium on average, especially in the case of the monthly and the quarterly contracts. Reverse flow, hence unnatural pricing, was identified for two interconnectors.

The results imply that theoretically it may be possible to continue with the EPAD-based system by using EPAD Combos in the Nordic countries, even if FTR contracts would prevail elsewhere in the EU. The authors note that in practice, however, the pricing of bi-directional EPAD contracts is more complex and may not always be efficient.

Swedish Energy Markets Inspectorate (2016): Area price hedging and the Nordic market model. Ei R2016:11.

The report describes the advantages and disadvantages of the various price hedging instruments in relation to the Nordic market model and the impact the instruments have on overall competition and consumer benefit. In addition to describing the instruments in the Nordic market context, the report summarizes relevant findings from interviews with market participants.

The report states that the Nordic market participants did not express any need for additional price hedging products and found that the instruments available were sufficient to meet the needs of securing both the underlying price risk and the specific area price risk associated with the respective BZ. The report points out that EPADs and LTTRs are not necessarily mutually exclusive but were they substitutes, and introduction of LTTRs would mean splitting of liquidity between instruments and therefore risk weakening the current market structure. Even if adding instruments could provide more options in risk management, they could also add to complexity and potentially result in smaller actors choosing to withdraw from the market deteriorating competition in the long-term. However, if more sellers and buyers could move across BZ boundaries, competition could also increase and lead to reduced spreads. Consequently, prices for end-users could marginally be reduced. This customer benefit is however likely to be limited. Also, trade in transmission rights could risk undermining the system price as a reference price on the market.

The report concludes that the overall benefits associated with the TSO auctioning transmission rights are too small to motivate such obligation considering the risks. Most interviewed market participants were also of the opinion that maintaining and developing the current market set up is the preferred option. This was also the conclusion that the Energy Markets Inspectorate arrived to.

Thema Consulting Group and Hagman Energy (2015): Measures to support the functioning of the financial electricity market. Commissioned by NordREG.

The study notes that while system price contracts have been liquid in the Nordics, the same has not been true for all EPAD contracts. The study therefore compares six different measures to support the functioning of the financial electricity market, would such involvement become necessary.

The authors point out that low liquidity is not a problem if there is sufficiently high correlation between the system price and the area price, or if market participants are hedged via bilateral contracts. The report therefore emphasizes the need for the NRA to assess whether lacking or low liquidity indeed implies a market failure in form of lacking hedging opportunities before intervening in the market. If this is not the case, a market intervention can imply an efficiency loss. Market participants feedback has been that they do not wish to replace basic hedging in the system price with basic hedging in area prices.

The models for TSO involvement in the EPAD market that have been compared in the report are the following:

1. TSO supporting the market making function by financing a sufficiently tight bid-ask spread and minimum volume.
2. TSO takes on itself the market maker function by guaranteeing minimum spreads. This is similar to alternative 1 but more costly and has been eliminated from further analysis.
3. TSO auctions a volume of EPAD contracts. It sells contracts if the cause is missing supply and buys contracts if the cause is missing demand.
4. TSO auctions a volume of EPAD combos. It sells in one BZ and buys the corresponding volume in another BZ.
5. TSO auctions FTR options related to the interconnection between two BZs according to the expected net transmission capacity between the BZs. FTR option entitles the holder to the congestion rent in one direction for each hour when it is positive. Thus, the price for an FTR option will reflect the expected sum for all hours with positive price differentials.
6. TSO auctions FTR obligations that oblige the owner to also pay the price differential for all hours when it is negative. Hence, the settlement of an FTR obligation equals, and will reflect, the average price differential for the period.

The report has evaluated the market impacts with respect to four key criteria; liquidity and hedging, impact on existing markets, impact on strategic behaviour and costs for market participants. The report finds that liquidity and hedging opportunities are likely to be improved by models that support the EPAD market by means of increased liquidity. Existing financial markets are particularly liquid in the Nordic market and as EPAD contracts are combined with hedging in the system price, TSO involvement in support the EPAD market will not split liquidity between products, nor reduce trading in system price contracts. Auctioning of FTR contracts would mean that a new product is introduced that would risk reducing in liquidity in existing EPAD contracts as well as system price contracts. The report also finds there are not indications of the alternative measures impacting strategic behaviour among market participants. Cost would be lower for the EPAD auctioning than for FTR auctioning, due to the different platforms and clearing requirements.

The report also investigated impacts on TSO costs and risk exposure related to administrative costs, price risks, volume/firmness risks as well as risk premiums.

The report concludes that FTR auctions (alternatives 5 and 6) are inferior to measures that support EPAD trading in the Nordic market due to the linkage to trading of system price contracts that supporting market making and auctioning of EPADs will strengthen, in contrary to FTRs. The authors therefore prefer the measures that support EPAD trading to introduction of FTRs. The preferred option between supporting market maker function or EPAD auctioning depends on the situation in the BZ. In a BZ with a skewed balance between demand and supply, support to a market maker function may be insufficient. Auctioning of individual EPAD contracts directly increase the traded volume. However, this may expose the TSO to risks for contract losses. Auctioning of EPAD Combos has the advantage that the magnitude of possible contract losses is smaller for the TSO since an EPAD Combo combines a buy in one area with a sell in another area.

Economic Consulting Associates (2015): European Electricity Forward Markets and Hedging Products – State of Play and Elements for Monitoring. ACER, Multiple Framework Contract ACER/OP/DIR/08/2013/LOT 2/RFS 05.

The report aims to provide insights regarding the functioning of forward markets, the availability of hedging products in the EU and to investigate potential indicators for monitoring the impact of the FCA NC's implementation of transfer capacity forward markets. The first task is a survey of different forward markets and hedging products. It is followed by a definition of an approach to evaluation of efficiency in forward markets. It highlights the main reasons for forward markets to exist to be (1) hedging opportunities that allow market participants to offset their exposure to price volatility, and (2) price discovery, that provides an indication of where prices are moving. Forward markets can also alleviate market dominance and facilitate contestability.

The report lists features that characterize a well-functioning forward market; effective hedging opportunities and sufficient liquidity, facilitation of price discovery, allowing market access at a reasonable cost, supporting contestability in the wholesale and retail electricity markets and effective competition. The report also evaluates some metrics and monitoring methods to assess the efficiency of forward electricity markets. Based on the evaluation it recommends the following to be monitored in forward electricity markets to ensure their functioning and capture deviations there of; turnover, churn rates, bid-ask spreads, reporting of trades, minimum number of companies needed to reach 50% market share and the Herfindahl-Hirschman Index (HHI).

The report also finds that there is a lack of coverage in previous literature concerning market monitoring methodologies for the efficiency of forward capacity allocation and provides an approach to determining market efficiency in EPADs. The methodology seeks to determine if EPADs provide a correctly priced hedge against cross zonal price differences in the Nordic market.

The report notes that market surveillance units in the Nordics have been successful in monitoring the efficiency of the market and conduct of market participants, providing confidence in the pricing mechanisms, the transparency of price relevant information and the integrity of the market.

EC Group (2015): Hedging possibilities and the Forward Capacity Allocation Network Code. Do transmission rights have merit in the Nordic electricity market? NVE Rapport nr 135-2015.

The study investigates consequences that introduction of LTTRs could have on the Nordic market. One of the arguments for such intervention is that missing markets for cross zonal hedging products hamper competition in the wholesale market, and tradable LTTRs could provide a solution for this problem. The authors find that there are in fact more direct and efficient measures to mitigate abuse of dominant positions and no improved competition cannot be expected by contract opportunities only. Also, any market intervention, including the requirement of a TSOs to offer LTTRs, should be designed to correct a market failure and be based on a cost-benefit analysis. Introduction of LTTRs would likely entail significant costs. It is also noted that there could be many reasons for missing markets, e.g. insufficient demand for the products, or lower willingness to pay for hedging than the costs involved, that is other than market failure as such.

The report also notes that Nordic TSOs are regulated to act independent of short-term profit or loss from congestion rent and therefore also sale of LTTRs. This means that requiring TSOs to sell LTTRs is not likely to change their practices when it comes to setting cross-border transmission capacities. Auctioning LTTRs would require market participants to perform hedging activities on two platforms with two types of contracts that are not fully compatible. Overall, LTTRs are not very compatible with a system price that is without geographical reference. Therefore, the report concludes that introducing LTTRs could risk significant loss of liquidity and lead to increased hedging costs in the Nordics. What the report suggests instead is to create better hedging opportunities by supporting current markets, e.g. by letting the TSO support a market maker service in order to increase liquidity.

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