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ISBN nr. 978-82-8368-090-4

Power Price Risk Hedging Opportunities in the Norwegian Market

Commissioned by Statnett

June 2021

THEMA Report 2021-06

About the project

About the report

Project number:	STN-20-02	Report name:	Power Price Risk Hedging Opportunities in the Norwegian Market
Project name:	Assessment of Risk Hedging Opportunities in the Norwegian Electricity Market	Report number:	2021-06
Client:	Statnett	ISBN-number:	978-82-8368-090-4
Project leader:	Julian Hentschel	Availability:	Confidential
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Brief summary

This report summarises information on 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 discussed, 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, bidding zone redesign, the creation of regional EPADs, TSO requirements to supply either transmission rights or EPADs, and enhanced market-making. We note that 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.

About THEMA Consulting Group

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CONTENT

1 INTRODUCTION

This report compiles a range of information relevant to a consideration of options to improve risk hedging opportunities in the Nordic power market, with a particular focus on Norway. The report is organised into two parts.

Part A considers whether there is a need to strengthen the risk hedging opportunities available to Norwegian market participants.

- Chapter 2 outlines the economic importance of opportunities to hedge power price risk in general. It notes that a lack of liquid hedging markets adds directly to hedging costs and, potentially, to a variety of other economic costs. Implicitly, it argues for the importance of liquid markets for the hedging of price risk.
- Chapter 3 summarises the formal metrics identified by NordREG for the assessment of the Nordic forward market. Although these metrics do not identify a threshold or target level of market liquidity, they do suggest that there has been a marked decline in the use of system price contracts for hedging, as well as an increase in the use of EPADs, over the past 1–2 years.
- Chapter 4 looks at the long-term decline in Nordic financial market liquidity since 2008 and notes the range of potential causes to which this decline is sometimes attributed. It concludes that several factors may well be involved.
- Chapter 5 considers market participants' stated views on the sufficiency of hedging opportunities and notes that many market participants claim that opportunities to hedge area price risk are insufficient.

Part B considers potential options to improve liquidity in the Nordic financial electricity market.

- Chapter 6 seeks to provide a comprehensive overview of potential interventions and to summarise their pros and cons.
- Chapter 7 comments on the appropriateness of these options and suggests that any intervention should ideally be selected to target the expected cause of low liquidity.

The report also contains an appendix that contains further detail on the NordREG metrics.

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A. IS THERE A NEED TO STRENGTHEN THE RISK HEDGING OPPORTUNITIES OF NORWEGIAN MARKET PARTICIPANTS?

2 THE ECONOMIC IMPORTANCE OF OPPORTUNITIES TO HEDGE POWER PRICE RISK

A lack of liquidity and transparency in hedging markets may result in a variety of economic costs. Illiquidity adds directly to the economic costs of hedging activity, as more time and additional resources are used to find counterparties, agree on terms and manage positions. In turn, this can weaken competitive pressure and limit investment in sectors exposed to the power price. A lack of pricing for hedging products also prevents the dissemination of valuable information about future prices, resulting in worse decision making. Ultimately these effects tend to reduce economic welfare and growth.

In this section we briefly set out:

- The economic rationale for hedging, and
- The economic benefits of access to liquid, transparent products for the hedging of power price risk.

2.1 The economic rationale for hedging

Hedging is ultimately about risk management. Our desire to manage risk stems both from the fact that extreme outcomes can add directly to economic costs—for example, the cost of having to liquidate a bankrupt firm—and the fact that individuals are often themselves risk-averse—preferring a predictable outcome to a lottery of famine or feast. By managing risks effectively, we can therefore avoid the economic costs of extremes and give risk-averse individuals the certainty they desire.

Hedging products allow risks to be transferred between participants. They potentially enable these risks to be offset, as is possible when parties have opposing exposures to a price, or at least shared among a broad base, hopefully avoiding extreme outcomes for any individual. Hedging strategies also take several forms including co-ownership, the use of bilateral contracts and the trading of financial derivatives.

Uncertainty as to the future power price means that market participants that are exposed to the future power price are exposed to some risk. This is true whether you are an electricity retailer agreeing to supply a fixed-price contract or an investor committing capital to a generation project. In both cases, these participants' desire to manage the risks that they face may encourage them to hedge this power price risk.

2.2 The economic benefits of access to liquid, transparent hedging products

Hedging activity results in some direct economic costs. Trading systems need to be established and operated and this involves the use of capital—for example, IT infrastructure—and labour—as individuals spend time hedging risk on behalf of their organisations. Liquid and transparent hedging products can help to keep these costs to a minimum while also supporting several economic benefits.

When hedging products are illiquid, this tends to increase the direct costs associated with hedging activity. The holders of illiquid products run the risk that they will not be able to alter their positions quickly, or only be able to do so at a high cost. As such, this risk is factored into the price at which they are willing to transact and illiquid products, therefore, have large bid-ask spreads that must be paid to trade. Market participants without access to liquid hedging products may also consider a wider variety of approaches to hedging, such as bilateral contracting, and therefore need to invest time and effort into seeking out counterparties and negotiating non-standardised terms. All of this adds directly to the economic costs of hedging.

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These higher hedging costs are not only an economic cost in their own right but can also harm economic welfare by:

- Limiting investment in higher-risk, higher-return projects, and
- Weakening competitive pressure in sectors exposed to power price risk.

Let us consider the likely impact on investment first. Investment generally entails some risk and an inability to cost-effectively manage these risks may prevent higher-risk, higher-return investments from occurring. Consider the developer of a wind power project with a lifetime of 15–20 years looking for capital to fund the project. Let us assume that the project is highly profitable according to current costs and power price expectations but that the future power price is uncertain and may be much lower than expected. Both the developer and prospective investors will consider potential risks before they decide to invest. The greater the downside risk, the greater costs of capital required to attract investment. If the risk is high enough, the project will not be commercially viable.

Ideally, hedging will enable the project developer to manage these risks and facilitate investments in projects that, as a group, have higher economic returns.[1] For example, assuming a suitable market were available, the developer might sell the expected generation from the project now using a futures contract. In doing so, an uncertain future price could be replaced by a known price, reducing uncertainty over the project's future revenues and helping to ensure that the project is realised.

On the impact of hedging on competition, it is important to realise that a lack of liquid hedging opportunities may help to protect firms from effective competition. Competition is supported, in part, by the threat of new entry into the relevant market. Incumbent firms know that if they seek to exploit their customers, new firms may enter the market and replace them. The higher the costs faced by a new firm seeking to enter a market, the weaker the threat facing incumbent firms. In some markets, high-cost hedging can add directly to the costs of entry into a market and thereby potentially weaken competition.

Most obviously, if the lack of hedging opportunities provides strong incentives for firms to integrate generation and power-use or supply into a single company to help manage power price risk, so-called vertical integration, this can be a barrier to entry. It implies the need to form an integrated business to enter the market. A standard example of this would be the integration of a local generation and supply company, where the supply company offers fixed-price contracts and manages the resultant risk internally using its generation portfolio. If we consider the retail market for fixed-price supply contracts, the lack of low-cost hedging opportunities means that a new entrant cannot manage the power price risk associated with selling fixed-price contracts. To do so, the prospective entrant would have to enter not just as a supply company, but as a vertically integrated generation and retail business. This adds significantly to the implied costs of new entry into the retail market and potentially dampens competition in that market.

Finally, and in addition to the benefits linked to lower-cost hedging noted above, transparency in the pricing of hedging products can support economic efficiency more broadly by allowing the valuable information contained in prices to inform decision-making elsewhere in the economy. The price for hedging products contains information on market participants' future price expectations. Economic actors taking decisions that depend on future price expectations can use this information to improve the decisions that they make. So, whether an actor is trying to decide when to retire a generation plant or how to price an energy-intensive manufacturing job with a future delivery date, these decisions can benefit from the input of all the actors operating in the hedging market. Indeed, even regulatory decisions on the competitiveness of the retail energy market can benefit from transparency over the market's future price expectations.

In summary, liquid and transparent markets for hedging power price risk have several economic benefits. They reduce the direct costs of hedging activity and, in doing so, support both investment efficiency and competition in markets facing significant power price risk. They also enable valuable

[1] Various research papers show the beneficial impact of financial markets on economic growth in developing economies.

information about future price developments to be shared across the economy and thereby contribute to efficiency in general. Ultimately, all of these benefits contribute to higher economic welfare and growth.

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3 NORDREG FORWARD MARKET METRICS

The Nordic energy regulators have defined a series of metrics to support the systematic assessment of the Nordic financial forward market. However, these are of limited use in assessing market participants' overall hedging opportunities since they do not cover bilateral hedging—which is commonplace—or establish a threshold against which to test sufficiency. The metrics suggest a notable decline in the use of system price contracts for hedging, as well as an increase in the use of EPADs, over the past 1–2 years. They also fail to suggest the presence of statistically significant premia in the price of Norwegian EPADs. Such premia could indicate the presence of a mismatch between supply and demand for an EPAD product.

In considering the sufficiency of current risk hedging opportunities, it is worth noting that the Nordic national energy regulatory have collectively agreed on a set of metrics intended to support the systematic assessment of the functioning of the Nordic electricity forward market.[2] These metrics were recently calculated based on detailed exchange data by THEMA on behalf of RME. The most interesting results are summarised here. The complete set of public results are also attached as an appendix to this report.

It is important to note that the NordREG methodology does not establish a clear test for the determination of the sufficiency of hedging opportunities. Furthermore, the metrics only cover hedging conducted using exchange-traded products and so fail to include a variety of other hedging opportunities, such as the use of over-the-counter trading, hedging service provides and power purchase agreements. A recent THEMA report on behalf of the Swedish, Danish and Norwegian National Regulatory Authorities[3] shows that the vast majority of market participants make use of at least some form of bilateral hedging, which would not be covered by the NordREG metrics. As such, the metrics provide only a partial view of the total set of hedging opportunities available to market participants.

What the metrics can help to reveal are trend changes related to the exchange-based hedging products.

One notable trend is the recent decline in open interest in Nordic system price contracts, as shown in Figure 1 below.

[2] The methodology document describing these metrics is available at:http://www.nordicenergyregulators.org/wp-content/uploads/2020/09/NordREG-Methodology-for-assessment-of-the-Nordic-forward-market-2020.pdf

[3] THEMA, "Investigation of Bilateral Hedging and Hedging Strategies," 2021, https://thema.no/wp-content/uploads/Bilateral-Hedging-and-Hedging-Strategies-Final-Public.pdf.

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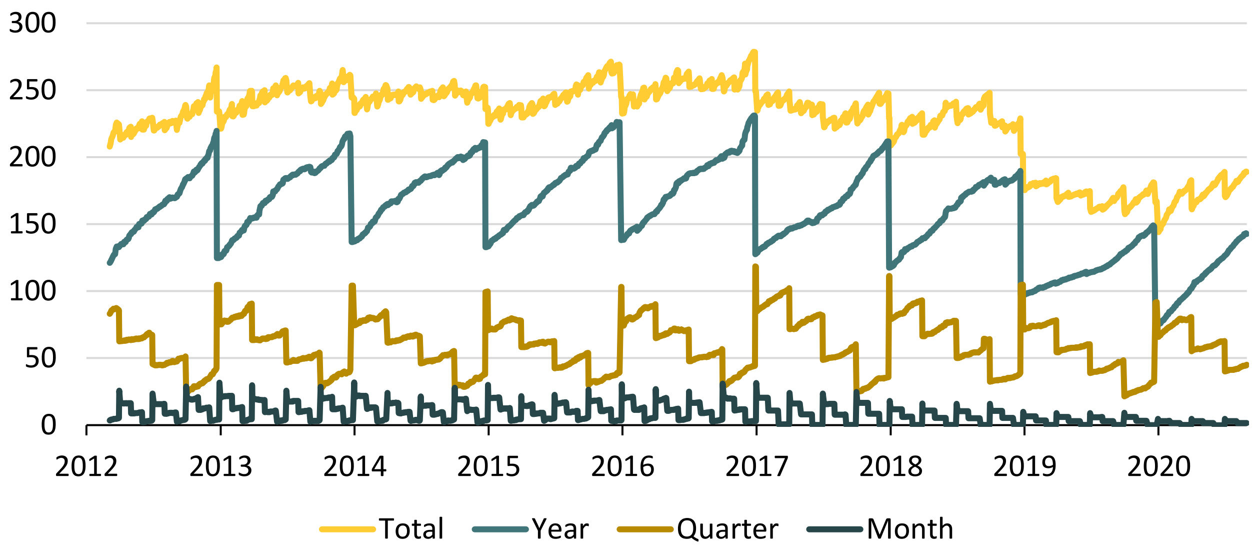
Figure 1: Open interest (TWh), Nordic system price contracts



Source: Nasdaq

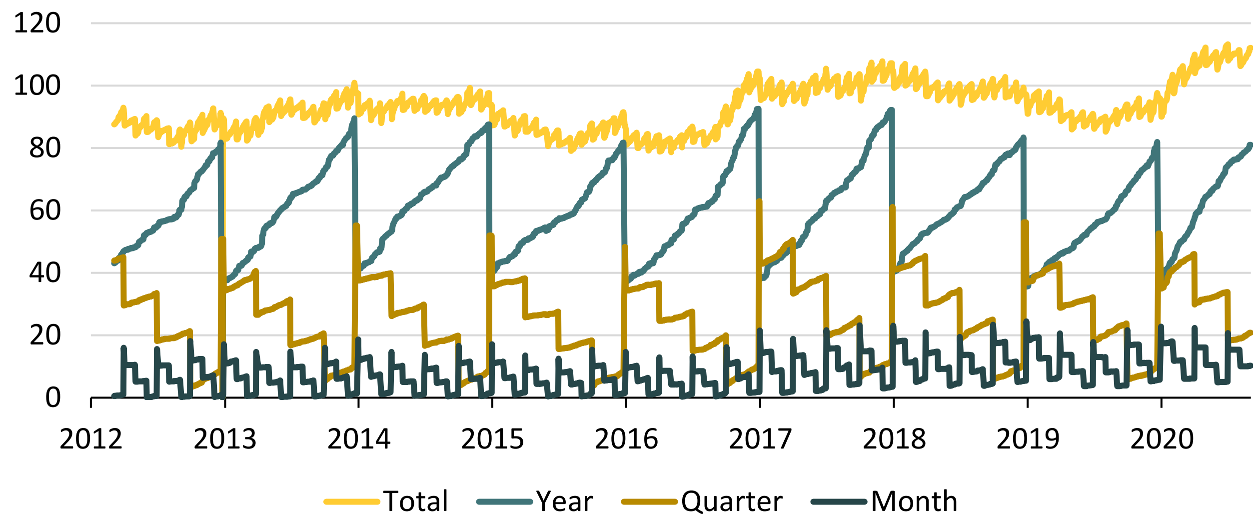
Open interest refers to the total size of open positions with a clearing house at a given point in time. When a market participant wishes to hedge a physical exposure to the power price using financial derivatives, they will create an open position for the relevant contract and keep this position until delivery. When a speculator trades such contracts, he or she will typically open a position by buying or selling the relevant contract and then close this position at a later point by making an offsetting trade. For example, they will try to buy the contract when it is priced low and then sell it at a higher price. As such, information on the size, distribution and dynamics of open interest can be used to infer the volume of physical exposures that are being hedged and the composition of products used to construct these hedges.

For individual contracts, there will typically be a steady increase in open interest from the beginning of the trading period until the last trading day before delivery. This occurs as hedges are built up over time. Just ahead of delivery there is a sudden drop in open interest caused by cascading, the process by which open positions in a specific contract are transformed into open positions in shorter contracts covering the same delivery period. For example, open positions in a yearly contract are transformed into open positions in four quarterly contracts. The resulting drop in open interest in the yearly contract is therefore perfectly offset by the increase in open interest for quarterly contracts. This results in the zig-zagging of total open interest for contracts for specific durations in Figure 1 above.

Figure 1 shows that the bulk of open interest in Nordic system price contracts is established in yearly contracts. It also shows that total open interest was stable from around 2013 to 2018, but there is a notable decline from the start of 2019. This decline suggests that the volume of exposures being hedged may have fallen.

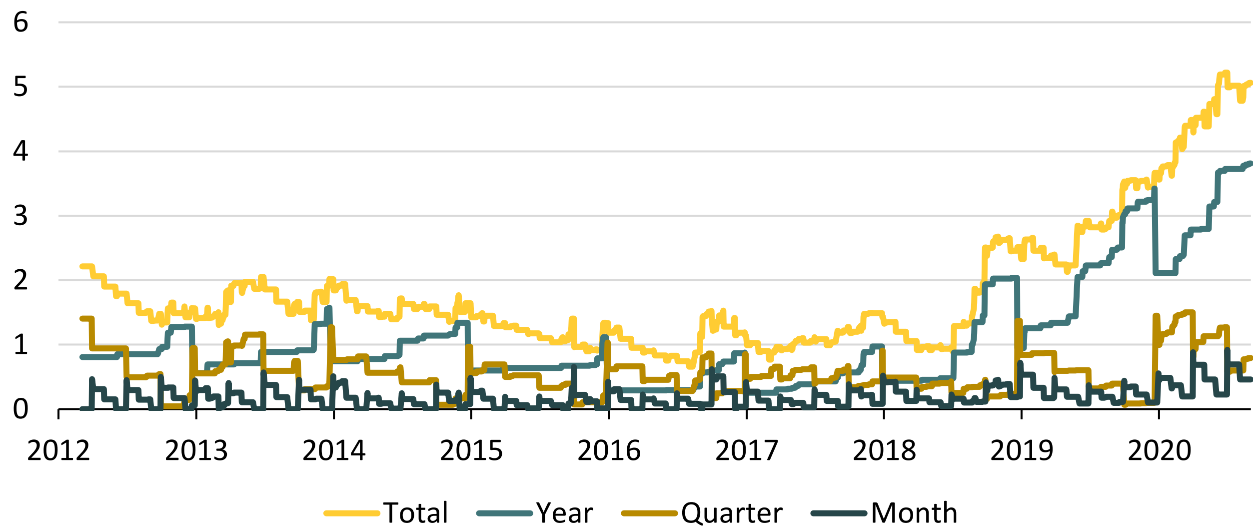
In contrast, open interest in EPAD contracts has experienced a slight increase (see Figure 2) and there is a notable uptick in open interest in the NO1 EPAD recently (see Figure 3), albeit from relatively low absolute levels. The growth in open interest in NO1 EPADs, which suggests that larger exposures are being hedged using these contracts, seems to begin around mid-2018.

Figure 2: Open interest (TWh), EPADs, all bidding zones



Data source: Nasdaq

Figure 3: Open interest (TWh), NO1 (OSL) EPAD



Data source: Nasdaq

It is not clear what is driving these changes in the market. One possible reason, although this is speculation, is that market actors are increasingly seeking to hedge area-price risk. This can be achieved either by holding EPADs in addition to a system price hedge or by hedging bilaterally, for example through the use of a Power Purchasing Agreement. In theory, a move to hedge area-price risk might trigger some actors to forgo system-price hedges, resulting in a decline in system-price-contract open interest, while others choose to add EPADs to their hedges, increasing EPAD open interest.

Certainly, the Nordic system experienced atypically large price dispersion among bidding zones in 2020. This reflected a combination of record-high water reserves in Norway and limited transmission capacity between Norway and Sweden due to transmission outages.

The metrics also include an assessment of ex-post risk premia, which can help to highlight systematic biases in the pricing of power derivatives. The ex-post risk premium for any contract is simply the difference between the contract's price and the underlying reference price during its delivery period. By looking at these premia over time, we can see if there is a systematic difference between the two. The ex-post risk premium can be interpreted as a mark-up or reduction on the underlying reference price that must be borne by traders, suppliers or consumers to hold the derivative. In the case of EPADs, one can think of the ex-post risk premium as an estimate of the mark-up or discount relative to the expected area-price spread. These differences could reflect differences in risk aversion between buyers or sellers or a mismatch in the scale of supply and demand. From the available data and empirical analysis, we cannot distinguish the underlying cause.

A limited analysis of Norwegian EPADs failed to provide evidence of statistically significant premia in the price of these EPADs. Figure 4 below shows the distribution of ex-post risk premia for both monthly Nordic system price and monthly Norwegian EPAD contracts in the form of histograms with observation counts on the y-axis and premia in EUR/MWh on the x-axis.

Figure 4: Ex-post risk premium, Monthly contracts

Data source: Nasdaq

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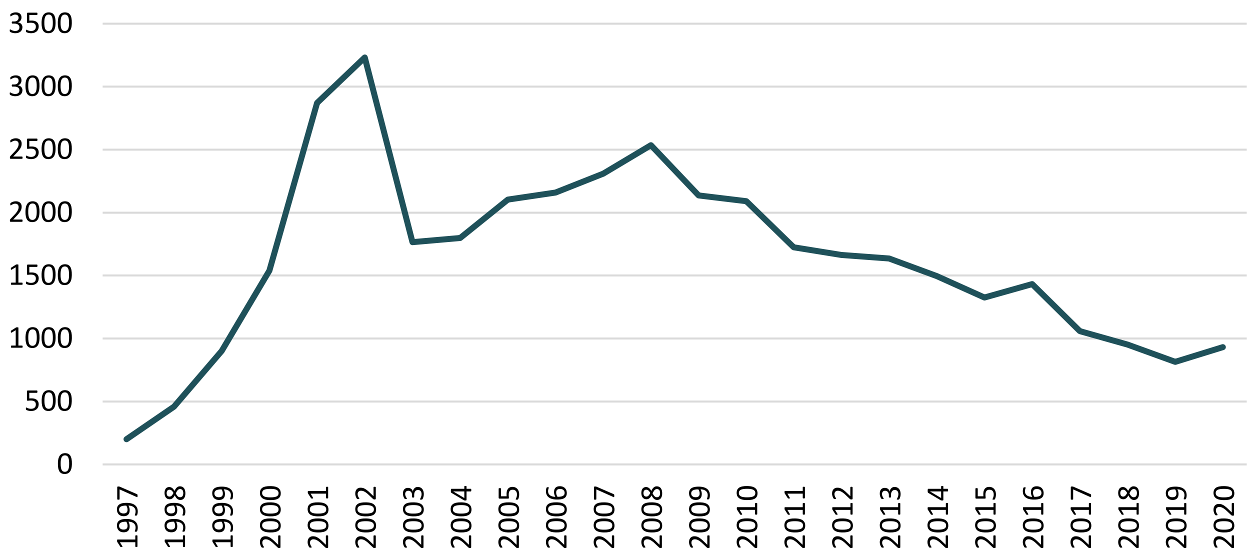
4 REASONS FOR DECLINING LIQUIDITY IN THE NORDIC MARKET

The liquidity of the Nordic financial power market has changed markedly since its inception in 1997. After a dramatic rise in the early years, trading volumes have fallen significantly since 2008. Market stakeholders point to a variety of factors as contributing to declining liquidity. These include greater collateral and regulatory costs, as well as the availability of potentially attractive alternative hedging possibilities. In practice, several factors may be involved.

Figure 5: Nordic Power Derivatives Traded and Cleared on Nasdaq Commodities (TWh), 1997–2020



Source: Nasdaq

Figure 5 shows how total Nordic financial market volumes have evolved from the market's inception in 1997 to the present day. These numbers include both traded and cleared volumes, thereby providing some insight into bilateral trade. They also cover options in addition to futures. As such, they provide a broad overview of the scale and liquidity of the Nordic financial power market as a whole. As can be seen, market volumes, and by extension liquidity, took off early in the market's development. However, in 2003 the collapse of Enron, an active player in the market and significant source of liquidity, brought a sharp reduction in volumes.

Thereafter liquidity increased gradually again until 2008 and the start of the financial crisis. Again, there is a noticeable decline in volumes the next year. In the 12 years that have followed, volumes have trended downwards, with 2019 volumes being the lowest since 1998.

Market stakeholders point to several causes for the trend decline in liquidity. These include:

- Increased collateral costs,
- More burdensome reporting requirements,
- Greater use of spot price retail contracts,
- Reduced downside price risk,
- The risk of bidding zone redefinition, and
- The greater attractiveness and availability of other hedging options.

We discuss each of them briefly below.

Increased collateral costs

The clearing of financial contracts requires that market participants post collateral. Before March 2016, market participants could use bank guarantees as an alternative to posting collateral. However, this practice was effectively banned by European Market Infrastructure Regulation (EMIR).

For non-financial companies, these guarantees were a markedly cheaper means of meeting their collateral obligations than borrowing or holding liquid assets. They were also administratively simpler. Before the change of law, around 60% of Nordic market participants used bank guarantees, with bank guarantees making up more than 70% of Nasdaq CCP commodities' total collateral. By effectively increasing the cost of collateral, EMIR may have encouraged exit from the market and discouraged the holding of large open positions.

THEMA recently conducted 29 interviews with a variety of Norwegian, Swedish and Danish market participants about their approaches to hedging.[4] In discussing participants' motivations for adopting different approaches to hedge power price risk, it was clear that the posting and management of collateral—as required when trading via the exchange—was a significant turn-off for many, especially among smaller participants. This was true of generators, consumers and retailers. Importantly, this covered not just the direct financial costs of the collateral, but also a desire to avoid the administrative costs and cashflow risk associated with managing an open position. These costs were deemed to be particularly large when taking longer-term positions via the exchange. Overall, these factors drove a preference for managing risk bilaterally.

More burdensome reporting requirements

One of the indirect consequences of the financial crisis was the introduction of new regulatory reporting requirements intended to reduce systematic financial risk, for example under EMIR (2012), REMIT (2014) and MFID/MFIR (2017). To the extent that this regulation has increased the administrative cost or regulatory risk associated with trading, it may have encouraged exit from the financial market. This is especially true for smaller non-financial companies, where the compliance costs may be disproportionate. It is important to note that the impact of this regulation may not be limited to the direct administrative costs associated with meeting the requirements, although these may be material where investments in IT infrastructure are required. They also include a need for organisations to understand and apply the regulation, which can be a burden that smaller organisations, in particular, wish to avoid.

In our interviews with Norwegian, Swedish and Danish market participants, exchange trading was perceived to bring with it a range of other administrative requirements, for example, related to reporting under the EMIR and MIFID regulation, which again made avoiding exchange trading preferable in terms of administrative simplicity and ease of ensuring compliance.[5] Again, this disproportionally affected smaller players.

Switch to spot price retail contracts

In both Norway and Sweden, retail market contracts have become increasingly linked to the spot price, arguably removing suppliers' exposure to the power price and their need to hedge. Some market stakeholders have suggested that this has removed liquidity from the forward market.

Figure 6 and Figure 7 below show data on the composition of retail market contracts in Norway and Sweden over time. These figures bear out the transformation away from fixed-price contracts.

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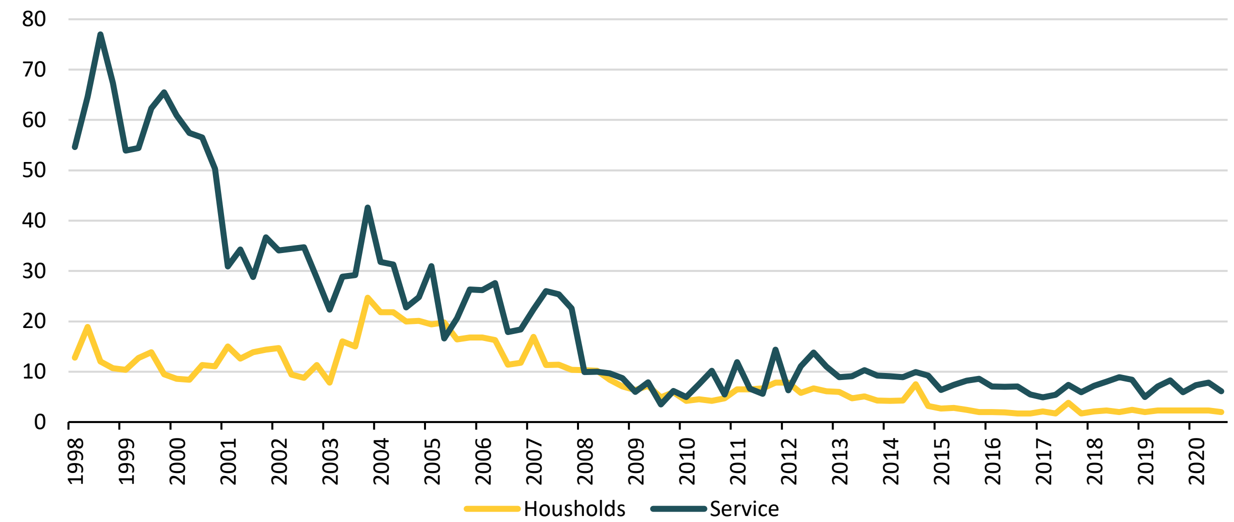
[4] The results of the associated work can be found in THEMA, "Investigation of Bilateral Hedging and Hedging Strategies," 2021, https://thema.no/wp-content/uploads/Bilateral-Hedging-and-Hedging-Strategies-Final-Public.pdf.

[5] MiFID II, for example, standardises regulatory disclosures in relation to financial instruments, which include power futures. Whether a hedging instrument is covered by MiFID II depends on whether the instrument falls within the regulatory definition of a 'financial instrument'. Non-standardised, physically-delivered contracts will, for example, generally fall outside the relevant definition, whereas exchange-standard products traded Over the Counter will generally be covered by the regulation.

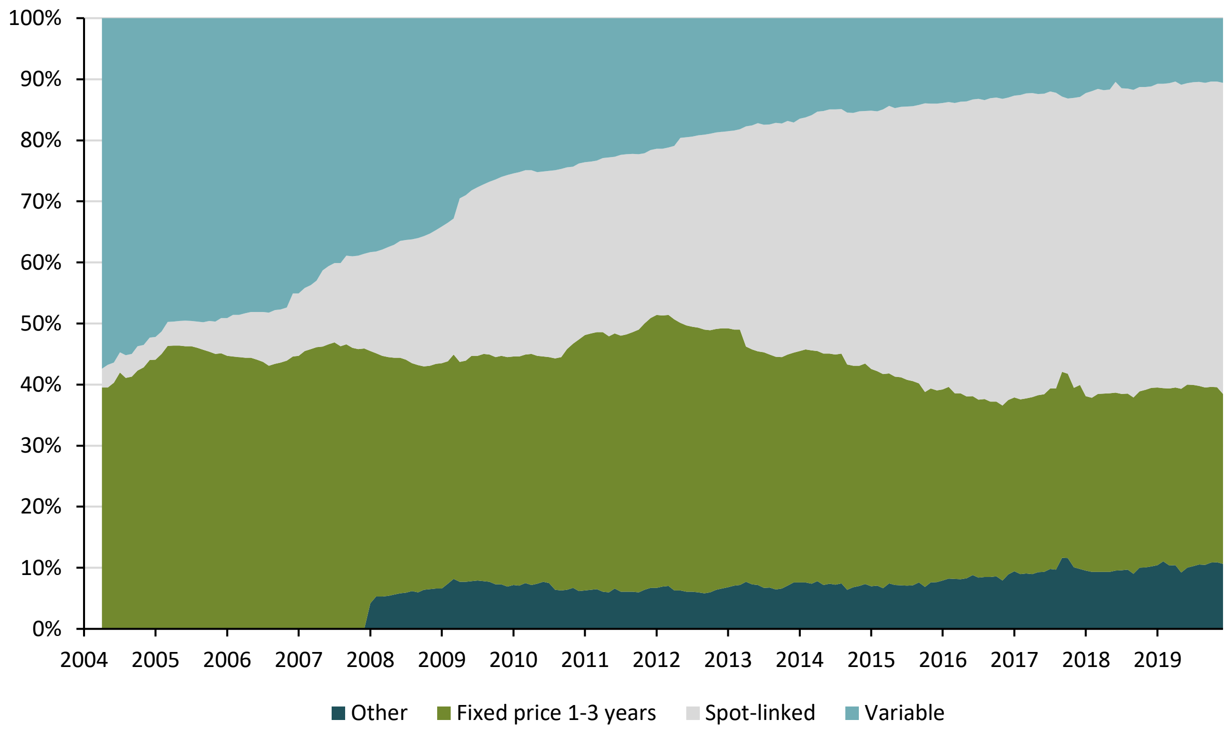
Looking at this data, it is worth noting that, in Norway, the declines in fixed-price contracts appear to predate recent reductions in liquidity. Meanwhile, for Swedish households, the switch to spot-linked contracts has mainly affected previously variable contracts. These variable contracts were presumably not fully hedged. As such, while there has been an undeniable and significant increase in the use of spot-priced contracts, the timing and nature of these changes don't fit neatly with observed changes in market liquidity.

Figure 6: Share of Norwegian End-User Sales on Fixed Price Contracts (%)



Source: SSB

Figure 7: Distribution of Swedish Household Contracts by Contract Type (%)



Notes: 'Other' includes fixed contracts longer than 3 years or agreements with mixed features. Before 2008, these were included within fixed contracts.

Source: Swedish Energy Agency, Energy in Sweden 2017 and 2020

More limited downside risk

One argument sometimes used to explain falling trading volumes after 2010 was a reduction in consumers' perceived price risk due to a trend of declining power prices from 2010–2015. According to this argument, benign fundamental conditions in the power market reduced consumers' hedging appetite and this was reflected in trading volumes.

In our opinion, this argument has limited explanatory power. To start with, falling trading volumes over this period were not matched by declines in open interest, which remained fairly constant. This suggests that the same fundamental volumes of power were being hedged, but that trading activity declined. Similarly, we did not see trading volumes pick up markedly when the threat of rising prices returned.

Also, from a purely theoretical perspective, while a trend decline in prices may put consumers at ease, it should worry generators and encourage them to hedge. Unless there is something fundamentally different about either the way consumers and generators hedge or else their risk preferences, then it is not clear why the price level or trend should significantly impact overall hedging activity.

Risk of bidding zone redefinition

For EPAD contracts specifically, a change to the definition of bidding zones leaves market participants with an EPAD position exposed to regulatory risk. To give a specific example, the Stockholm EPAD is linked to the power price in Stockholm, which is currently a part of the SE3 bidding zone. The Stockholm EPAD can, therefore, be used to hedge area-price risk for actors across SE3, which covers a large swathe of central southern Sweden. However, the current bidding zone review process is considering an alternative bidding zone configuration in which Stockholm is placed in a separate bidding zone. Were this to happen, the reference price of the Stockholm EPAD could potentially be very different to prices elsewhere in what is now SE3. According to this argument, (greater) regulatory uncertainty about bidding zone definitions has discouraged participants from using EPAD contracts to hedge. Instead, market participants may prefer to use alternatives, like PPAs, which allow them to have greater control over the defined delivery point.

Attractiveness of other hedging options

Regardless of what one makes of the regulatory risk argument, it is true that the attractiveness of Nordic power derivatives needs to be seen in the context of the other hedging options available to market participants. PPAs, bilateral risk management services and proxy hedging using other futures—either for power in interconnected markets or for commodities—all represent potential alternatives to hedging using the Nordic financial market.

The construction of proxy hedges using non-Nordic power futures may be particularly relevant for some areas of the Nord Pool system. Prices in DK1, for example, are correlated with comparatively liquid continental European markets and futures in these markets might therefore offer a viable alternative to hedging using the Nordic system price.

PPAs are illiquid but may offer a better alternative if the hedging party wants to cover area-price risk, establish a long-term hedge or provide evidence of the provenance of the power. As a result, PPAs may be a preferable way to hedge for new renewable projects. To the extent that new generation capacity is being hedged via PPAs, a significant share of the projects' generation capacity may bypass the exchange. Exchange trading may still be used to hedge the difference between expected generation and PPA volumes but this will reflect only a fraction of total output.

It is certainly the case that Nordic PPA volumes have increased significantly in recent years (see Figure 8). However, it is hard to say to what extent this growth in total PPA activity simply reflects the increased development of renewable projects or a change in market participants' preferred approach to hedging power price risk.

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Figure 8: New European PPA Capacity Signed each Year

Source: ICIS Power Perspective Outlook for corporate PPAs in the Nordic region

It is also worth noting that some market actors, like small scale retailers, opt to hedge bilaterally through contracts with hedging services providers. These contracts often bundle a range of relevant risk-management services, notably covering power-price and exchange-rate risk. To the extent that hedging-services providers can net the hedging demands of their customers, such hedging activity may effectively split liquidity out of the observable public exchange.

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5 MARKET PARTICIPANTS' STATED VIEWS ON THE SUFFICIENCY OF HEDGING OPPORTUNITIES AND THE CHALLENGES FACED

Although opinion is divided, a significant share of Nordic market participants reports that there are insufficient opportunities to hedge power price risk in the Nordic market. These concerns are not specific to a particular type of market participant or a particular area and primarily reflect widespread concern about a lack of liquidity and depth in the EPAD market. Several factors are seen as contributing to this lack of liquidity, including the small number of players active in individual products and, in some cases, asymmetry in the scale of local generation and consumption.

5.1 Views on the sufficiency of hedging

THEMA recently interviewed a variety of Nordic market participants on the sufficiency of hedging opportunities in the Nordic markets on behalf of the Danish, Swedish and Norwegian energy regulatory authorities. In parallel with these interviews, we interviewed several actors representing market participants in the Norwegian, German, British and Dutch markets to solicit their opinions about the potential impact of transmission rights on the NordLink, NorNed and North Sea Link cables. We conducted six interviews with participants outside the Nordics as part of this work. These included interviews with the branch organisations for electricity utilities in Germany and the Netherlands, the European Federation of Energy Traders and several energy trading companies active in the use of transmission rights. In this section, we summarise the key insights from these interviews.

As part of the work for the Danish, Swedish and Norwegian energy regulatory authorities, market participants were invited to answer an online questionnaire on hedging opportunities in the Nordics and the sufficiency of current hedging arrangements. In total, 59 market participants responded to the online questionnaire, of which 15 were Norwegian stakeholders. Following the survey, a representative subset of the survey respondents was invited to participate in a more in-depth interview. These interviews covered, among other things, options to improve hedging opportunities in the Nordics. The interviews with the Norwegian actors also covered the stakeholders' opinions on the issuance of transmission rights across the three interconnectors. A total of 10 Norwegian stakeholders were interviewed, including one stakeholder that did not answer the online survey.

The survey participants were asked two questions on the sufficiency of hedging opportunities in the Nordics: one covering their own hedging activities and one on the general sufficiency of available hedging arrangements. Figure 1 summarises the stakeholders' responses to these questions. More than half of the questionnaire respondents believed that there were insufficient opportunities to hedge power price risk in the Nordics. Looking only at Norwegian respondents, a similar share thought that they had insufficient opportunities to hedge their power price risk exposure.

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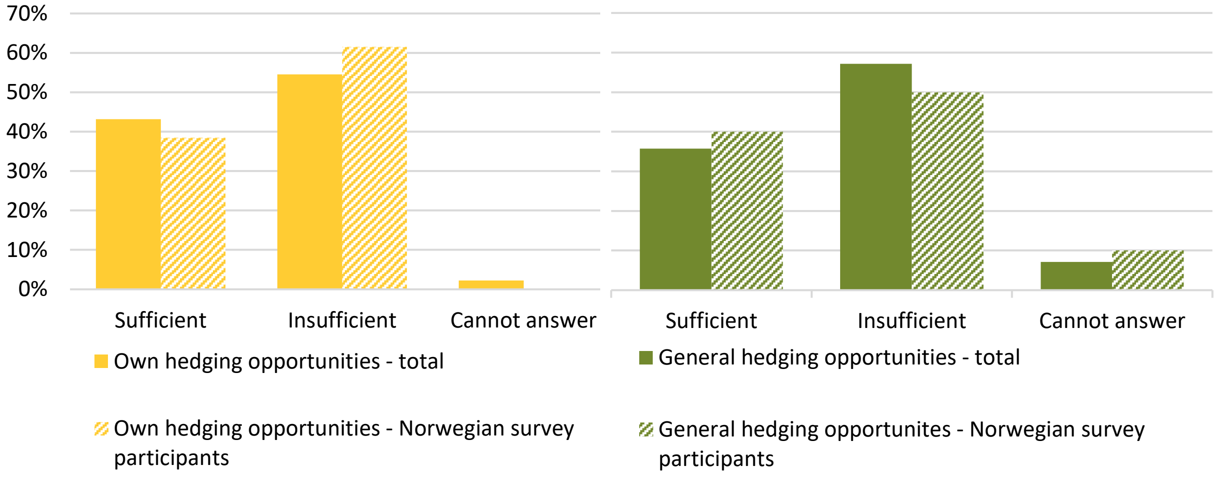
Figure 9: Survey respondents' views on the sufficiency of current hedging opportunities in the Nordics



Source: THEMA questionnaire

This belief that there are insufficient hedging opportunities does not appear to be restricted to a subset of Nordic bidding zones, nor are there obvious differences of opinion among different stakeholder types. It is possible to characterise the sorts of organisations that were likely to consider hedging opportunities to be sufficient. These include (i) large generator or trader organisations with trading desks and relatively sophisticated hedging operations, (ii) large consumers that have found success using PPAs, and (iii) retailers that are happy with the hedging solutions provided by brokers or hedging service providers.

The vast majority of those Norwegian stakeholders that stated that there were insufficient opportunities to hedge power price risk cited a lack of liquidity and depth in the EPAD market as the most serious problems faced. NO2 and NO5 notably do not have an exchange-listed EPAD, but OTC options are available.

5.2 Factors contributing to a lack of liquidity

The stakeholders participating in this study noted several factors as contributing to the lack of liquidity and we divide them below into those that might affect exchange liquidity in general and those that are specific to EPAD liquidity.

Factors affecting liquidity on the exchange:

- Collateral requirements
  In discussing participants' motivations for selecting different approaches to hedge power price risk, it was clear that the posting and management of collateral—associated with trading directly via the exchange—was a significant turn-off for many. This was especially true for smaller participants. It was also true across generators, consumers and retailers. Importantly, this covered not just the direct financial costs of the collateral, but also a desire to avoid the administrative costs and cashflow risk associated with managing an open position. These costs were deemed to be particularly large when taking longer-term positions via the exchange. Overall, these factors drove a preference for managing risk bilaterally.
- Reporting requirements
  Exchange trading was perceived to bring with it a range of other administrative requirements, for example related to reporting under the EMIR and MIFID regulation.

Again, this made avoiding exchange trading preferable in terms of administrative simplicity and ease of ensuring compliance.[6] This also disproportionally affected smaller players.

- Attractiveness of PPAs
Some participants noted that, to the extent that new generation capacity was being hedged via PPAs, the associated capacity would largely bypass the exchange and therefore might limit total volumes. This is not to say that such projects would never be associated with trade on the exchange—exchange trades might be used, for example, to cover the difference between volumes covered by a PPA and actual output. Nevertheless, to the extent that PPAs were an attractive substitute to hedging via the exchange, this might reduce the volumes traded in the exchange and potentially the depth of the exchange market.
- Vertical integration
Some participants also noted the significant presence of vertically integrated players in some areas, covering both generation and supply. The structure of these organisations allows them to hedge internally via their supply arrangements and, again, limits the total volumes that might be alternatively hedged through the use of the exchange.

Factors affecting EPAD liquidity:

- Small number of market actors
Some participants noted that there were typically only a few organisations potentially interested in trading any individual EPAD product, namely the major generators and consumers with direct exposure to the relevant zone. This was a consequence of relatively small bidding areas, the lack of transmission rights between areas and little to no interest from speculative traders. Since the set of potentially interested counterparties is small and their identities are known in advance, the value of a public exchange, relative to bilateral trade, is fairly limited.
- Market power
Related to the above, some participants felt that the presence of market power in the provision of area price hedging encouraged hedging outside the exchange. Specifically, it was felt that large incumbent generators were, in some cases, dominant providers for hedging area-price risk given their large share of local generation and lack of competition from non-physical players. One respondent speculated that such firms might prefer to sell power forward bilaterally, rather than via the exchange, because doing so enabled them to secure the best possible price for the power and the implied hedging service. Another suggested that even where a dominant provider was not actively seeking to exploit its position, it might be reluctant to trade actively on the exchange due to concerns about (i) the exchange's depth and ability to absorb its large volumes and (ii) making overly explicit its own expectations of future prices via the exchange, given its dominance in the market.
- Asymmetry in local supply and demand
Several participants, including generators, consumers and retailers, pointed to a structural imbalance between generation and consumption within a zone as a reason for poor EPAD liquidity. Low EPAD liquidity discourages participation in the market by speculators, given the liquidity risk involved. As such, supply and demand for EPADs in most zones reflects the positions of players with physical exposure to the relevant area price. In some zones, there is a structural imbalance between generators and consumers, such that one side of the market simply cannot find counterparties with which to hedge the local area price. The absence of transmission rights prevents these actors from hedging this risk with

[6] MiFID II, for example, standardises regulatory disclosures in relation to financial instruments, which include power futures. Whether a hedging instrument is covered by MiFID II depends on whether the instrument falls within the regulatory definition of a 'financial instrument'. Non-standardised, physically-delivered contracts will, for example, generally fall outside the relevant definition, whereas exchange-standard products traded Over the Counter will generally be covered by the regulation.

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counterparties in neighbouring zones, which provide the other side of the physical power market. Meanwhile, poor liquidity stops financial players from stepping in to meet the unmet demand for area-price hedging.

- Risk of bidding zone redefinition
  Some participants pointed to the regulatory risk of zone redefinition as a potential reason for avoiding the use of EPADs as means to hedge area-price risk. EPAD contracts are tied to specific locations and so the risk of bidding zone redefinition is limited for participants close to the reference location. For market participants that face a plausible risk of bidding zone redefinition, however, it may be preferable to manage this risk through the use of PPAs tied to their offtake point, thereby effectively transferring this risk to the counterparty.

The stakeholders also raised a wide variety of possible interventions to improve hedging opportunities and these are accounted for in the list of options discussed in section 6.

B. OPTIONS TO IMPROVE LIQUIDITY IN THE NORDIC FINANCIAL ELECTRICITY MARKET

6 OPTIONS TO IMPROVE HEDGING OPPORTUNITIES IN THE NORDICS

In this section, we seek to provide a comprehensive overview of potential interventions to support liquidity in the Nordic financial electricity market. In identifying options, we have looked to:

- earlier papers on this issue,[7]
- the policy options raised by market stakeholders during our discussions with them on market liquidity, and
- similar policy discussions on mechanisms to support electricity market liquidity in Great Britain and the Irish Single Electricity Market.

Some of the options listed below group together several related possibilities.

We cover the following options:

- Bidding zone redesign
- Regional EPADs
- TSO supply of transmission rights
- TSO supply of EPADs
- Enhanced market participation
- Enhanced market-making
- Auctions, and
- Limits to self-supply

6.1 Bidding zone redesign

This option involves restructuring bidding zones and could be used to create bidding zones that are larger and more balanced. Larger bidding zones would tend to increase the number of actors that are interested in trading each zone's financial products, while more balanced bidding zones would help to avoid a situation in which one side of the market cannot find a counterparty. This would help to address some of the potential structural factors identified by stakeholders as contributing to a lack of liquidity in EPADs.

A less dramatic version of this option would involve amending the objectives used as part of the long-term bidding zone review process to place a greater emphasis on the potential hedging liquidity impacts in the hope of encouraging gradual changes to bidding zone definitions over time.

Pros

Redesigning bidding zones would provide considerable scope to directly address potential structural causes of low liquidity in EPADs, notably a lack of interested parties and an imbalance in supply and demand. By altering the scope of area-price products, this option also has the potential to alter competitive dynamics for such products and, potentially, help address any market power issues that might exist.

Cons

Bidding zone redesign also has important implications for the physical power market and larger zones imply a poorer representation of structural network congestion in the market design. This may

[7] Notably THEMA and Hagman Energy, "Measures to Support the Functioning of the Nordic Financial Electricity Market," 2015 and Nordic TSOs Transmission and Wholesale Group, "Examination of Possible Arrangements to Ensure Cross-Zonal Risk Hedging Opportunities," 2018.

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impose additional economic costs, for example in terms of more costly congestion management activity by the system operator and less efficient locational investment signals.

Any change to bidding zone definitions is also likely to impose an implementation cost, as consumers and generators must adjust to the revised bidding zone definitions.

Finally, a change to bidding zone definitions may increase the perceived risk of further changes in future. As noted previously, some market participants believe that the perceived risk of bidding zone redefinition itself contributes to a lack of liquidity in area-price hedging products. The extent to which this is an issue will depend on how lasting any change is expected to be.

Table 1: Pros and cons of bidding zone redesign

Pros	Cons
Could address fundamental structural issues (small number of potential participants, asymmetry)	Greater inefficiency in the physical market (congestion management costs and weaker locational investment signals)
Could address market power concerns	Implementation costs
	Heightened perceived risk of further bidding zone redesign?

6.2 Regional EPADs

One idea raised in discussion with some market participants was the possibility of developing EPAD-like products that covered larger areas.[8] This might enable some of the benefits of bidding zone redefinition but avoid some of the potentially costly implications for the physical market.

In practice, new regional reference prices would need to be developed that acted as good proxies for multiple bidding zones. Financial derivatives could then be created for the spread between these regional reference prices and the system price (similar to EPADs). To avoid splitting liquidity between such regional products and existing EPADs, these regional products would presumably need to replace the existing EPAD products for the regions in which they were implemented.

Regions would presumably be defined to balance a desire to cover more bidding zones, and therefore create products of interest to more participants, with the need to ensure that the reference price is a highly correlated (and therefore attractive) proxy for the underlying zonal area prices. Very large regions risk failing to adequately cover participants area-price hedging needs due to the weak correlation between the regional reference prices and the specific area price to which participants are exposed.

Pros

Similar to bidding zone resign, the creation of regional products could potentially help address structural causes of low liquidity in EPADs, e.g. a lack of interested parties and an imbalance in supply and demand. It could also potentially address market power concerns related to the supply of a specific bidding zone area EPAD. The extent to which this is possible will depend on the existence of constellations of correlated bidding zones that, when taken as a group, are not subject to the same asymmetry or market power problems.

Unlike bidding zone redesign, the creation of regional products avoids the need to change the actual bidding zone definitions and so avoids the associated efficiency and implementation costs. As such,

[8] Participants also raised the possibility of essentially replacing the system price with regional reference prices. This would have the effect of splitting liquidity in system price contracts but reduce any residual area price risk. We have not included this option here as we believe that market participants are likely to be broadly opposed to any move that jeopardised liquidity in system price contracts.

this option would imply relatively low implementation costs, associated with developing the new product set definitions.

Cons

The problem is that regional reference prices would not necessarily equal the bidding zone prices to which market participants are exposed. As such, hedging using such reference products would imply accepting a residual basis risk that is not currently present with the use of EPADs. If regional EPADs replaced existing EPAD products, as may be necessary to avoid splitting liquidity, the implementation of regional EPADs would effectively prevent full area price hedging using financial contracts. The extent to which this is an issue will depend on the extent to which the regional reference is correlated with area prices.

The creation of regional EPADs may also introduce a variant of bidding zone redesign risk as market participants fear changes to the calculation of the reference price. Changing the reference of a financial product would be far simpler to achieve than a bidding zone redesign since the impacts would be limited to the regional EPAD contracts themselves. However, the users of such contracts may be somewhat reassured by the fact that the construction of the reference prices is essentially a decision taken by the market via the exchange, rather than by the regulatory authorities. As such, the product's users can reasonably expect to have greater influence over the nature and timing of any changes.

Table 2: Pros and cons of regional EPADs

Pros	Cons
Could address fundamental structural issues (small number of potential participants, asymmetry)	Introduces basis risk between the reference price and the area price
Could address market power concerns	Possible perceived risk of reference price redefinition
Low implementation costs (relative to bidding zone redesign)	

6.3 TSO supply of transmission rights

Article 30 of the Forward Capacity Allocation Guideline (FCA GL) establishes that, unless the competent National Regulatory Authorities decide otherwise, TSOs “shall issue long-term transmission rights” for the bidding zone borders for which they have responsibility. This effectively establishes a default requirement that TSOs supply such rights. The implied objective of this requirement is ensuring the sufficiency of cross-zonal risk hedging opportunities.

Alternative transmission-right product designs

Transmission rights are currently issued almost exclusively as so-called Financial Transmission Rights (FTRs). These are essentially a financial derivative the pays the right’s holder the day-ahead price spread across the relevant bidding zone border.

An individual transmission right product will cover a specific direction of flows on the border. For example, there will be one product that covers flows from market A to market B and a separate product covering flows in the opposite direction.

An FTR *obligation* will pay out the spread that would be earned from flowing power in the specified direction, regardless of whether the price spread is positive or negative. So, an FTR obligation on flows from market A to market B will pay P_B-P_A. Notionally, we assume that revenues are earned from the transmission right by selling power that is bought in market A into market B. If the price in market A is lower than in market B, this arbitrage is profitable and the

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holder of the FTR obligation gets paid. However, if the price in market A is higher than in market B, the holder makes a loss and is liable to pay.

An FTR *option* effectively operates the same way except that the right holder is not responsible for paying anything when flows in the specified direction would result in a loss. As such, unlike an obligation, an option cannot result in the holder of the right being liable to pay. This means that, whereas the value of an FTR obligation may be negative, i.e. the obligation may have a negative price, an option must always have a non-negative price.

There are two main mechanisms by which the supply of transmission rights can affect the liquidity of futures products in the connected bidding zones.

The first of these occurs when the transmission rights are used to help substitute the use of a futures product referenced against one zone for the use of a futures product referenced against the other zone. For example, assume that I am exposed to the area price in zone A. I could construct a hedge for the price in zone A. Alternatively, I could construct a hedge against the price in zone B and then use an FTR to hedge the difference in prices between zones A and B. The latter may be preferable if it is easier or cheaper to construct a hedge against the price in zone B, for example, due to better liquidity for the associated products. For this reason, transmission rights are sometimes said to provide a ‘bridge to liquidity’. The use of transmission rights in this way may encourage participants that do not currently hedge in zone A to start hedging using zone-B products. However, it may also encourage participants that currently hedge in zone A to start hedging using zone-B products. In the latter case, liquidity is liable to worsen in the low-liquidity market and increase in the high-liquidity market as market activity naturally coalesces in high-liquidity products and zones.

The second liquidity effect is the result of trading activity, rather than hedging. Here, we can imagine that a trader acquires a transmission right with a view to offsetting the resulting exposure, hopefully at a profit, using a variety of other products. In this case, the issuance of transmission rights will support the liquidity of the other products used by the trader to offset the transmission right. For example, a trader might acquire an FTR and then seek to offset the resulting exposure by trading in EPADs. In this case, the induced trading activity in related products helps to boost the liquidity of these products.

Pros

By making it easier for market participants to hedge using products in neighbouring bidding zones, transmission rights might offer a sort of safety valve that could be used to overcome some of the structural causes for low EPAD liquidity noted above. For example, if asymmetry is a serious challenge and a surplus of demand in one zone is met by excess supply in a neighbouring zone, then transmission rights might help support hedging between counterparties across the relevant border. Specifically, one of the parties may, realising they cannot find a counterparty in their home zone, choose to hedge in a neighbouring zone where they can find a counterparty and use a transmission right to hedge the basis risk that results from hedging in the wrong zone.

Similarly, if a zone suffers from issues of local market power, transmission rights might make it easier for participants to hedge in neighbouring zones, weakening the dominant firm’s market power.

The issuance of transmission rights would also bring the Nordic model into line with standard market design in Continental Europe. This would remove the obligation on Nordic regulators to routinely review the justification for Nordic exceptionalism.

Finally, it is worth noting that the choice of transmission right design will also influence the likely benefits. Transmission right obligations are more useful when trying to hedge using products in a neighbouring zone (bridge-to-liquidity) since they ensure that the price spread between the two zones is hedged in all circumstances. In contrast, transmission right options can frustrate the use of transmission rights as a bridge to liquidity precisely because the option only pays the spread if the spread is positive. Put simply, buying an option allows one to hedge if the relevant price spread is positive, since the pay-out will then vary with the spread. However, if the spread is variable but negative, then buying an option does not hedge your exposure, since the option's pay-out is limited at zero in all cases. This wouldn't be an issue if hedgers could originate FTR options, i.e. become net sellers, but, to our knowledge, this is not possible. As a result, options can only be used to form a reliable bridge to liquidity in some instances.

Obligations may also be more valuable for traders, although we have not discussed this with them. This is because, as we discuss in more detail in section 6.4, EPADs' pay-out structure more closely resembles that of an obligation than an option since it pays the relevant price spread irrespective of whether it is positive or negative. This consistency in the pay-out structure may make it easier for traders to conduct trading strategies involving a combination of transmission right obligations and EPADs.

Cons

Requiring TSOs to supply transmission rights for Norway, let alone the Nordics, would significantly complicate the product set and the market design. 22 transmission right products would need to be created just to cover the borders of Norwegian bidding zones with other Norwegian or Nordic bidding zones. If separate products were created for different durations (e.g. annual and monthly contracts), this would add to the total.

This complication of the market design was noted by several of the market participants we spoke to in our work for the Swedish, Danish and Norwegian NRAs as one of the reasons that they were opposed to the introduction of transmission rights in the Nordics. General opposition to the introduction of transmission rights among market participants, while not universal, is widespread and was also noted when NordREG organised a hearing on the FCA GL in 2015. In general, participants would far prefer to use the existing EPAD products than to introduce new ones.

One of the potential practical problems implied by the extension of the product set is that, even though FTR and Nordic futures might need to be traded in tandem, whether as part of a hedging or trading strategy, they are unlikely to be auctioned or traded on the same platform. Transmission rights must be auctioned using the single allocation platform, JAO, whereas EPADs are likely to be primarily traded via Nasdaq. Market participants may therefore have to have access to both.

Some of the other potential cons will depend on the extent to which transmission rights are used directly by hedgers, seeking to use them as a bridge to liquidity, or traders, seeking to trade their position at a profit.

If the former, then the resultant flight from low-liquidity products may result in the liquidity of these products getting worse. If some market participants cannot use transmission rights to access more liquid products in other zones, e.g. small businesses without the capacity to pursue sophisticated cross-zonal hedging strategies, there may be a distributional argument against facilitating such strategies.

If the transmission rights are predominantly used by traders, then it is worth noting that introducing transmission rights only indirectly supports liquidity in the hedging products of interest. To the extent that traders hedge using other products, or are willing to hold some area-price risk exposure, the beneficial impact on EPAD or system-price-contract liquidity may be muted.

Another potential downside of the sale of transmission rights is that the auction revenue received may be systematically lower than the implied congestion revenue paid. If so, and as explained below, this represented an additional cost to network-tariff payers.

In theory, the auction revenue received from the sale of transmission rights may be systematically above or below the expected stream of congestion income generated by the physical transmission assets. A hedger wishing to use a transmission right to hedge in a neighbouring zone may be willing to pay a premium for the transmission right, for example, if it enables him or her to construct a lower cost hedge overall. Conversely, a trader may only be interested in purchasing a transmission right if he or she can get it at a price that represents a profitable trading opportunity, potentially implying a price below the expected value of the revenue stream.

Under the Norwegian revenue regulation of Statnett, variations in congestion income are offset against network tariffs.[9] Assuming that transmission right auction incomes are treated equivalently to congestion income, as seems likely, a change in total revenues from Statnett's congestion assets will therefore affect network tariffs with a short time delay through the regulatory account mechanism used to settle differences between actual and allowed revenues (with interest compensation). All variations in transmission revenues are borne by electricity consumers, as the tariffs for generators are already at the maximum level established in EU Regulation 838/2010.[10]

In previous work conducted by THEMA for Statnett, we examined data on past auction prices for transmission rights from JAO to see whether auction revenues appeared to deviate systematically from market participants' expectations of congestion income. The dataset used covers transmission rights for delivery in the period 2011-2017. Not all products were auctioned or had data for the full period.[11]

Our analysis suggests that lagged congestion incomes are a better predictor of auction prices than actual congestion incomes during the delivery period. In other words, auction prices for a transmission right for 2017 more closely reflect congestion income on the border in 2016, than in 2017. This makes intuitive sense since bidders are likely to place bids based on the most recent available data on price spreads and will not know the outturn congestion income at the time of the auction. We, therefore, use congestion incomes for the year before delivery (lagged congestion incomes) as a proxy for bidders' expectations of congestion incomes in the delivery period.[12]

Figure 10 below charts auction prices against lagged congestion incomes. Each dot reflects a specific auction result. The grey dashed line shows the line of equality – points on this line reflect auction prices that exactly equal lagged congestion income. Any points above this line reflect auction prices that are greater than lagged congestion income. Any points below this line reflect auction prices that are less than lagged congestion income.

[9] The regulatory process for approving use of congestion income follows the procedure set out in Article 19 of EU Regulation 2019/943, but the end result is that congestion income is offset against tariffs. Statnett is therefore not exposed to congestion income risk.

[10] Energy charges and connection charges are not subject to this cap, but these charges are set on the basis of actual costs (marginal cost of losses and customer-specific investment costs respectively) and are not affected by variations in congestion income.

[11] Transmission rights for the following borders and directions were included in the analysis: AT-CH, AT-CZ, AT-HU, AT-IT, BE-FR, BE-NL, CH-AT, CH-DE, CH-IT, CZ-AT, CZ-DE, DE-CH, DE-CZ, DE-DK1, DE-DK2, DE-FR, DE-NL, DK1-DE, DK2-DE, ES-FR, FR-BE, FR-CH, FR-DE, FR-ES, FR-GB, FR-IT, GB-FR, GB-NL, HU-AT, HU-SK, IT-AT, IT-CH, IT-FR, NL-BE, NL-DE, NL-GB, PL-CZ, PL-DE, PL-SK and SK-HU.

[12] We have removed some results for auctions on rights to GB for which prices were likely affected by the British Levy Exemption Certificate scheme.

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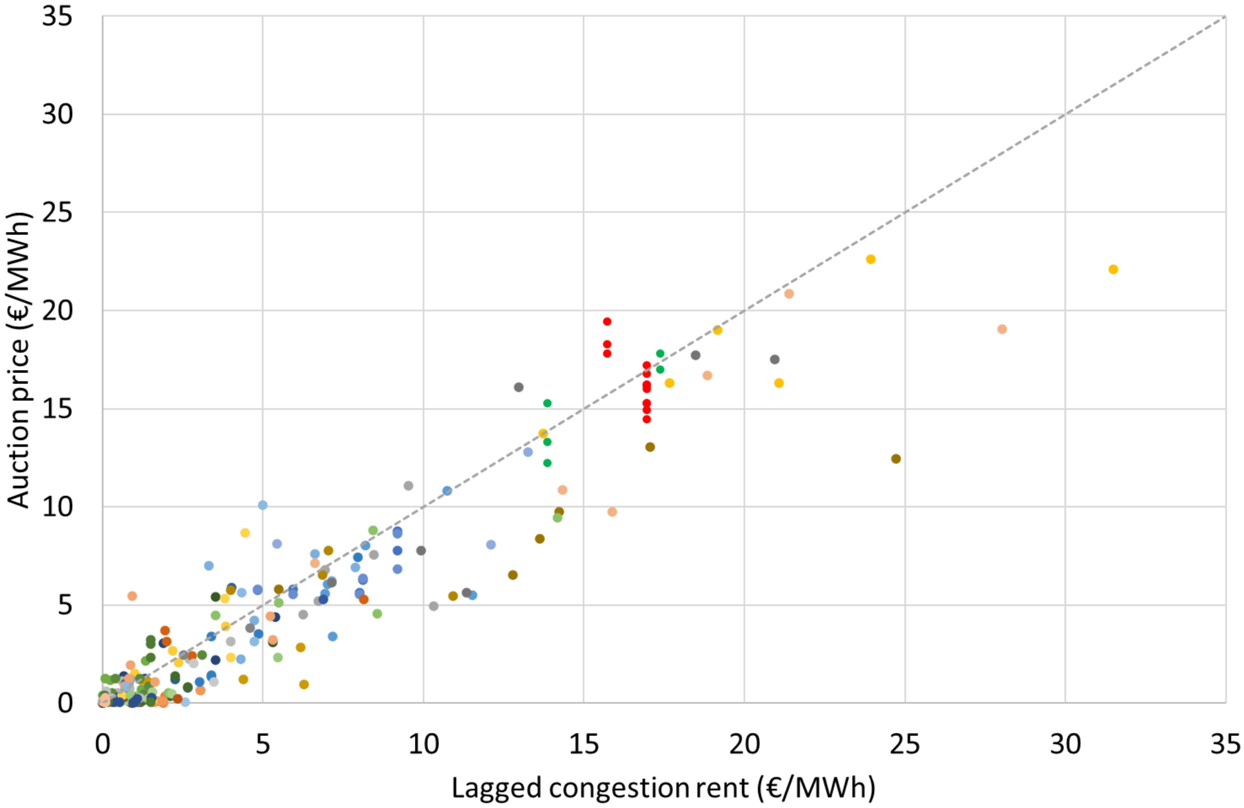
Figure 10: Transmission right auction prices against lagged congestion rent



It is important to note that the data points shown do not represent data on actual mark-ups and discounts relative to expectations, since bidders' price expectations are unknown. Furthermore, these auctions may not be representative of bidding behaviour for transmission rights on borders in Norway, especially if the rights genuinely help to overcome some of the structural issues raised above. However, the results do suggest that transmission rights frequently fetch prices at auction that are significantly below expected congestion income.

Were auction prices to be systematically below congestion income, this would imply a transfer from the payers of consumption network tariffs to the holders of such rights. Analysis of the implied tariff effects for the NordLink, NorNed and North Sea Link showed that the implied tariff impact assuming transmission rights were issued on all these cables could be very significant. Specifically, consumption network tariffs could be up to around 15% higher or lower assuming a discount or mark-up to expected revenues similar to the spread observed in Figure 10 above.

Issuing transmission rights would also imply an administrative cost to the TSOs involved. However, based on Energinet's experience of issuing LTTRs on its borders, we expect this cost to be relatively small relative to the distributional impacts noted above.

Chapter 4 of the European Guideline on Forward Capacity Allocation requires that the auctioning and settlement of transmission rights be conducted via a single allocation platform. This platform is the Joint Allocation Office (JAO). We assume that, were transmission rights to be issued in Norway, the auctioning and settlement of these transmission rights would be administered by JAO, consistent with the requirements of the Guideline on Forward Capacity Allocation. JAO's administrative costs are socialised among the TSOs that it serves and so Statnett would therefore be liable to contribute to JAO's administrative costs.

Statnett would also bear some administrative costs directly, most notably as the cost of staff time spent implementing and overseeing Statnett's operational relationship with JAO.

We have discussed the scale of the associated costs with Energinet, which currently issues transmission rights on their cross-zonal borders in the form of Financial Transmission Right options via JAO. They have suggested that Energinet's contribution to JAO's socialised costs amounts to approximately EUR 35,000 per year per border. Importantly, this cost assumes that Energinet is the responsible TSO on only one side of the relevant border and that the TSO for the other bidding zone is sharing the total costs. Where Energinet is the responsible TSO in both zones, Energinet's approximate costs for the relevant border would therefore be around EUR 70,000 per year. This cost covers the administration of one annual and twelve monthly auctions for a product in both directions across the relevant border, as well as the subsequent settlement of contracts. We understand that some borders have additional auctions, e.g. for quarterly products, and that the responsible transmission owners bear a larger cost as a result.

The direct administrative costs to Energinet were considered to be on the order of 0–0.1 FTE staff member.

Finally, again, it is worth noting that transmission right obligations and options differ somewhat in terms of their pros and cons. We noted in the section on pros that obligations were more useful to hedgers seeking to use transmission rights as a bridge to liquidity since obligations continued to pay the relevant spread even if it is negative. Another way of putting this is that obligations can require payments by the obligation holder. This structure means that TSOs issuing obligations face the risk of a potential default on the obligations. To manage this, such obligations would likely need to be cleared, unlike FTR options. The need for clearing is another potential barrier to the use of transmission rights by smaller players. In a worst-case scenario, you could end up with separate clearing arrangements for transmission rights and EPADs that require participants wishing to use both to post collateral with two separate clearinghouses, thereby increasing the costs of collateral.

Table 3: Pros and cons of TSO supply of transmission rights

Pros	Cons
Could help address fundamental structural issues (small number of potential participants, asymmetry) provided participants can find counterparties in neighbouring zones	Complicates the market design—opposed by market participants and liable to imply different products trading across different platforms
Could help address market power concerns provided participants can find counterparties in neighbouring zones	Bridge-to-liquidity hedging may harm the liquidity of low-liquidity products (harming actors that fail to substitute for other products)
Brings Nordic market design into line with standard market design in Continental Europe	Affects EPAD liquidity only indirectly
	May increase consumer network tariffs if auction revenue is systematically below congestion incomes
	Imposes administrative cost on TSOs
Obligations would be more useful to hedgers seeking to use transmission rights as a bridge to liquidity and (possibly) better at stimulating EPAD liquidity	*Obligations would require clearing (possibly with a separate clearing house) or else expose the TSO to default losses*

6.4 TSO supply of EPADs

This option would require TSOs to buy or sell EPADs or EPAD combos to support market liquidity. However, unlike simple market-making (described in section 6.6 below), there is an expectation that the TSO would take a net position in some of these products, i.e. that it would be a net buyer or seller.

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We have not seen a clear description of the basis on which the TSO would take such a position in the papers we have reviewed. As such, we seek to provide a more concrete description of a proposal here to facilitate an assessment of the option.

We begin with the fact that TSOs, unlike other market participants, own cross-zonal transmission capacity and are therefore exposed to the price spread between the relevant zones in terms of congestion income. As noted above, this revenue is passed through to consumer network tariffs and so it is ultimately these consumers that are exposed to the price risk. However, for the sake of simplicity, we will continue to talk about the TSO's risk exposure below and assume that it acts as an agent on behalf of tariff payers.

We presume that this monopoly ownership of cross-border transmission capacity is the reason why TSOs face what is, in effect, a requirement to supply transmission rights under the FCA GL.

As noted above, the parallel use of transmission rights and EPADs will complicate the market design and limit the potential benefits to market liquidity of TSO's supply of transmission rights. Therefore, we envisage a requirement on TSOs to supply EPADs as an attempt to replicate—using EPADs—the requirement to supply transmission rights found in the FCA GL. Implicitly, we see the justification for such a requirement to be TSO's monopoly ownership of cross-zonal transmission infrastructure and therefore the requirement to be limited by the extent of TSO's exposure to cross-zonal price variations as a result of this ownership.

Alternative ways of constraining the TSO's obligation can be imagined, but at least some restriction would seem to be necessary to avoid consumer-network-tariff payers excessively subsidising hedging activity by the rest of the market.

Unfortunately, converting TSO's position due to their asset ownership into an equivalent EPAD position is not trivial due to differences in the structure of the pay-outs. Put simply, transmission assets act like options to flow power in either direction and effectively pay the absolute value of the spread across the border. By selling transmission right options in both directions, TSOs can sell a pay-out structure that closely matches their congestion income. EPAD Combos also pay out the spread across a border but, unlike transmission assets or FTR options, the pay-out structure resembles an obligation and results in negative pay-outs when the price spread reverses. We discuss the practicalities of creating an equivalent EPAD supply requirement in the box below.

Equivalent EPAD supply requirement

Differences in their pay-out structures make it impossible to replicate the pay-outs and risk exposures implied by the ownership of cross-zonal transmission capacity using Nordic financial market products, even if we ignore the issue of operational risk. However, the pay-outs and risk exposures are related. As a result, TSOs (or more accurately consumption-network-tariff payers) can reduce their price risk exposure by taking net positions in EPAD products. Here we draw a parallel between requirements on TSOs to supply transmission rights—which effectively have TSOs offload all of their power price exposure to third parties—and a net position in EPAD products that would minimise the TSO's exposure to power price risk.

Let us consider the border between bidding zones A and B.

$$\text{Congestion revenue} = |P_A - P_B|$$

In words, the TSO earns a congestion revenue from its ownership of cross-zonal capacity equal to the absolute value of the price spread between the zones. We have normalised the capacity and time duration to one for ease of exposition.

An EPAD Combo that is long in zone A and short in zone B (Combo_{AB}) provides the following pay-out:

$$\text{Combo}_{AB} \text{ pay-out} = P_A - P_B$$

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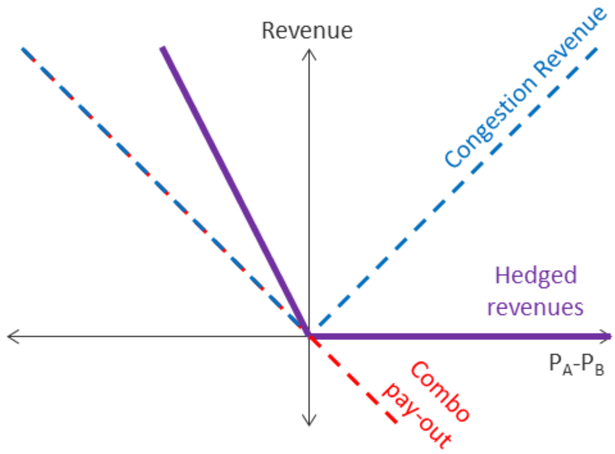
It is clear to see that if $P_A>P_B$, then the TSO's congestion income precisely matches the pay-out from the EPAD Combo and the TSO could remove any exposure to the price spread by selling this EPAD Combo.

However, when the price spread reverses, i.e. when $P_A<P_B$, selling this EPAD Combo actually amplifies the TSO's exposure to any price change as both the congestion revenue and the EPAD Combo pay-outs move in tandem.

This relationship is shown graphically below.

Hedging congestion revenues using an EPAD Combo



Given this, what position would a TSO that wishes to minimise its risk exposure take? The answer will depend on potential price developments. If we were certain that $P_A>P_B$, then it is best to sell the EPAD Combo discussed above. If we were certain that $P_A<P_B$, then the price exposure would be minimised by taking the offsetting position, i.e. buying the EPAD Combo described above. Faced with uncertainty about the direction of the price spread, the optimal position will lie somewhere between these two positions and depend on the assessed likelihood of the spread going one way or the other.

More generally, we can consider a TSO's total revenue to be given by its congestion revenue, the sale value of any EPAD Combos and the pay-outs made as a result of any EPAD positions.

$$|P_A-P_B| + \alpha(EPAD_{AB}) - \alpha(P_A-P_{SYS}) + \alpha(P_B-P_{SYS})$$

The first term above represents the TSO's congestion revenue. The second is the revenue earned from selling the EPAD Combo. It is multiplied by α, which represents the share of capacity that is hedged. This share can take values $-1 \le \alpha \le +1$. The last two terms give the pay-outs (or payments) attributable to each EPAD within the EPAD Combo and are similarly adjusted by α depending on the share of capacity that is hedged.

We can think of the problem of determining an equivalent EPAD obligation as identifying a value for α at each border that would minimise the TSO's exposure to price risk. Alternatively, we can think about this as finding a value for α that transfers the inherent hedging capabilities of transmission asset ownership to the market to the greatest extent possible.

Altering the value of α alters the strength of the effects we observed previously (which were based on the case of $\alpha=1$). The TSO's exposure is partially dampened when the spread is in one direction and partially amplified when the spread is in the opposite direction. The different effects of hedging all capacity ($\alpha=1$) and half of the capacity ($\alpha=0.5$) are shown below.

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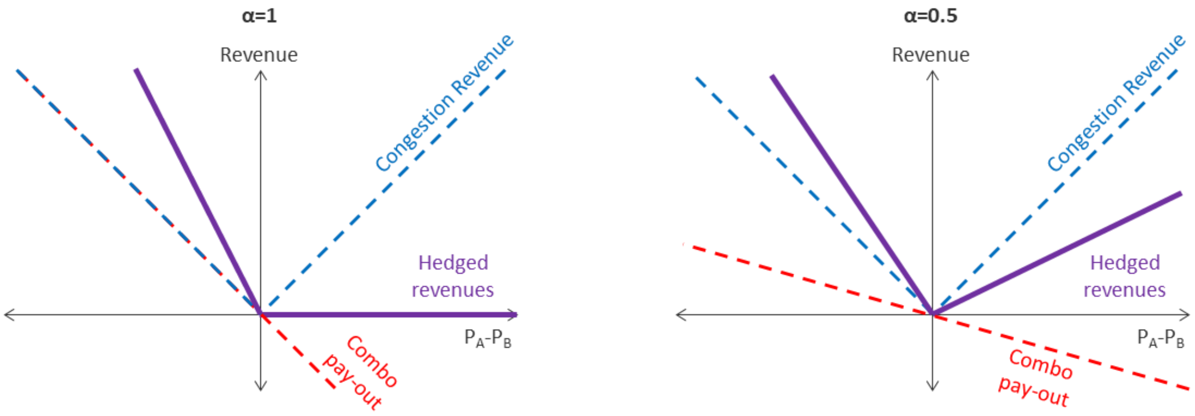
Effect of different EPAD Combo hedging ratios



From this, it can be surmised that the greater the likelihood that the price spread between the two zones is in one direction, the greater the reduction in price risk achieved by hedging using an EPAD Combo in the opposing direction. Conversely, the less dominant or certain the direction of the price spread, the lower the share of capacity that should be hedged.

Identifying an optimal α would require an explicit objective function, such as reducing the variance in expected revenues, as well as a view as to potential price spread outcomes. Defining these would not be trivial. However, given these, it should be possible to mechanistically calculate a net position in EPAD contracts that transfers the hedging properties of the TSO's transmission assets to the market to the greatest extent possible and that is, in this sense, equivalent to a requirement on the TSO to supply transmission rights.

Assuming that it is possible to define an EPAD equivalent to the supply of transmission rights, a requirement on TSOs to supply EPADs would otherwise look fairly similar to a requirement to supply transmission rights. The TSO would hold regular EPAD Combo auctions with the TSO's net position in any EPAD product limited by the equivalency conditions. Unlike transmission right options (but like transmission right obligations), EPAD Combo positions can be netted. In other words, if an EPAD Combo is sold in both directions, the payment streams are offsetting, leaving the auctioneer with no net obligation. As a result, it is at least theoretically possible for bids and offers into the auction to clear even for borders where the TSO cannot take a net position in the relevant products. However, this requires that there are offsetting demands among market participants that have failed to result in trade via other market means.

A TSO EPAD auction would ideally be held as a so-called combinatorial auction, i.e. a series of interconnected auctions for products that are cleared simultaneously. This would allow market participants to submit bids to buy or sell individual EPADs or EPAD combos. The combined EPAD auction would then clear across all EPAD products subject to the TSO not taking on an excessive net position in any EPAD product as defined by the equivalency conditions.

In the discussion of pros and cons below, we assume that an auction process like the one described above is followed except where noted otherwise.

Pros

Similar to a requirement to supply transmission rights, a requirement to supply EPADS that allowed the TSO to take a net position in EPADs could help alleviate some of the potential structural causes for low EPAD liquidity. The extent to which this is the case will depend on the extent to which the TSO's net position aligns with the needs of the market.

Considering the specific case of a limit on the TSO's net position based on the extent of a dominant price direction across a border, as described in the box above, this position would imply that TSOs take an opposing position in EPAD Combos, i.e. selling into the high-price zone and buying EPADs in the low-price zone. This could be potentially useful in addressing asymmetric supply and demand for EPADs if, as seems reasonable, the low-price zone had an excessive volume of generation looking to sell EPADs and the high-price zone had an excessive volume of consumption looking to buy EPADs.

Alternatively, the TSO could be instructed to address this asymmetry directly, potentially taking on a net EPAD position that increased its risk exposure. However, in this case, consumption-network-tariff payers would potentially be subsiding hedging activity in the market.

Again, similar to a requirement to supply transmission rights, a requirement to supply EPADs might also help address market power if the TSO ends up taking a net position that effectively makes it a net supplier of EPADs in an affected zone. Whether or not this is the case is likely to be largely coincidental unless the TSO's supply requirements are set with market power objectives in mind.

The biggest additional advantage relative to a requirement to supply transmission rights is that an EPAD auction would be fully consistent with the existing product set and directly increase EPAD liquidity when considered as a whole. The use of EPADs would also be more likely to enable secondary trading relative to the use of transmission rights since the market infrastructure is already well-suited to facilitate this.

The presence of the EPAD auction may also act as a natural focal point for EPAD trading. The TSOs' internal analysis appears to consider this a drawback, as the auction may cannibalise EPAD trading activity from the continuous market. However, by focussing liquidity, auctions can provide several benefits relative to continuous trade: A well-functioning auction can help provide credible and robust reference prices, which in turn can be used to help inform secondary trading. Auctions can also provide easier access for smaller market players that do not have the resources to actively monitor the continuous market, effectively providing a low-cost alternative to brokerage.

Cons

Although the use of EPADs significantly simplifies the market design, it requires greater effort to specify the nature of the requirement placed on the TSO. While this requirement could be simple, establishing some sort of equivalence to a transmission-right requirement is liable to be complicated, as explained in the box above.

Importantly, a requirement to supply EPADs that operated similarly to a transmission-right requirement would also face the risk that auction revenues differed systematically from the expected pay-outs under the relevant contracts. We assume that the TSO is a price-taker in the auction process, in that it assigns no estimate of fair value to the contracts and imposes no reserve price in the auction. This is advantageous in the sense that it limits the need for the TSO to evaluate the market as well as the scope for any abuse of the TSO's position. However, this price-taker approach implies that the TSO could accept trades that represent poor value for consumption-network-tariff payers, potentially reducing their exposure to price risk at unreasonable cost.

The EPAD-based requirement may offer some greater protection for tariff payers relative to a transmission-right requirement to the extent that EPADs are more likely to be bid on by actual hedgers, which could place significant value on obtaining a hedge. However, the theoretical risk that EPADs will be auctioned at unfavourable prices remains. Again, this will have the effect of redistributing value from consumption-network-tariff payers to participants in the EPAD auction.

Implementing EPAD auctions will also impose an administrative cost on TSOs. The extent of this cost may differ significantly depending on whether or not the TSO is a price-taker in the auction.

Assuming the TSO is a price-taker and offers EPADs at auction mechanistically based on a process set by the regulator, then the TSO's role can be seen as purely administrative rather than having any genuine trading function. Although the ongoing internal staffing requirements implied by this role are likely to be greater than those implied by a transmission-right supply requirement, they are unlikely to be very large.

More significant may be the costs of establishing the relevant trading system in the first place. The costs of the auctioning platform will depend on the willingness of exchanges to support the auction process. Although the auction might cannibalise some EPAD trading activity, it might also support total trading volumes in the long term and would be likely to support higher clearing volumes. This may provide an incentive for exchanges to provide at least some in-kind support to developing an auction solution.

As discussed extensively in the TSOs' earlier analysis of a requirement to supply EPADs, TSOs would bear the additional administrative costs associated with financial reporting, notably under European Market Infrastructure Regulation (EMIR). They would, however, likely be exempted from compliance with MiFID II regulation, though there remains some legal uncertainty.[13]

If the TSOs took a more active role in trading EPADs, as appears to be assumed in the TSOs' own analysis, this would likely require the creation of both a more specialised trading team and Chinese walls separating this team from the TSO's other functions. The TSOs' internal estimates suggest that establishing Chinese walls adds significantly to the implied costs. An active trading team would probably also be larger, include more specialised staff and incur additional costs linked to the procurement of trading tools and licenses, relative to a team responsible for administering a price-taking auction.

The choice of whether or not the TSO acts as a price-taker may also influence market participants' confidence in the TSO as a neutral party. Market participants have previously expressed concern about the TSO's involvement in the market. To the extent that the TSO's ability to influence the auction is limited, there is presumably little cause for concern. This is generally the case in transmission rights auctions, as TSOs can effectively only determine the split of capacity among product types and the timing of auctions. They generally cannot influence the total volume of capacity auctioned or impose any reservation price on the sale of capacity. An EPAD auction in which the maximum volume auctioned was effectively set by the regulator and the TSO set no reserve price would, presumably, give little cause for concern. However, if the TSO had discretion over the total volume traded or the prices at which trades occur, this could provide a mechanism for the TSO to actively influence the market and therefore potential grounds for concern. It might be possible to establish some non-discretionary price limits on trades, for example to protect tariff payers from unfair trades, but these limits would have to be established mechanistically in such a way that neither the TSO nor market participants were able to unduly influence them.

It is worth noting that the TSOs' assessment of the cons of EPAD auctions also lists the fact that it may not be legal to use congestion rents to directly offset an EPAD position given the restrictions on the use of congestion rents established under Article 19 of the FCA GL. However, we consider that this is unlikely to make any meaningful difference provided that TSO's EPAD obligations are treated equivalently, i.e. as pass-through costs, in the calculation of network tariffs.

The TSOs' assessment also highlights the potential for an EPAD auction to split EPAD liquidity between the auction platform and the continuous market. This risk stems from a legal requirement that TSOs procure the provision of the platform in such a way that it is open to all potential providers. We are somewhat sceptical as to the significance of this risk. First, a split in liquidity between platforms needn't be particularly detrimental to the market provided that (1) some market actors are participants on both and are willing to arbitrage the market and (2) both platforms accept common clearing arrangements. Second, although we are not experts in the legal obligations placed on public procurement processes, it seems reasonable that the TSO could justifiably consider the overall implications for market liquidity when selecting a preferred provider. After all, supporting liquidity is the rationale for the intervention. If this is possible, then the TSO would have considerable control over the risk.

[13] Nordic TSOs Transmission and Wholesale Group, "Examination of Possible Arrangements to Ensure Cross-Zonal Risk Hedging Opportunities," sec. 7.

Table 4: Pros and cons of TSO supply of EPADs

Pros	Cons
Could help address fundamental structural issues (small number of potential participants, asymmetry) provided TSO takes an appropriate net position	Requires definition of the requirement placed on the TSO, which—if based on equivalence to a transmission-right requirement—may be complicated
Could help address market power concerns provided TSO takes an appropriate net position	May increase consumer network tariffs if EPADs are traded at unfavourable prices
Uses the existing product set and therefore contributes directly to EPAD liquidity and is more likely to support secondary trading	Imposes administrative cost on TSOs. These are likely to be significantly larger if the TSOs take an active position in the market compared to simply acting as a price-taker.
Creates a natural focal point for EPAD liquidity, thereby supporting robust reference prices and easier access to the market	May harm confidence in TSO neutrality, especially if the TSO is not a price-taker in the auction
	Implies implementation costs to establish auction platform

6.5 Broadening market participation

There is a broad range of measures that have been suggested in various contexts to help broaden market participation. These include:

- Reducing minimum contract sizes,
- Altering exchange membership requirements, and
- Adjustments to collateral requirements.

In general, these initiatives have tended to focus on getting smaller or demand-side participants interested in using financial products for hedging.

We have grouped these proposals together given their common objective and the fact that there seems to be very little published material considering these options in the Nordic context. However, the different measures imply potentially different pros and cons.

Our discussions with market participants as part of earlier work suggest that the cost and administrative burden associated with meeting collateral requirements is a significant turn-off for many. Earlier consideration of potential options to address high collateral requirements for smaller players in Great Britain identified a couple of possible options. These generally involved some socialisation of collateral costs for small market actors.

Specifically, Ofgem's original proposals for options to improve liquidity in the GB wholesale electricity market included the idea of credit pooling, among others.[14] Credit pooling would impose an upper bound on credit requirements and socialise any shortfall among other players, effectively subsidising small actors collateral costs and potentially simplifying the cash flow implications.

[14] Ofgem, "Liquidity Proposals for the GB Wholesale Electricity Market," 2010, chap. 8, https://www.ofgem.gov.uk/ofgem-publications/40485/liquidity-proposals-gb-wholesale-electricity-marketpdf.

Pros

Broader market participation would help address a lack of active participants in some products. To the extent that these measures are successful, they would help counteract the fact that smaller bidding zones tend to result in fewer active market participants.

These measures may also help somewhat in addressing market power to the extent that new participants compete with dominant actors. However, any impact would likely be relatively small unless new participation brought with it significant changes in total available volumes, something that might not be expected from the participation of relatively small actors.

Smaller contract sizes have the small additional benefit of enabling greater precision in the implementation of hedging strategies.

Cons

Broader market participation is a positive outcome but the various options designed to help achieve it can have undesirable consequences. Smaller contract sizes may, for example, increase trading costs.

Efforts to reduce the burden of collateral costs can be especially problematic, notably where they imply changes to participants' incentives to take and manage risk. If poorly designed, the resultant incentives can lead to excessive risk-taking and higher consumer costs.

Table 5: Pros and cons of broadening market participation

Pros	Cons
Could help address a lack of potential participants due to small bidding zones	
Might help address market power concerns if measures bring significant competing volumes of demand and supply	
Smaller contract sizes enable more precise hedging	*Smaller contract sizes can increase trading costs*
	The socialisation of collateral costs can weaken incentives for prudent risk management

6.6 Enhanced market-making

A market-maker is a market participant that commits to post both bids and offers for a certain product, thereby ensuring the presence of a counterparty and a price. They are a common feature of many financial and commodity markets and many exchanges operate with officially designated market-makers. Official market-makers generally have an agreement with the exchange that stipulates the minimum volume to be offered, the 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.

For a market participant taking the role of market-maker, these obligations entail both cost and risk. In particular, in fast-moving markets, an ill-informed market-maker that fails to react quickly to market developments will make losses as a result of trades with better-informed, fast-acting counterparties. Near-term physical markets are often thought to be fast-moving. A network outage, for example, may have sudden significant implications for the value of an EPAD covering the following week and a market-maker needs to react quickly to such developments if it is to avoid losses. It also needs to be suitably protected against information asymmetries through robust 'insider trading' regulation.

Market-makers may undertake the role as a result of financial incentives, strategic considerations or regulatory requirements.

Exchanges will, for example, typically discount or waive trading fees for market-makers. In some cases, market-makers may be paid directly, for example following a procurement round, to fulfil the relevant obligations.

Market-making obligations may also contain specific rules intended to help mitigate some of the risks faced by the market-maker. Both Nasdaq and EEX market-making contracts have clauses that weaken or remove the requirements placed on the market-maker—for example by widening the acceptable bid-ask spreads—during periods in which the market is stressed or fast-moving.

Organisations may have a variety of strategic interests that underpin their desire to be a market-maker. Trading organisations may have an interest in supporting liquidity. Companies with large structural imbalances (for example between generation and supply) may wish to stimulate liquid and anonymous hedging markets to support their needs for risk management. Companies with dominant positions may view the creation of a liquid market as a defence against regulatory intervention. In some cases, market-making obligations have effectively been part of the regulatory response to concerns about competition. Thus, in 2003, Elsam and E2 (which became Dong Energy and then Ørsted) agreed to market-make Danish CfDs, which eventually became EPADs, as part of an agreement with the Danish Competition Authorities. The British energy regulator also effectively imposed (and then removed) market-making obligations on large energy firms as part of its Secure & Promote efforts to stimulate market liquidity.

Nasdaq has official market-makers for the Finnish, Swedish and Danish EPAD contracts. It also has a part-time market-maker for the Trondheim contract.

Enhanced market-making would entail either tightening the conditions imposed on market-makers or increasing the number of market-makers. This would likely be achieved by tendering for the market-making role. Reducing the maximum bid-ask spread would act to reduce trading costs. Increasing volume requirements would make it easier to conduct larger trades. Larger volume requirements would also make it easier to exit a position rapidly and may be important to minimise the liquidity risk faced by speculative traders, thereby encouraging them to enter the market. The presence of multiple market-makers can help to distribute the risks of market-making and reduce the risk faced by any individual organisation, potentially lowering costs for all.

Market-making requires a good understanding of the product's price determination, the risks associated with trading and an ability to manage these risks. As such, market-makers in power futures tend to be large, well-capitalised firms with a generation portfolio. They are frequently the largest utility in a region and have the balance sheet strength, trading experience and generation portfolio required to evaluate and manage any risk associated with market-making more cost-effectively than alternative providers.

Pros

Enhanced market-making can directly address some of the negative effects of illiquidity. It ensures price transparency (in the event there isn’t already a market-maker), can reduce trading costs by reducing the bid-ask spread and may help actors find a counterparty. The usefulness of the market-maker in providing a counterparty will depend on the volumes offered and the extent to which the market price is skewed away from the expected value by supply/demand imbalance, as discussed in the cons section below. In general, however, market-making tends to directly address the symptoms of illiquid markets and can thereby mitigate some of the wider economic harms discussed in section 2.

Market-making may also be relevant in breaking a vicious cycle of illiquidity. Trading in financial products can be thought to result in so-called ‘reciprocal externalities’. Put simply, this means that additional trading activity can make it attractive to trade more, and vice versa. This is because, for example, greater trading makes the market more liquidity, reducing speculators’ liquidity risk and so making additional speculative trading opportunities potentially profitable. Such systems have been

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theoretically shown to result in multiple steady-state equilibria.[15] In other words, it is possible for the market to stably persist in either a low-liquidity or a high-liquidity state. In theory, at least, market-making might offer an opportunity to shift from a low-liquidity to a high-liquidity state, at which point market-making obligations could be removed without negative effect. This assumes, in effect, that a lack of liquidity is itself a major cause of low liquidity in the market. By injecting liquidity, speculative trading can return and become self-sustaining.

Finally, enhanced market-making is relatively simple to incorporate into the existing market design. It uses existing products and could largely re-use the existing commercial arrangements between exchanges and official market-makers.

Cons

Although market-making directly targets some of the symptoms of illiquidity, it arguably fails to address some of the structural causes. In particular, market-making may be of limited value when addressing a structural asymmetry between supply and demand.

Take SE4, for example. Our understanding is that the Malmö (SE4) EPAD contract is structurally imbalanced in that demand significantly outstrips supply. This contract is already covered by market-making arrangements such that a price is available. Enhancements to market-making are unlikely to address the fundamental imbalance between supply and demand. This is because the market-marker is more likely to adjust its mid-price so that effective demand and supply are balanced than to take on the net position needed to redress the fundamental imbalance directly. So, for example, there is likely to be a mark-up on the EPAD price that encourages parties on one side of the market to walk away, preventing the market-maker from building up a large position and from satisfying the excess demand.

Enhanced market-making also implies a cost to the market-maker. Where the market-making obligation is entered into voluntarily as a result of a procurement process, then this procurement would need to be funded. One possibility would be for network-tariff payers to fund this process via the TSO, possibly with contributions from other beneficiaries, notably the exchanges. However, funding would have to come from somewhere.

One potential problem that a procurement process may face is a lack of competition among potential providers of market-making. Market-making is often provided by incumbent generators given their trading experience, strong balance sheets and generation portfolio. In bidding zones where some market participants are already concerned about limited competition in the supply of EPADs, there may be little competition for the supply of market-making. In this case, market-making may not only fail to address the fundamental problem but could end up exacerbating it by providing dominant firms with another opportunity to exploit their market power.

Finally, an analysis conducted by TSOs' procurement departments suggests that a TSO-led procurement process would be prevented by European law from restricting the procurement to a specific exchange. There is, therefore, a possibility that the process would result in market-making on an exchange with relatively little trade and act to split liquidity among exchanges. Although we are not experts in procurement law, we assume that that the TSO could justifiably consider the overall implications for market liquidity when selecting a preferred provider as long as it does not unduly discriminate among different exchanges when doing so. As a result, although the TSO cannot foreclose the possibility of using different exchanges, it can consider to what extent the supplier's proposal is liable to enhance liquidity and maximise the benefits of market-making.

[15] Peter A. Diamond, "Aggregate Demand Management in Search Equilibrium," *Journal of Political Economy* 90, no. 5 (October 22, 1982): 881–94, https://doi.org/10.1086/261099.

Table 6: Pros and cons of enhanced market-making

Pros	Cons
Directly addresses some symptoms of illiquidity, notably price transparency and high trading costs	Does not address structural causes of illiquidity (small number of potential participants, asymmetry)
Could address low liquidity as a potential cause of low liquidity	Imposes a cost on the market-maker or funding body
Uses existing product set and could largely re-use existing market-making arrangements	Is susceptible to a lack of effective competition among potential providers

6.7 EPAD auctions

The current market design involves continuous, exchange-based trade in EPADs, mirroring the processes used for other commodity derivatives. However, as noted when discussing a TSO requirement to supply EPADs, EPADs could also be traded via an auction. Continuous and auction trading may operate in parallel as part of a hybrid system and, indeed, the European intraday power market is expected to change from a design that is based almost entirely around continuous trading to a mixture of auctions and continuous trading as part of amendments currently being consulted on by ACER.

This option would involve the creation of regular EPAD auctions that take place alongside continuous trade. Unlike a TSO requirement to supply EPADs, as discussed in section 6.4, under this option the TSO would not take any role in the EPAD market, via the auctions or otherwise.

Pros

An EPAD auction could act as a natural focal point for EPAD trading, potentially making it easier to find counterparties and acting as a substitute for brokerage.

Auctions can reduce trading costs by effectively eliminating the bid-ask spread.

They can also provide easier access to smaller players, which may not have the resources to actively monitor the continuous market.

Finally, where a market-maker does not exist and assuming that the auctions attract sufficient participation, auctions can help to create credible and robust reference prices.

Cons

The introduction of auctions would not meaningfully address any structural or market power issues that contribute to a lack of liquidity. At most, auctions might encourage broader market participation, increasing the number of participants in the market.

Auctions may also cannibalise trading activity from the continuous market. If market participants place significant value on hedging area-price risk instantaneously, something that seems unlikely, this could be a problem. However, depending on how trading fees for trade via the auction and the continuous market differ, the resultant change in patterns of trade may have distributional implications.

Finally, the creation of an auction process would entail some set-up and implementation costs.

Table 7: Pros and cons of EPAD auctions

Pros	Cons
Creates a natural focal point for EPAD liquidity, making it easier to find a counterparty	Does not address structural causes of illiquidity (small number of potential participants, asymmetry)

Pros	Cons
Reduces trading costs	Does not address any market power issues
Supports participation by smaller players and may increase the number of market participants	May cannibalise trading activity from the continuous market, altering trading fee payments
Could support the creation of reference prices where a market-maker does not already exist	Entails some set-up and implementation costs

6.8 Forcing (large) vertically integrated companies to trade

Vertically integrated firms combine business units that generate power with business units that require power. Since these business units are naturally both long and short in power, they have opposing exposures to the power price. When a generation unit benefits from unexpectedly high power prices, the consumption or retail unit loses, and vice versa. This organisational structure, therefore, provides a natural hedge against power price risk.

Other things being equal, a power industry with extensive vertical integration will have a lower absolute need for hedging products relative to an industry with little vertical integration. This lack of hedging need makes the market for hedging products smaller and therefore less liquid.

One approach to stimulate liquidity would be to try and force vertically integrated companies to trade hedging products despite their naturally reduced hedging needs.

Broadly speaking, international examples of mechanisms intended to get vertically integrated companies to trade have either taken the form of explicit obligations to trade or else restrictions on self-supply.

Obligations to trade, as the name implies, essentially imposes a trade requirement on the firm. This requirement could, for example, require that a vertically integrated firm sell a specified volume of power forward using a combination of Nordic system price and EPAD contracts.

Self-supply restrictions limit generation and consumption units within the same business from contracting bilaterally for future supply. The strength of these restrictions can vary from relatively light requirements—which make it illegal to transfer power bilaterally among specific business units—right up to the complete legal and operational separation of the upstream and downstream businesses.

These different variants have different pros and cons, as discussed below.

Pros

To the extent that vertical integration is reducing total trading volumes and activity, obligations to trade and self-supply restrictions offer a means of promoting higher trade volumes and liquidity. In the case of self-supply restrictions, they may also offer greater transparency over internal pricing within the firm. However, it is worth noting that companies could respond to a self-supply restriction by not trading power forward at all and instead relying on the natural hedge between the profits and losses of different business units. Ultimately, restrictions on self-supply do not remove the natural hedging properties of vertical integration.

In contrast, obligations to trade effectively guarantee increased trading volumes and provide far greater regulatory control over the timing and volumes traded, as well as the products used.

Obligations to trade in which the obligated firm cannot control the price can, and frequently have, been used as a remedy in the presence of market power concerns.

Cons

Although self-supply restrictions and obligations to trade might increase trade volumes, they will not directly address a structural asymmetry between demand and supply within a specific zone. As noted in section 6.6, a fundamental mismatch between supply and demand is liable to lead to a mark-up on or discount to the EPAD price and this will not be addressed simply by increasing trading volumes.

It is also important to realise that vertical integration may offer an efficient means for a firm to manage its power price risk exposures, handling this risk while avoiding trading costs and counterparty risk. To the extent that self-supply restrictions or obligations to trade frustrate the organisation's ability to hedge, they may well impose an economic cost on the organisation that is ultimately borne by its shareholders and customers. Self-supply restrictions may require, for example, that a firm operates two distinct trading desks for its upstream and downstream businesses, thereby adding to the business' operating costs. In addition to these efficiency losses, additional compliance and enforcement costs will likely be required to ensure that any restrictions or obligations are adhered to.

Finally, obligations to trade also bring with them the risk that the obligated party ends up as a distressed seller, i.e. that the party is forced to sell even when the price obtained does not reflect the fair value of the product. This would distort the market price and, similar to the concerns raised about supply requirements for TSOs, would (unfairly) redistribute revenues between sellers and buyers. Some regulatory safeguards can be introduced to help prevent this, but these often rely on a regulatory assessment of fair value which may itself artificially influence market pricing.

Table 8: Pros and cons of forcing (large) vertically integrated companies to trade

Pros	**Cons**
Can promote higher trade volumes and liquidity where vertical integration is reducing trade	Does not address structural causes of illiquidity (small number of potential participants, asymmetry)
	May reduce or eliminate genuine efficiencies from vertical integration
	Entails some compliance and enforcement costs
Obligations to trade provide extensive regulatory control over the timing and volumes traded, as well as the products used	*Obligations to trade entail a risk that the obligated party becomes a distressed buyer/seller, distorting prices and redistributing costs and benefits among the trading parties*
Obligations to trade can be used to address market power	
Self-supply restrictions can increase the transparency of internal pricing	

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7 APPROPRIATENESS OF THE DIFFERENT OPTIONS

In considering the appropriateness of the different options discussed in section 6, it is apparent that the effectiveness of these options depends on the underlying causes of low liquidity. In general, an intervention that is well-targeted at the root causes of illiquidity is more likely to be effective and to avoid potential adverse side-effects.

Unfortunately, although we have identified a variety of factors that may contribute to low liquidity for Nordic financial products in general, we have not examined in detail the extent to which these factors are relevant at a specific product level. It also seems likely that, even considering the liquidity of a single product, there may be multiple causal factors at work.

A more thorough understanding of the specific causes of low liquidity at a product or bidding-zone level is likely to be necessary to understand which set of options is most appropriate.

In considering the most appropriate response, we distinguish between four sets of causes and their associated options. These causes are:

- Market power,
- Barriers to participation,
- Structural issues (notably bidding zone asymmetry), and
- Low liquidity itself and the absence of speculative trading.

Market power

Taking each in turn, where market power is a problem, it would seem to be especially important that this is addressed as directly as possible. Consider, for example, the implementation of enhanced market-making. If market power exists in a market, then not only will the tendering of market-making fail to resolve the problem, it may exacerbate it by creating another opportunity for this power to be exploited.

It is also important to note that the relevant market definition when considering the competitiveness of an EPAD product is likely to be far smaller than for wholesale power, since EPADs cannot be effectively traded with parties outside of a bidding zone. As such, the fact that a market player does not have market power in the physical power market does not necessarily imply that they do not have market power in an EPAD product market.

It is also important to point out that we have not made any competition assessment of the EPAD market or the market power of any firm. We simply note that some market participants have cited market power as a factor that contributes to a lack of EPAD liquidity.

Barriers to participation

Participation in the financial power market is not attractive to all hedgers. Many, and particularly smaller players, seem to be turned off by the burden of collateral management and the regulatory reporting requirements. Ideally, ways could be found to lessen these barriers to participation. Unfortunately, we have found relatively few concrete suggestions that address these issues. This reflects both the fact that some of the challenges stem from European regulation, which is not easily changed, and the fact that collateral arrangements exist for good reason, such that altering them can create perverse incentives with regards to risk management. That said, our work has only sought to identify ideas highlighted in existing work and has not explored this area in detail.

A move to EPAD auctions may make the market more attractive to smaller players by reducing trading costs. However, this change would not materially influence the collateral and regulatory reporting issues that are more often cited as barriers to wider participation.

Structural issues

As discussed in section 5.2, structural elements of the Nordic market and bidding zone design may contribute to a lack of financial market liquidity. In particular, small bidding zones limit the size of the market for any EPAD product and limit the number of parties with a hedging interest in the associated

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product. Where zones are asymmetric in terms of local supply and demand, this may compound the problem, making it hard to find counterparties and further reducing liquidity. Although we have not examined the symmetry of specific zones in detail, limited analysis of historic Norwegian EPAD prices suggests that these prices are not significantly skewed up or down, as one might expect in a market with a significant imbalance. However, this could also reflect a willingness on the part of market participants to leave area-price risk unhedged rather than pay a significant premium.

It is in addressing these structural issues where we see the strongest argument for TSO intervention.

In theory, the bidding zones themselves could be redesigned, although we consider this to be a rather drastic option given the impacts on the entire physical market. Alternatively, regional EPAD products could be created, however, the effectiveness of this approach will depend on the existence of highly correlated constellations of bidding zones with balanced overall supply and demand.

Asymmetry could also be at least partly addressed by facilitating trading across bidding zone borders. TSOs are particularly well placed to enable supply and demand for EPADs to spill into neighbouring zones due to their exposure to the cross-zonal price spread, a result of their monopoly ownership of cross-zonal transmission assets. As discussed in sections 6.3 and 6.4, which cover TSO supply of transmission rights and EPADs respectively, TSOs can, by selling this exposure to the market, help facilitate trade between counterparties in neighbouring zones. The sale of transmission rights enables this through bridge-to-liquidity hedging. Auctions for EPAD Combos achieve this by having the TSO act as a sort of middleman, the counterparty to buyers and sellers in neighbouring zones.

We are sceptical about requiring TSOs to issue transmission rights for internal borders within the Nordic system. Market participants appear to have little interest in such rights for their own sake and any impact that transmission rights have on the liquidity of the products used for hedging, notably EPADs, will be indirect. Introducing transmission rights would significantly complicate the market design. It would also expose network tariff payers to a risk that these rights are sold below their fair value, a risk that is exacerbated by hedgers' limited interest in the product. In our view, requiring TSOs to supply existing financial products is far more likely to contribute to liquidity, given that it supports trade in the relevant products directly. We also believe that it poses less risk to network tariff payers since the products have a direct hedging value to a broader set of actors.

A requirement on TSOs to supply EPADs could be devised in such a way that the TSO had little to no discretion as to the volume or price offered. In this case, we consider that the administrative cost to the TSO would be small, relative to a case in which the TSO had to manage its own trading operation. Limiting the TSO's discretion should also help to minimise the risk of undermining the market's faith in the TSO's neutrality.

The extent of any requirement to supply EPADs placed on the TSO could vary. We have, in the box starting on page 28, sought to set out a mechanism for identifying a supply requirement that minimises revenue risk for tariff payers. We consider that a requirement structured in this way is as close as possible to a requirement to provide transmission right options. However, other means of defining the requirement, for example targeting the scale of structural asymmetry, can be envisaged. Different definitions of the requirement would imply different distributions of risk and revenue between consumption-network-tariff payers and the TSOs' commercial counterparties in the EPAD auctions. The acceptable and appropriate distribution of these risks and costs is a fundamental policy question.

Again, where structural issues are an important reason for a lack of liquidity, market-making may not be an appropriate solution. This is most obvious where illiquidity is the result of asymmetric supply and demand for EPADs in a specific zone. The clearing price of EPADs in such a zone will necessarily be skewed to ration supply or demand appropriately and to get the market to clear. Market-making may reduce the bid-ask spread, but it won't alter the fundamental balance of supply and demand. As such, it won't remove the mark-up or discount to the expected area price spread needed to get the EPAD market to clear. Ultimately, a significant number of interested actors may still be unable to find a counterparty. As noted above, asymmetry is, therefore, better addressed by options that help hedgers find counterparties in other bidding zones.

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Low liquidity and the absence of speculative trading

This is not to say that enhanced market-making is never appropriate. On the contrary, enhanced market-making would, perhaps more so than any of the options considered, directly address the symptoms of illiquidity. Specifically, enhanced market-making can reduce bid-ask spreads and guarantee the presence of bids and offers. However, it is important to consider whether the market-making solution is treating the symptoms of illiquidity or seeking to address an underlying cause.

As discussed in section 6.6, illiquidity may, in some sense, be self-reinforcing. In theory, therefore, promoting liquidity could alter the nature of the market, encouraging speculative trading of financial contracts and creating a sustainable liquid market. It is difficult for us to say with any confidence how likely such an outcome is. However, it is worth noting that the value of EPADs is always likely to be heavily dependent on detailed technical developments, for example local transmission capacity use and generation conditions. The complexity of price determination and its reliance on data which is often private means that it may be challenging to encourage considerable speculative investments by organisations that are not already heavily involved in the physical market.

Conclusion

In conclusion, the choice of option should ideally reflect an explicit diagnosis as to the causes of illiquidity. These causes may differ between products and a lack of liquidity may be the result of multiple causes. We identify four causes that are especially important to distinguish between, as they imply the need for different responses. These are:

- Market power,
- Barriers to participation,
- Structural issues (notably bidding zone asymmetry), and
- Low liquidity itself and the absence of speculative trading.

The case for TSO intervention is strongest when resolving structural issues, notably asymmetric bidding zones. Relevant options to address asymmetry include bidding zone redesign, the creation of regional EPADs or the introduction of EPAD supply requirements for the TSO. We believe that a TSO supply requirement based on existing products (notably EPADs) is likely to be better at supporting hedging opportunities than a requirement to supply transmission rights.

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APPENDIX – NORDREG METRICS

In this appendix, we present the NordREG metrics for the assessment of the Nordic forward market with a focus on the performance of Norway in particular. The metrics cover open interest, the trading horizon, traded volumes, bid-ask spreads, churn rates, ex-post risk premia and the correlation between various prices. These metrics have been calculated using data from Nasdaq.

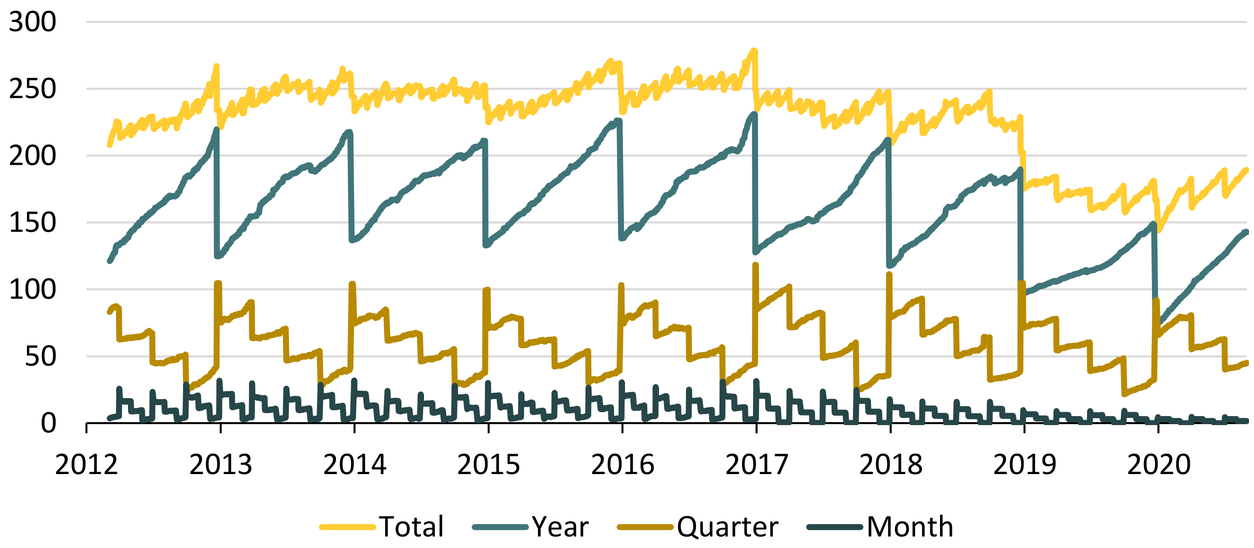
Open interest

Open interest refers to the total size of open positions with a clearinghouse at a given point in time. When a market participant wishes to hedge a physical exposure to the power price using financial derivatives, they will create an open position for the relevant contract and keep this position until delivery. When a speculator trades such contracts, he or she will typically open a position by buying or selling the relevant contract and then close this position at a later point by making an offsetting trade. For example, they will try to buy the contract when priced low and then sell it at a higher price. As such, information on the size, distribution and dynamics of open interest can be used to infer the volume of physical exposures that are being hedged and the composition of products used to construct these hedges.

For individual contracts, there will typically be a steady increase in open interest from the beginning of the trading period until the last trading day before delivery. This occurs as hedges are built up over time. Just ahead of delivery there is a sudden drop in open interest caused by cascading, the process by which open positions in a specific contract are transformed into open positions in shorter contracts covering the same delivery period. For example, open positions in a yearly contract are transformed into open positions in four quarterly contracts. The resulting drop in open interest in the yearly contract is therefore perfectly offset by the increase in open interest for quarterly contracts.

Figure 11 presents total open interest (TWh) for all Nordic system price contracts for the period included in the sample (04.03.2012 – 31.08.2020). Separate lines are shown for monthly, quarterly and yearly contracts.[16]

Figure 11: Open interest (TWh), Nordic system price contracts

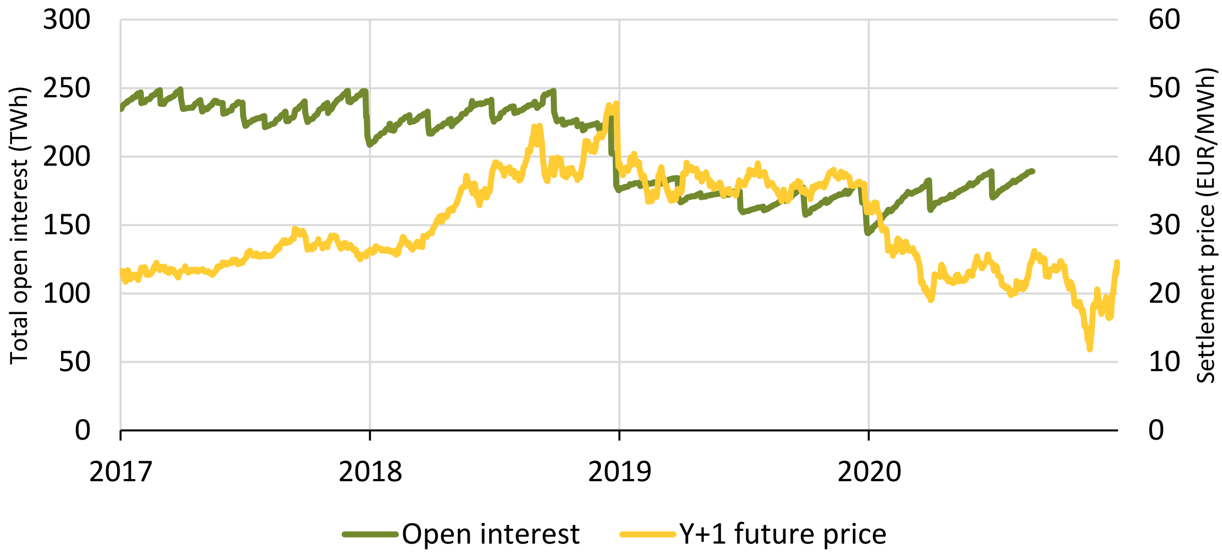


Source: Nasdaq

[16] Open interest for weekly contracts is low relative to other durations. The line for weekly contracts is therefore excluded from the figure, but the numbers are included in the total line.

The figure shows that the bulk of open interest in Nordic system price contracts is established in yearly contracts. It also shows that total open interest was stable from around 2013 to 2018, but there is a notable decline from the start of 2019. This decline suggests that the volume of exposures being hedged may have fallen.

Figure 12: Daily total open interest (TWh) against front year daily settlement price (EUR/MWh)



Data source: Nasdaq

Our work examining hedging strategies suggests that generators may adjust the share of their total exposures that they hedge based on their view of market fundamentals and the perceived downside risk. As such, they may reduce the volume of exposures hedged when they have little reason to fear lower prices. To examine whether price levels might have played a role in the decline in total open interest observed, Figure 12 shows total open interest against the settlement price of the front-year (Y+1) futures contract. In interpreting this chart, it is important to bear in mind that the direction of causality may also run the other way, with a lack of hedging demand depressing the price of futures contracts.

Prices for the 2020 contract were indeed much lower than those of the 2019 contract at the end of 2018, as shown by the significant drop in front-year prices at the start of 2019, i.e. when the front-year changes from 2019 to 2020. However, the prices of the 2020 contract, at just under 40 EUR/MWh, were not low compared to prices in earlier years. As such, it appears that low-price expectations alone are probably not responsible for the reduction in open interest from 2019.

Figure 13 shows, for any given delivery date, the open interest (MW) in Nordic system price contracts covering that date one month ahead, one quarter ahead and one year ahead of time. Thus, the line covering open interest one quarter ahead might include open interest from a combination of yearly, quarterly and monthly contracts with delivery periods covering the relevant date. Looking at the relative heights of the different lines helps to provide a sense of how far ahead the market is hedging, in aggregate, and how the composition of hedging is changing. The results show that open interest builds from a year out to a quarter out, suggesting that the market is still building up the hedge within-year. However, by a quarter ahead of delivery, most of the volume that is to be hedged will have been hedged.

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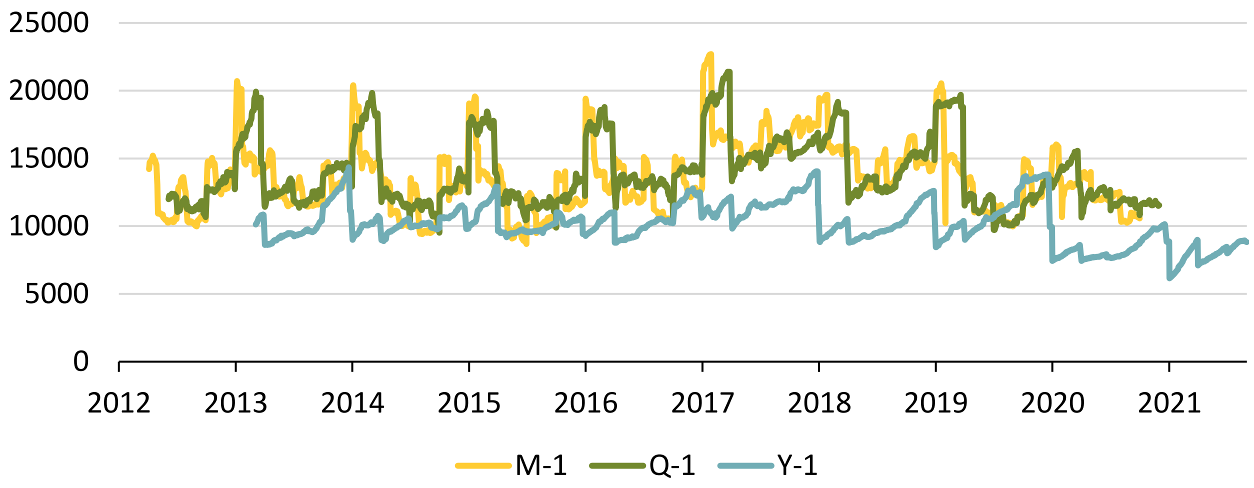
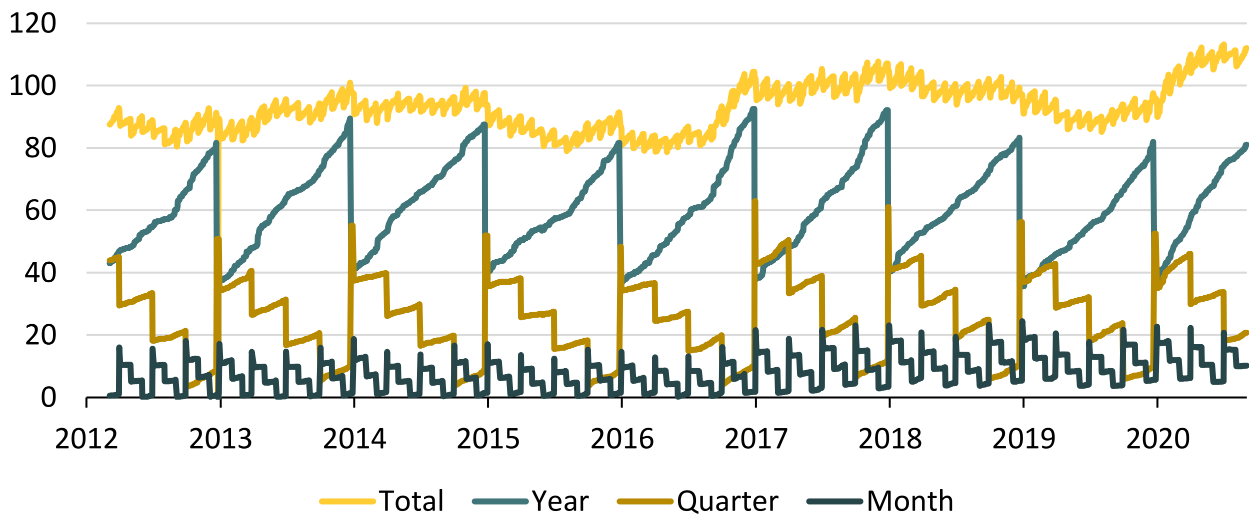
Figure 13: Open interest (MW), Nordic system price contracts, 1 year, quarter and month ahead, by delivery date



Data source: Nasdaq

Figure 14 shows open interest (TWh) for EPAD contracts for all bidding zones. Total open interest in EPAD contracts has been stable throughout the studied period. There is even a slight increase in the use of EPADs in 2020. This may reflect higher perceived area-price risk—2020 was marked by large water reserves in Norway and limited transmission capacity between Norway and Sweden due to transmission outages.

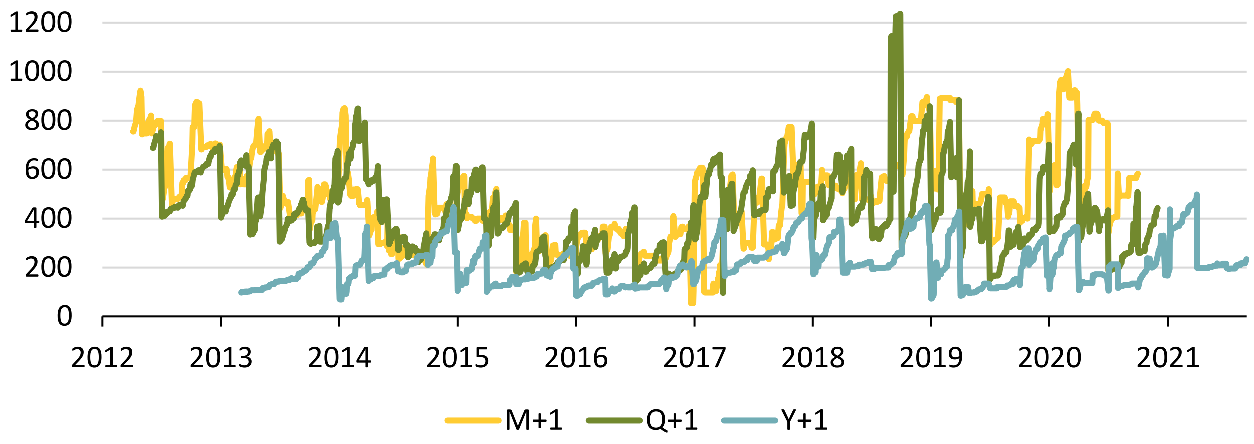
Figure 14: Open interest (TWh), EPADs, all bidding zones



Data source: Nasdaq

In Figure 15, we replicate the approach used for Figure 13 to show total open interest for a future delivery date but for EPADs. The figure shows open interest (MW) in EPADs for all bidding zones and all contracts with a delivery period one month ahead, one quarter ahead and one year ahead of time. The relatively large volumes of month-ahead open interest in 2020, especially in contrast to quarter-ahead interest, may indicate that the market was becoming increasingly concerned about the need to manage area-price risk just a few months ahead of delivery.

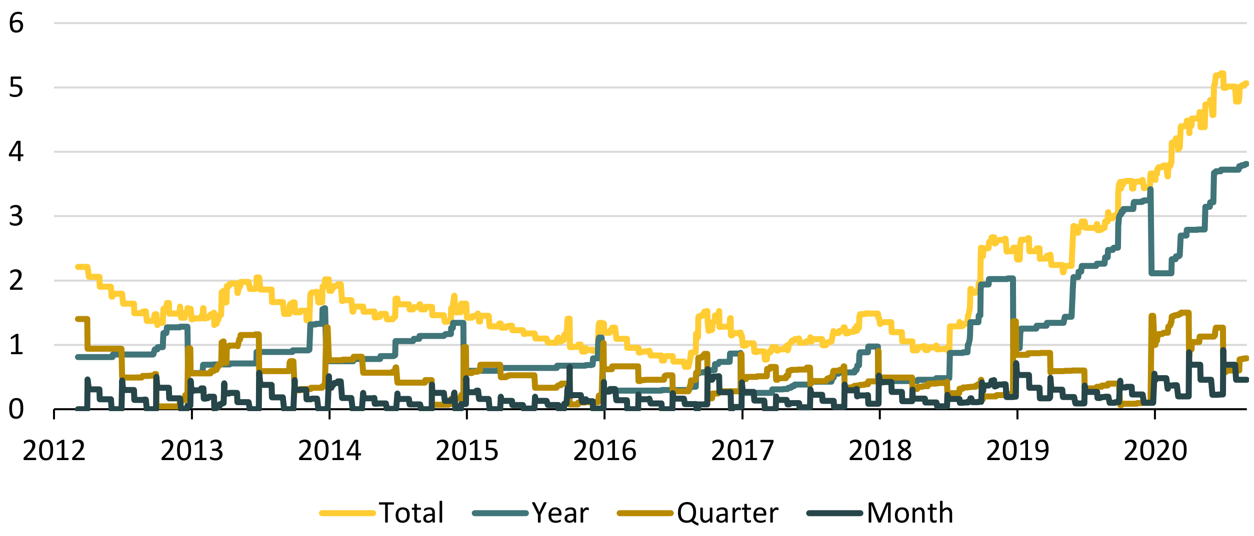
Figure 15: Open interest (MW), EPADs, all bidding zones, 1 year, quarter and month ahead, by delivery date



Data source: Nasdaq

We have also looked at developments in the NO1 bidding zone specifically. Figure 16 shows open interest (TWh) for EPAD contracts for NO1 (Oslo). Over the last two years, there has been a noticeable increase in open interest for the NO1 EPAD. Most of this increase has been in yearly contracts.

Figure 16: Open interest (TWh), NO1 (OSL) EPAD

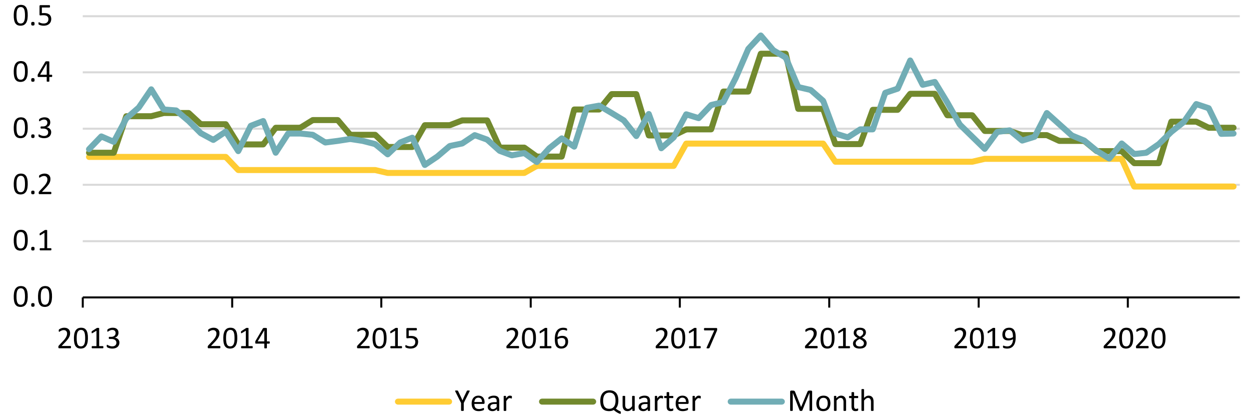


Data source: Nasdaq

Open interest in relation to physical consumption

By dividing open interest by physical consumption, we can get an indication of the share of physical consumption that is hedged in the futures market. Figure 17 shows, for monthly, quarterly and yearly contracts, the open interest recorded for the contract shortly prior to delivery divided by total physical consumption in the relevant delivery period. Note that since yearly contracts cascade into quarterly contracts etc., total open interest tends to grow as we move from longer to shorter contracts. The results show that this measure has remained largely stable throughout the studied period, at around 0.2–0.4. Again, this suggests that Nordic system price futures hedge something like 20–40% of physical consumption in the Nordics.

Figure 17: Open interest in relation to physical consumption, Nordic system contracts



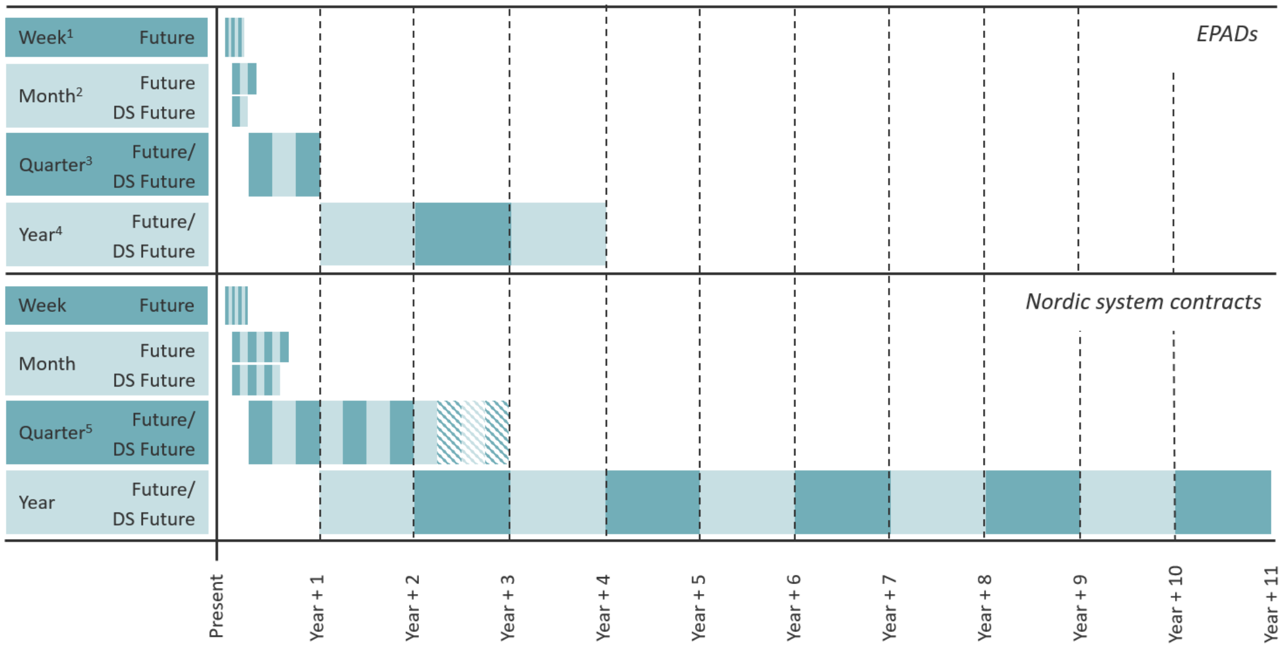
Data source: Nasdaq; Nord Pool

Trading horizon

The trading horizon is a descriptive measure and sets out the different listed series that can be traded and cleared on the exchange. This describes the technical hedging opportunities that exist via exchange-based derivatives.

Figure 18 shows the trading horizon for different contract types on Nasdaq, including EPADs and Nordic system contracts.

Figure 18: Trading horizon for different contract types, EPADs and Nordic system contracts[17]



Notes: [1]*Weekly EPADs exist only for Swedish and Finnish bidding zones.*
[2]*Monthly Futures have three listed series for Norwegian, Danish, Estonian and Latvian areas and four listed series for Swedish and Finnish areas; Monthly DS Futures have two listed series for Norwegian, Danish, Estonian*

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[17] *Futures contracts* refer to contracts with daily (mark-to-marked) settlement against the closing price during the trading period. For *Deferred Settlement (DS) Futures*, there is no settlement during the trading period, and the (mark-to-market) settlement accumulates throughout the trading period, and then is realized in the delivery period.

and Latvian areas and four series listed for Swedish and Finnish areas.
[3]Both quarterly contract types have three series listed for Norwegian, Danish, Estonian and Latvian areas and four series listed for Swedish and Finnish areas.
[4]Both yearly contract types have three series listed for Norwegian, Danish and Estonian areas, two series listed for Latvian areas and four series listed for Swedish and Finnish areas.
[5]The number of concurrently listed quarterly futures varies from eight to eleven, shown here by the striped area. The reason for this variation is that the quarterly contracts are added for one year (four quarters) at a time. There are always series listed for the next two years (eight quarters) and, in the first quarter of the year, a new full third year is added to the listed series, making eleven series (two years and three quarters) in total.

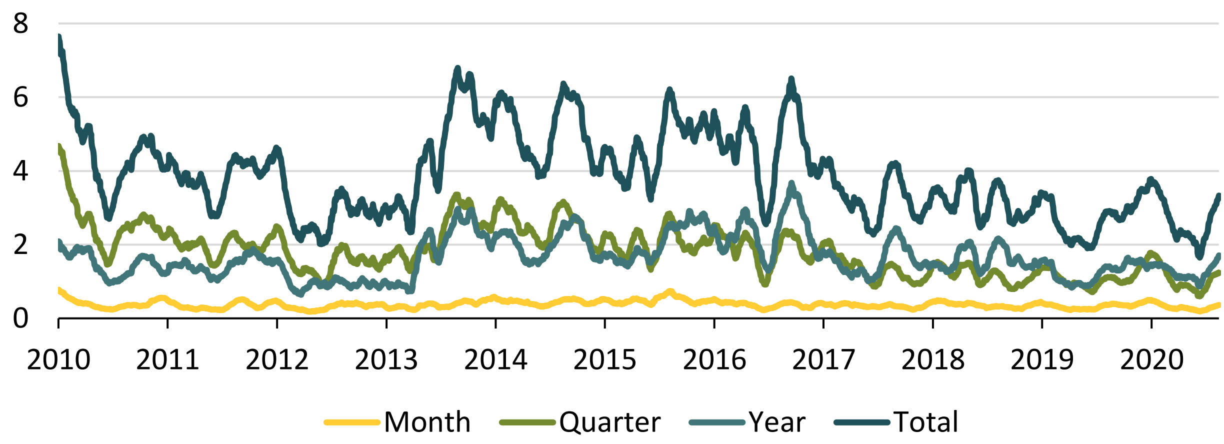
Traded volumes

Traded volumes show the number of MWh bought and sold during a specific period. Larger volumes will tend to indicate more active trade and suggest that the market for the relevant product is more liquid.

Figure 19 shows daily traded volumes (TWh) for monthly, quarterly and yearly Nordic system price contracts.[18] Note that the traded volumes are averaged over a rolling time window of 45 days, backward from the date shown, to make trends easier to see. The traded volumes shown have been compiled using end-of-day totals covering the period 04.01.2010-22.10.20. The traded volumes in the end-of-day data include exchange-traded volumes only, and will therefore not include cleared over-the-counter volumes.

The results show total daily traded volumes in Nordic system price contracts to be in the range of 2–6 TWh. Total volumes appeared to increase between 2014 to 2017 and to have fallen back in recent years. Most of the traded volumes concern the trade of quarterly and yearly contracts, implying that these contracts are more liquid than monthly contracts.

Figure 19: Traded volumes (TWh) Nordic system

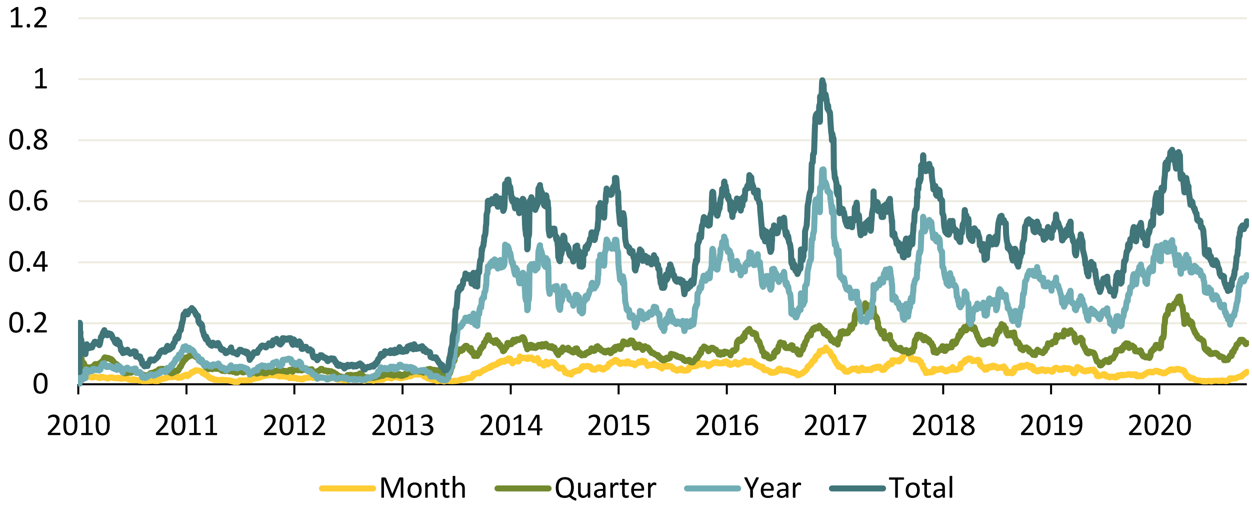


Data source: Nasdaq
Note: The traded volumes are averaged over a rolling time window of 45 days, backward.

Figure 20 shows daily traded volumes (TWh) of EPADs for all bidding zones for monthly, quarterly and yearly contracts. Daily traded volumes for EPADs have been around the 0.5 TWh level for several years.

[18] Total traded volumes of weekly contracts are low relative to other durations and are therefore excluded from the figure. Total traded volumes of weekly contracts are included in the total line.

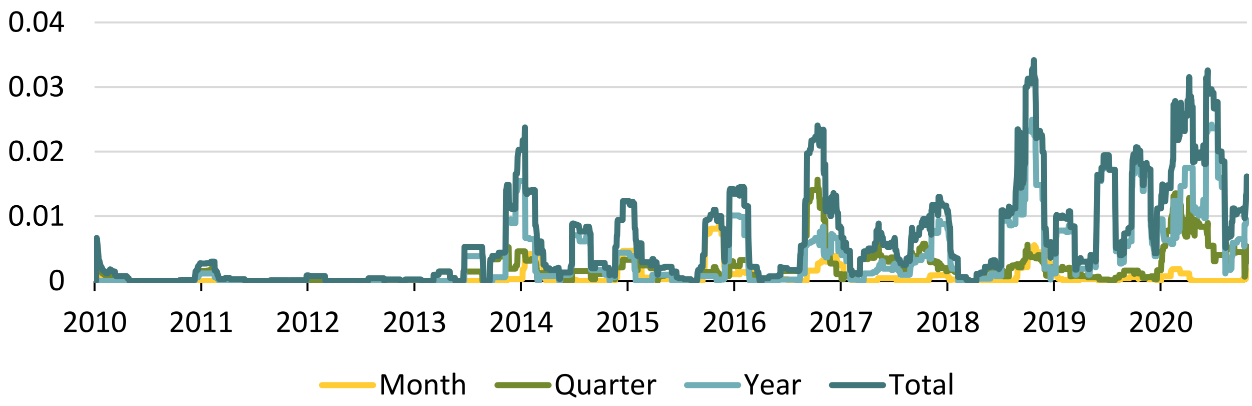
Figure 20: Daily traded volumes (TWh) of EPADs (all bidding zones)



Data source: Nasdaq
Note: The traded volumes are averaged over a rolling time window of 45 days, backward. There was a re-organisation of the markets in 2013. Early Contracts for Differences were renamed EPADs.

Figure 21 shows daily traded volumes (TWh) for the NO1 (Oslo) EPAD for monthly, quarterly and yearly contracts. Traded volumes pick up in 2020. This mirrors the uptick observed in open interest and suggests that greater volumes are being hedged using the NO1 EPAD. The relatively large increase in the trading of quarterly EPADs at the start of 2020 may reflect the loss of more than half of southern Norway's export capacity after an anchor damaged the Outer Oslo fjord connection in mid-February. This significantly reduced transmission capacity from eastern Norway to central Sweden (NO3) and contributed to atypically low prices in NO1.

Figure 21: Traded volumes (TWh) of NO1 (Oslo) EPAD



Data source: Nasdaq
Note: The traded volumes are averaged over a rolling time window of 45 days, backward.

Traded volumes in relation to physical consumption/Churn rate

The ratio between total traded volumes and total electricity consumption gives the churn rate. This provides an indication of how many times a MWh of power is traded before it is delivered to the final consumer.

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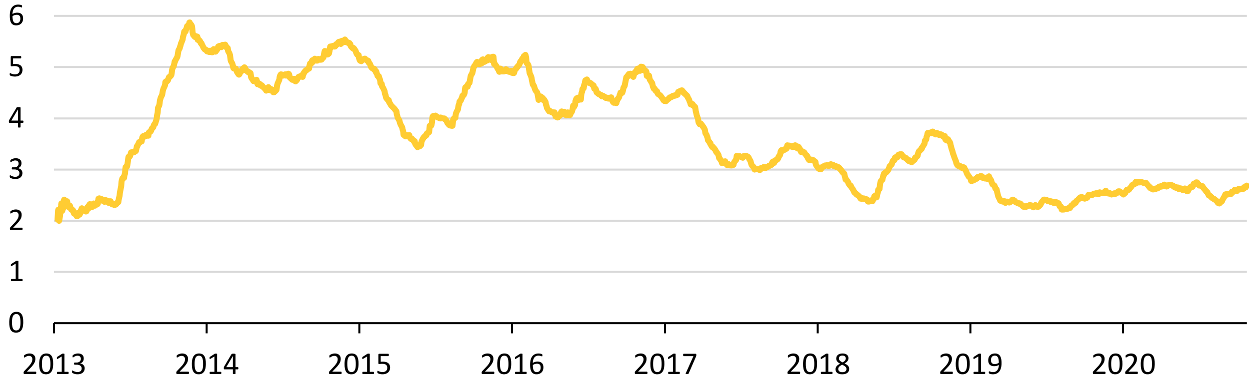
Figure 22 shows, for each date, the daily traded volumes in Nordic system contracts in relation to daily physical consumption in the Nordic system.[19] The figure shows a decline in the churn rate over the last six years, reaching a level of around 2 in 2019.

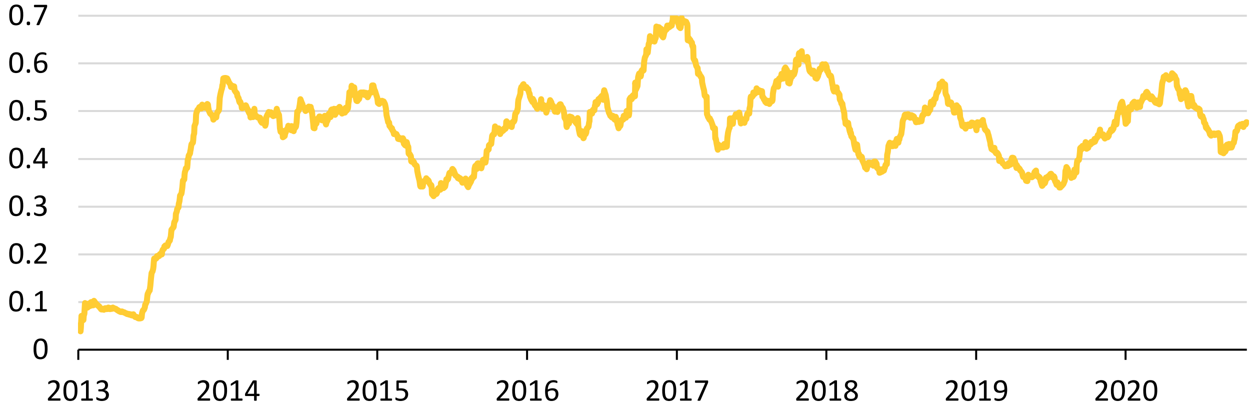
Figure 22: Traded volumes in relation to physical consumption (Churn rate), Nordic system



Data source: Nasdaq; Nord Pool
Note: The churn rate is averaged over a rolling time window of 120 days, backward.

Figure 23 shows daily traded volumes in EPAD contracts (all bidding zones) in relation to daily physical consumption in the Nordic price areas. There is no obvious trend in the churn rate of all EPADs, which has held steady at roughly 0.4 to 0.6 over the last six years.

Figure 23: Traded volumes in relation to physical consumption (Churn rate), EPADs (all)



Data source: Nasdaq; Nord Pool
Note: The churn rate is averaged over a rolling time window of 120 days, backward.

Figure 24 shows the daily traded volumes in each Norwegian EPAD contract in relation to daily physical consumption in that bidding zone. As can be seen, these EPADs have churn ratios that are relatively low in comparison to the all-EPAD equivalent, implying relatively low volumes of trade given the level of consumption in the zone.

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[19] Note that, strictly speaking, the volumes traded will be for different delivery periods with levels of consumption that are different from the date on which the trades occur. As such, it only makes sense to look at broad changes over time.

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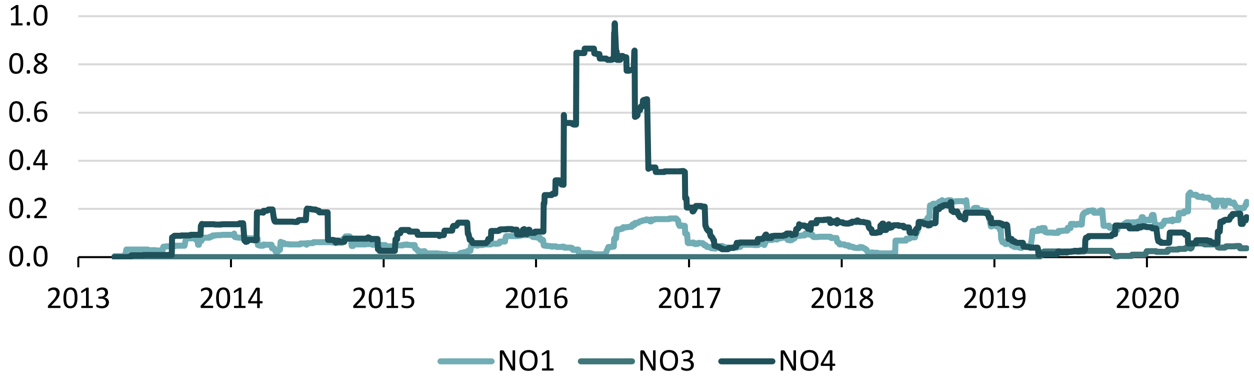
Figure 24: Traded volumes in relation to physical consumption (Churn rate), EPADs



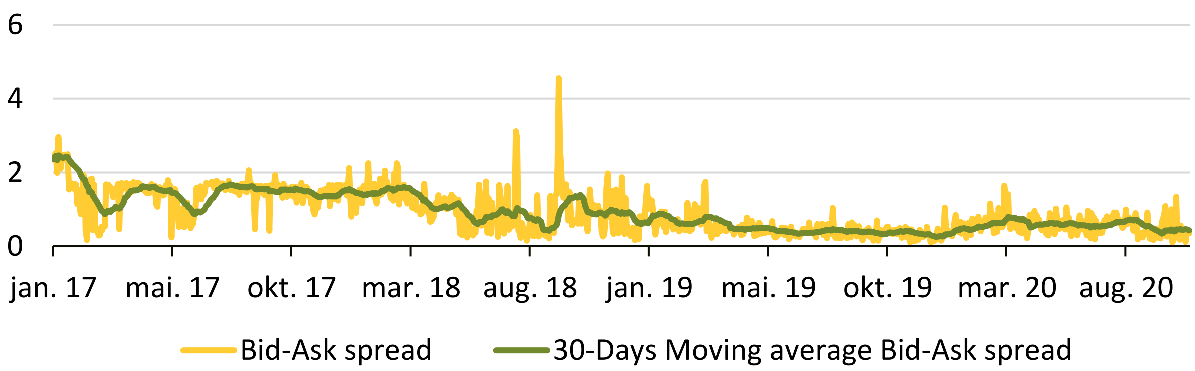
Data source: Nasdaq; Nord Pool
Note: The churn rates are averaged over a rolling time window of 120 days, backward.

Bid-ask spreads

The bid-ask spreads are calculated using data on daily best bids and best asks for each traded contract. The data contained a number of seemingly spurious zero values. To remove these data points from the results, days with non-positive best bids or non-positive best asks are filtered out of the dataset and are not included in the calculations.[20]

Figure 25 to Figure 29 show the absolute bid-ask spread for all Nordic system price futures and DS futures. For each date within each contract category (daily, weekly, monthly, quarterly and yearly contracts), the data is averaged over all traded contracts (with varying time to delivery). Then, for the remaining dates with no trading, spreads are inferred by (linear) interpolation. These figures show the daily bid-ask spreads averaged over a (backward) rolling time window of 30 days.

Figure 25: Absolute bid-ask spread, Nordic yearly power futures (EUR)



[20] Note that although this filter could conceivably remove (valid) datapoints with two non-zero values, all the removed datapoints contain at least one zero or blank entry.

Figure 26: Absolute bid-ask spread, Nordic quarterly power futures (EUR)

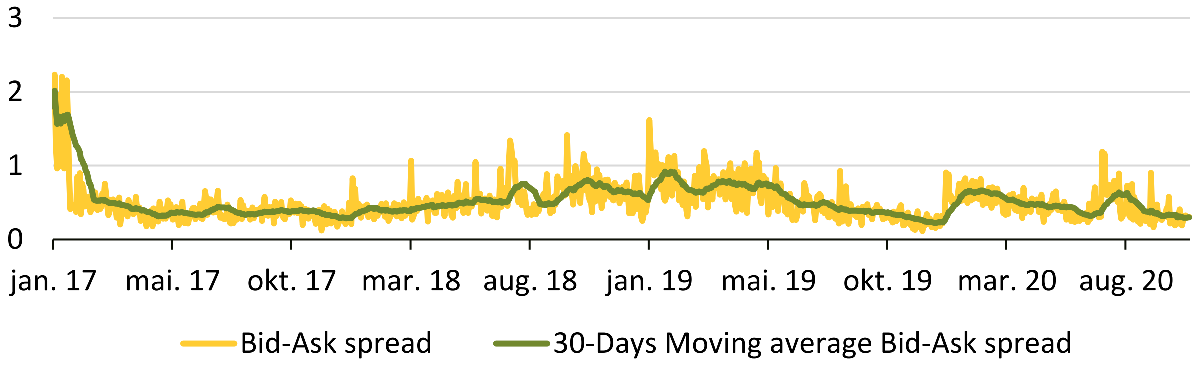


Figure 27: Absolute bid-ask spread, Nordic monthly power futures (EUR)

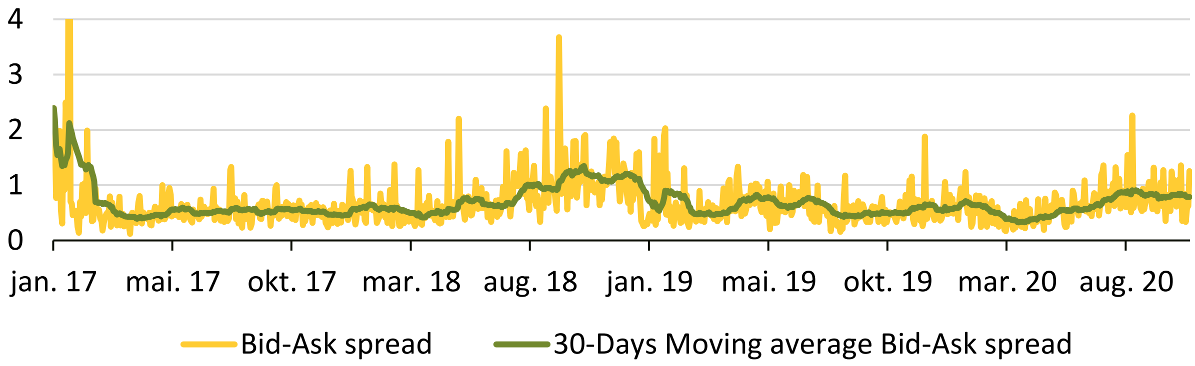


Figure 28: Absolute bid-ask spread, Nordic weekly power futures (EUR)

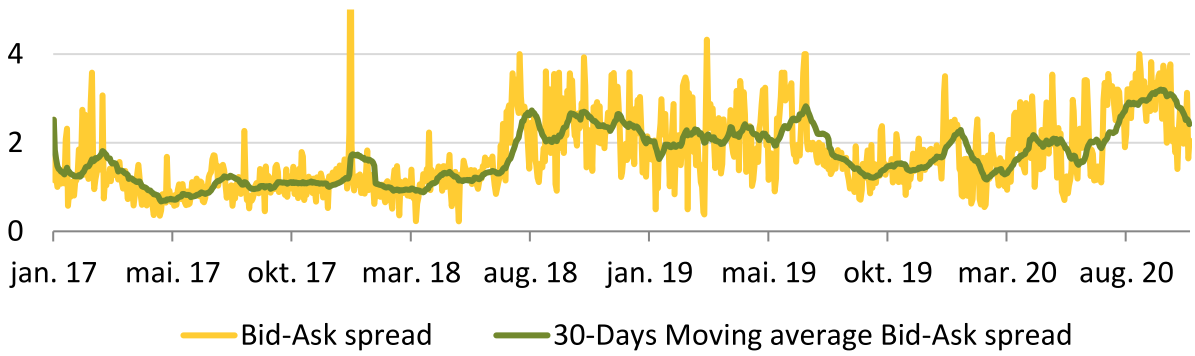


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Figure 29: Absolute bid-ask spread, Nordic daily power futures (EUR)

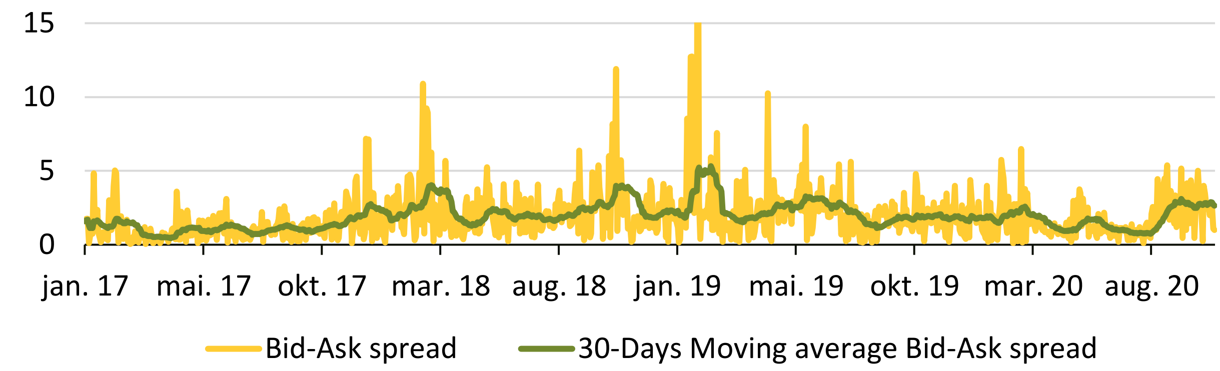

Figure 30 to Figure 32 show the absolute bid-ask spreads for the Norwegian, Swedish, Danish, and Finnish EPAD contracts. Similar to the power base futures, the bid-ask spreads are averages over all contract types and linearly interpolated for days without trading. The results shown in these figures are averaged over a (backward) rolling time window of 30 days. For the quarterly and monthly contracts shown in Figure 31 and Figure 32, a spike in spreads can be observed in the first quarter of 2020 for the Swedish and Finnish price areas. Before this event, the spreads in the Swedish and Finnish zones seem, for the most part, but with a few exceptions, to be capped at 1.0 EUR/MWh. It may be that limits on the acceptable bid-ask spread for the market-maker were relaxed at this point due to the stress placed on the Nordic system in 2020 by the combination of a record-high hydrological balance in Norway and limited transmission capacity between Norway and Sweden due to outages. The traded volume of Norwegian EPAD contracts is low and no data prior to May 2019 is available. Table 9 shows some summary statistics for Nordic Power contracts and selected EPAD contracts. It can be seen that the number of data points available for the OSL EPAD contracts are significantly lower than all Swedish and Danish EPAD contracts.

Figure 30: Absolute bid-ask spread, EPAD yearly contracts

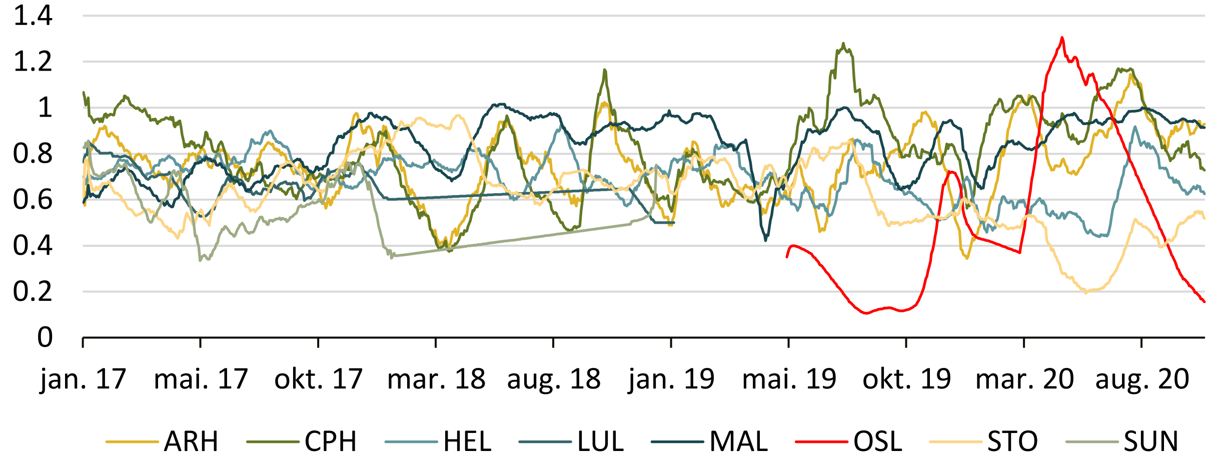

Figure 31: Absolute bid-ask spread, EPAD quarterly contracts

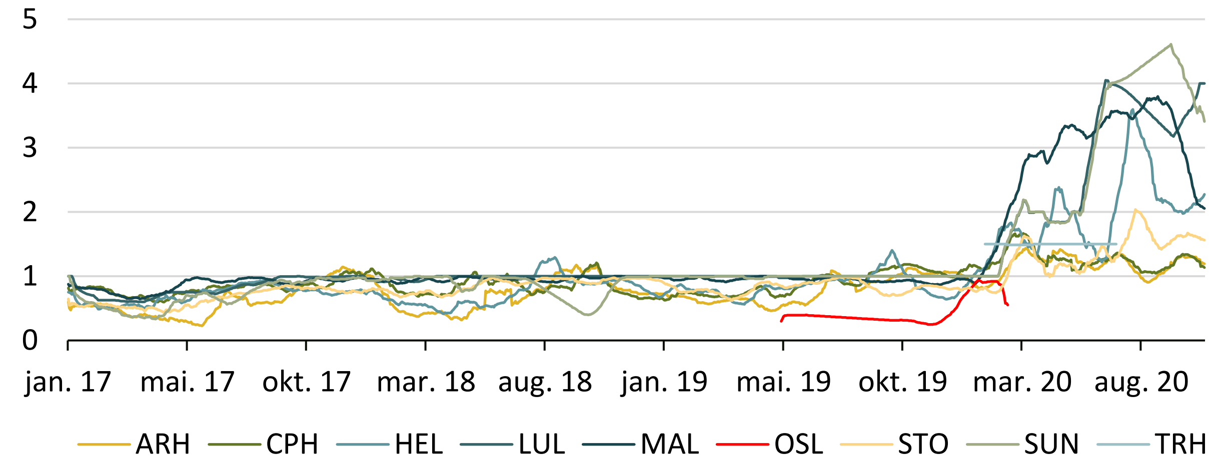

Figure 32: Absolute bid-ask spread, EPAD monthly contracts

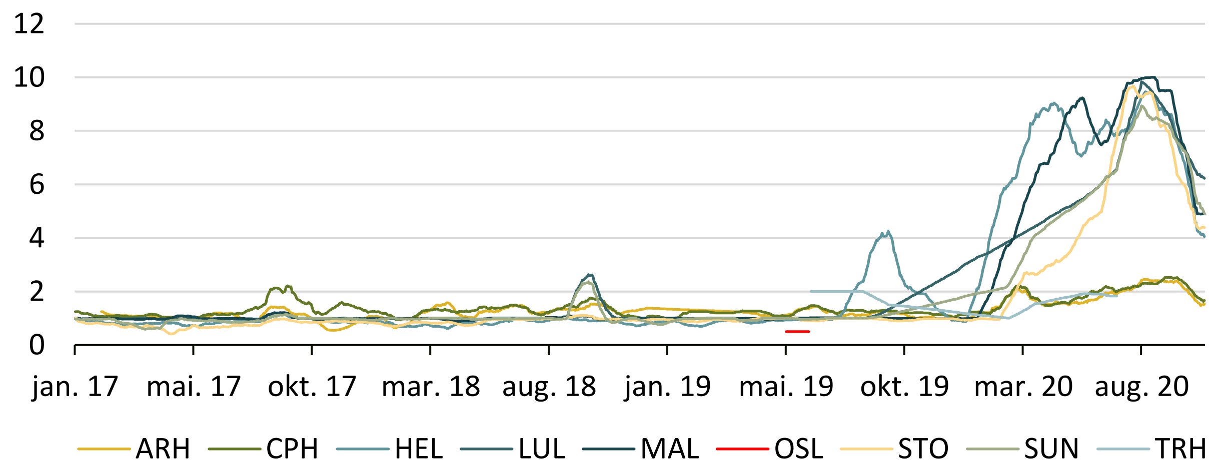

Table 9 Bid-Ask spread summary statistics for selected Nordic Power contracts and selected EPAD contracts

Main Category	EPAD area	count	mean	std	min	25 %	50 %	75 %	max
Power Base	N/A	2482	0.5207	0.6479	0.01	0.12	0.25	0.65	4.5
Power EPAD	ARH	1298	0.7678	0.3428	0.05	0.55	0.75	0.95	2.2
	CPH	1297	0.882	0.3679	0.1	0.6	0.85	1.25	3
	HEL	1804	0.6435	0.3429	0.02	0.35	0.6	1	2.1
	MAL	1774	0.8591	0.2329	0.05	0.75	1	1	1
	OSL	62	0.756	0.476	0.09	0.225	0.95	1.1	1.8
	RIG	707	4.4832	1.4061	0.75	3.275	4.5	6	6.5
	STO	1788	0.5546	0.3491	0.05	0.2	0.5	1	1
	TAL	6	6.3833	1.4905	4.7	5.1	6.35	7.75	8

Figure 33 and Figure 34 show bid-ask spreads vs. time to delivery for each type of contract. The x-axis shows the days until the delivery period starts. In each figure, the hue indicates different relative contracts. So, for example, the chart for yearly contracts shows bid-ask spreads for the next delivery year (Y+1) as light teal at the far left of the chart. By definition, Y+1 contracts are traded between 1 and 365 days ahead of delivery. The next colour from the left shows the bid-ask spreads for Y+2 contracts and so on. The same logic applies for different contract durations. For example, the chart for weekly contracts shows the bid-ask spread for W+1 contracts in one colour, W+2 in another and so on. The solid dark lines indicate the median value, whilst the lighter shaded region indicates an estimated 95% confidence interval.

We would expect bid-ask spreads to be driven, at least in part, by uncertainty as to the spread between area and system prices. Assuming this uncertainty diminishes closer to delivery, we would expect the bid-ask spread to narrow. However, this pattern is not clearly visible for most of the contract durations below.

Figure 33: Bid-ask spread vs. time to delivery for Nordic power futures

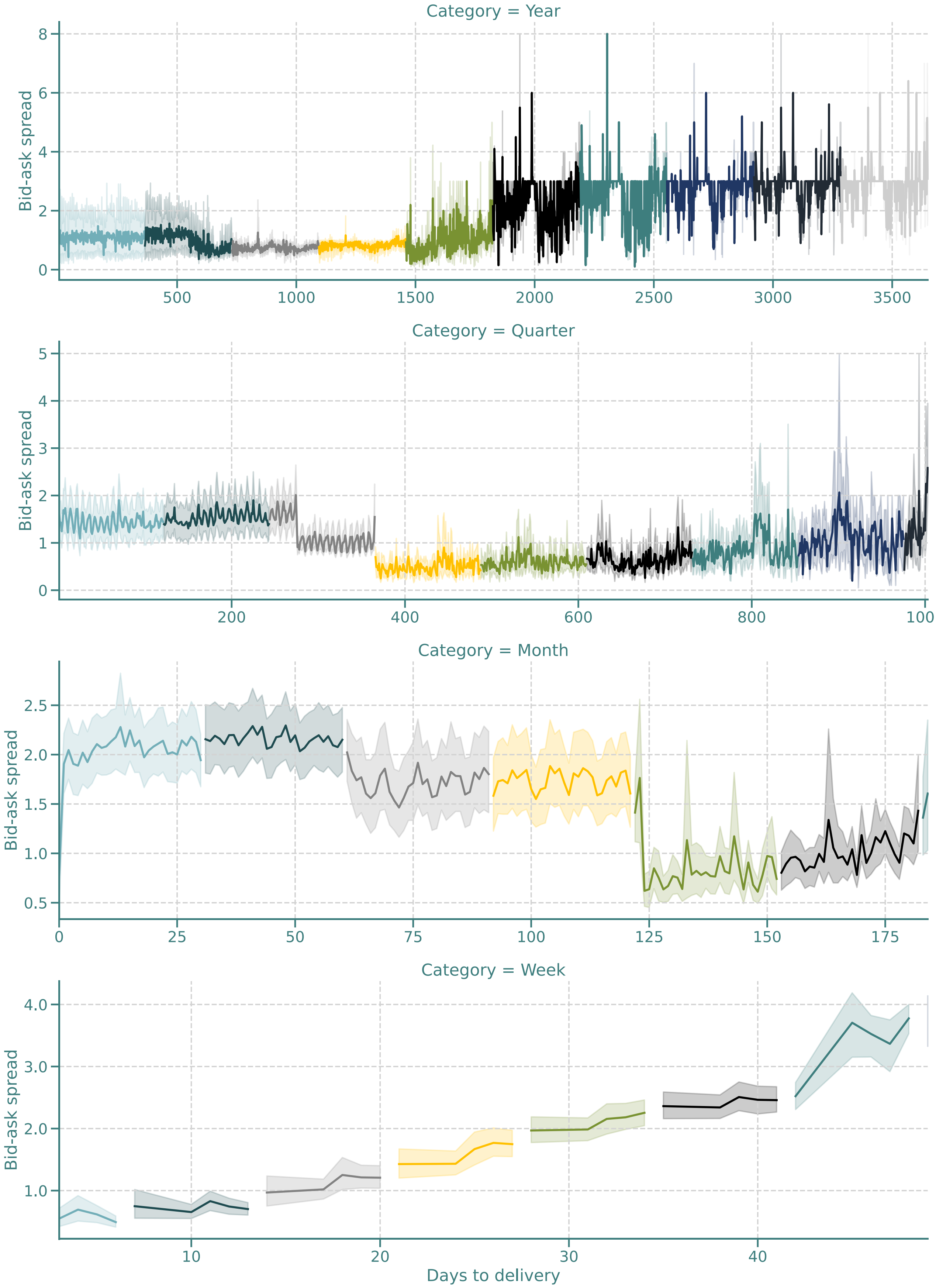

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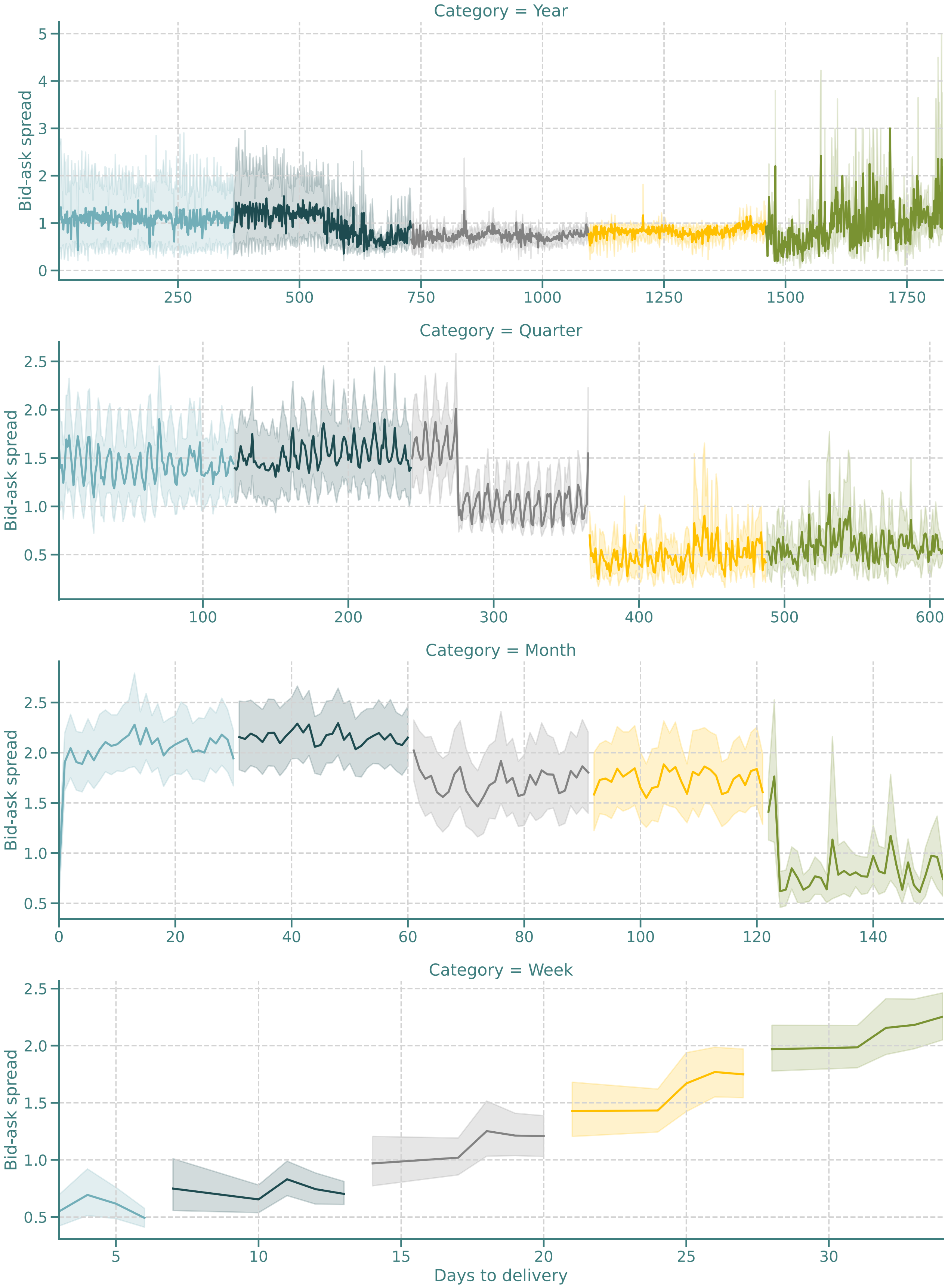
Figure 34: Bid-ask spread vs. time to delivery for EPAD contracts



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Ex-post risk premiums

One way of investigating any systematic biases in the pricing of power derivative contracts is to calculate ex-post risk premiums. The ex-post risk premium for any contract is simply the difference between the contract's closing price and the reference price during its delivery period. By looking at these premia over time, we can see if there is a systematic difference between these two prices. The ex-post risk premium can be interpreted as a mark-up or reduction on the price of power that must be borne by traders, suppliers or consumers, in order to hold the price risk. Any such mark-up or discount may reflect the willingness of risk-averse market participants to pay (accept) a risk premium (discount) for transferring the price risk. However, it could also denote inefficiency in the market. From the available data and empirical analysis, we cannot distinguish between the two directly.

It is important to note that there will typically be a difference between the closing value of a futures contract and resultant spot prices due purely to forecasting error. This error is captured in the calculated ex-post risk premia. As such, we can only infer the size of any ex-ante risk premium by looking at the ex-post premia over time and assuming that forecasting errors are not systematically different from zero.

To test whether the ex-post risk premia are different from zero, i.e. whether there is a systematic mark-up or reduction in prices, we use a t-test. Statistically significant results suggest that futures prices appear to be systematically different from the underlying spot prices during the delivery period.

The results from these t-tests are shown below. The ex-post risk premia for system price futures are calculated as the difference between the contract price on the last trading day before the delivery period and the average spot price over the delivery period. For the EPAD-contracts, we use the difference between the contract price on the last trading day before the delivery period and the average spread between the system price and the area price over the delivery period. We have tested whether these premia are significantly different from zero in either direction.

None of the tests show ex-post risk premia that are significantly different from zero. This implies that contract prices are a reflection of the underlying reference price and do not contain a mark-up or discount to expectations of the underlying reference price.

We have done tests for autocorrelation with Durbin Watson statistics. Some of the contracts had significant autocorrelation at a five percent level of significance. As such, some of the OLS estimates below may biased, however the conclusion of no significant results should be robust.

Table 10: Ex-post risk premiums, monthly contracts

Area	Obs.	Mean	Min	Max	Std. Dev	t stat	t crit (5%)	p value	Significant 5% level	95% CI lower	95% CI upper
System DS	129	0.83	-19.65	25.53	5.12	1.84	1.98	0.07	No	-0.06	1.72
System non-DS	61	0.37	-7.80	10.67	3.82	0.76	2.00	0.45	No	-0.61	1.35
Oslo DS	88	0.07	-2.80	4.82	1.26	0.55	1.99	0.58	No	-0.19	0.34
Oslo Non-DS	61	-0.12	-2.80	2.81	1.11	0.82	2.00	0.42	No	-0.40	0.17
Tr.heim non DS	16	0.27	-3.36	3.10	1.47	0.74	2.13	0.47	No	-0.51	1.06
Tromsø DS	88	-0.25	-4.28	5.01	1.75	1.32	1.99	0.19	No	-0.62	0.12
Tromsø non-DS	61	-0.41	-4.28	5.01	1.85	1.76	2.00	0.08	No	-0.89	0.06

Data source: Nasdaq

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Table 11: Ex-post risk premium, quarterly contracts

Area	Obs.	Mean	Min	Max	Std. Dev	t stat	t crit (5%)	p value	Significant 5% level	95% CI lower	95% CI upper
System DS	42	1.03	-11.56	19.71	6.11	1.09	2.02	0.28	No	3.31	-1.26
System non-DS	20	-0.41	-6.67	19.71	6.08	0.30	2.09	0.76	No	1.86	-2.68
Oslo DS	29	0.00	-2.46	3.11	1.13	0.02	2.05	0.99	No	0.43	-0.42
Oslo Non-DS	20	-0.16	-2.46	1.75	1.02	0.70	2.09	0.50	No	0.22	-0.54
Tr.heim non DS	5	0.51	-0.91	3.12	1.53	0.75	2.78	0.50	No	1.09	-0.06
Tromsø DS	29	-0.03	-4.48	4.29	1.84	0.09	2.05	0.93	No	0.65	-0.72
Tromsø non-DS	20	0.01	-2.51	4.29	1.90	0.02	2.09	0.98	No	0.72	-0.70

Data source: Nasdaq

Table 12: Ex-post risk premium, yearly contracts

Area	Obs.	Mean	Min	Max	Std. Dev	t stat	t crit (5%)	p value	Significant 5% level	95% CI lower	95% CI upper
System DS	9	1.78	-18.56	14.95	10.24	0.52	2.31	0.62	No	9.65	-8.97
System non-DS	4	-4.86	-18.56	8.29	11.35	0.86	3.18	0.45	No	13.20	-16.77
Oslo DS	8	0.72	-0.41	3.13	1.24	1.64	2.36	0.14	No	1.75	-0.58
Oslo Non-DS	4	-0.07	-0.41	0.42	0.35	0.39	3.18	0.72	No	0.50	-0.44
Tromsø DS	6	0.18	-1.78	1.65	1.47	0.29	2.57	0.78	No	1.72	-1.36
Tromsø non-DS	4	0.30	-1.07	1.60	1.25	0.48	3.18	0.67	No	2.29	-1.01

Data source: Nasdaq

Figure 35 below shows the distribution of ex-post risk premia in the form of histograms with observation counts on the y-axis and premia in EUR/MWh on the x-axis.

Figure 35: Ex-post risk premium, Monthly contracts

Data source: Nasdaq

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Correlation

The correlation analysis below helps to show the extent to which different instruments represent reasonable proxies for hedging exposure to a specific power price. Thus, we can get a sense, for example, of to what extent one can hedge NO2 price risk using an NO1 EPAD. Good proxy hedges provide market participants with additional opportunities to hedge power price risk.

Table 13 shows the correlation of calendar-month-average spot prices. It covers the Norwegian bidding zones and the Nordic System price for the period 01.01.2015 to 31.11.2020. The use of monthly average prices reflects an assumption that market participants are not concerned about deviations in prices over shorter periods and will therefore be satisfied if prices are well correlated from month to month.[21]

It is critical to note that this analysis is exclusively backward-looking and limited to the stated period between 2015 and 2020. Changes in pricing dynamics brought about by the commissioning of new interconnectors and the development of new generation capacity may alter the extent of price correlation between zones in the future.

The results show a high degree of correlation between prices in the Norwegian bidding zones and the Nordic system price. Indeed, there appears to be a perfect correlation between NO1, NO2 and NO5 monthly-average prices.

Table 13: Correlation, monthly average spot, last five years

	NO1	NO2	NO3	NO4	NO5	SYS
NO1	1.00					
NO2	1.00	1.00				
NO3	0.99	0.99	1.00			
NO4	0.98	0.98	0.98	1.00		
NO5	1.00	1.00	0.98	0.98	1.00	
SYS	1.00	0.99	0.99	0.98	0.99	1.00

Source: THEMA calculations, Montel data

Table 14 shows the correlation of calendar-month averages of the difference between the system price and the bidding zone price for each of the Nordic bidding zones, covering the period 01.01.2015 to 31.11.2020. This difference or spread is the underlying reference of EPAD contracts.

Among those Norwegian bidding zones with exchange-traded EPADs (NO1, NO3 and NO4), there is little correlation among the associated spreads. This implies the presence of different local price dynamics in these zones and potentially justifies the existence of different hedging products for them. For those Norwegian bidding zones currently without exchange-traded EPADs (NO2 and NO5), the system-price spread has been reasonably well correlated with the spread between the system and NO1 price. If the NO1 EPAD is a reasonable proxy for those wishing to hedge area-price risk in NO2 and NO5, it might be appropriate to pool liquidity into a single (NO1) EPAD rather than have distinct products for each bidding zone. However, even these relatively high levels of monthly correlation may hide potentially important differences. For example, retailers trying to hedge a fixed-price contract may still be exposed to significant risk if the timing of consumption under their contract tends to occur during those hours in which price variations are most prevalent. In this case, a strong monthly correlation may be insufficient to form a useful hedge.

The chart shows that there is a negative correlation between Norwegian spreads and those in the Swedish and Danish bidding zones.

[21] See section 3.2.4 of Bjørndalen et al., "Methods for Evaluation of the Nordic Forward Market for Electricity" for a discussion of appropriate time thresholds for the correlation analysis.

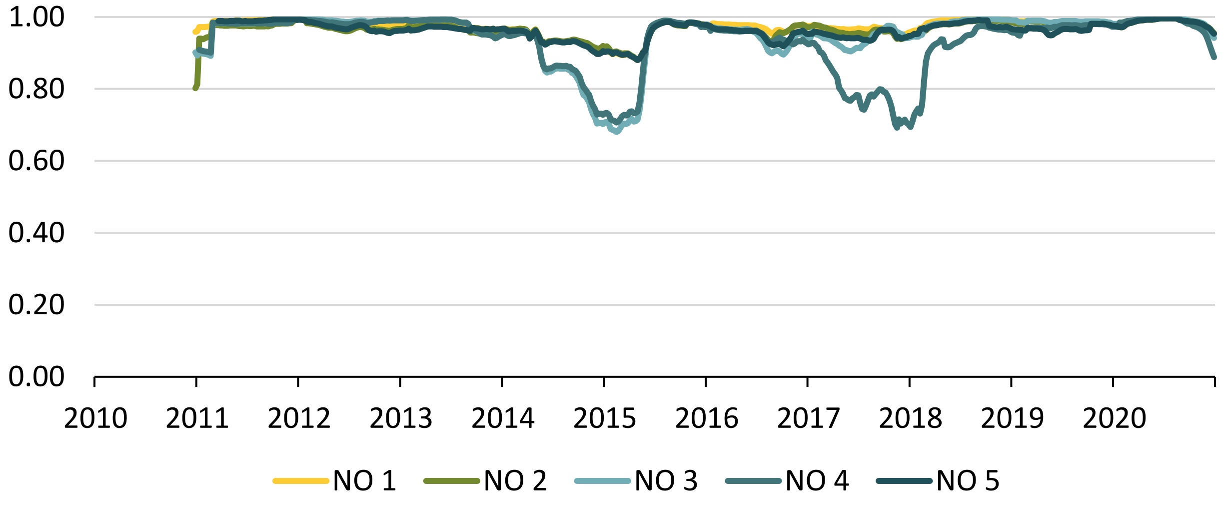
Table 14: Correlation, monthly-average spot-price spreads, last five years, EPADs

	NO1-SYS	NO2-SYS	NO3-SYS	NO4-SYS	NO5-SYS	SE1-SYS	SE2-SYS	SE3-SYS	SE4-SYS	DK1-SYS	DK2-SYS
NO1-SYS	1.00										
NO2-SYS	0.85	1.00									
NO3-SYS	-0.01	-0.09	1.00								
NO4-SYS	-0.01	0.12	0.29	1.00							
NO5-SYS	0.86	0.96	-0.12	0.06	1.00						
SE1-SYS	-0.72	-0.72	0.01	-0.40	-0.71	1.00					
SE2-SYS	-0.72	-0.72	0.01	-0.40	-0.71	1.00	1.00				
SE3-SYS	-0.66	-0.64	-0.18	-0.24	-0.62	0.78	0.78	1.00			
SE4-SYS	-0.60	-0.54	-0.25	-0.15	-0.54	0.68	0.68	0.93	1.00		
DK1-SYS	-0.61	-0.46	-0.31	-0.14	-0.48	0.67	0.67	0.85	0.91	1.00	
DK2-SYS	-0.62	-0.53	-0.24	-0.11	-0.54	0.66	0.66	0.90	0.96	0.97	1.00

Source: THEMA calculations, Montel data

To give further insight into the trend of the correlations between the relevant price areas, we expand this analysis by looking at the development of the correlation over the last decade. First, we show in Figure 36 the correlation in weekly average spot prices between the Nordic system price and the relevant bidding zones for the period 2010 to 2020. The figure shows the correlation in the weekly average spot prices over a rolling time window of one full year, backward, meaning the data point for the last week of 2010 shows the correlation of the full year of 2010. Following this approach, Figure 37–Figure 41 show the equivalent results from the perspective of the NO2, NO1, NO3, NO4 and NO5 bidding zones, respectively.

Figure 36: Correlation, weekly average spot, between Nordic System price and relevant bidding zones



Data source: Montel.
Note: The correlation covers a rolling time window of one year (52/53 weeks), backward.

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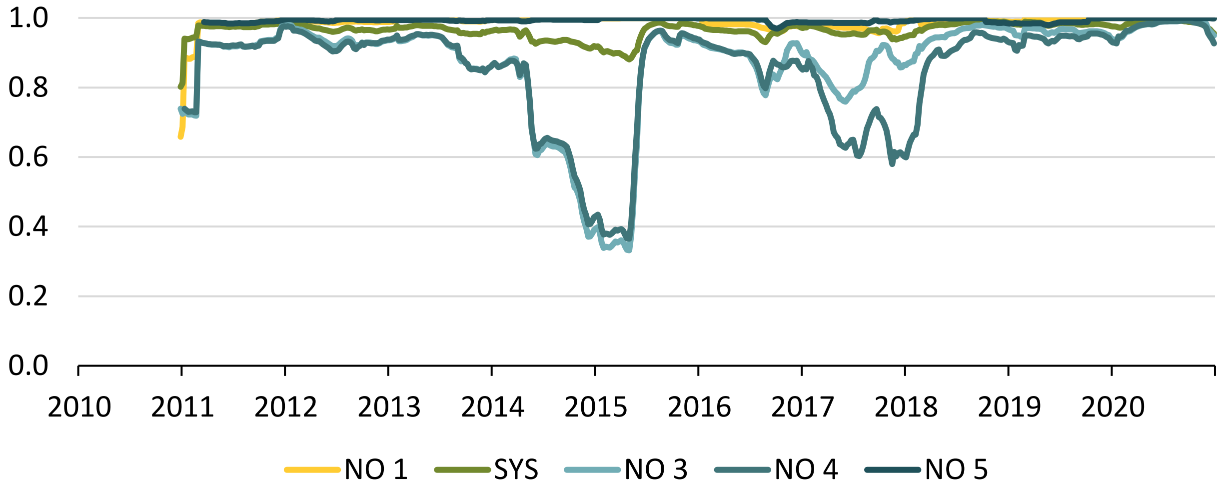
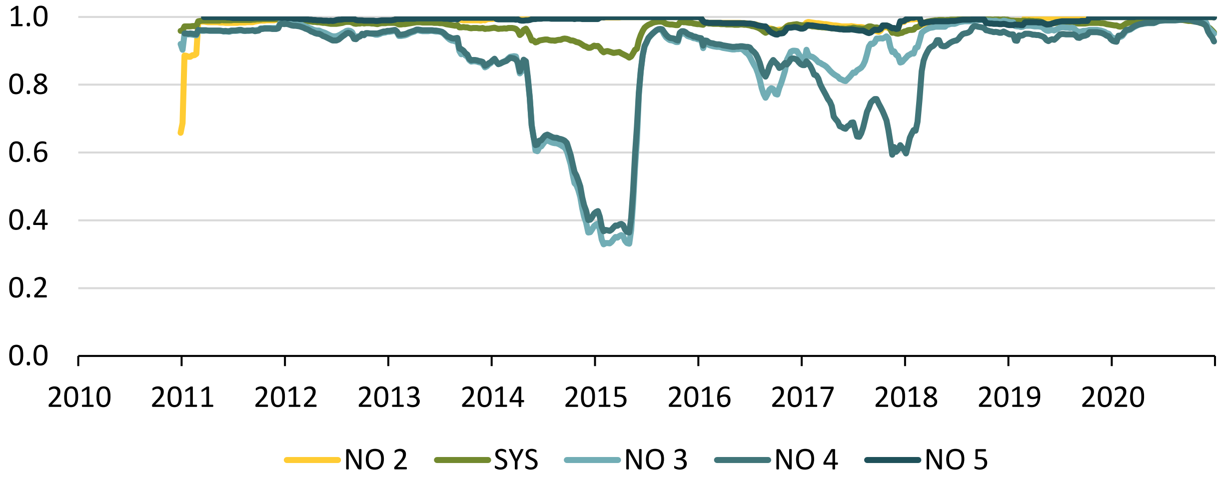
Figure 37: Correlation, weekly average spot, between NO2 spot price and relevant bidding zones



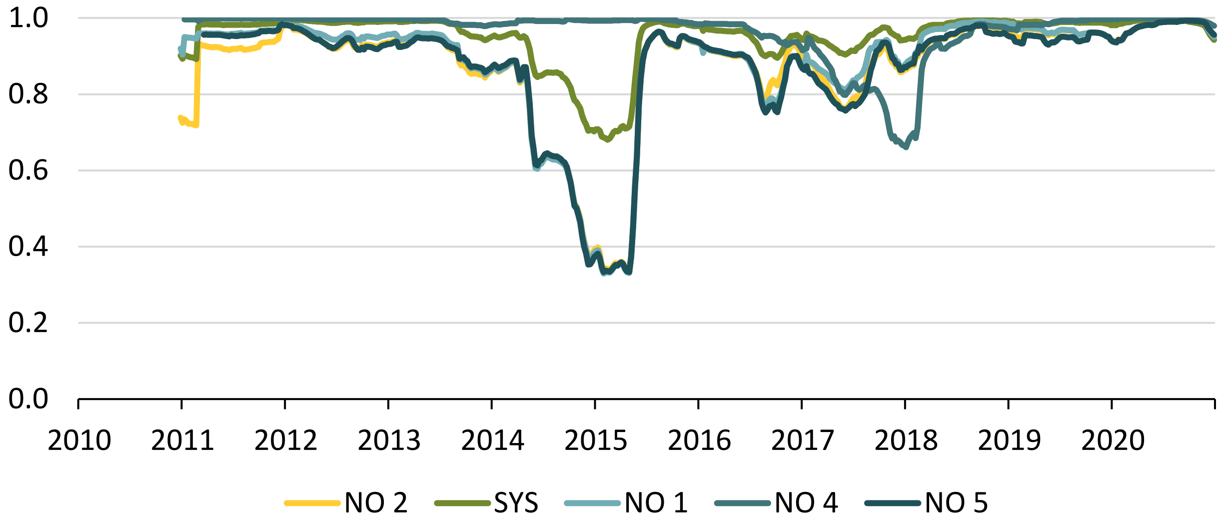
Data source: Montel.
Note: The correlation covers a rolling time window of one year (52/53 weeks), backward.

Figure 38: Correlation, weekly average spot, between NO1 spot price and relevant bidding zones



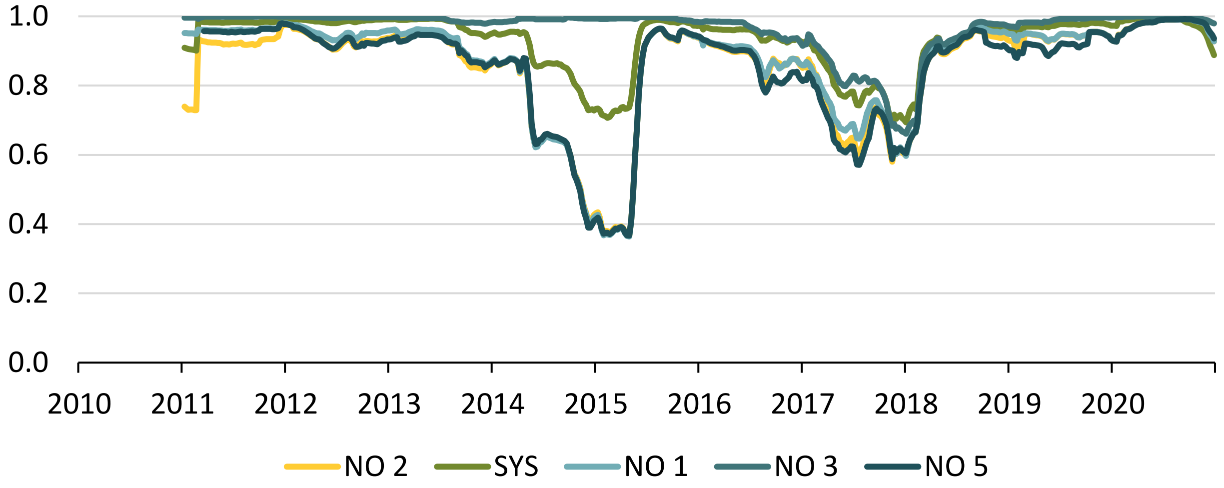
Data source: Montel.
Note: The correlation covers a rolling time window of one year (52/53 weeks), backward.

Figure 39: Correlation, weekly average spot, between NO3 spot price and relevant bidding zones



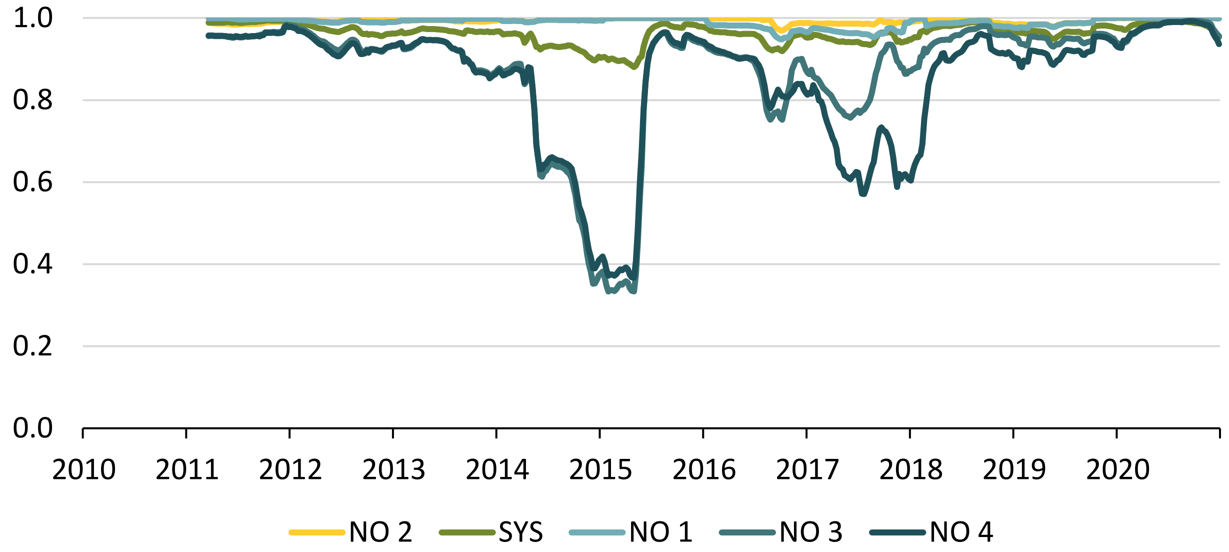
Data source: Montel.
Note: The correlation covers a rolling time window of one year (52/53 weeks), backward.

Figure 40: Correlation, weekly average spot, between NO4 spot price and relevant bidding zones



Data source: Montel.
Note: The correlation covers a rolling time window of one year (52/53 weeks), backward.

Figure 41: Correlation, weekly average spot, between NO5 spot price and relevant bidding zones



Data source: Montel.
Note: The correlation covers a rolling time window of one year (52/53 weeks), backward.