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

A REPORT TO THE SWEDISH ENERGY MARKETS INSPECTORATE

Presentation

22 March 2022

CONTENT

Content item	Responsible party
1. Introduction	Merlin & Metis
2. Literature review	Merlin & Metis
3. Measures to strengthen the current risk hedging system	Merlin & Metis
4. Methodology	Compass Lexecon
5. Traded volume analysis	Compass Lexecon
6. Bid-ask spread analysis	Compass Lexecon
7. Cost analysis	Compass Lexecon
8. Conclusion of the analysis	Compass Lexecon
9. Roadmap	Merlin & Metis

Disclaimer

This presentation has been prepared by Merlin & Metis AB and FTI France S.A.S., trading as Compass Lexecon (“Compass Lexecon”) for Ei under the terms of the Ei engagement with Merlin & Metis (the “Contract”).

This presentation has been prepared solely for Ei and no other party is entitled to rely on it for any purpose whatsoever.

Compass Lexecon and Merlin & Metis accept no liability or duty of care to any person (except to Ei under the relevant terms of the Contract) for the content of the presentation. Accordingly, Compass Lexecon and Merlin & Metis disclaim all responsibility for the consequences of any person (other than Ei on the above basis) acting or refraining to act in reliance on the presentation or for any decisions made or not made which are based upon the presentation.

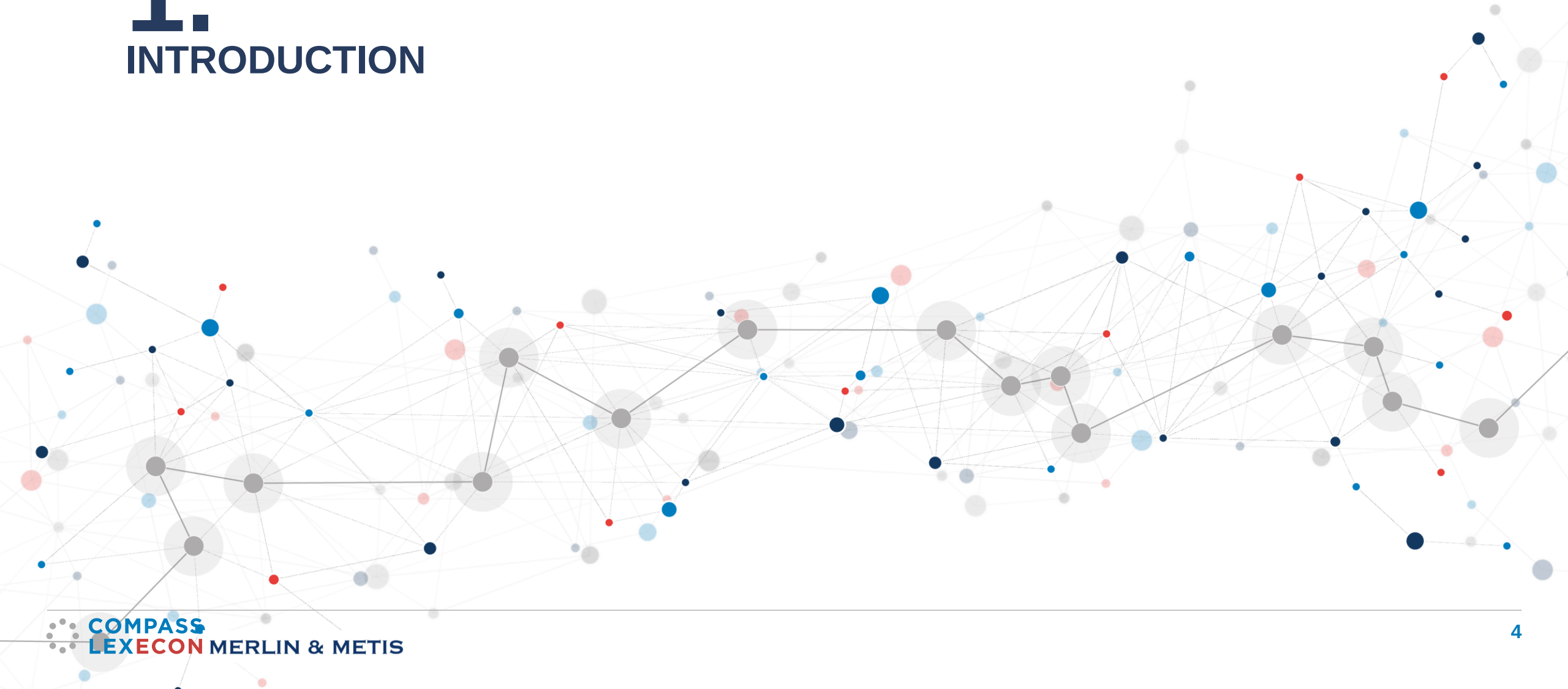
The presentation contains information obtained or derived from a variety of sources. Compass Lexecon and Merlin & Metis do not accept any responsibility for verifying or establishing the reliability of those sources or verifying the information so provided.

No representation or warranty of any kind (whether express or implied) is given by Compass Lexecon and Merlin & Metis to any person (except to Ei under the relevant terms of the Contract) as to the accuracy or completeness of the presentation.

The presentation is based on information available to Compass Lexecon and Merlin & Metis at the time of writing of the presentation and does not take into account any new information which becomes known to us after the date of the presentation. We accept no responsibility for updating the presentation or informing any recipient of the presentation of any such new information.

Any recipient of this presentation (other than Ei) shall not acquire any rights in respect of the presentation. All copyright and other proprietary rights in the presentation remain the property of Compass Lexecon and Merlin & Metis and all rights are reserved.

1.
INTRODUCTION



TEAM AND PROJECT

The team

- The team was set up in collaboration between the energy market consultant **Merlin & Metis** and the economic consulting firm **Compass Lexecon**.

Dr Petr Spodniak
Compass Lexecon

Dr Dmitri Perekhodtsev
Compass Lexecon

Christian Holtz
Merlin & Metis

Saara Hollmén
Merlin & Metis

Project background

- It is required that National Regulatory Authorities review cross-border hedging opportunities at least every four years. In 2021 Ei concluded that hedging opportunities are sufficient but there is potential for improvement of the risk hedging opportunities for electricity in Sweden. In this context Ei wants to analyze potential measures to improve risk hedging opportunities in the electricity market in Sweden.

REMINDER: BRIEF OVERVIEW OF TASKS

Task 1: Review earlier studies and present at least three measures to strengthen the risk hedging opportunities

- Analyse previous studies, consultancy reports and consultation viewpoints on this field. Based on this choose three measures to improve risk hedging opportunities, if the risk hedging opportunity isn't considered sufficient, while it is sufficient in a neighbouring bidding zone.

Task 2: Estimate transaction costs, benefits and implementation time for the defined measures

- Estimate transaction costs and implementation time for the three defined measures from task 1 above and compare whether the alternatives are considered more cost-effective than the introduction of LTTR's. The cost-effectiveness will be assessed from a societal perspective.

Task 3: Compare and discuss the measures effect on market participants, legal issues and present a roadmap to implement the most efficient alternative

- The measures will be compared based on how they impact market participants both in the short term and in the long term. What are the pros and cons as well as opportunities and challenges with each measure? Are there legal obstacles? The alternatives that are considered the most cost-efficient and practically feasible overall will be presented with a roadmap.

The study consisted of a literature review, qualitative and quantitative analysis as well as 12 interviews.

HEDGING INSTRUMENTS

Nordic system price electricity futures

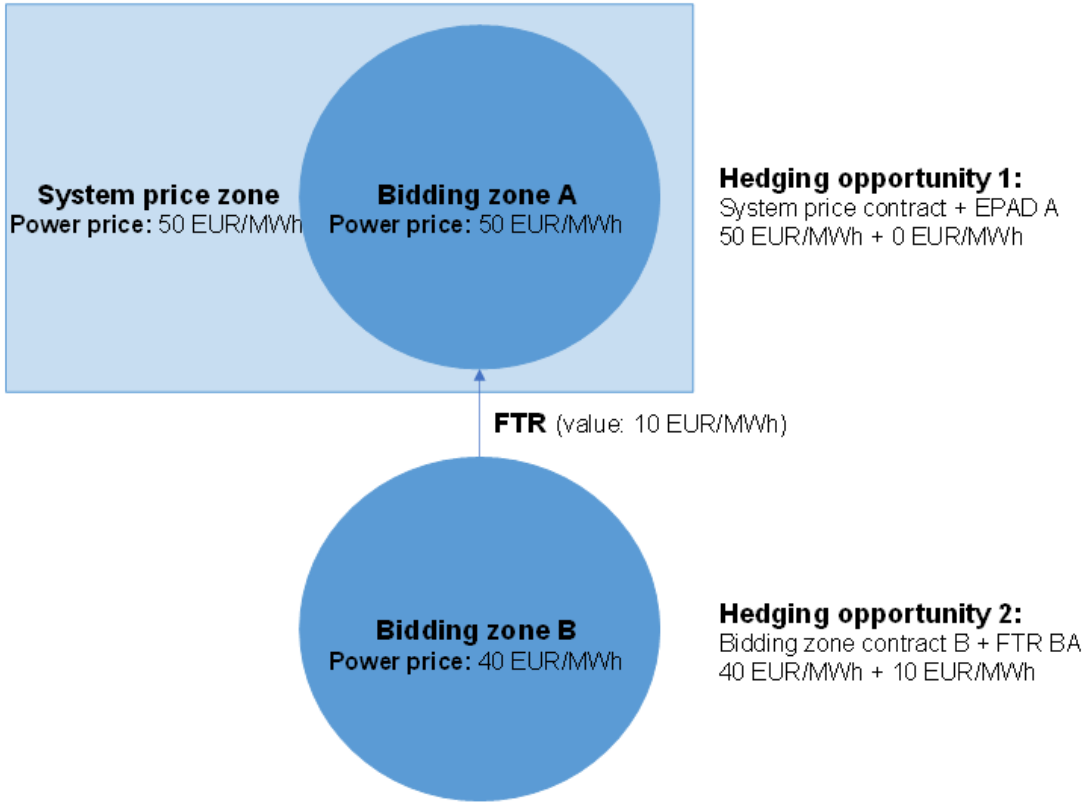
- Future contracts are the most common risk hedging instrument on the electricity market in Sweden today.
- The Nordic system price, is the price that would have been obtained if the entire Nordic was without grid congestions and cleared as a single BZ.

Electricity Price Area Differential (EPADs)

- Contracts that pay to the holder the price difference between the system and the BZ price.

Long-Term Transmission Rights (LTTRs)

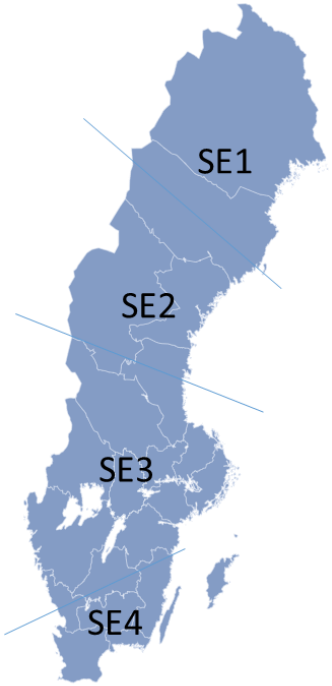
- Long-Term Transmission Rights (LTTRs) are contracts issued by TSO's, that provide the holder with a right (option) or obligation to flow electricity between connected BZs during a specified time period.

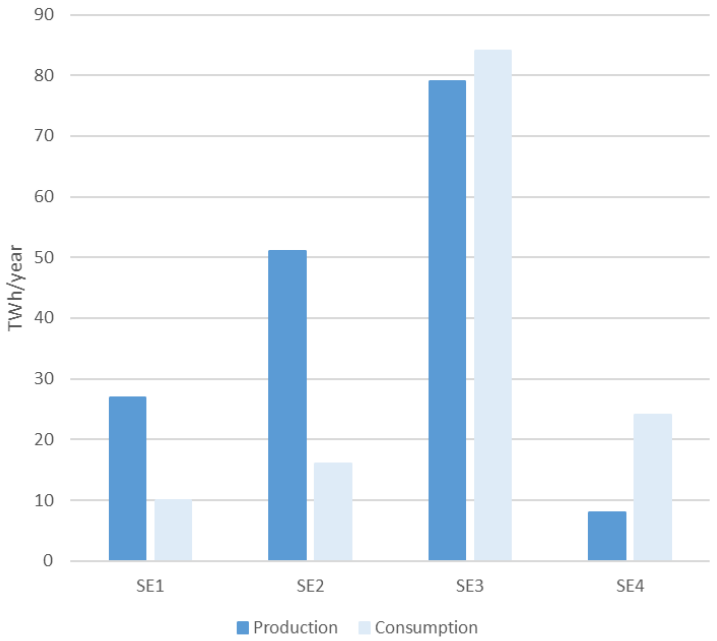


ASYMMETRY BETWEEN CONSUMPTION AND PRODUCTION IN BZ:S

The Swedish bidding zones

- The northern bidding zones (SE1 and SE2) have a substantially higher power production then consumption.
- SE4 in the south have a substantially higher power consumption then production.
- SE3 is rather balanced between power production and consumption.
- **The imbalance between consumption and production in SE1, SE2 and SE4 contributes to an asymmetry** between buying and selling interest of EPADs in these BZs.

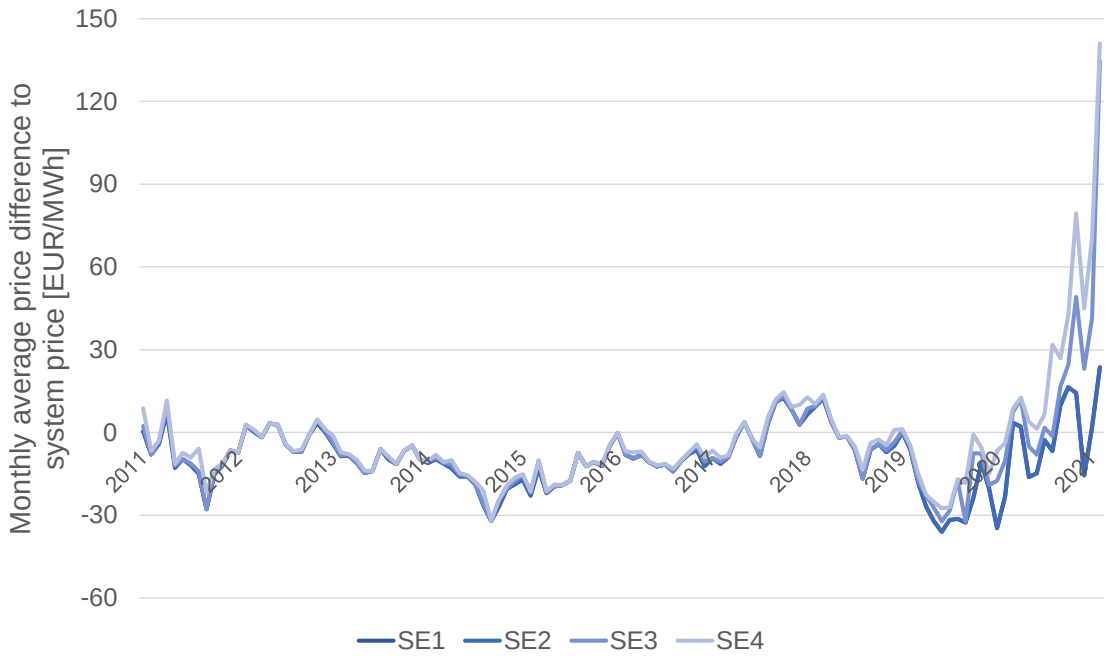




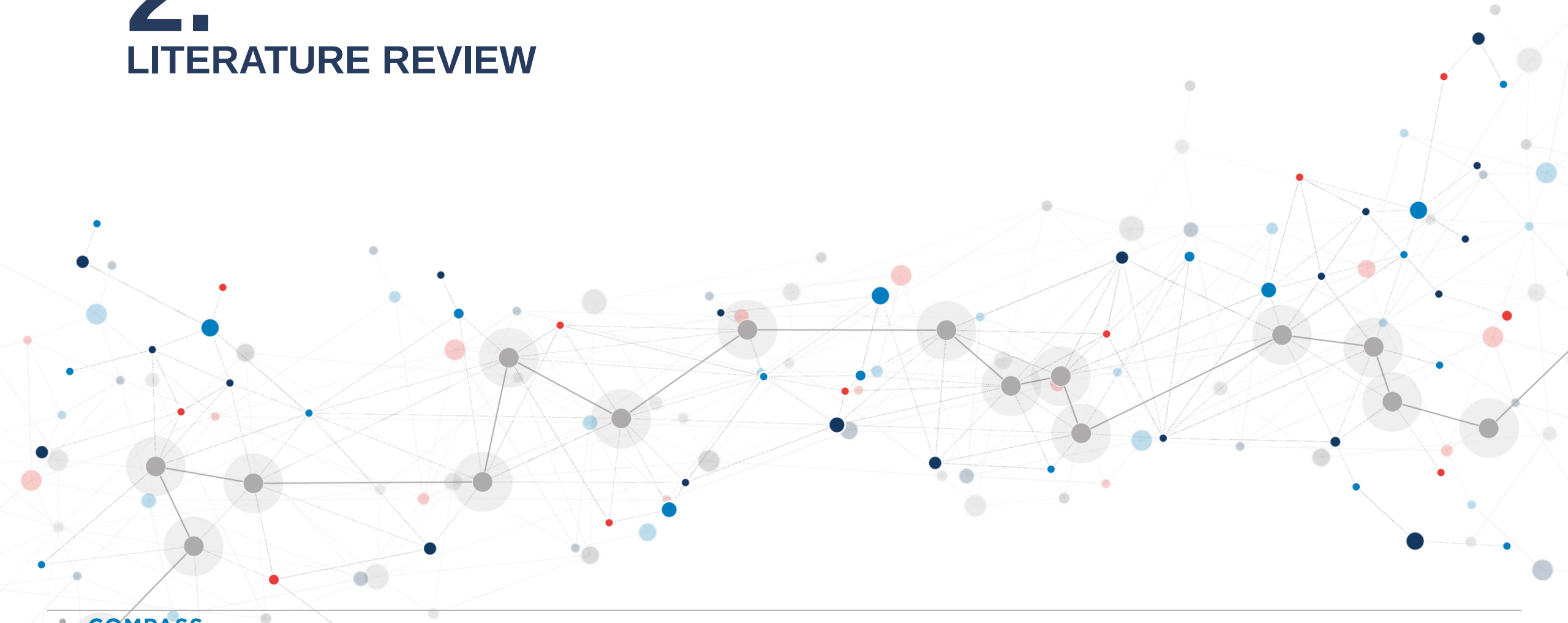
PRICE DIFFERENCES BETWEEN SWEDISH BZ:S AND THE SYSTEM PRICE HAVE RECENTLY INCREASED SUBSTANTIALLY

Market development

- Price differences between the Swedish BZs and the system price were rather modest since Sweden was split into four BZs in November 2011 until 2020.
- During 2020 and 2021 prices in SE3 and SE4 have been substantially higher compared to the system price and also compared to SE1 and SE2.
- Larger price differences between the system price and the BZ prices have increased the interest for EPADs.



2.
LITERATURE REVIEW



MARKET EFFICIENCY AND LIQUIDITY – PERCEPTIONS AND METRICS OF MEASUREMENT

A well-functioning forward market:

- Provides effective hedging opportunities and is sufficiently liquid
- Facilitates price discovery
- Allows market access at a reasonable cost
- Supports contestability in the wholesale and retail electricity markets
- Is characterised by effective competition
- Metrics: Liquidity, product availability, transparency, low transaction and entry costs, level of granularity, diversity of counterparties and low market concentration

Definition of liquidity:

- *Market liquidity may refer to the speed and easiness by which assets can be bought or sold without drastically impacting the underlying market price. Concretely, for energy traders, this translates into several requirements such as having volumetric markets with many counterparties, sufficient product variety, adequate price discovery, low transaction fees and execution complexity*."
- Metrics: Turnover, open interests, churn rates, market depth, bid-ask spread, time to maturity, risk premiums

Many market participants view hedging opportunities being insufficient due to:

- Low number of market participants
- Market asymmetry between generation and consumption volumes
- Market power
- Administrative costs related to direct exchange participation (partially due to regulatory requirements)
- Lack of market depth in longer-dated exchange contracts
- Other regulatory considerations, e.g. BZ reconfiguration

POSSIBLE MEASURES TO IMPROVE HEDGING OPPORTUNITIES

1) TSO involvement

- TSO supporting market making by financing a sufficiently tight bid-ask spread and minimum volume – questions about its efficiency as the only measure
- TSO involvement by auctioning EPADs or EPAD combos – could address the underlying asymmetry and support current hedging system structure

2) Re-defining market for improved symmetry

- BZ reconfiguration – should make spot prices right first
- Regional EPADs – even with high correlation, an imperfect hedge

3) Actions from market actors

- System price based on a weighted average – current system price is widely used and therefore ‘sticky’
- Forcing vertically integrated companies to trade – intervention at agent level

POSSIBLE MEASURES TO IMPROVE HEDGING OPPORTUNITIES (CONT'D)

4) Introducing LTTRs

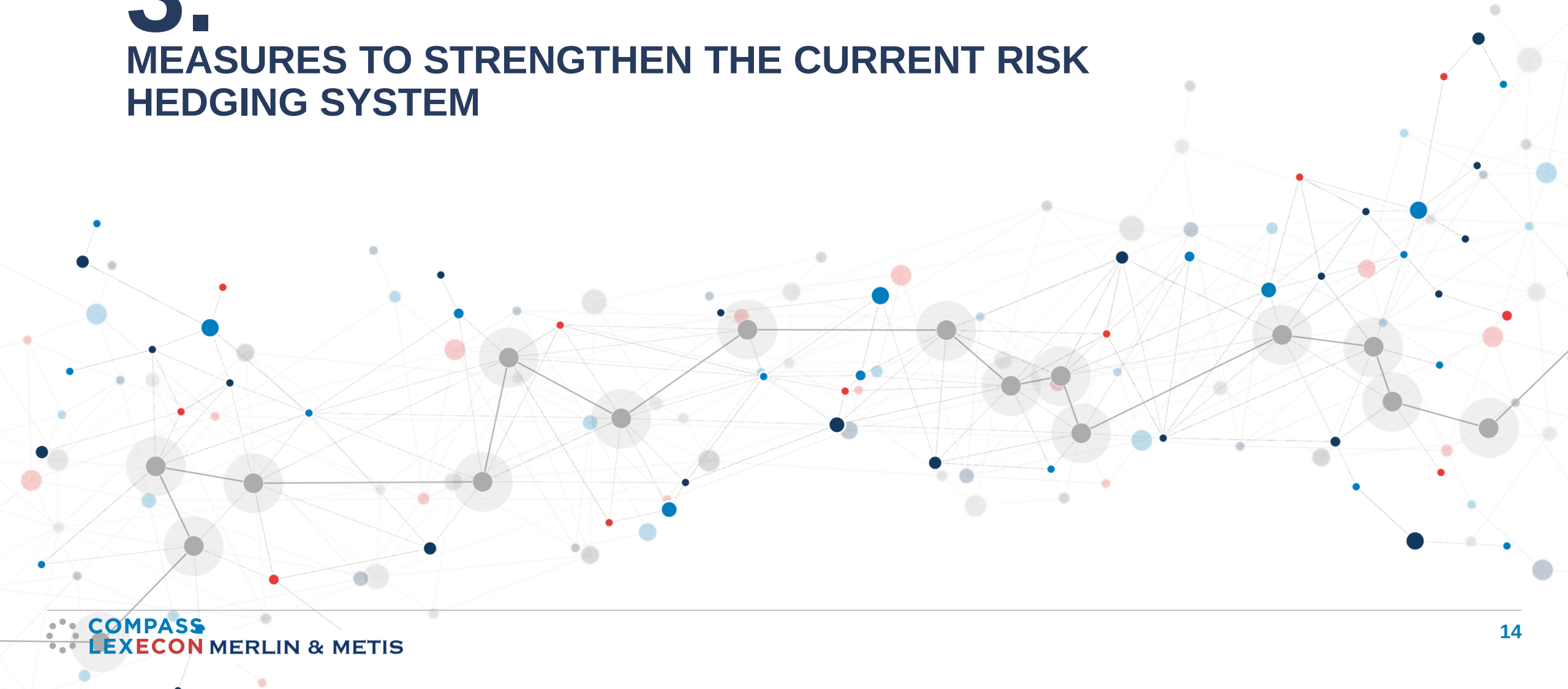
- EPADs and FTRs not mutually exclusive, however, introducing LTTRs could risk splitting liquidity between products
- Together with additional administrative costs to market participants (two contract types, two platforms etc), LTTRs could increase hedging costs
- In contrary, measures that support EPAD markets are linked to and strengthen the trading of system price contracts
- Market participants have expressed strong support to current market setup (system price + EPAD)

Report table 6: Comparison of market impacts of the different measures

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

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

3.
MEASURES TO STRENGTHEN THE CURRENT RISK HEDGING SYSTEM



IMPROVED EPAD MARKET MAKING FUNCTION

- A market maker is obliged to post bids and offers with specified requirements regarding bid-offer spreads and order depth, thus **ensuring presence of a counterparty and a price**.
- Market makers are generally compensated for taking on these obligations in the form of lower trading fees or direct payments. **In EPAD markets the trading fees are low in comparison to the spreads, and the financial incentive offered by an exchange (i.e. Nasdaq) may be small in comparison to risks.**
- **Market participants may have other strategic interests to be a market maker**, e.g. structural needs to either buy or sell, interest in supporting liquidity, as well as having a market platform to reduce the risk of regulatory intervention.

Pros	Cons
• Reduces bid-ask spreads • Increased price transparency • May help to break a cycle of illiquidity • Simple to implement	• Doesn't handle the structural causes of illiquidity, e.g. market asymmetry • Requires funding • May have legal challenges

TSO BUYING/SELLING EPADS OR EPAD COMBOS

- This measure would require TSOs to buy or sell **EPADs or EPAD combos through auctioning or continuous trading** (executed by procured market participant(s)).
- The TSO owns cross-zonal transmission capacity and is therefore exposed to the price spread between the relevant bidding zones in terms of congestion income. As an alternative, the TSO could hedge parts of its cross-zonal transmission with EPADs or EPAD combos. The TSO could take a net-position.
- **Auctions can reduce trading costs by effectively eliminating the bid-ask spread and attract smaller market participants while continuously trading would tackle a lack of liquidity on the continuous markets and possibly attract new market participants.**

Pros	Cons
• Could contribute to solving the underlying structural problem with asymmetry between consumers and producers in some bidding zones • Could add substantial trading volumes • Could increase transparency on order depth	• May affect the TSO:s credibility as an independent actor • If the TSO involvement is done by continuous trading by one procured market participant, this may concentrate much market power to that market participant

BIDDING ZONE RECONFIGURATION

- **This measure and could be used to create bidding zones that are larger and more balanced between producers and consumers of power. involves reconfiguring bidding zones**
- The Swedish bidding zone configuration is currently being analysed and may be reconfigured. This process is in a rather late stage and the methodology for this process is already decided upon by the Agency for the Cooperation of Energy Regulators (ACER). Svk is expected to submit a proposal in 2023.
- **A challenge with larger bidding zones in Sweden is that under the current EU regulation a minimum of 70 percent of interconnector capacity must be made available to the market. This may be challenging with large bidding zones and limited possibilities to counter-trade or redispatch the day-ahead flows.**

Pros	Cons
• Larger and more balanced bidding zones would directly address some of the structural causes of low liquidity in EPADs	• If the bidding zone design isn't based on physical structural bottlenecks in the grid, economic costs will rise, including congestion management and less efficient location of new power consumption/production • Will not be implemented before 2025, more likely later

REGIONAL EPADS

- **Regional EPADs could be created by pooling bidding zones into larger zones (Regional EPADs) with more liquid financial products that may work as a proxy hedge for the bidding zones included**. To avoid splitting liquidity, the new products would most likely need to replace the existing EPADs for the regions in which they are implemented.
- The choice of how to pool bidding zones into regional EPADs would presumably be made to reflect the expected future price correlation between the underlying bidding zones. There is a trade-off where products for larger areas may lead to a higher liquidity, but work as a less perfect hedge for the underlying price exposure.

Pros	Cons
• Could address structural issues (small bidding zones and asymmetry between consumers and producers in some bidding zones) • Easier to implement than a bidding zone reconfiguration • Economic costs that may occur from a bidding zone configuration that is not based on physical bottlenecks in the grid can be avoided	• Introduces basis risk between the regional EPADs price and the bidding zone price

SYSTEM PRICE BASED ON WEIGHTED AVERAGE OF PRICE AREAS

- The current system price is based on a theoretical calculation of what the price would have been without any constrains within the system price area.
- Changes could be made to the system price calculation in order to improve the reference price's correlation with actors' underlying price exposure and make it perceived as less complicated.
- **An option could be to reconfigure the system price calculation to instead reflect a volume weighted average of area prices. This would potentially increase the correlation between the system price and high-volume bidding zones.**
- This measure would have been relatively easy to implement if there really was an interest for it, but hasn't caught much attention from most actors.

Pros	Cons
• Might make the system price contracts more relevant as a hedge for some market participants (though not all) • Could be a good complementary measure	• The system price contract needs to be complemented with an EPAD to eliminate the price area risk • Limited interest by market participant

FORCING (LARGE) VERTICALLY INTEGRATED COMPANIES TO TRADE

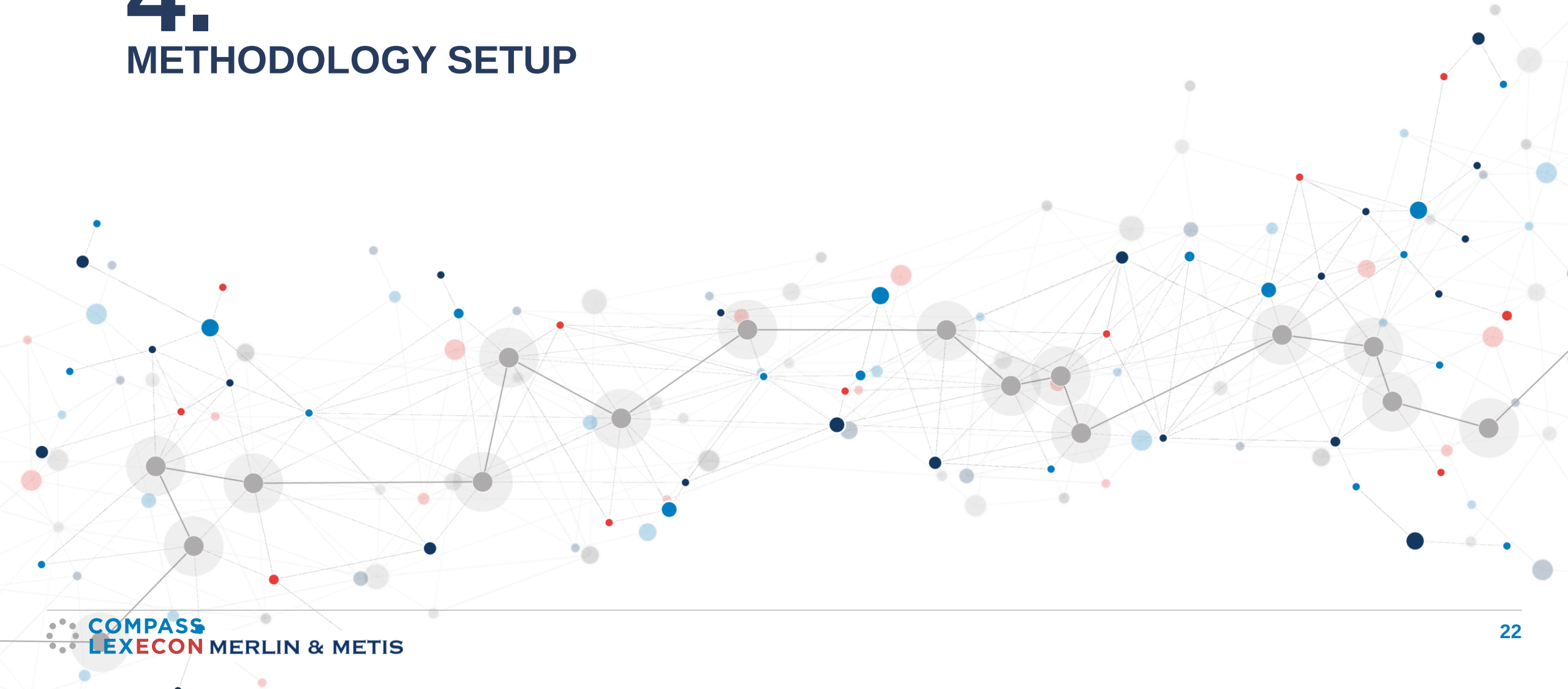
- The Nordic energy markets involve many larger vertically integrated companies that have both power generation and business units that require power. These companies have both buying and selling interest as they have opposing exposures to the power price. These interests can be internally netted, or seen as providing a natural hedge.
- This can be achieved by explicit obligations to trade or restrictions on self-supply.
- **A lighter version to self-supply restrictions would be to offer advantageous trading fee structures for companies that handle their hedging needs for both buying and selling on an exchange.**

Pros	Cons
• If vertically integrated firms' trading is reducing exchange traded volumes, obligations to trade and self-supply restrictions could offer a mean of promoting higher exchange traded volumes, liquidity and transparency	• To form and maintain well-functioning obligations to trade and self-supply restrictions can be complicated and administratively demanding • Efficient means for a firm to manage its power price risk exposures, handling this risk while avoiding trading costs and counterparty risk would be lost

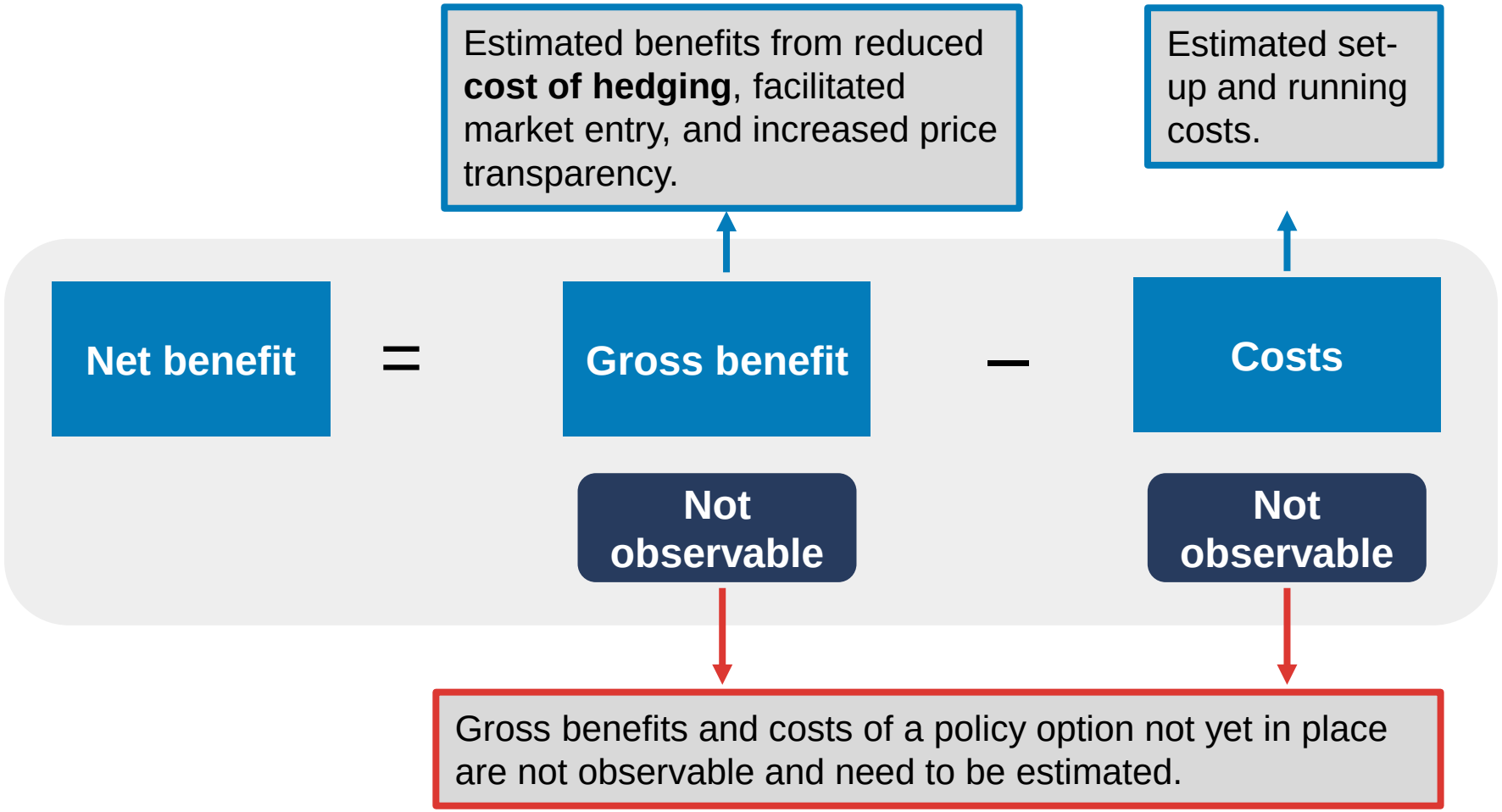
PROPOSED MEASURES FOR FURTHER ANALYSIS

Measure	Evaluation	Selected
Improved EPAD market making function	Improved market making could improve liquidity, however it does not solve the underlying market asymmetries.	
TSOs buying/selling EPADs (not EPAD Combos)	Mentioned as one of the most interesting measures to improve the price hedging opportunities in previous qualitative studies. Also mentioned in positive terms during interviews with market participants, Nasdaq and the Swedish TSO.	
Bidding zone reconfigurations	The bidding zone reconfiguration is an ongoing process with a set methodology (by ACER).	
Regional EPADs	Regional EPADs is one of few measures that addresses the underlying structural issues and enables any combination of bidding zones. A less familiar measure to market participants, but none have expressed a negative view on regional EPADs.	
System price based on a weighted average of price areas	Although this measure may make the relatively liquid system price contracts more relevant to some market participants, it will make it less relevant to others. The system price contract will still need to be completed with an EPAD to eliminate the price area risk.	
Forcing (large) vertically integrated companies to trade	Could improve liquidity, however may lead to obligated party becoming a distressed buyer/seller, distorting prices and redistributing costs and benefits among the trading parties.	

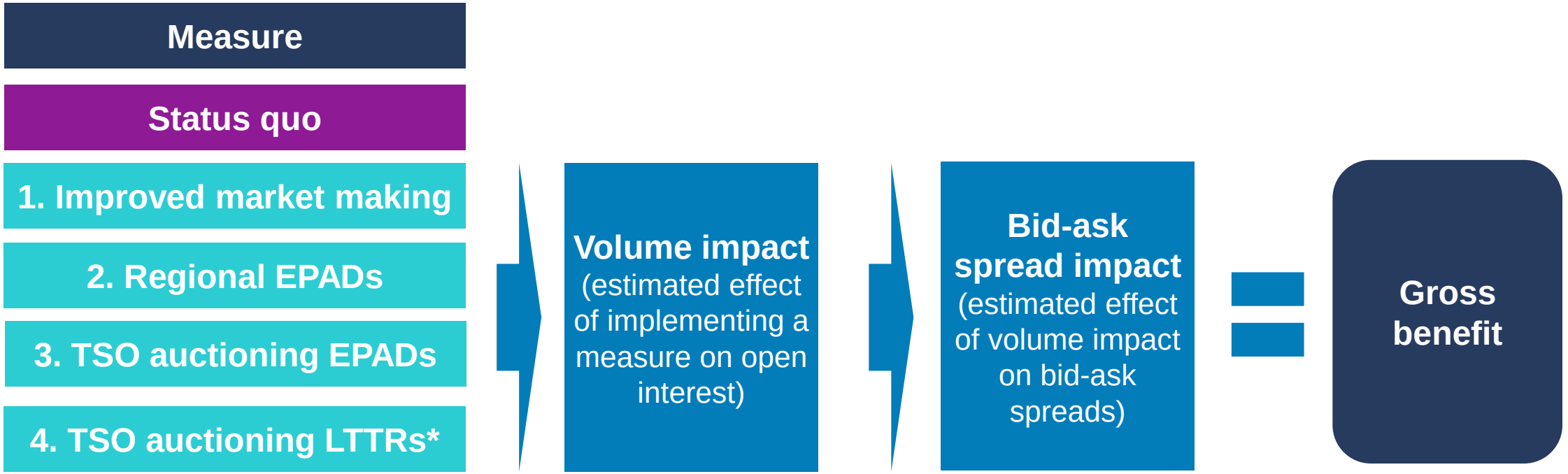
4.
METHODOLOGY SETUP



METHODOLOGY – HIGH LEVEL OVERVIEW



METHODOLOGY – GROSS BENEFIT ESTIMATION



* Note that volume impact of TSO auctioning LTTRs is estimated but its impact on the reduced cost of hedging is left out of scope of this study.

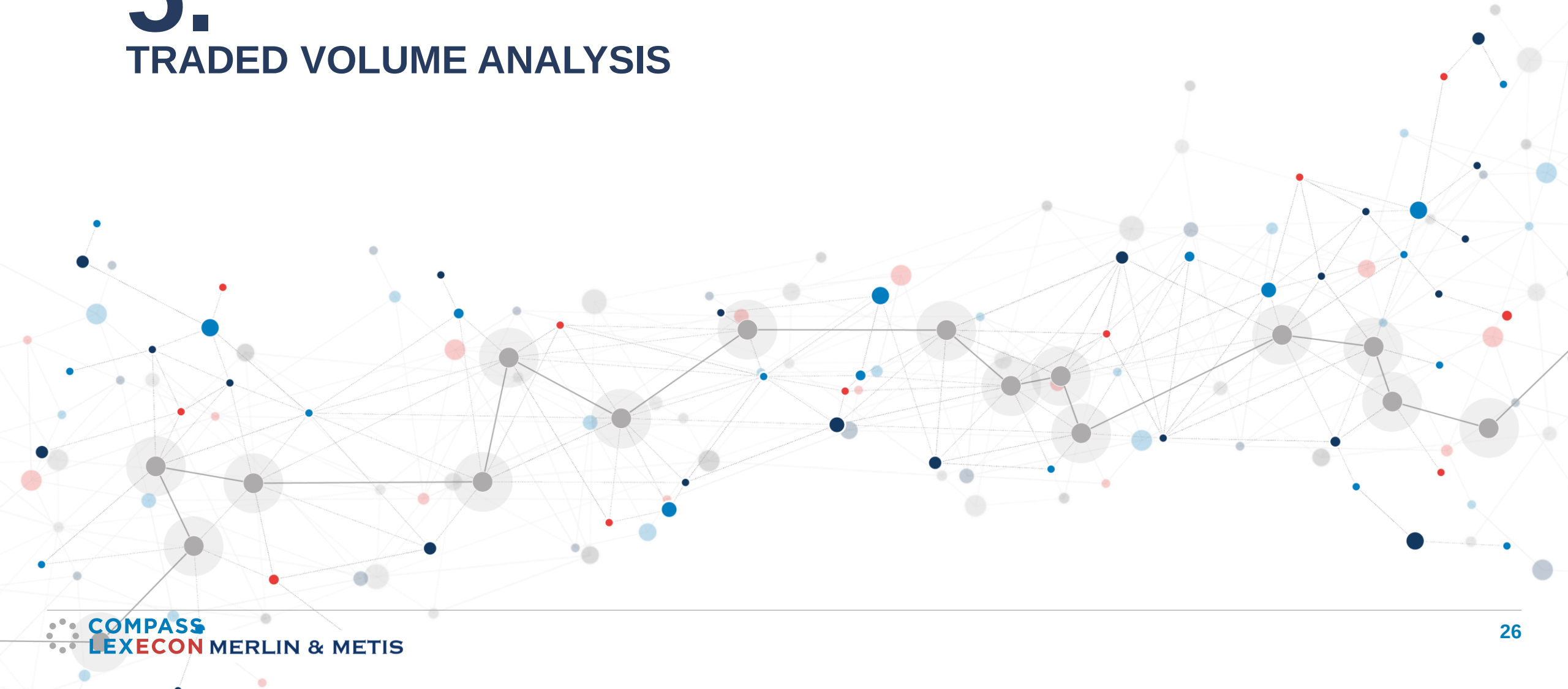
DATA OVERVIEW

Data overview

Nasdaq		Nord Pool		Derived indicators	
Variable	Definition	Variable	Definition	Variable	Definition
Open interest	Daily data on open interest (GWh), which refers to the total size of open positions with the clearinghouse (Nasdaq) at a given point in time.	**Day-ahead prices**	Hourly day-ahead (Elspot) prices for all bidding areas	**Ratio of traded volume to physical consumption**	Churn rate, refers to the number of times each MWh is traded before it is delivered
Traded volumes	Daily data on bought and sold volumes (GWh), which is a proxy to trading activity and product relevance.	**Day-ahead capacities**	Hourly day-ahead trading cross-border (Elspot) capacities	**Average traded volumes**	Average volume of hedging products traded in a market over a period.
Bid ask spreads	Daily best, worst, mean and median bid ask spread (€/MWh) per day based on a minute granularity of buying and asking quotes. An additional variable of counted minutes per day with available bid ask spread is also included.	**Day-ahead flows**	Hourly planned day-ahead cross-border power (Elspot) flows resulting from the day-ahead price calculation	**Volume turnover**	Sum of volume of hedging products traded in a market over a period.
Market depth	Summed volume of the best four asking and the best four bidding offers from the order book per day.	**Power consumption**	Hourly consumption for all bidding areas		
Daily fix	Daily closing prices for EPAD and SYS contracts.				

Source: Compass Lexecon, data provided by Nasdaq and Nord Pool

5.
TRADED VOLUME ANALYSIS



VOLUME TURNOVER

NORDIC SYSTEM PRICE AND EPAD CONTRACTS

Nordic system price contracts

- Higher shares of on-orderbook traded volumes
- Over recent time a declining trend in volume turnover

EPAD contracts

- The share of off-orderbook dominates; turnover relatively stable overtime
- The share of the Nordic EPAD turnover in a total turnover (EPAD + Nordic system price contracts) is approximately 15% (in 2017-2021) => an increase (from ~9% in 2015) but mainly due to declining trade in SYS.

Figure: Volume turnover* of Nordic system contracts, TWh

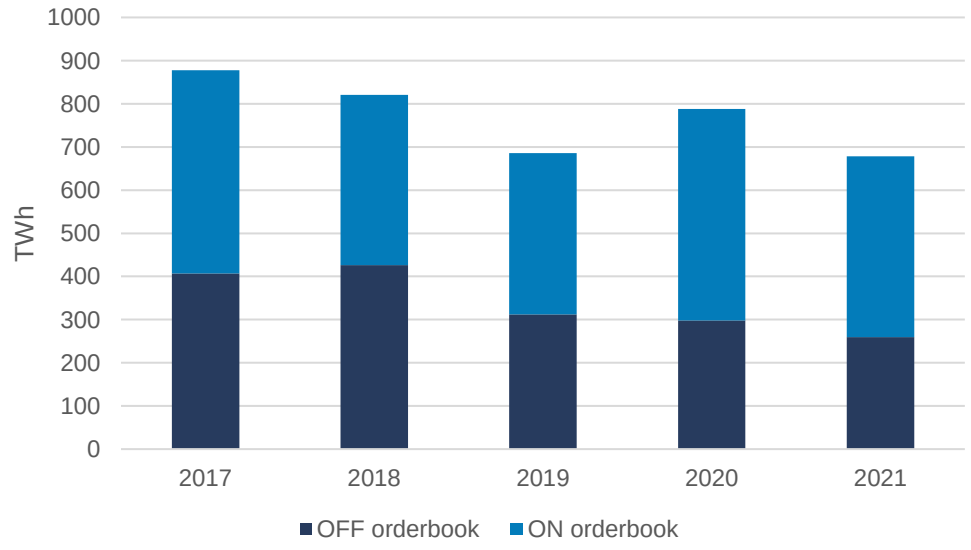
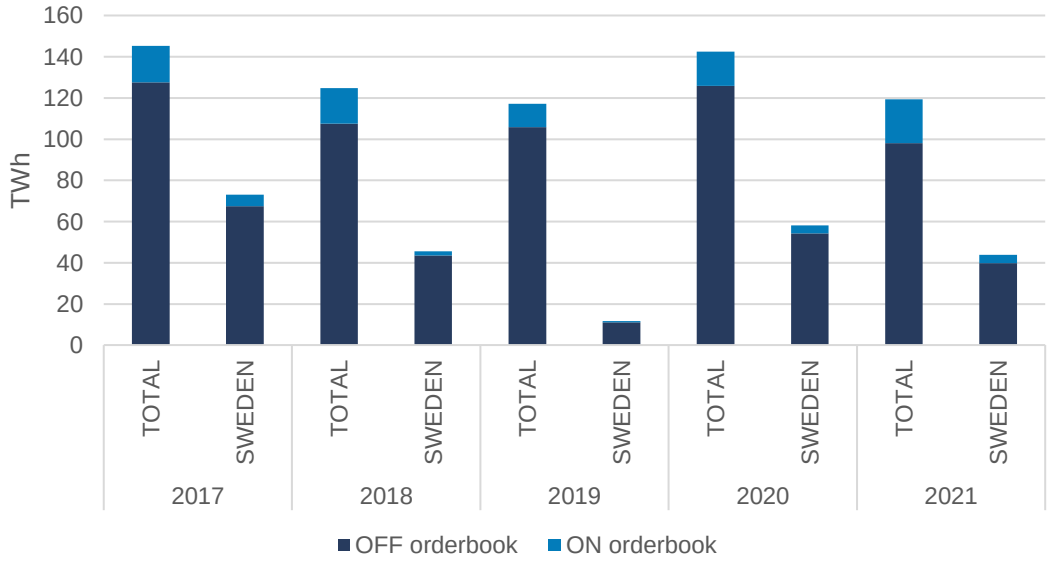


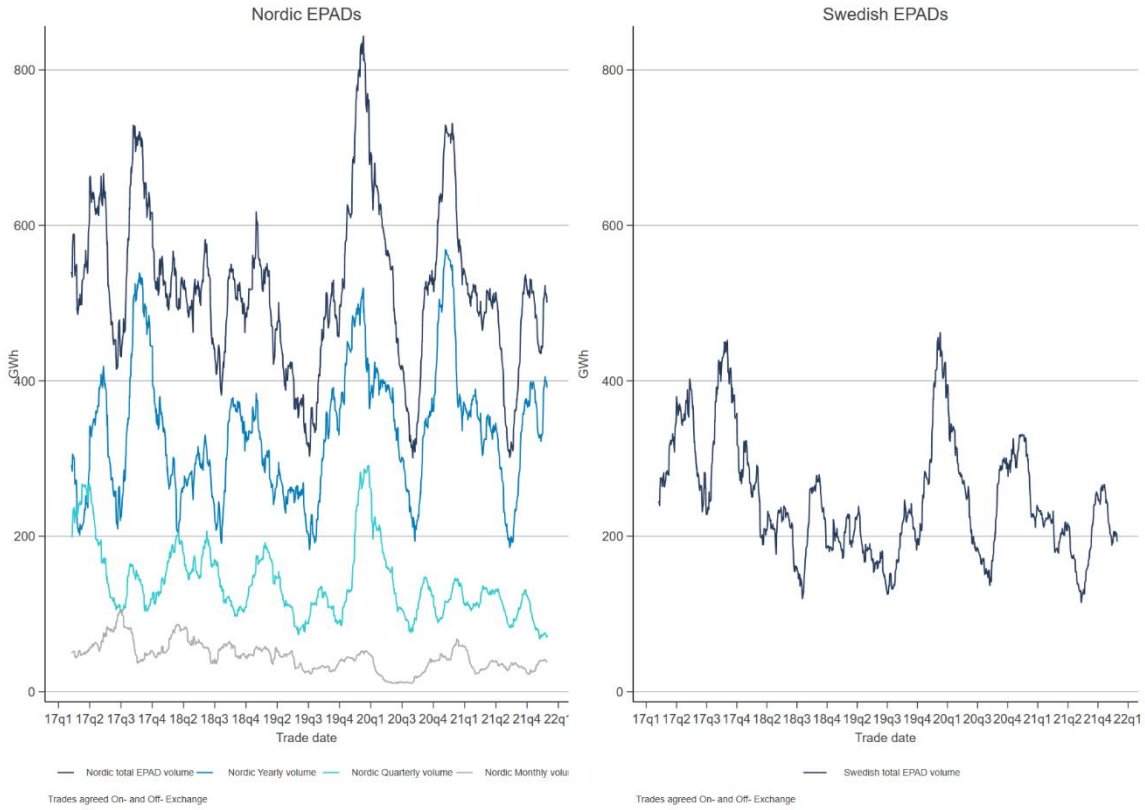
Figure: Volume turnover* of EPADs overall (Total) and in Sweden, TWh



*Volume turnover is the sum of volume of a hedging product traded in a market over a period.

TRADED VOLUMES
EPAD CONTRACTS

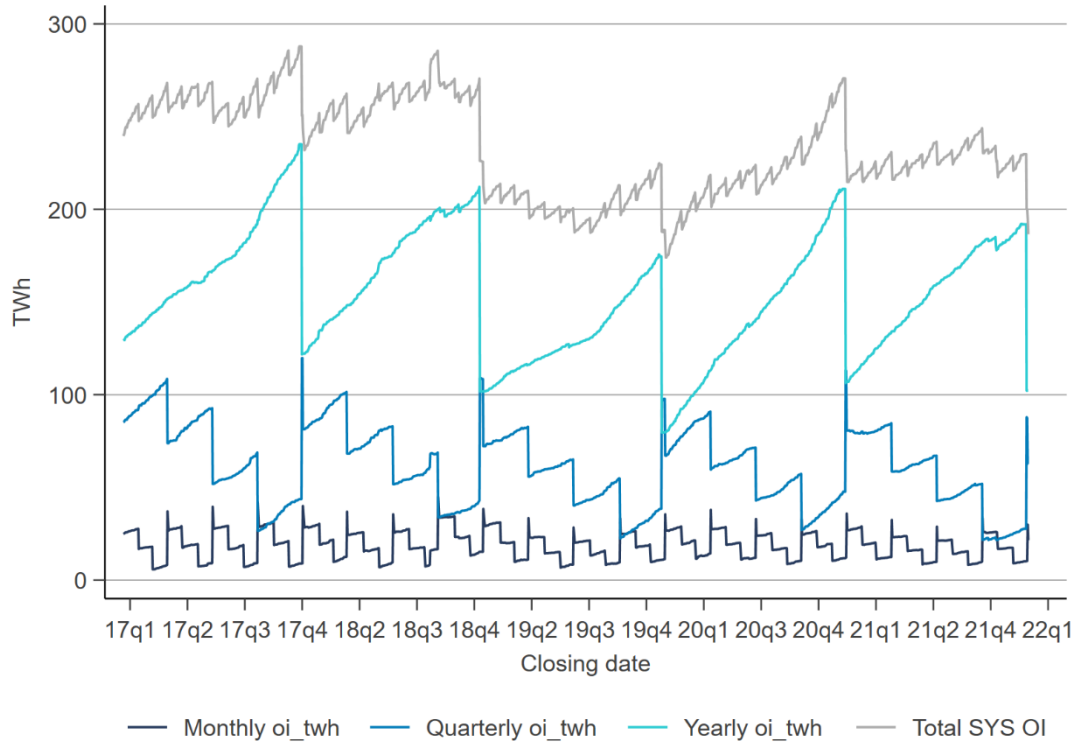
Figure: Daily average traded volumes of Nordic and Swedish EPADs, GWh



- Daily average traded volumes in all EPADs (left panel) is ~0.5 TWh/day
- In the Swedish EPADs (right panel) the daily average traded volumes are ~0.25 TWh/day
- The Swedish EPADs represent a significant share of average traded volumes in the Nordic EPAD market

OPEN INTEREST
NORDIC SYSTEM PRICE CONTRACTS

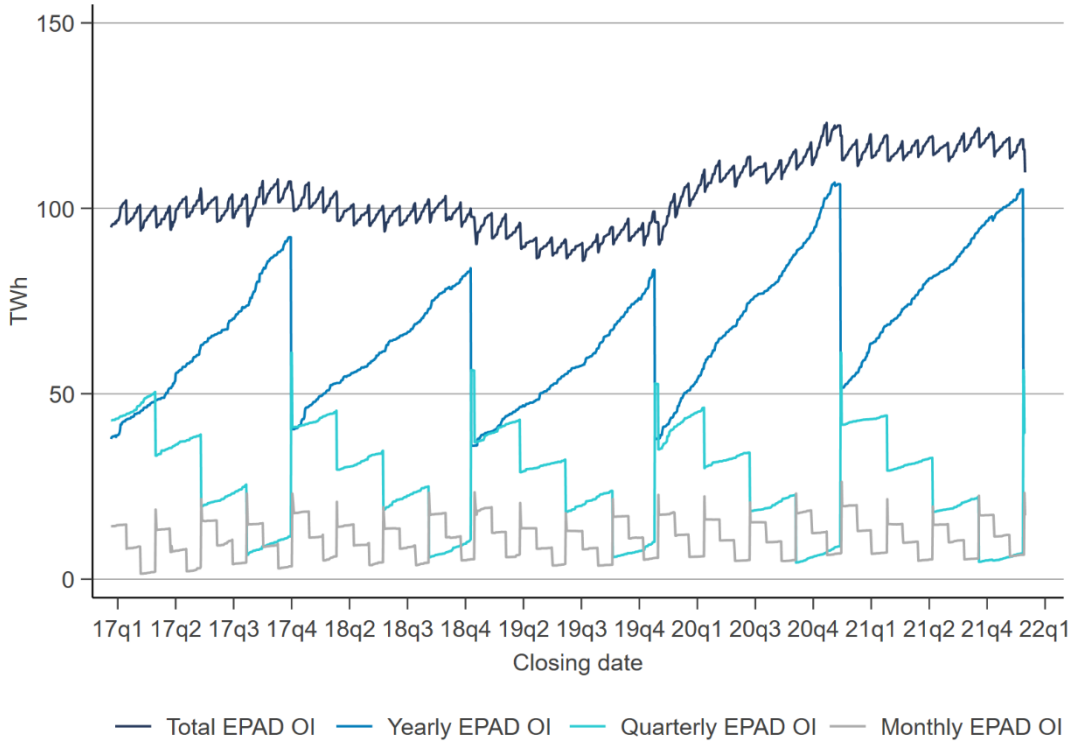
Figure: Open interest of Nordic system price contracts, TWh



- Declining open interest in the Nordic system price contracts
- Implies reduced interest in SYS contracts
- Reducing relevance? Increasing costs?

OPEN INTEREST
EPAD CONTRACTS

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

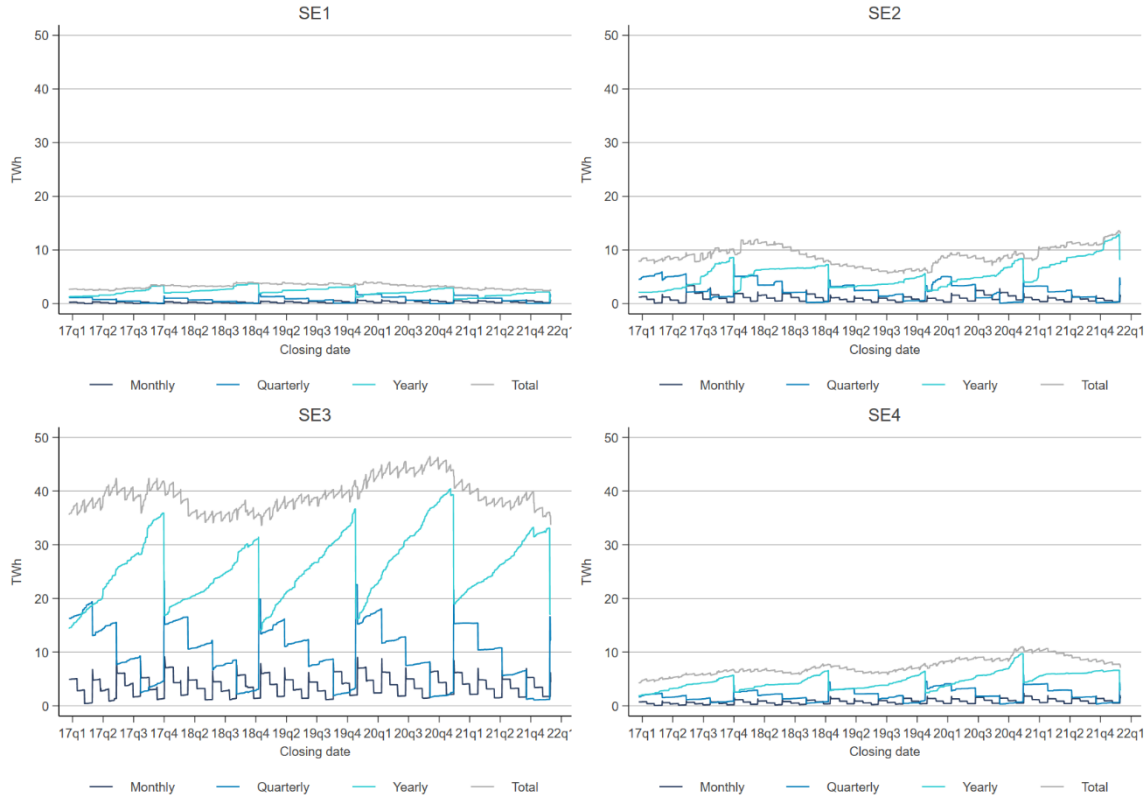


- Increasing open interest in EPAD contracts over time, esp. since 2020
- Area price hedging becoming more important

OPEN INTEREST

EPADS CONTRACTS IN SWEDEN

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

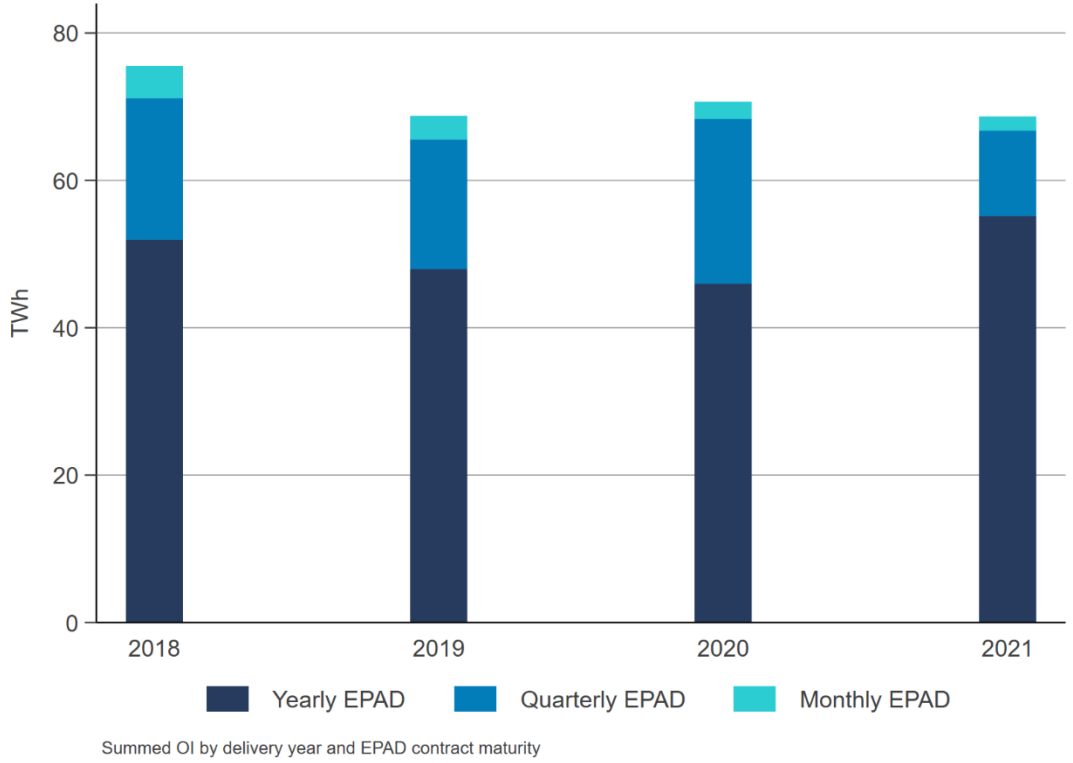


- SE3 dominates the open interest in Swedish EPADs (~40TWh) followed by SE4 and SE2
- Total volumes relatively stable across time and SE bidding zones

OPEN INTEREST – NORDIC EPAD

DELIVERY TIME, ENERGY

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



- **~ 70 TWh** of EPADs held until just before expiry are delivered per year => vast majority of the approximately 100 TWh of open interest during the trading time.
- This implies that most of the volumes are traded for near-term future.

OPEN INTEREST – NORDIC EPAD

DELIVERY TIME, CAPACITY

- The figure shows that approximately **8 GW of EPADs** of different maturities is delivered per year in the Nordics, of which 6 GW of yearly, 2 GW of quarterly, and 0.3 GW of monthly EPADs for every hour of the delivery year.

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

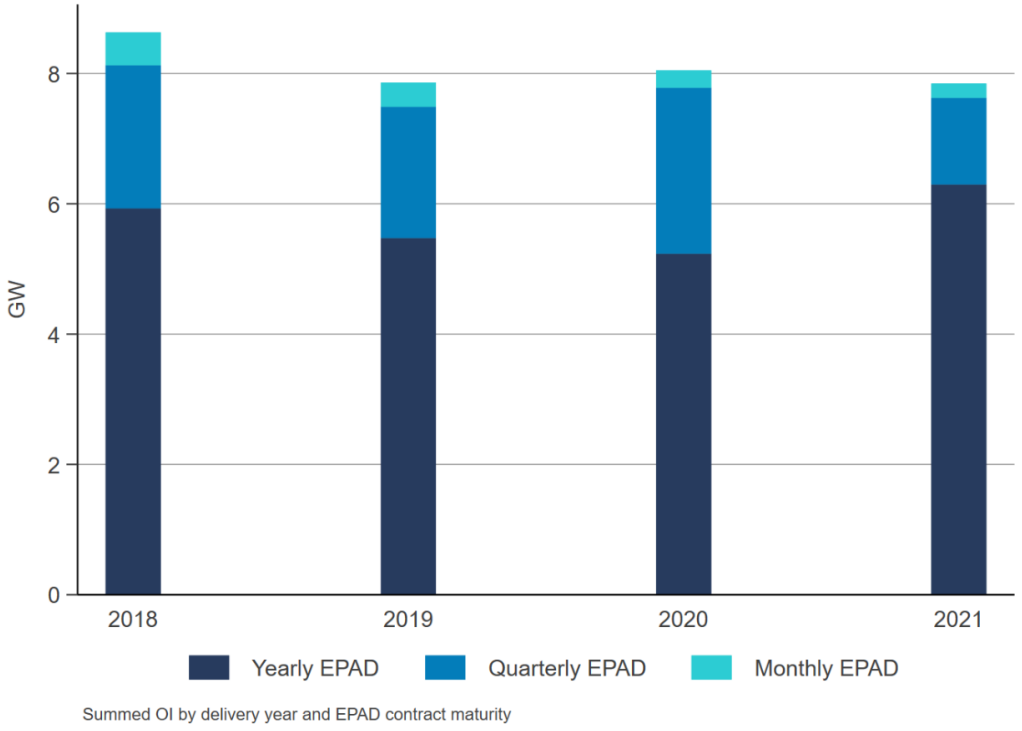
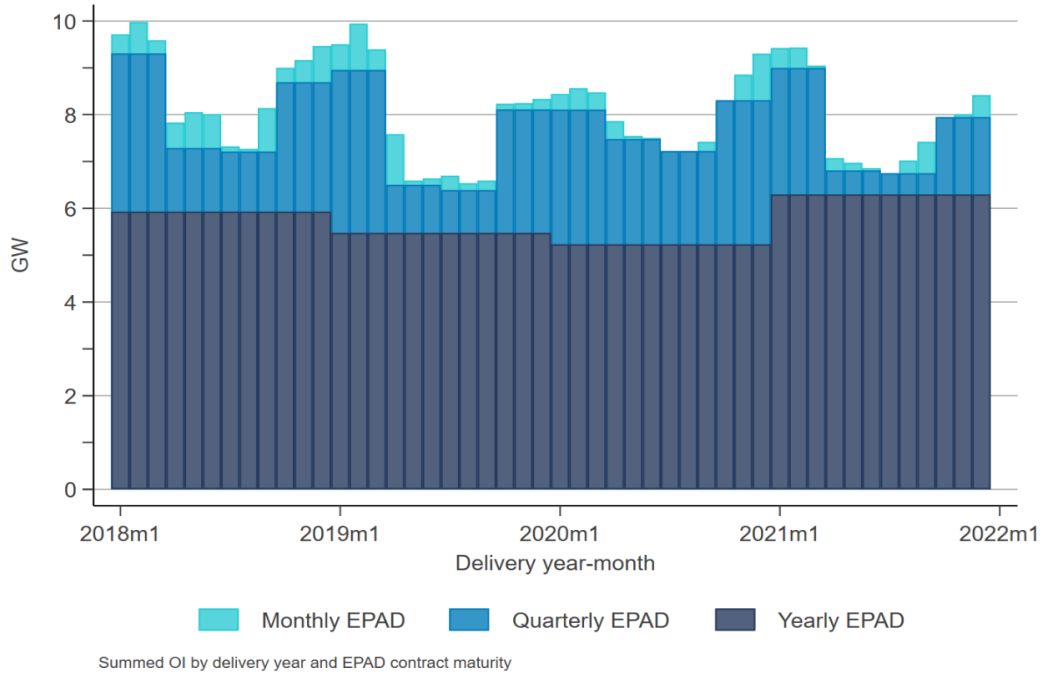


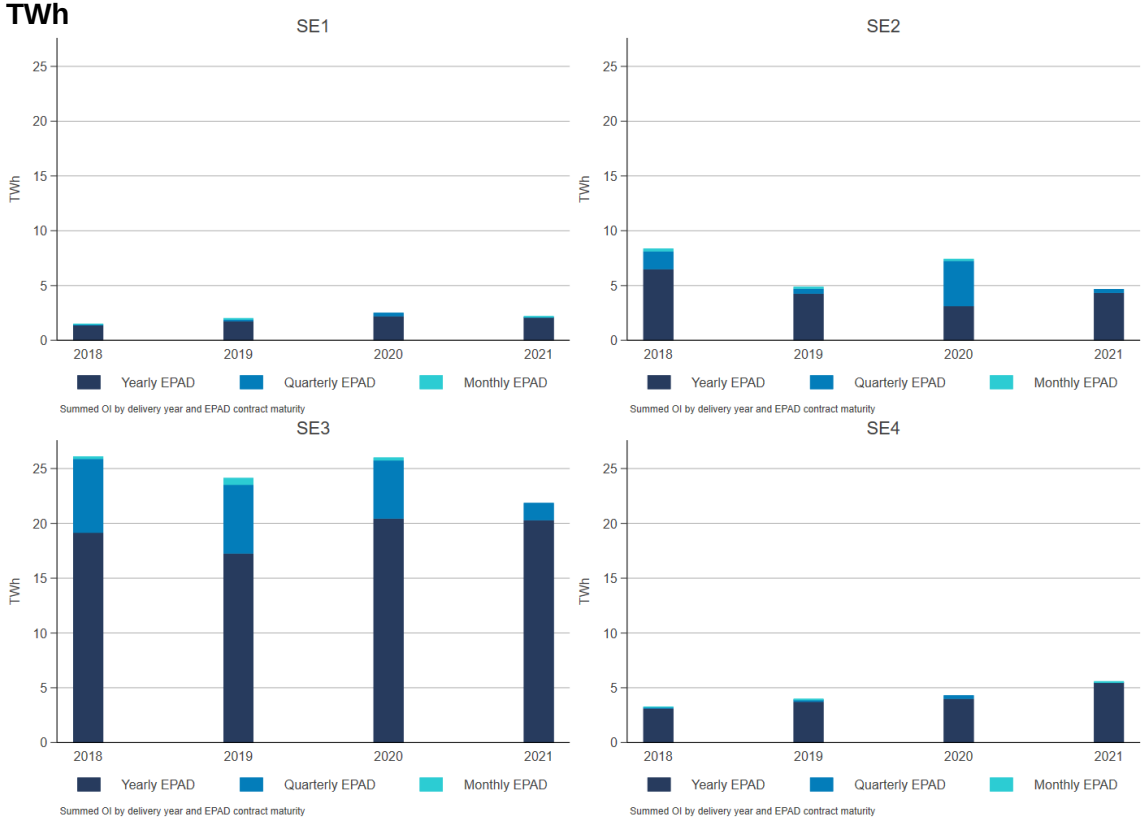
Figure: Open interest (capacity) of EPADs in all bidding zones by delivery year, GW – monthly visualization



OPEN INTEREST – SWEDISH EPAD

DELIVERY TIME, ENERGY

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



- In **SE1**, **SE2** and **SE4** about half of the trading date volume (~5 TWh compared to ~10 TWh) is held for hedging (until expiry) in the delivery year.
- In **SE3**, about approximately 25 TWh (compared ~40 TWh during trading period) during the delivery year

OPEN INTEREST – SWEDISH EPAD

DELIVERY TIME, CAPACITY

- In capacity terms, the average (2018-2021) annual EPAD open interest in delivery year in the individual BZs in Sweden is (total of approximately **4240 MW**):
- **SE1**: 230 MW, **SE2**: 720 MW, **SE3**: 2800 MW, **SE4**: 490 MW

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

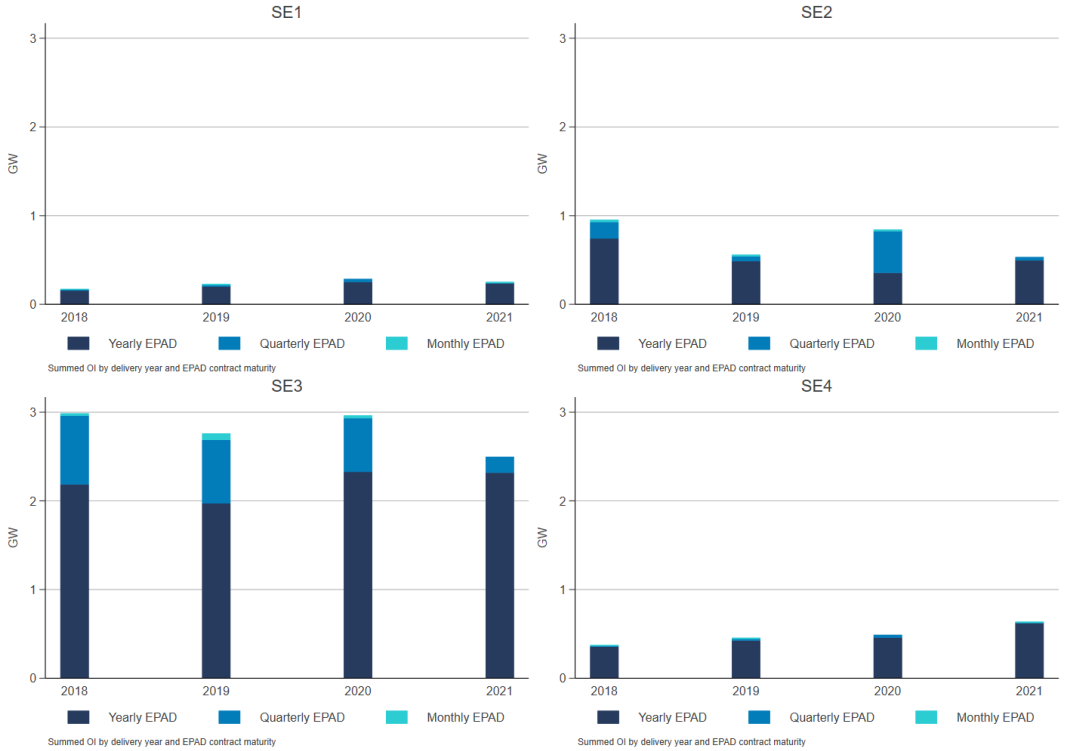
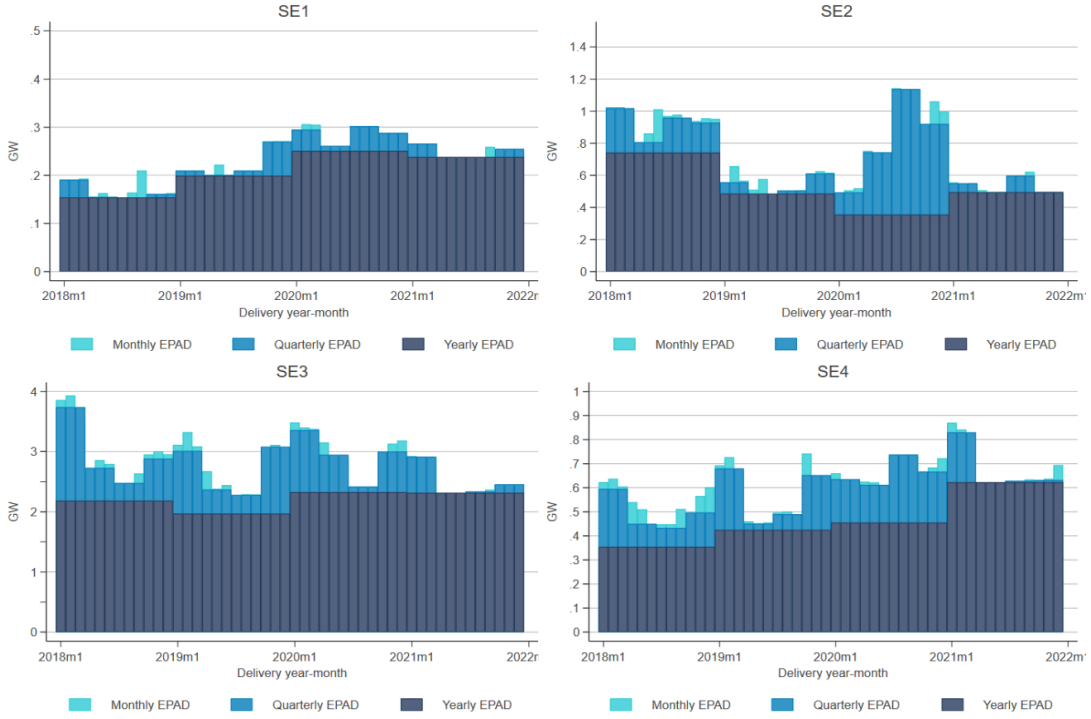


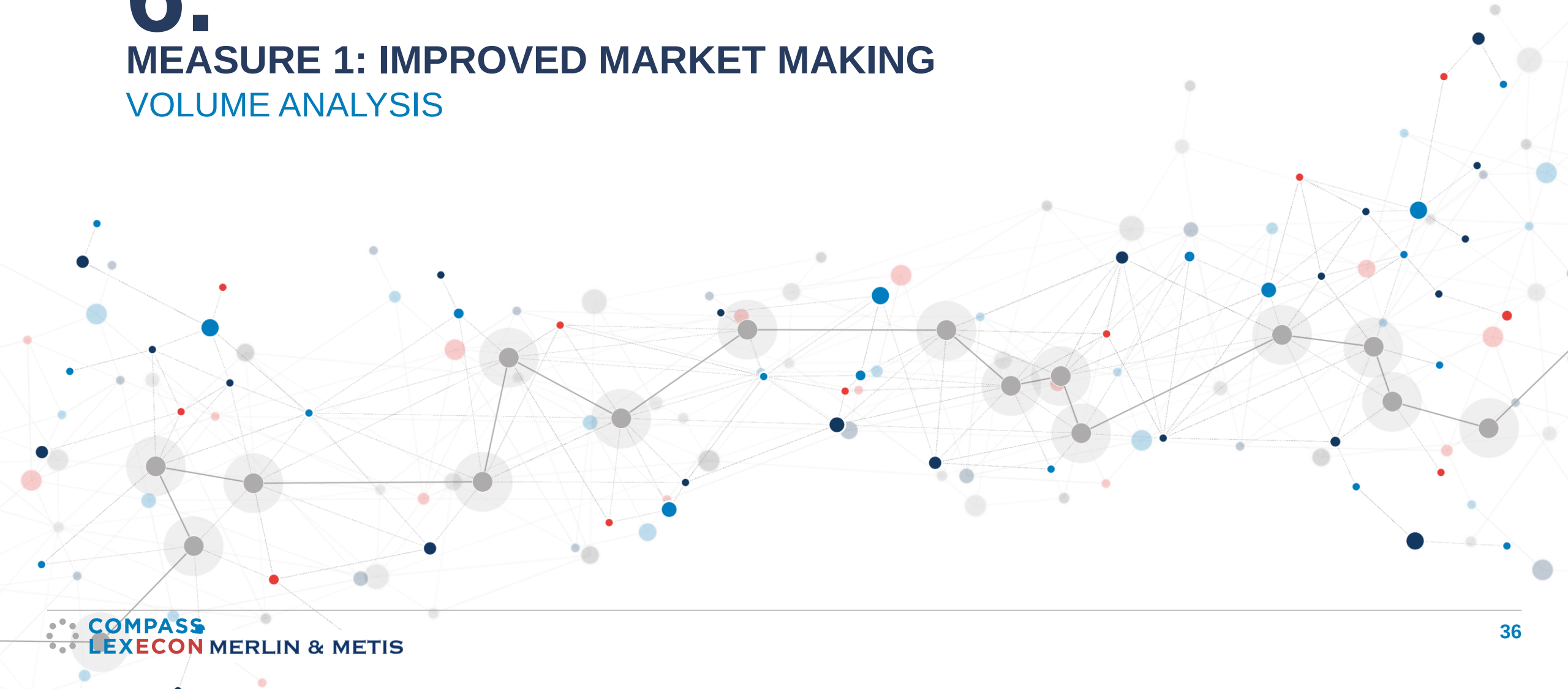
Figure: Open interest (capacity) of EPADs in Swedish bidding zones by delivery year, GW – monthly representation



6.

MEASURE 1: IMPROVED MARKET MAKING

VOLUME ANALYSIS



IMPROVED MARKET MAKING
APPROACH TO DERIVE VOLUME IMPACTS

Approach:

- On **26.11.2021** Vattenfall AB ceased its market making role for Nordic Electricity Price Area Differential (EPAD) future contracts: **FI** (Helsinki), **SE1** (Luleå), **SE2** (Sundsvall), **SE3** (Stockholm), and **SE4** (Malmö).
- We create daily sums of **open interest (OI)** by BZ and contract maturity and observe their developments **before** and **after** Vattenfall's departure from the MM role in EPADs for **FI** (Helsinki), **SE1** (Luleå), **SE2** (Sundsvall), **SE3** (Stockholm), and **SE4** (Malmö) bidding zones.

Open interest difference:

- In the studied period (2017-2021) the Swedish EPADs represent approximately 57% of all EPADs' open interest.
- Compared to the average historical OI of Swedish EPADs in December months ~60TWh (2017-2020), the December 2021 open interest was **lower by 1.23 TWh**, which is 2% lower than the historical average.

Impact of 1 market maker

- Study the impacts of up to 5 market makers on open interest and traded volumes.
- We assume the marginal (additional) liquidity benefit of an additional MM stays the same.

IMPROVED MARKET MAKING

IMPACT ON OPEN INTEREST

- **5 MM active in the Swedish EPADs** could increase **open interest** in the Swedish EPADs by **10% (+6TWh)** compared to the historical value of ~59TWh

- If the additional Swedish EPAD open interest was pooled into the historical EPADs market =>
- The total **Nordic EPAD open interest** would be approximately 110 TWh or **6% higher** than historically
- For comparison to the historical average of 230 TWh of open interest in the Nordic system price contracts

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

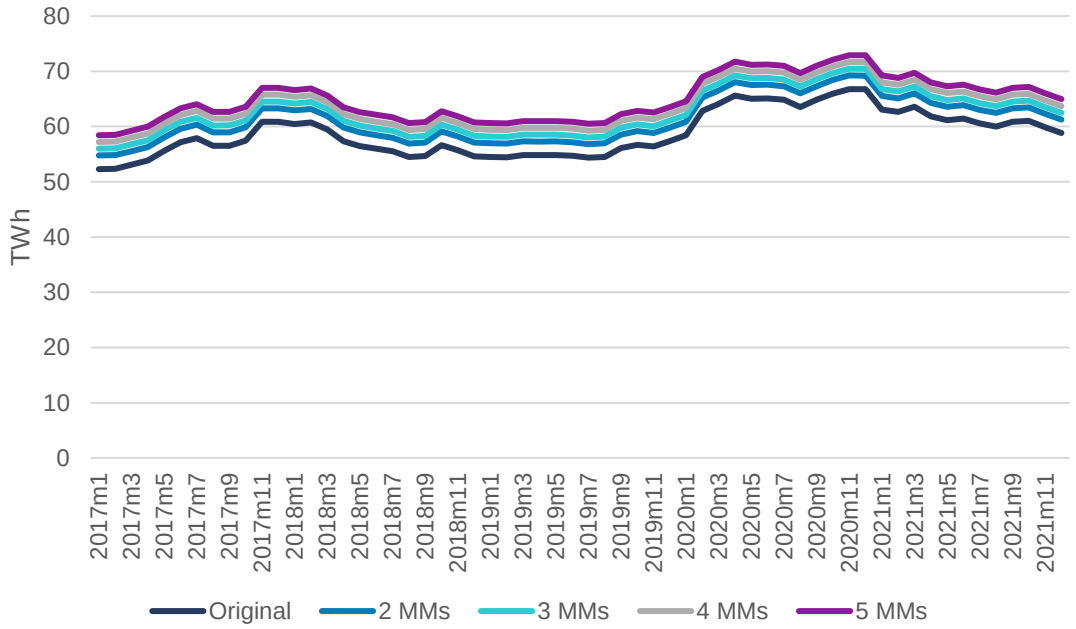
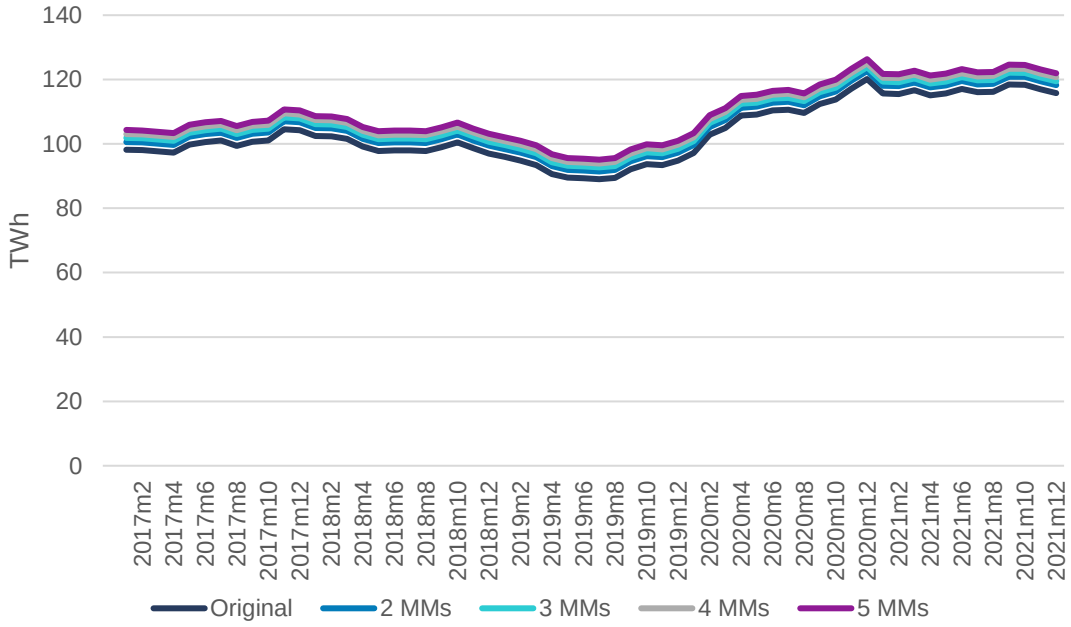


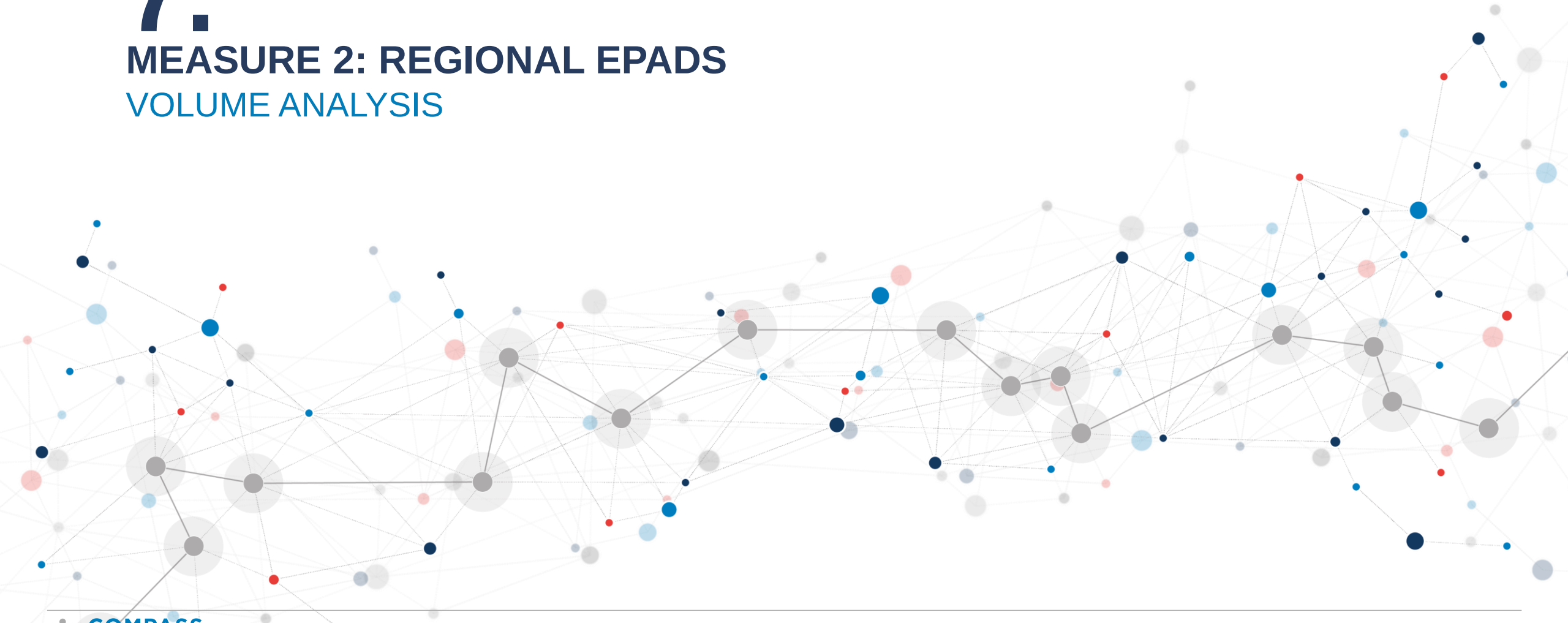
Figure: Nordic EPAD open interest by month with Swedish MM impact



7.

MEASURE 2: REGIONAL EPADS

VOLUME ANALYSIS



CORRELATION ANALYSIS – DEFINE REGIONS

DAY-AHEAD PRICE CORRELATION OF AREA AND SYSTEM PRICES

- Correlation analysis provides insights into the **appropriates of a hedge**
- **Norway** has stable correlations to the system price except for the last year in NO3 and NO4
- **Swedish** bidding zones used to be relatively well correlated to the system price in 2018-2019
- **Finland's** and **Denmark's** bidding zones have a lower average correlation to the system price
- **The Baltic** bidding zones have historically had poor correlation to the Nordic system price but last year it has markedly improved

Table: Day-ahead price correlation of area and system prices, 2017-2021

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

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

CORRELATION ANALYSIS – DEFINE REGIONS

PROPOSED REGIONS

Based on the correlation analysis, we propose to pool together several Swedish and Norwegian bidding zones and define them as **Regional EPADs**, namely:

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

CORRELATION ANALYSIS – DEFINE REGIONS

DAY-AHEAD PRICE CORRELATION OF AREA PRICES BY PROPOSED REGIONS

- Price correlations between the area prices of the proposed regions
- Good historical price proximity between the pairs of the pooled region, all beyond >0.8

Day-ahead price correlation of area prices by the proposed regions

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

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

CORRELATION ANALYSIS – DEFINE REGIONS

DAY-AHEAD PRICE CORRELATION OF AREA PRICES AND REGIONAL CONSUMPTION-WEIGHTED PRICES

- Pooled region's **consumption-weighted prices** and the **area prices of the bidding zones** included in the respective region
- This correlation **measures the fit of the regional price to the underlying bidding zone price**, showing almost perfect average correlation for all the included bidding zones, i.e., >0.96 in all cases
- The high correlations imply that the regional EPADs that we propose provide **almost a perfect hedge for the individual BZs**

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

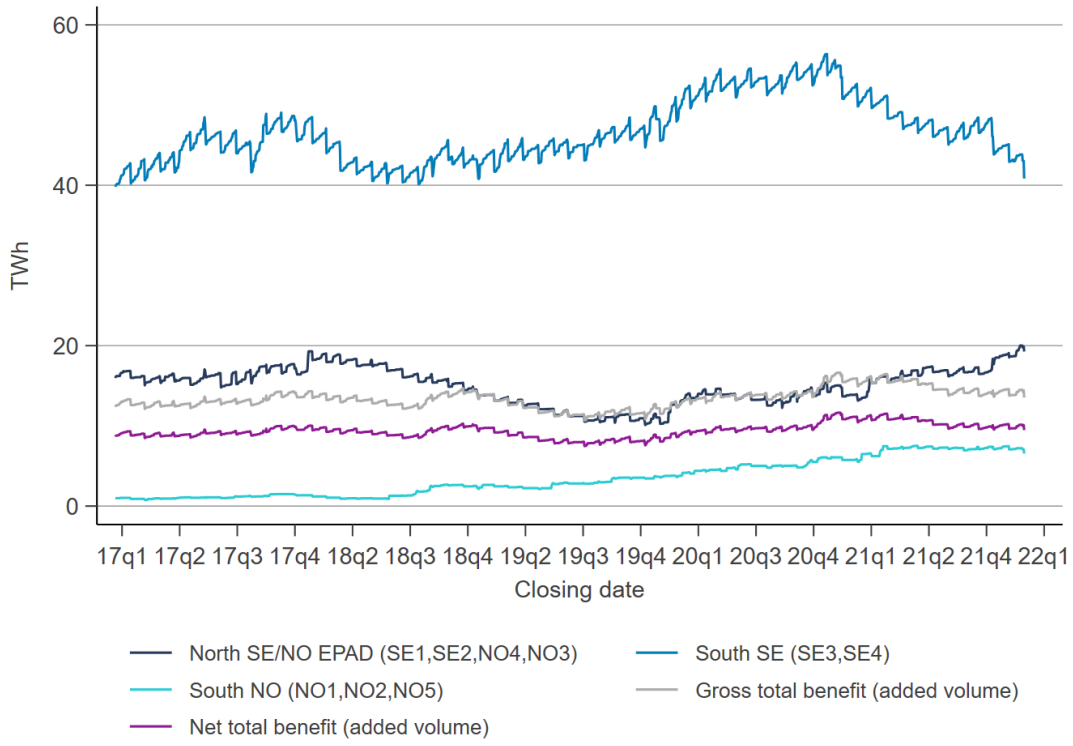
Region	North SE/NO				South NO			South SE	
Zone	SE1	SE2	NO3	NO4	NO1	NO2	NO5	SE3	SE4
2017	0.9	0.9	0.93	0.75	0.99	0.99	0.98	1	0.95
2018	0.98	0.98	0.99	0.96	0.97	0.98	0.95	0.99	0.94
2019	0.95	0.95	0.98	0.97	1	1	1	1	0.96
2020	0.88	0.88	0.88	0.83	1	1	0.98	0.99	0.93
2021	0.98	0.98	0.99	0.94	1	1	1	1	0.95
Total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

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

CORRELATION ANALYSIS – VOLUME IMPACTS

OPEN INTEREST OF REGIONAL EPADS

Figure: Open interest of the regional EPADs

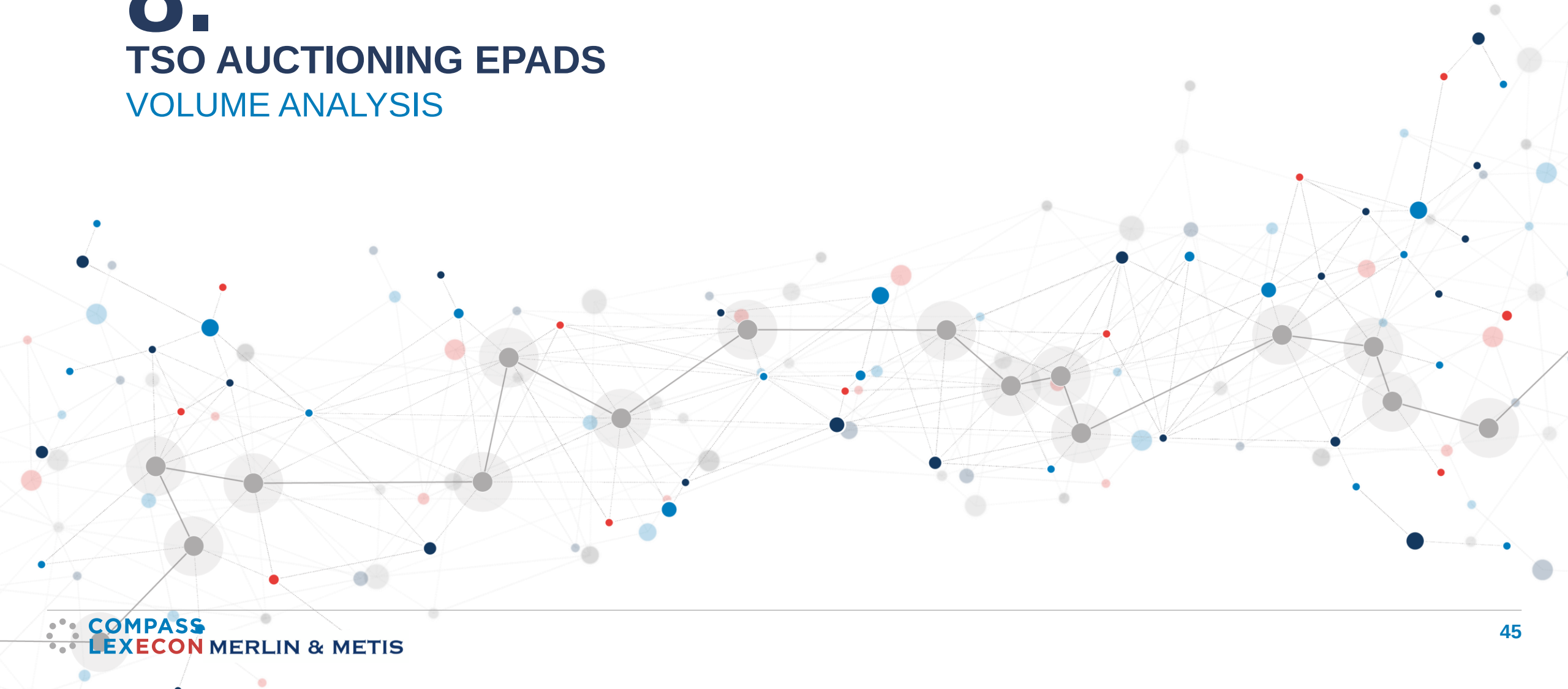


- **South SE EPAD** would be the product with largest volumes, followed by the **North SE/NO**, and **South NO**
- We assume the pooled product would increase the open interest during the trading time by the value equal to the regional EPAD's open interest net of the open interest volume of the largest underlying BZ.

  => Netting SE2 from North SE/NO, SE3 from South SE, and NO1 from South NO.

- On average, this would increase open interest by approximately 20% or **13 TWh** during the trading time (gross benefit) on average.
- The assumed net benefit during the delivery time (the actual hedging need, ~70% of trading time) would be approximately **9 TWh.**

8.
TSO AUCTIONING EPADS
VOLUME ANALYSIS



TSO AUCTIONING EPADS

Option 1

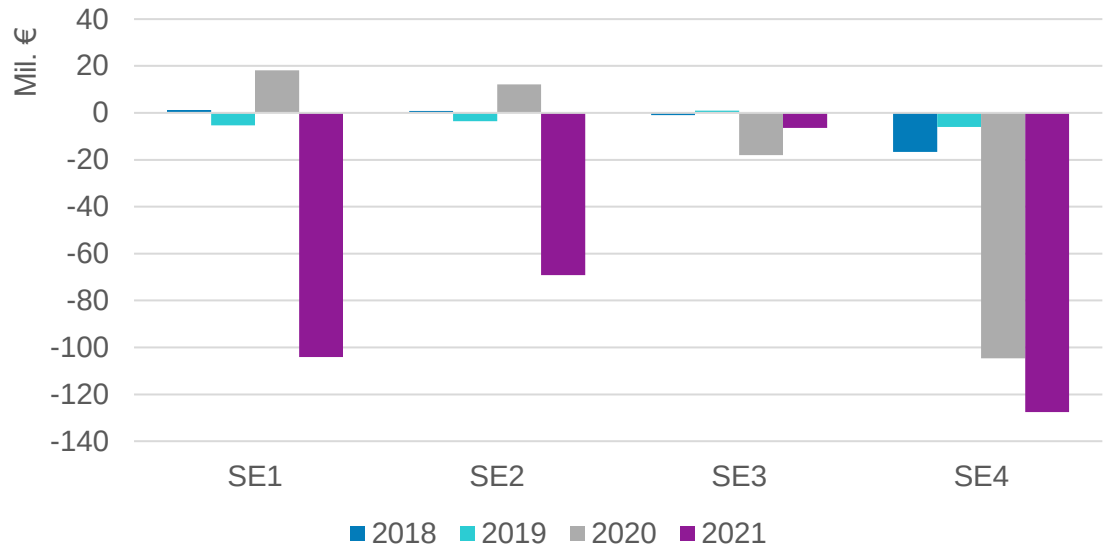
- We use a hypothetical estimate of the EPAD volumes per bidding area that a **Swedish TSO could auction** to address the current EPAD market limitations.
- Buying and selling EPAD volumes in a combination of bidding zones is also presented as **net volumes**: buying 600 MW (SE1) and 400 MW (SE2), and selling 200 MW (in SE3) and 800 MW (in SE4) => total (absolute) of approximately 2000 MW/year (17.5 TWh/year).
- **In 2021**, the total congestion rent cost would be ~ **€300 million** for the Swedish internal interconnections; ~20% of the congestion rent collected on these lines in 2021.

Table: Auctioned EPAD volumes, Option 1

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

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

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



TSO AUCTIONING EPADS

Option 2

- To derive EPAD auction volumes, in Option 2 we propose to **link** together the **(il)liquidity measure** (bid-ask spread) from the futures market and the **fundamental imbalance** between power supply and demand in a BZ.
- We achieve the link, **in short**, by **ranking** and **weighting** the best bid-ask spreads, approximating the **maximum TSO-auctioned** EPAD volumes, and calculating the **yearly imbalances** (weights) between power production and consumption in each bidding zone.
- **In 2021**, total of ~**4100 MW** (~36 TWh) of EPADs would be auctioned when applying Option 2 approach. This would lead to ~ **€660 million** of congestion rent cost , which is ~42% of congestion rent collected in 2021 on the internal Swedish cross-border lines.

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

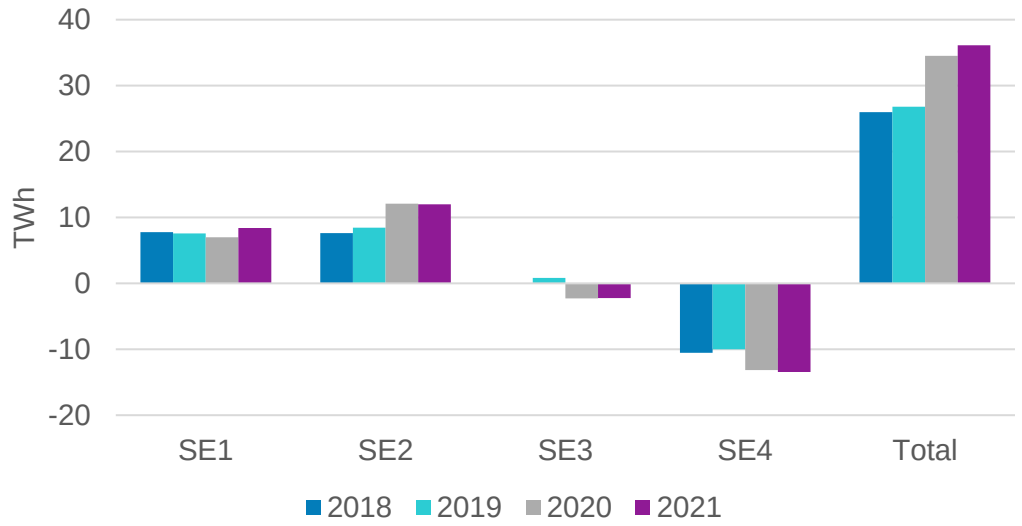
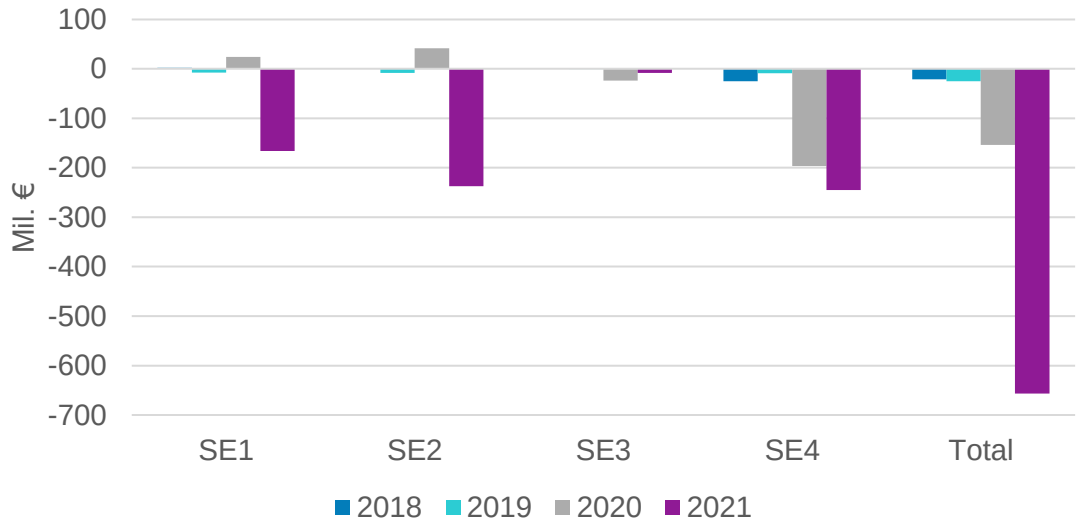


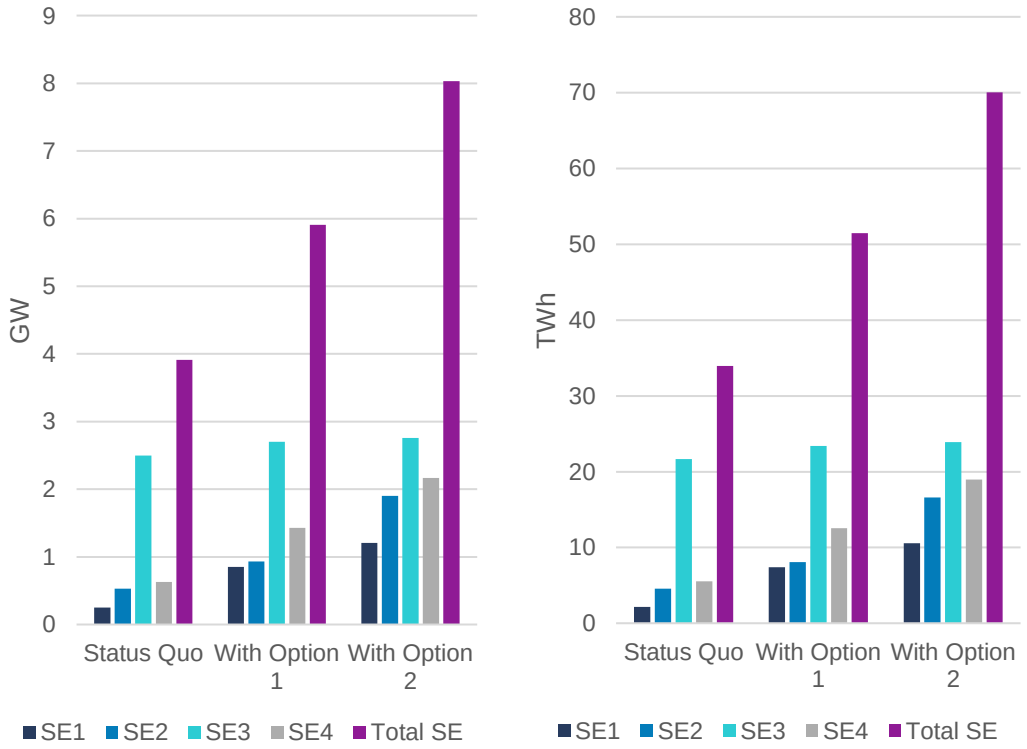
Figure: Annual congestion rent cost to TSO auctioning EPADs, Option 2



TSO AUCTIONING EPADS

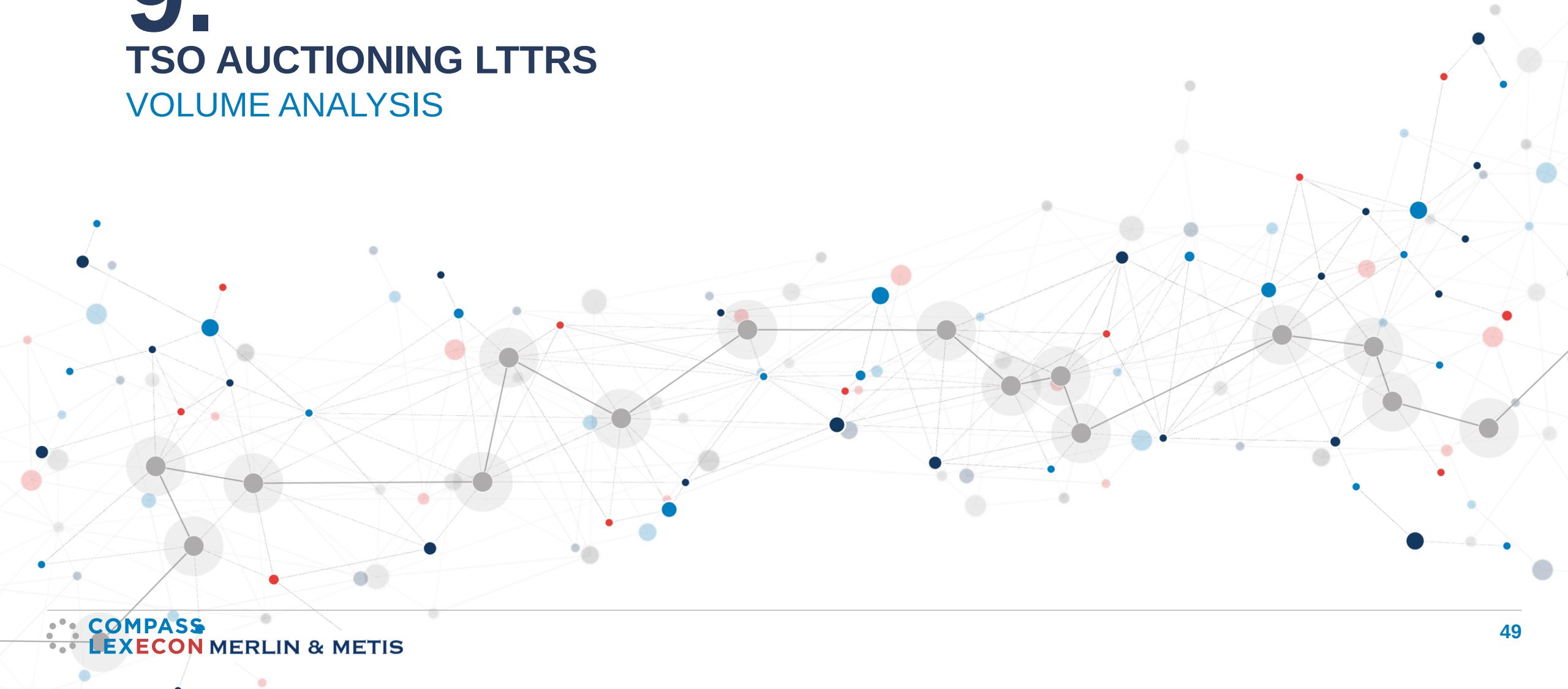
COMPARISON OF STATUS QUO TO OPTIONS 1 AND 2

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



- Compared to status quo, Option 1 adds approximately 50% of additional volumes (+2000 MW/ 17.5 TWh)
- Compared to status quo, Option 2 doubles the volumes (+4100 MW/ 36 TWh).
- The volume increases behind Options 1 and 2 may further attract speculative market participants and trigger a positive liquidity spiral.

9.
TSO AUCTIONING LTTRS
VOLUME ANALYSIS



TSO AUCTIONING FTRS

Figure: Congestion rent for FTR obligation and option in SE3>SE4 direction

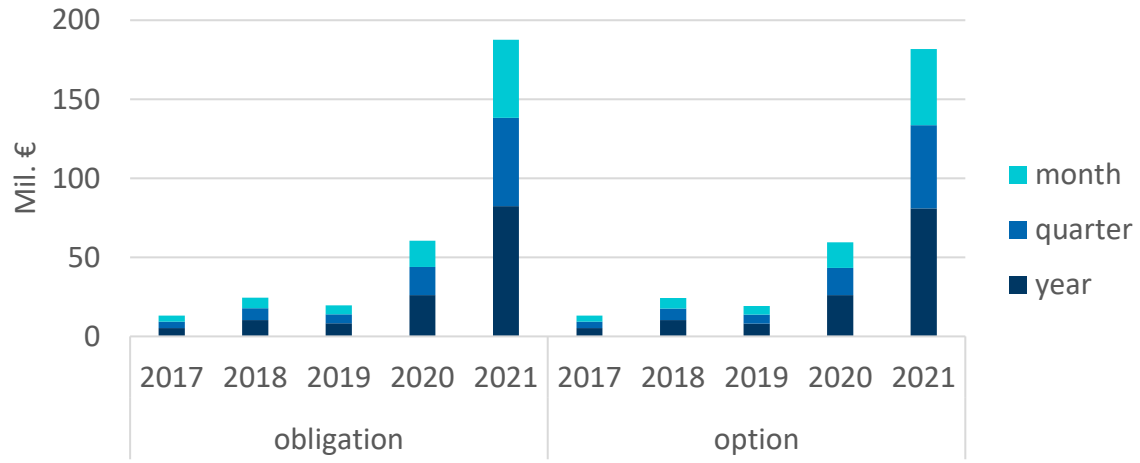


Table: Auctioned FTR volumes on internal interconnectors in Sweden in 2021

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

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

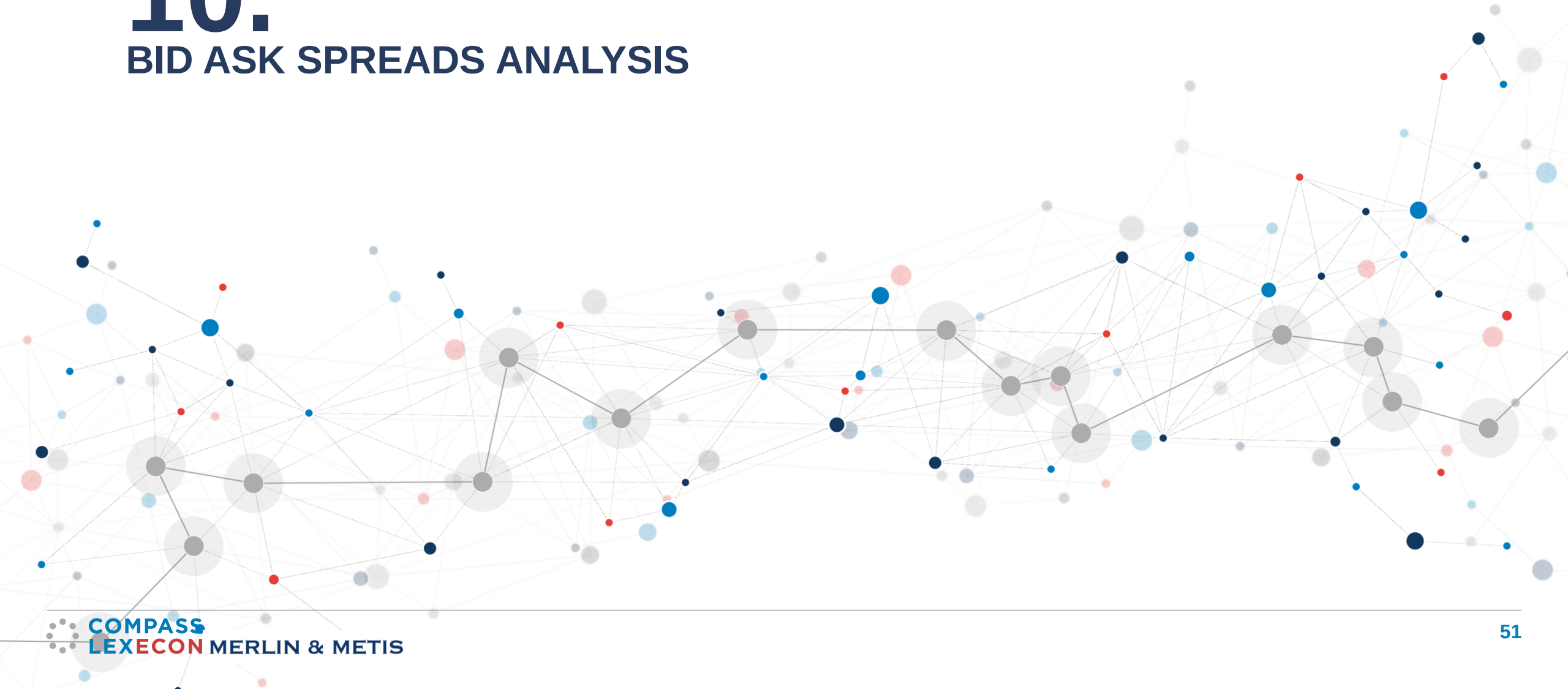
Approach

- Focus on internal cross-zonal lines in Sweden (SE1>SE2, SE2>SE3, and SE3>SE4)
- Define 30% of the maximum NTC allocated to the day-ahead over a full year, each quarter, each month
- For FTR obligations, consider NTC capacities in all hours
- For FTR options, consider NTC capacities for hours with positive price difference on the interconnector (direction)
- Split the auctioned volumes into yearly (40%), quarterly (30%), monthly (30%) contracts
- Assume FTRs are auctioned for the value equal to the realized price difference between the underlying BZs

Results

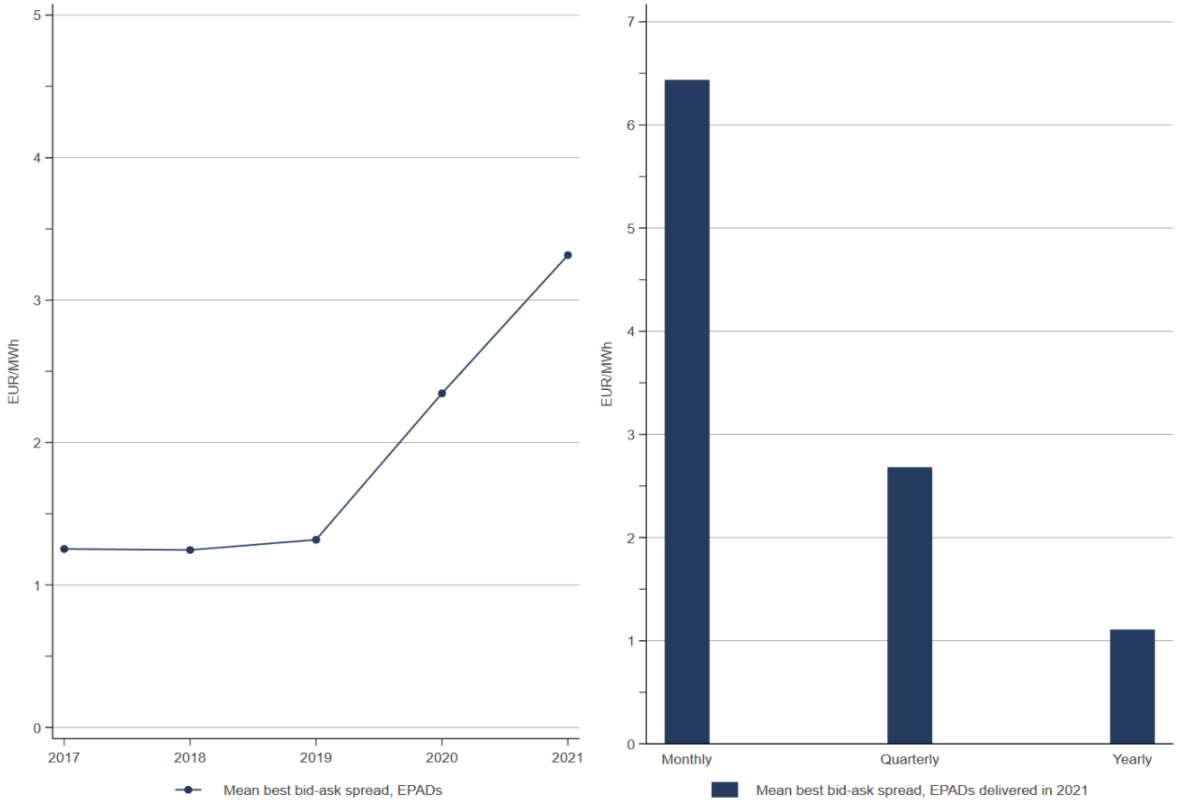
- The TSO would auction approximately **4000 MW/year** (~35TWh) for approximately €600 million in 2021
- These are similar and slightly lower values as for the Option 2 of TSO EPAD auctions, which were approximately €660 million (~4100 MW/36TWh)

10.
BID ASK SPREADS ANALYSIS



BID-ASK SPREAD ANALYSIS

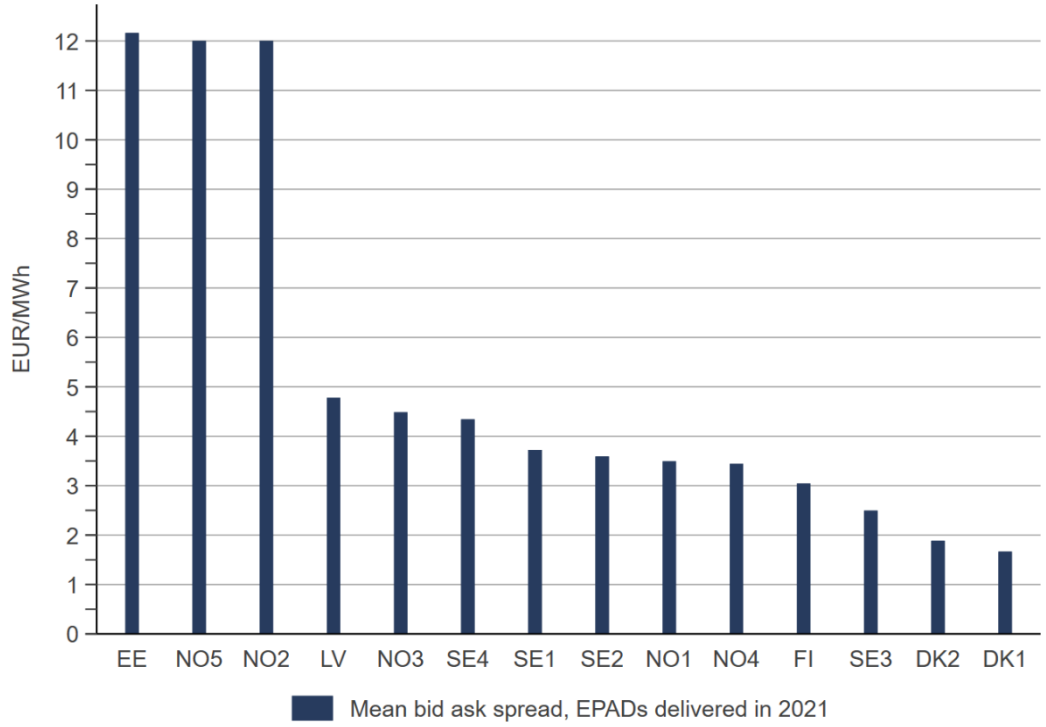
Figure: Mean daily best bid-ask spreads for EPADs, by delivery time



- Mean daily best bid-ask spreads of EPADs have been increasing especially over the last two years.
- EPADs delivered in 2020 had the mean best bid-ask spread almost **2.5 EUR/MWh** and in 2021 over **3 EUR/MWh.**
- Longer contract maturities have lower bid-ask spread.

BID-ASK SPREAD ANALYSIS

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



- The mean best bid-ask spreads of EPADs delivered in 2021 by BZ show that :
  - The highest values are in **EE**, **NO2** and **NO5** (12 EUR/MWh); and
  - The lowest values are in **DK1** and **DK2** (~1.70 EUR/MWh) and **SE3** (2.50 EUR/MWh)

BID-ASK SPREAD ANALYSIS

- Mean best bid-ask spread for the **Swedish BZs EPADs** by delivery year show an increasing trend over the last 4 years in all contract maturities
- Mean best bid-ask spread for the **Nordic system price** contracts also show a slightly increasing trend overall (much lower in absolute terms than EPADs), but the front contracts only keep their spreads relatively stable over the last 4 years.

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

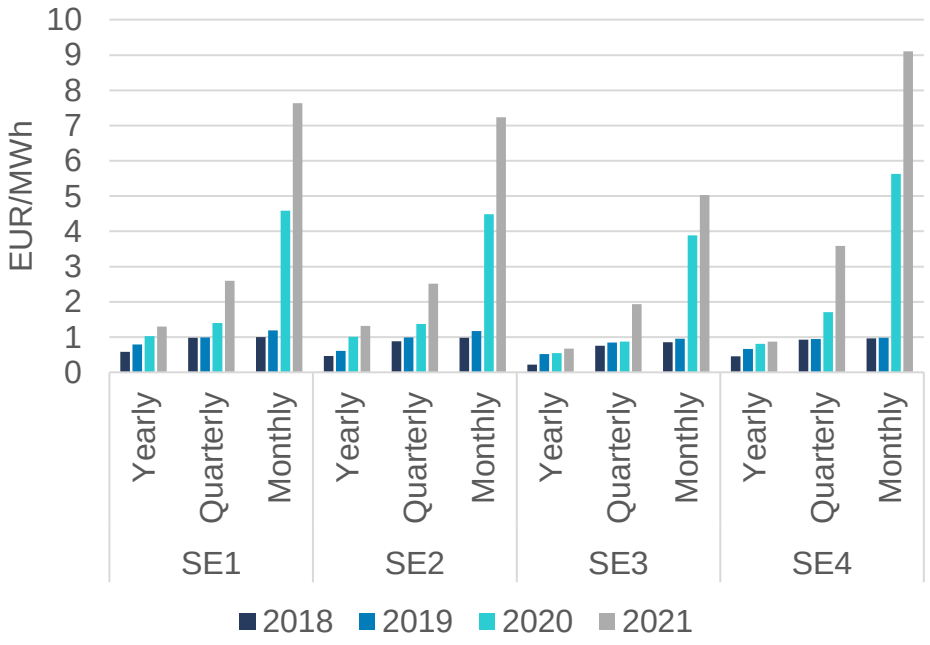
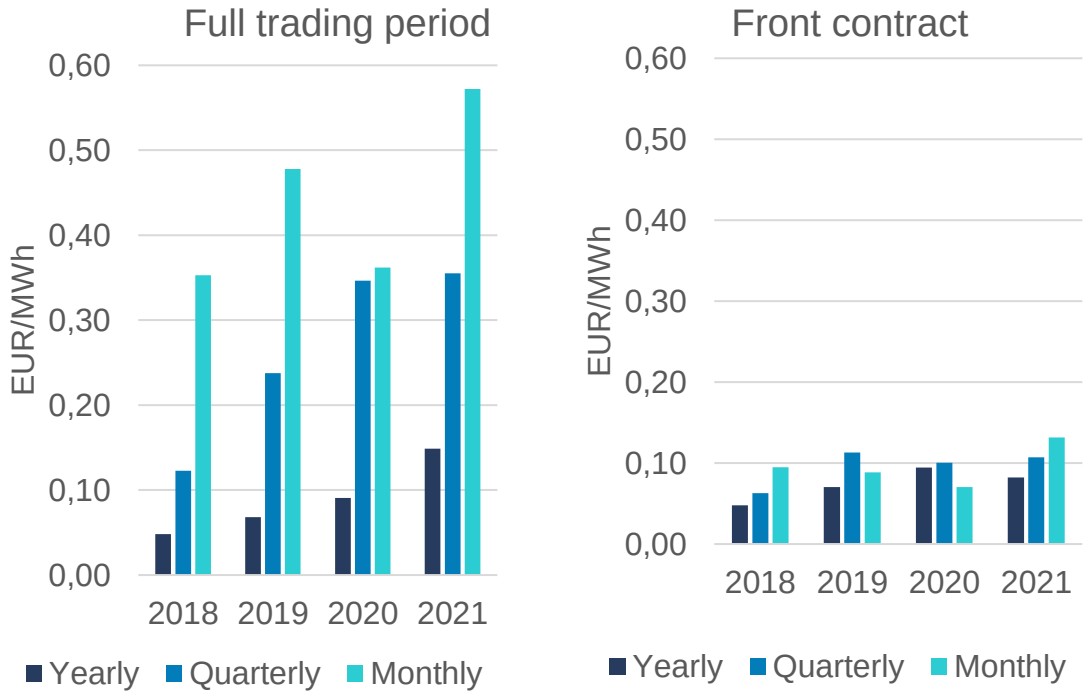
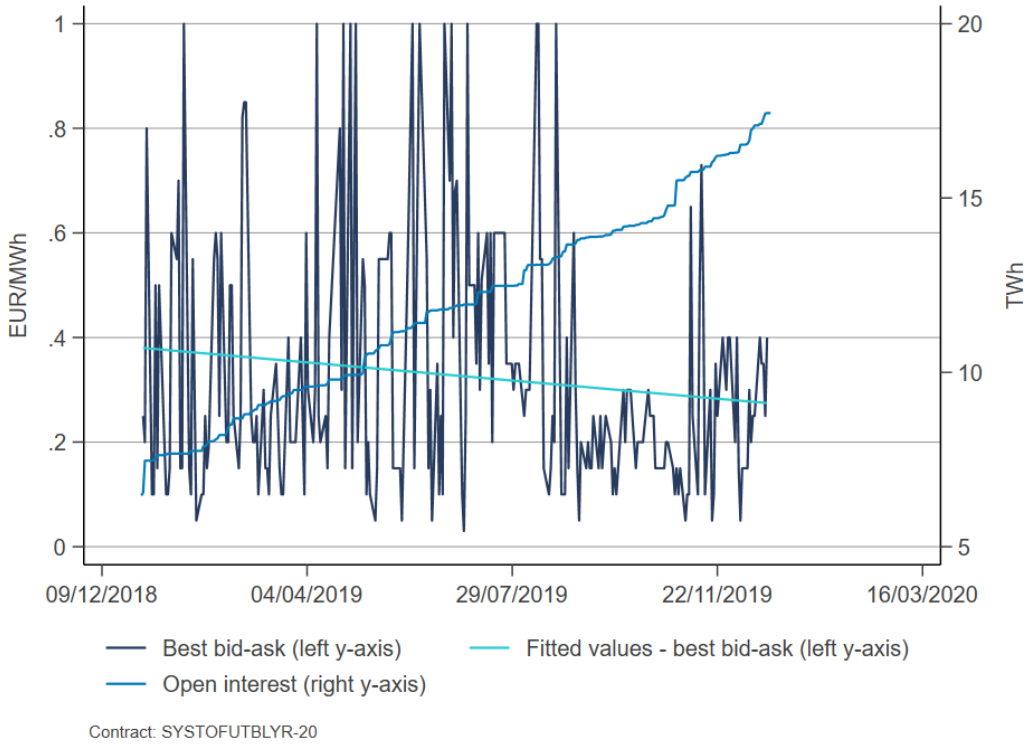


Figure: Mean SYSTEM contract best bid-ask spreads by contract maturities and delivery year



RELATIONSHIP BETWEEN BID-ASK SPREAD AND OPEN INTEREST

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



Approach

- **Bid-ask spread** data sample with 1639 unique contracts traded in the period 2017-2021.
- We merge this dataset with an **open interest** dataset to observe the quoted best bid-ask spread behaviour in relation to the open interest.
- We also use the variable "**Count**" which includes the number of minutes per day with available bid-ask spread => control for trading opportunity.
- We estimate the following **relationship**:

$$\boldsymbol{BidAskSpread_{z,m,t} = c + \beta_1 * OpenInterest_{z,m,t} + \beta_2 * Count_{z,m,t}}$$

- Where *z* stands for bidding zone, *m* stands for contract maturity, and *t* stands for trading day.

Results

- The relationship of both, Open Interest ($\boldsymbol{\beta_1}$) and Count ($\boldsymbol{\beta_2}$), is negative and statistically significant.
- The coefficient $\boldsymbol{\beta_1}$ (Open Interest) ranges between **-0.122** (SE3) and -**0.597** (SE1), with -**0.166** for Sweden overall.

GROSS BENEFITS

MEASURES IMPROVING THE EXISTING EPAD MARKET

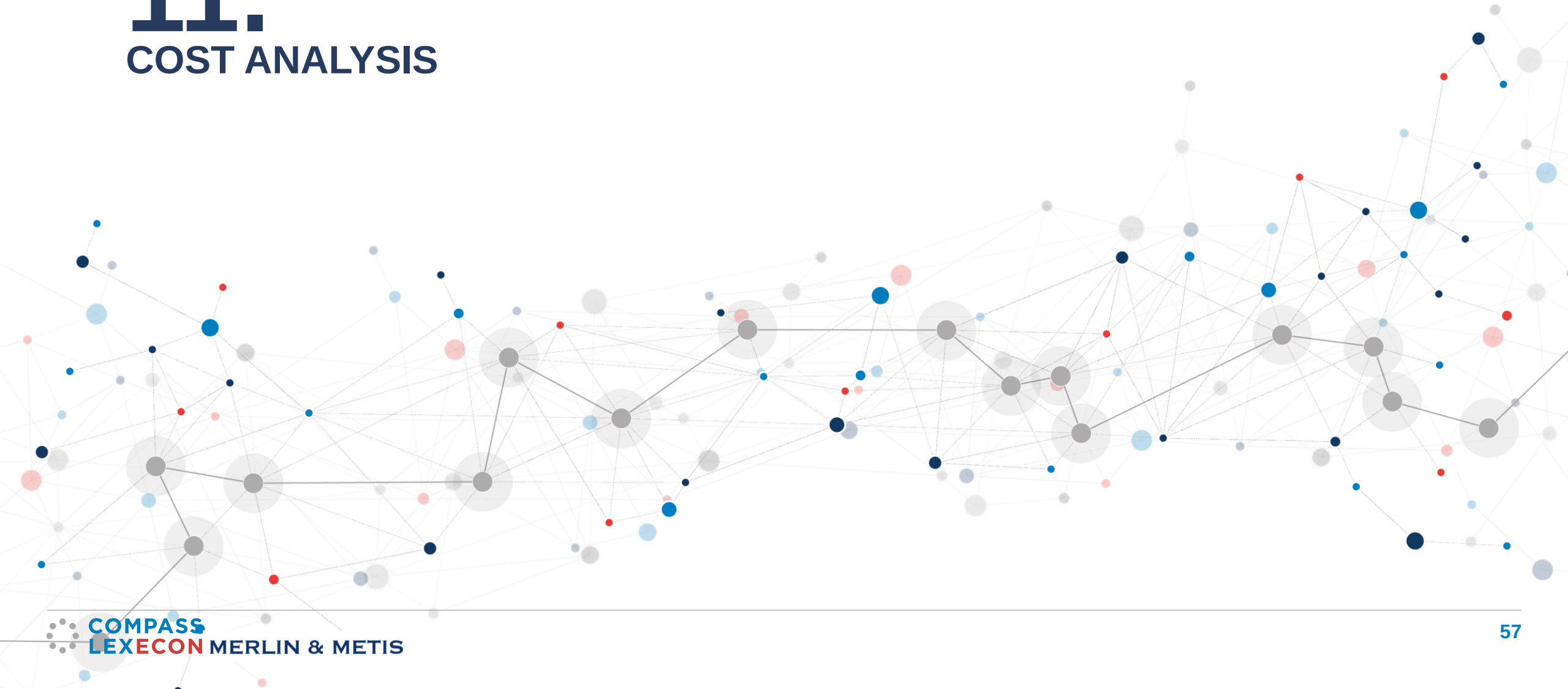
- We quantify **gross benefit** of each measure improving risk hedging in Sweden by using the estimated increased volumes (open interest) and the estimated relationship between open interest and bid-ask spread.
- **Measure 3** brings the largest benefits via the largest added volumes and largest bid-ask spreads reductions.

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

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

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

11.
COST ANALYSIS



COST ANALYSIS
OVERVIEW OF FOUR MEASURES

Measure 1: Improved market making

- Costs are dependent on the actual design elements and conditions specified in a market making agreement. Nonetheless, **two main cost components** are:

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

Table: Annual societal cost of tendered market making

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

Source: Compass Lexecon analysis based on Ofgem report 2019

Measure 2: Regional EPADs

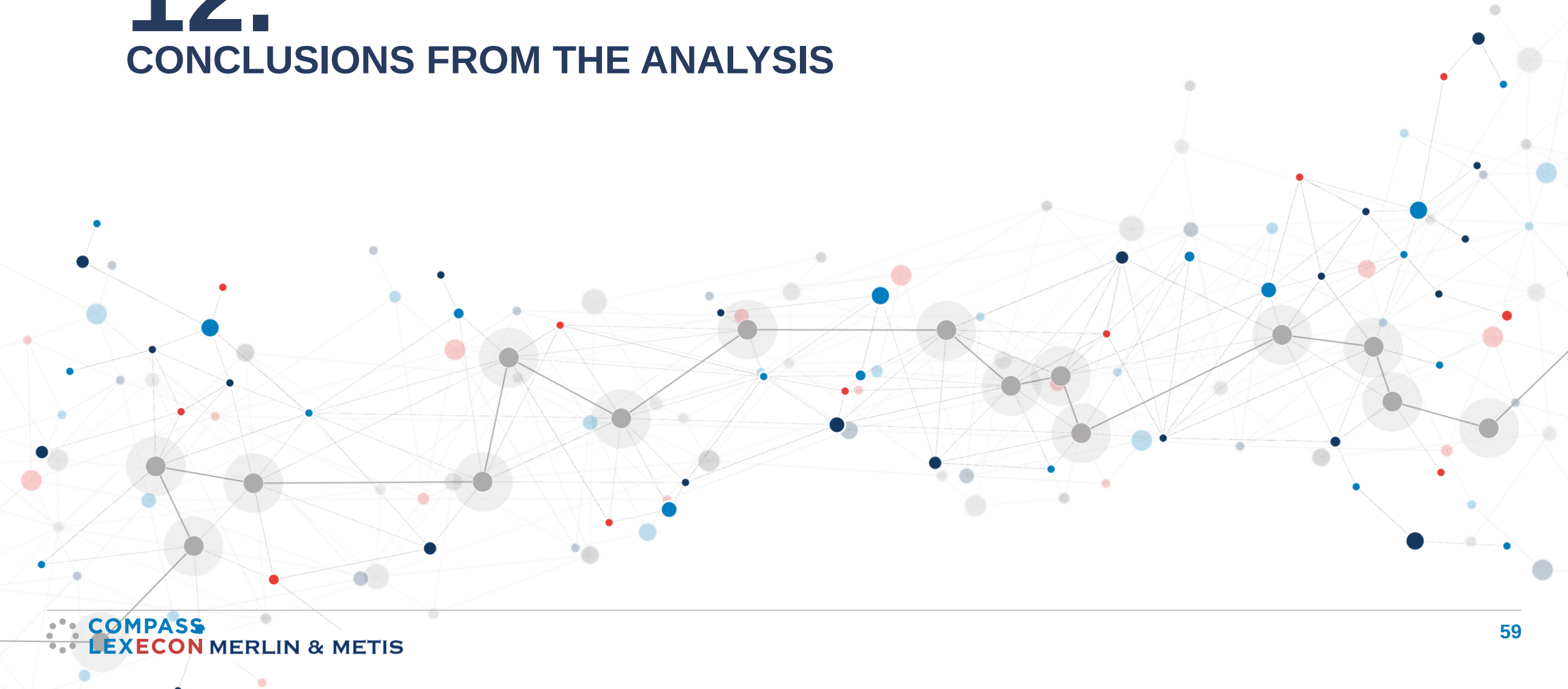
- Introduction of Regional EPADs would rely on the existing infrastructure and processes and the actual redesign costs of the existing EPAD product would be negligible for the exchange to implement. We therefore assume the cost of approximately **0 €** or **negligible**.

Measure 3 and 4: TSO auctioning EPADs and FTRs

- The measure of TSO auctioning FTRs on the Single Allocation Platform JAO would cost approximately €150k /year for 3 products (yearly, quarterly, monthly) per border*. We assume the TSO auctioned EPADs would cost the same because a platform of very similar nature would be used.
- For the three internal borders in Sweden, the TSO auctioning EPADs or FTRs cost would be **€450k** per year.

*If the FTR auction on the given border would involve two TSOs, the annual cost would be €300k /year split by half. However, since this study focuses only on the three internal borders in Sweden operated by a single TSO, the costs per border do not double. This is because some of the costs are shared per TSO and do not depend on the number of borders or FTR products offered.

12.
CONCLUSIONS FROM THE ANALYSIS



NET BENEFITS
CONCLUSIONS FROM THE ANALYSIS

Measures improving the existing hedging market in Sweden,

- The **TSO-auctioned EPADs delivers the highest societal net benefit.**
- Detailed implementation and financing options of this measure is a **work-to-be-done.**
- TSO auctioned EPADs is a measure with a **good potential to improve the market** that the market participants have been relying on, are familiar with, and are asking for its improvement rather than its overhaul.

LTTRs

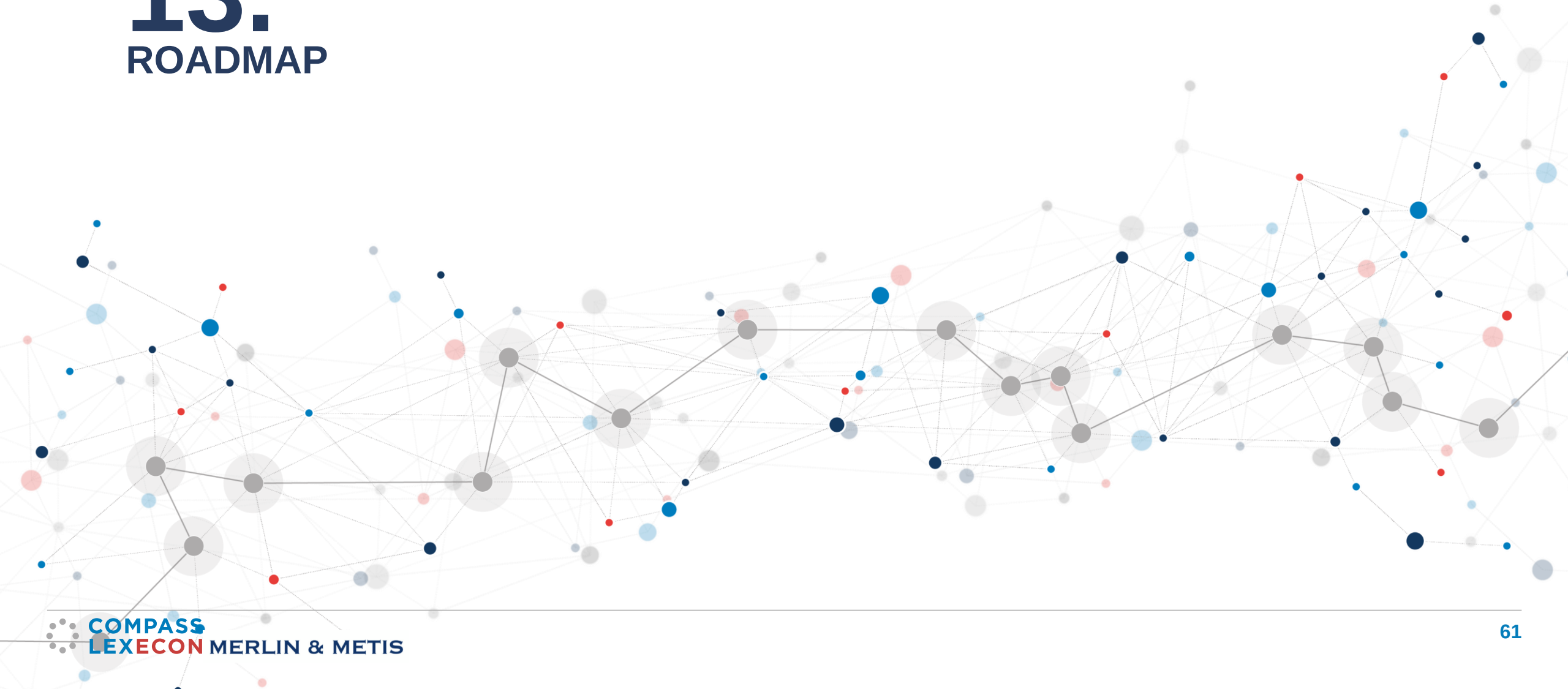
- Direct and/or indirect societal benefits of FTRs were left outside of this study (N/A in the table below)
- The potential benefits of FTR auctions for hedging may come, for example, from indirect effects of increased liquidity in other hedging products, such as Nordic system price. However, these benefits are expected to be small.

Table: Summary of annual benefits and costs

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

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

13.
ROADMAP



ROADMAP TO IMPLEMENT RECOMMENDED MEASURES

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

Best case	Worst case
Measures implemented in 12 months.	Implementation takes 24 months or longer.

- **Step 2:** Measures within Sweden can be decided upon by Ei. Ei can soon request from Svk to develop the necessary arrangements to implement suggested measures. Svk than have six months to do so.
- **Step 3:** When Svk has finalized its task, Ei approval is required. Ei then have the following three options:
  - Approve the TSOs work.
  - Ask the TSO for adjustments and completions.
  - Adjust the work provided by the TSO.
- **Step 4:** Necessary arrangements shall be implemented no later than six months after approval.
- The implementation time may be extended by a period of no more than six months.

TIME SCHEDULE CHALLENGES

During step 2: Important to give time for public consultation

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

During step 4: Many steps can be run in parallel

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

FOLLOW UP ONCE THE MEASURES ARE IMPLEMENTED

- It will be difficult to find the volumes for EPAD auctioning or optimal market making requirements from the start.
- Even if the optimal settings would be achieved from the start, they are likely to change over time.
- It will be important to have a model to continually evaluate liquidity and how the measures affect liquidity in contrast to what they cost.

CONTACTS

MERLIN & METIS

Christian Holtz

Senior consultant, partner

E-mail: christian.holtz@merlinmetis.se

Tel: + 46 70 382 4922

Saara Hollmén

Senior consultant, partner

E-mail: saara.hollmen@merlinmetis.se

Tel: + 46 76 946 5135

COMPASS LEXECON

Dmitri Perekhodstev

Vice president

E-mail: dperekhodtsev@compasslexecon.com

Tel: + 33 1 53 05 36 24

Petr Spodniak

Economist

E-mail: pspodniak@compasslexecon.com

Tel: +358 45 359 6565