ALEXANDER workshop
TSO-DSO Coordination

TSO-DSO coordination for procurement and activation of system services

Janka Vanschoenwinkel, Luciana Marques, Wicak Ananduta, Anibal Sanjab, Helena Gerard

2013-2016 — evolvDSO

2016-2019 — SmartNet

2017-2021 — EU-SysFlex

2019-2022 — coordiNET

2020-2024 — ONENET — one network for Europe

2020-2023 — EUniversal UMEI

2024-2027 — TwinEU

vito

vito.be

Goal

TSO-DSO coordination

From concept to implementation outcomes based on ALEXANDER

vito

Workshop Agenda

Time	Item
09:00 - 09:30	Welcome and coffee
09:30 - 09:40	Why DSO-TSO coordination?
09:40 – 12:20	4 steps to set up DSO-TSO coordination
09:45 - 09:50	Step 1
09:50 – 10:05	Step 2
10:05 – 11:30	Step 3
10:05 – 10:25	1 DSO-TSO coordination type 1
10:25 – 10:45	2 DSO-TSO coordination type 2
10:45 – 11:05	3 DSO-TSO coordination type 3
11:05 – 11:30	COFFEE BREAK
11:30 – 11:50	Model explanation
11:50 – 12:10	4 DSO-TSO coordination type 4
12:10 – 12:30	Step 4 and conclusions

vito

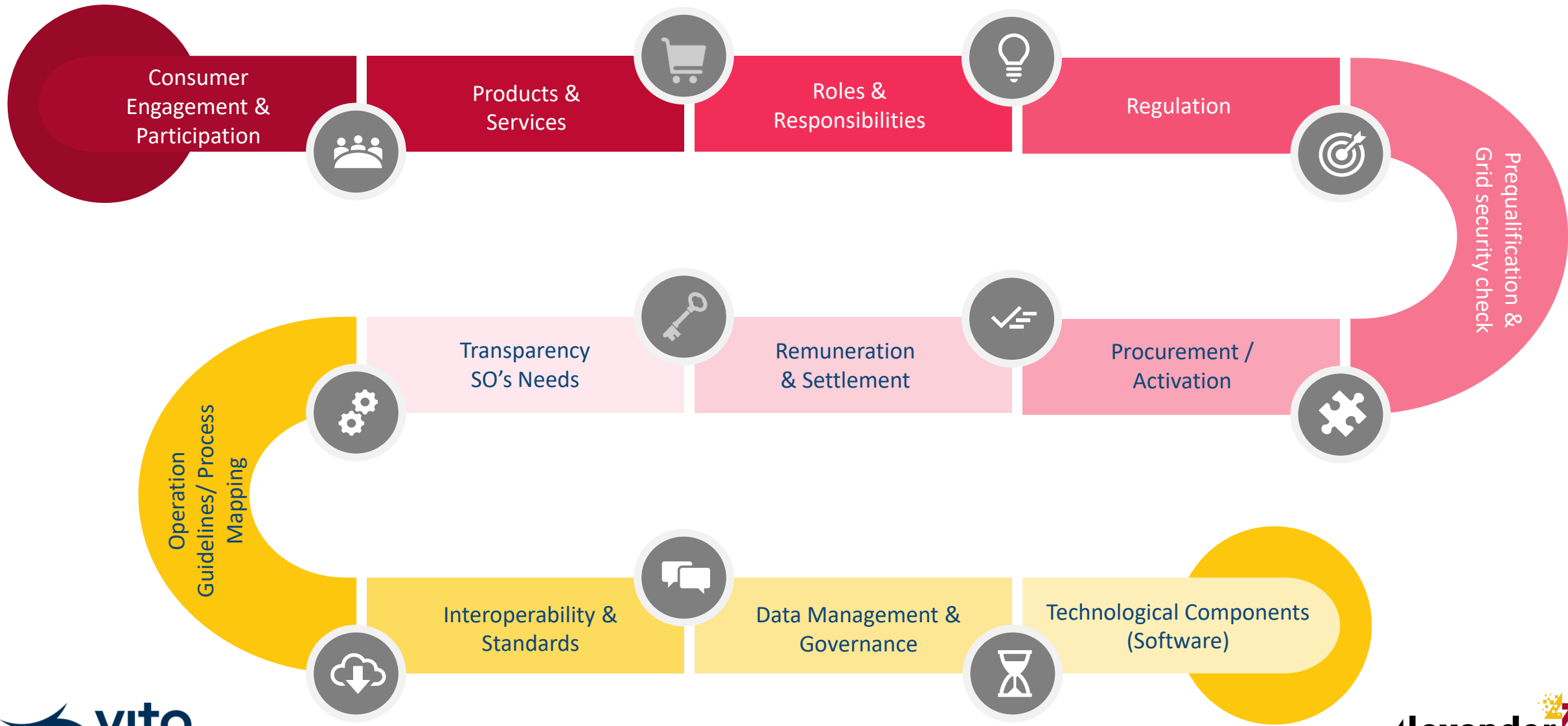Alexander

"To preserve the right to turn on the light at will, we should build a new world where turning it off is an opportunity"

- ARERA (Italian regulator) -

FLEXIBILITY MECHANISM DESIGN

# Ingredients to efficient and effective flexibility

Consumer Engagement & Participation

Products & Services

Roles & Responsibilities

Regulation

Prequalification & Grid security check

Operation Guidelines/ Process Mapping

Transparency SO's Needs

Remuneration & Settlement

Procurement / Activation

Interoperability & Standards

Data Management & Governance

Technological Components (Software)

INTEROPERABILITY

vito

Alexander

"A boat doesn't go forward if each one is rowing their own way."

Why do we need DSO-TSO coordination?

- Both DSO and TSO are working on the same "ingredients"
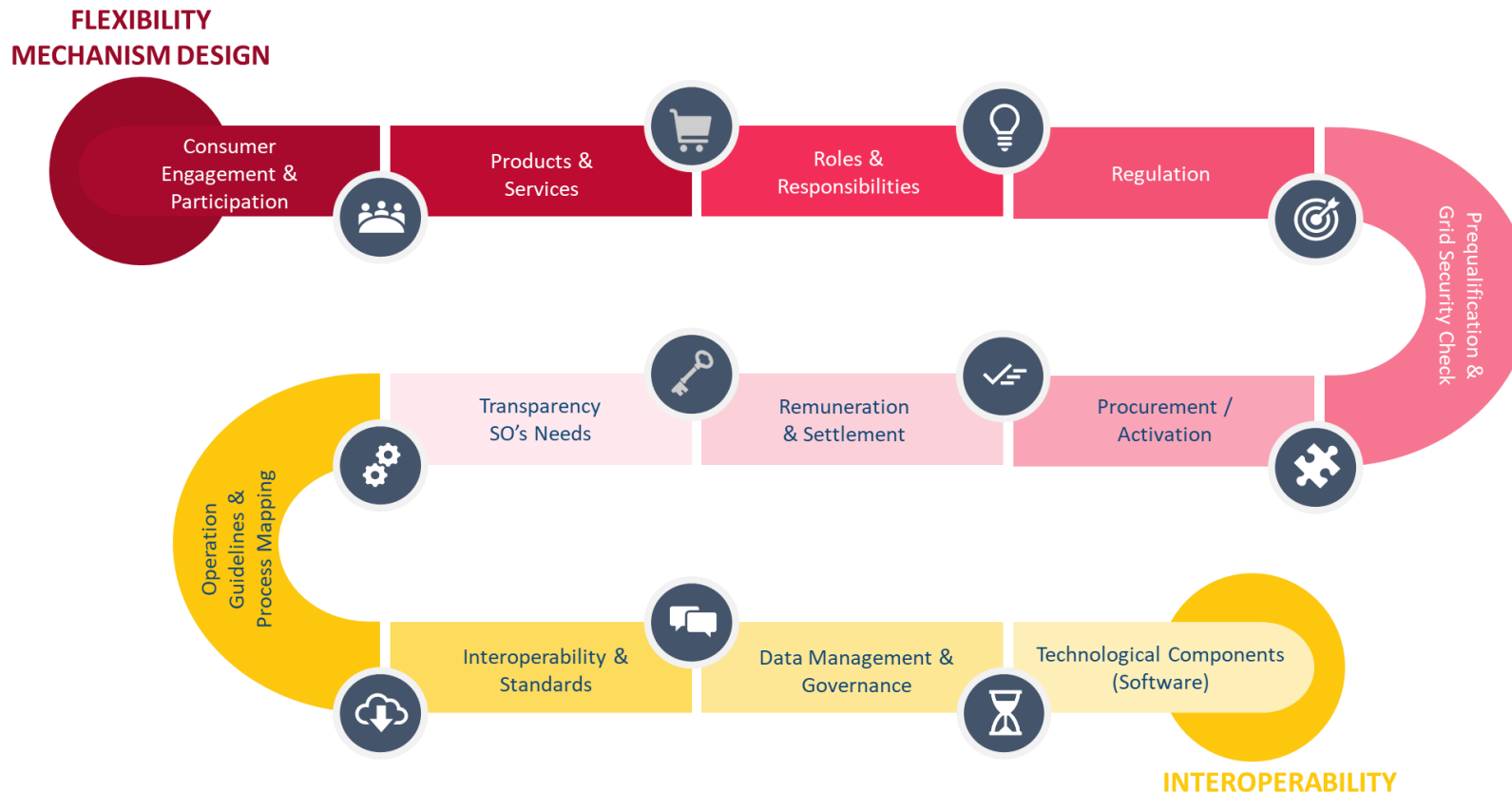
"A boat doesn't go forward if each one is rowing their own way."

Why do we need DSO-TSO coordination?

- Both DSO and TSO are working on the same "ingredients"
  - It is important to learn from each other, to not conflict with each other and to align with each other
  - Cooperation is acknowledged and expected by the draft NCDR

Article/chapter	Content citations
TITLE VII	TSO-DSO COORDINATION AND DSO-DSO COORDINATION
Article 54	1. No later than [6 months] after the approval of the national rules of procedure of a Member State pursuant to Article 4, all system operators of a Member State shall develop a proposal for national terms and conditions for TSO-DSO and DSO-DSO coordination. 2b Actions to solve balancing, congestion or voltage issues: (i) shall not create or aggravate congestion or voltage issues on other systems or regenerate problems that have been solved by actions taken by operators of those systems or endanger system security;
Article 57	2. To contribute to solving congestion or voltage issues on other grids, each system operator shall: (a) cooperate with system operators of those grids and consider grid-reconfiguration on its grid; and (b) cooperate with procuring system operators to facilitate and enable the delivery of local services by service providing groups or service providing units connected to its grid;
Article 59	Data exchange between system operators shall ensure: (a) that each system operator has access to data related to other system operators' systems, that are necessary to determine the condition of its own system, to forecast and detect congestion and voltage issues and to identify solutions; (b) the coordinated access of all system operators to all available resources to provide local and, where relevant, balancing services, and the optimal selection and activation of selected resources

"A boat doesn't go forward if each one is rowing their own way."

Why do we need DSO-TSO coordination?

- The Draft NCDR even goes further:
  - Coordination between multiple markets is needed
  - Resources should be optimally used from a system perspective

Article/chapter	Content citations
Article 43	Coordination and interoperability between local and day-ahead, intraday, and balancing markets
Article 54	2d Available resources to provide balancing and local services are optimally used, by enabling the delivery of local services at least cost and where they provide the most value to the whole system, consistent with market outcomes.

- In addition:
  - DSO and TSO have the same goal: making sure the light stays on.
    - Historically: rather independent grid management
    - Today: Their performance is starting to become depend upon each other due to
      - Bi-directional flows
      - Energy transition challenges and flexibility needs
      - More active participation of all types of consumers

4 key steps towards DSO-TSO coordination

1 **WHERE AND WHEN**

2 **OPTIONS**

3 **IMPLICATIONS**

4 **VISION**

When and where is coordination needed? What are priority use cases to study?

What are all the coordination options?

What are the consequences in practice when implementing these options?

How to move forward?

STEP 1

1 **2** **3** **4**

WHERE AND WHEN OPTIONS IMPLICATIONS VISION

When and where is coordination needed? What are priority use cases to study?

What are all the coordination options?

What are the consequences in practice when implementing these options?

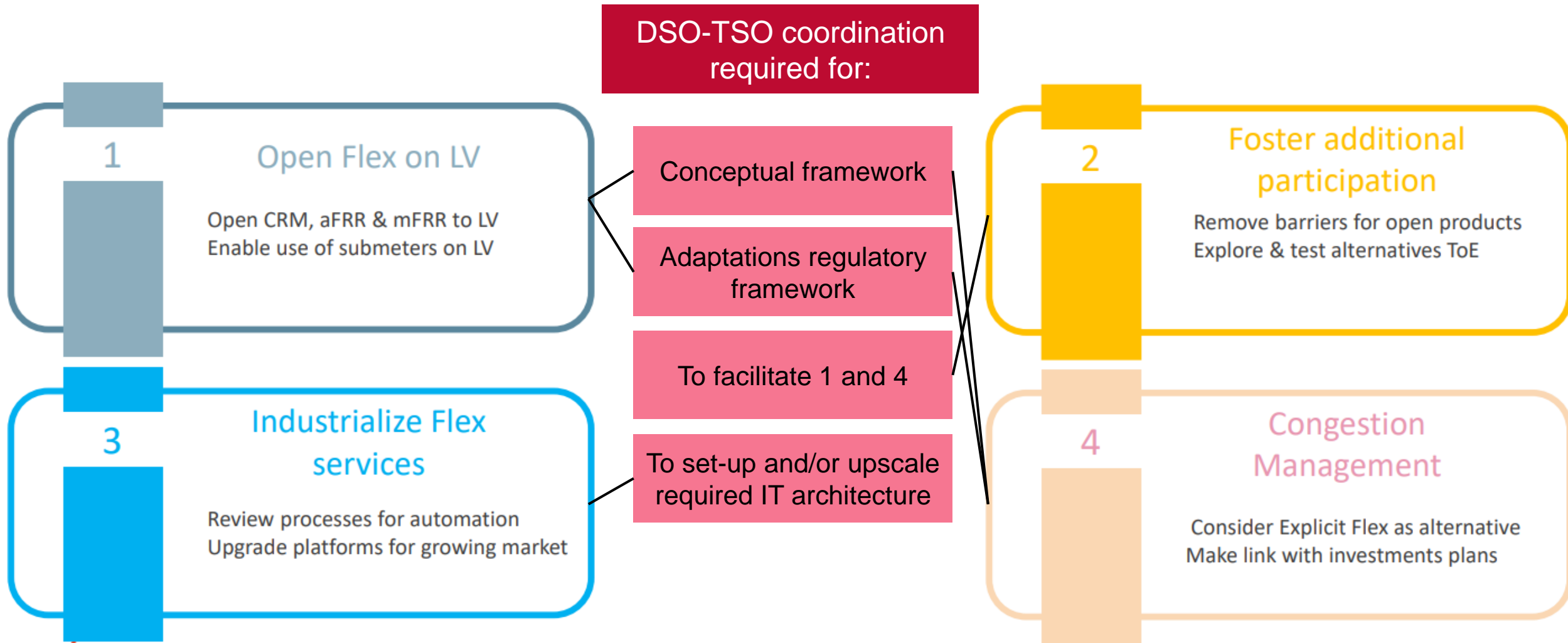How to move forward?

STEP 1

1

WHERE AND WHEN

When and where is coordination needed? What are priority use cases to study?

Use cases defined by Synergrid
1) Network planning
- SO remuneration
- Scenarios
2) Network operation
- Balancing
- Congestion and voltage issues
3) Data management
- …

Flex… a shared ambition

1 Open Flex on LV

Open CRM, aFRR & mFRR to LV
Enable use of submeters on LV

3 Industrialize Flex services

Review processes for automation
Upgrade platforms for growing market

DSO-TSO coordination required for:

Conceptual framework

Adaptations regulatory framework

To facilitate 1 and 4

To set-up and/or upscale required IT architecture

2 Foster additional participation

Remove barriers for open products
Explore & test alternatives ToE

4 Congestion Management

Consider Explicit Flex as alternative
Make link with investments plans

Synergrid
Voice of the networks

Alexander

STEP 2

1	2	3	4
WHERE AND WHEN	**OPTIONS**	**IMPLICATIONS**	**VISION**
When and where is coordination needed? What are priority use cases to study?	What are all the coordination options?	What are the consequences in practice when implementing these options?	How to move forward?

Two elements that dominate the coordination discussion

Who is procuring flexibility?

How do we ensure grid-safe flexibility procurement at system level?

Two elements that dominate the coordination discussion

Who is procuring flexibility?

How do we ensure grid-safe flexibility procurement at system level?

| TSO | DSO - TSO | TSO - DSO | DSO & TSO |

How do we ensure grid-safe flexibility procurement at system level?
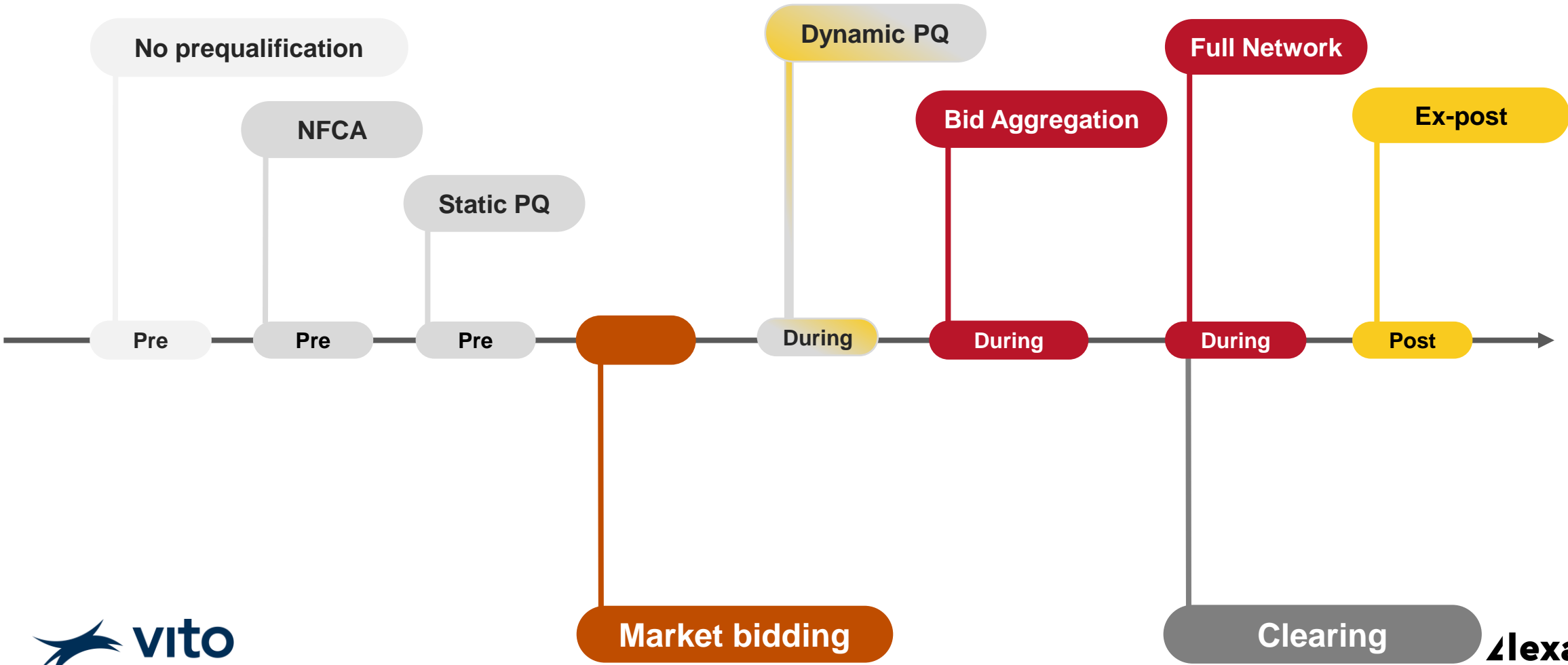
Different coordination ways, depending on different parameters

Where is the need located in the system?

Who is the Flexibility Requesting Party (FRP)?

How many markets are utilized to buy flexibilities?

combined

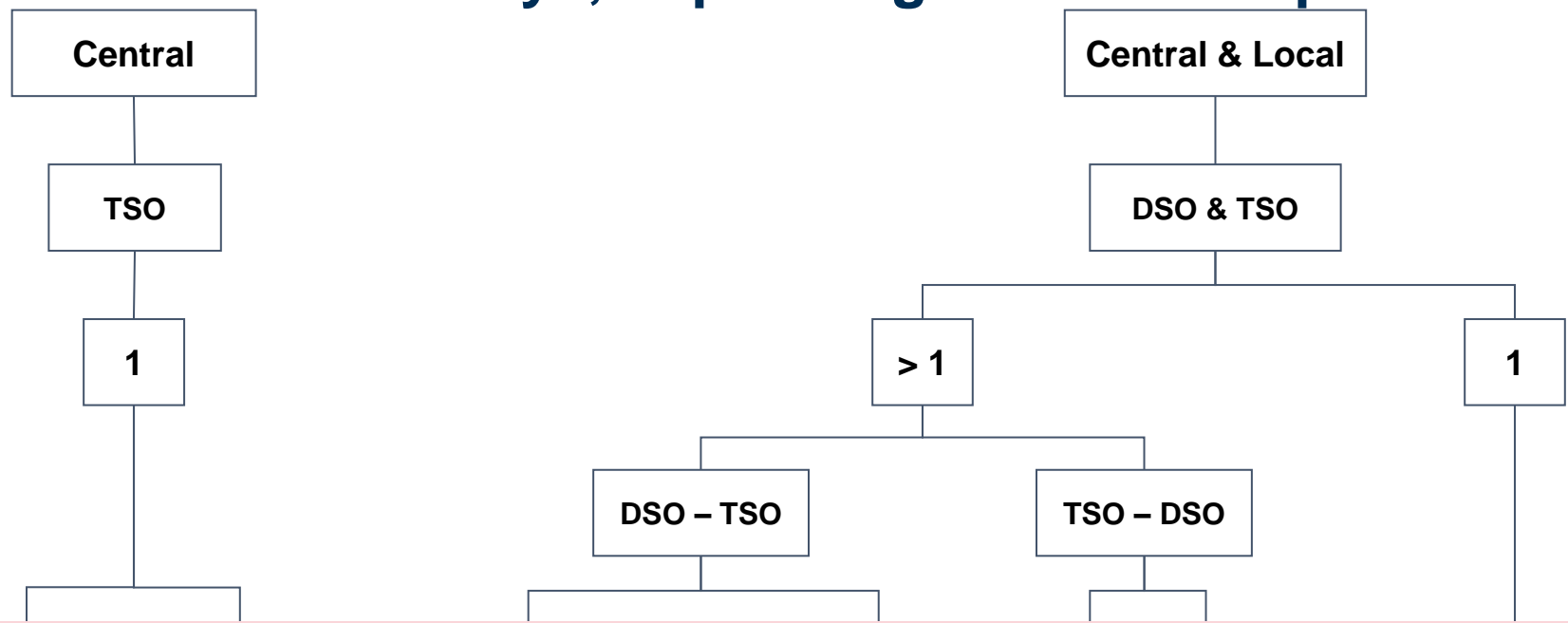**Which SO has priority in the procurement process?**

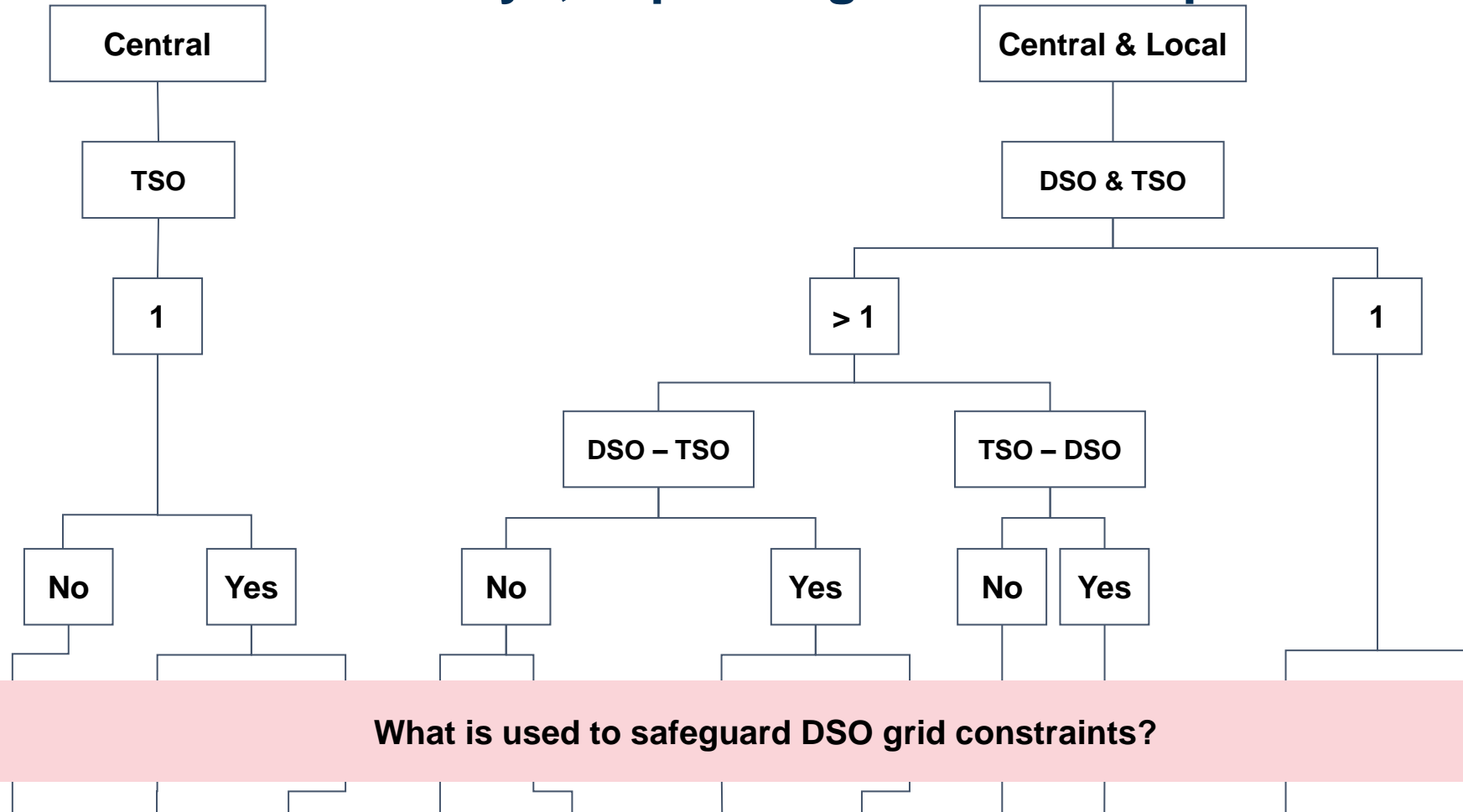**Are the distribution constraints included in the TSO market?**

What is used to safeguard DSO grid constraints?

Resulting Coordination ways

Different coordination ways, depending on different parameters

Need

Central

Central & Local

Who is the Flexibility Requesting Party (FRP)?

How many markets are utilized to buy flexibilities?

combined

Which SO has priority in the procurement process?

Are the distribution constraints included in the TSO market?

What is used to safeguard DSO grid constraints?

Resulting Coordination ways

Different coordination ways, depending on different parameters

Need

FRP

Central

Central & Local

TSO

DSO & TSO

How many markets are utilized to buy flexibilities?

combined

Which SO has priority in the procurement process?

Are the distribution constraints included in the TSO market?

What is used to safeguard DSO grid constraints?

Resulting Coordination ways

Different coordination ways, depending on different parameters

Need

FRP

 # markets

Central		Central & Local		

TSO

DSO & TSO

1

> 1

1

Alternative schemes combined

Which SO has priority in the procurement process?

Are the distribution constraints included in the TSO market?

What is used to safeguard DSO grid constraints?

Resulting Coordination ways

Different coordination ways, depending on different parameters

Need

FRP

 # markets

SO priority

Central

Central & Local

TSO

DSO & TSO

1

> 1

1

DSO – TSO

TSO – DSO

Alternative schemes combined with a market

Are the distribution constraints included in the TSO market?

What is used to safeguard DSO grid constraints?

Resulting Coordination ways

Different coordination ways, depending on different parameters

Need

FRP

 # markets

SO priority

DN constraints in TSO market

Central		Central & Local

TSO

DSO & TSO

1

> 1

1

DSO – TSO

TSO – DSO

No **Yes**

No **Yes**

No **Yes**

Alternative schemes combined with a market

What is used to safeguard DSO grid constraints?

Resulting Coordination ways
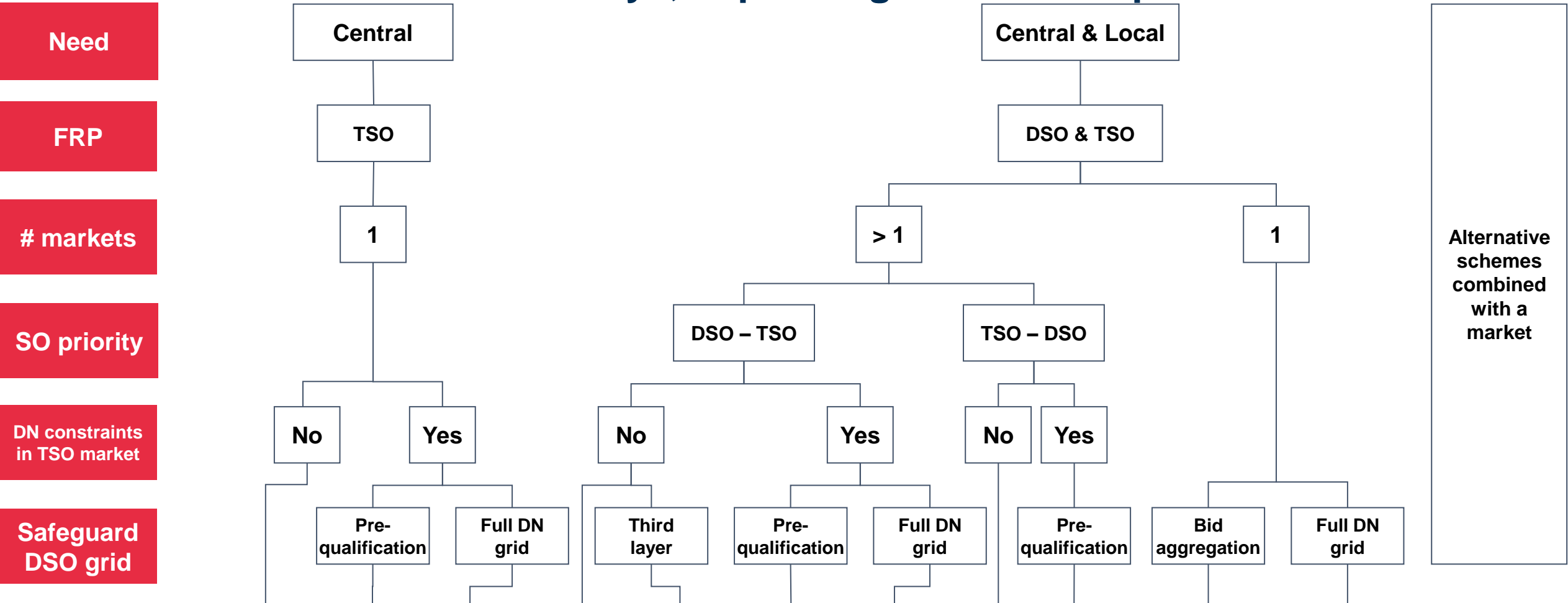
Different coordination ways, depending on different parameters

Different coordination ways, depending on different parameters
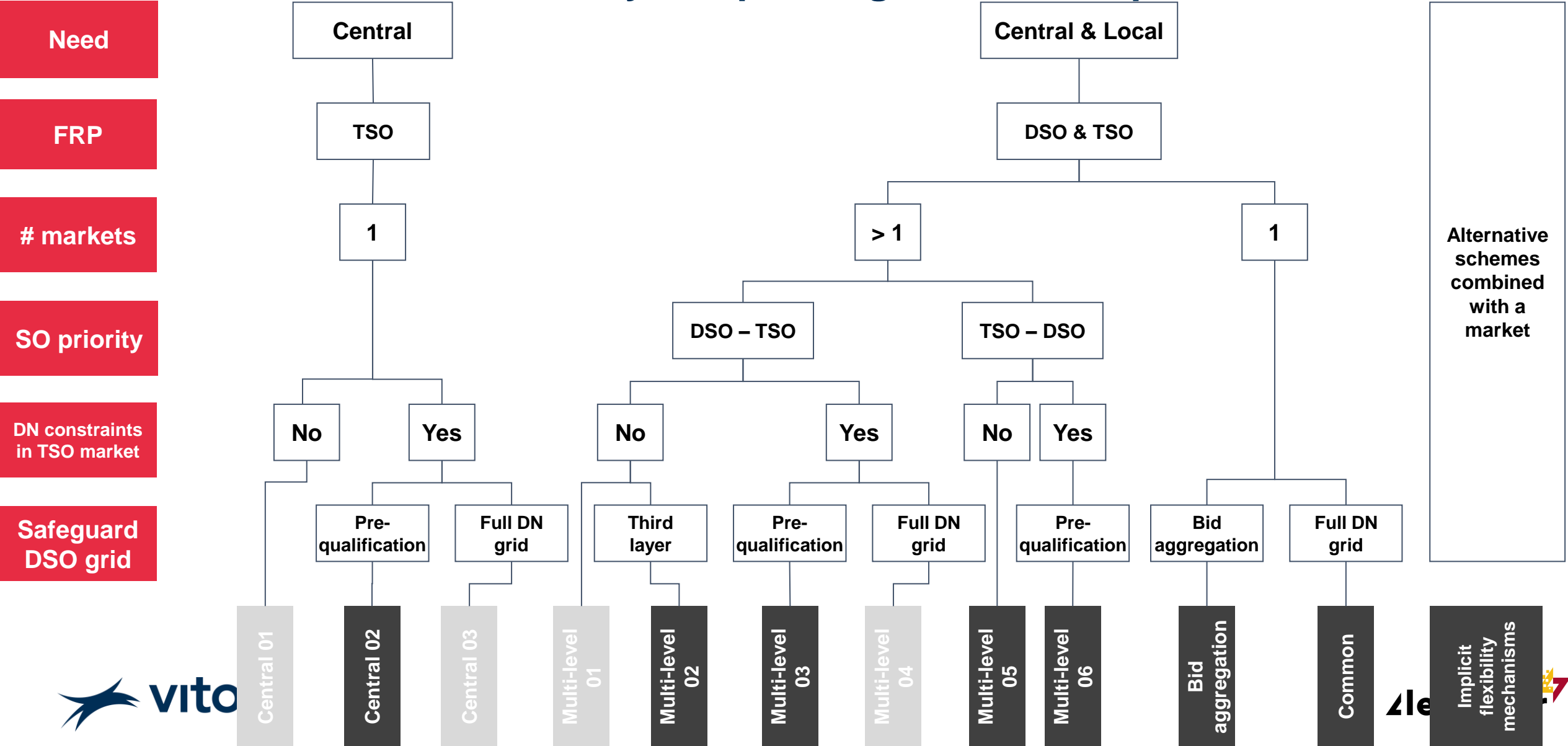
Two elements that dominate the coordination discussion

Who is procuring flexibility?

How do we ensure grid-safe flexibility procurement at system level?

Different coordination clusters


```
Central                           Central & Local              Alternative
   |                                    |                       schemes
  TSO                               DSO & TSO                combined with
   |                                    |                     a market
   1                      ┌─────────────┴──────────────┐
   |                     > 1                            1
┌──┴──┐         ┌─────────┴─────────┐          ┌────────┴────────┐
No   Yes     DSO – TSO           TSO – DSO
         ┌──────┴──────┐      ┌─────┴─────┐
        No            Yes    No          Yes
```

Central 01
Central 02
Central 03
Multi-level 01
Multi-level 02
Multi-level 03
Multi-level 04
Multi-level 05
Multi-level 06
Bid aggregation
Common
Implicit flexibility mechanisms

Pre-qualification · Full DN grid · Third layer · Pre-qualification · Full DN grid · Pre-qualification · Bid aggregation · Full DN grid

---
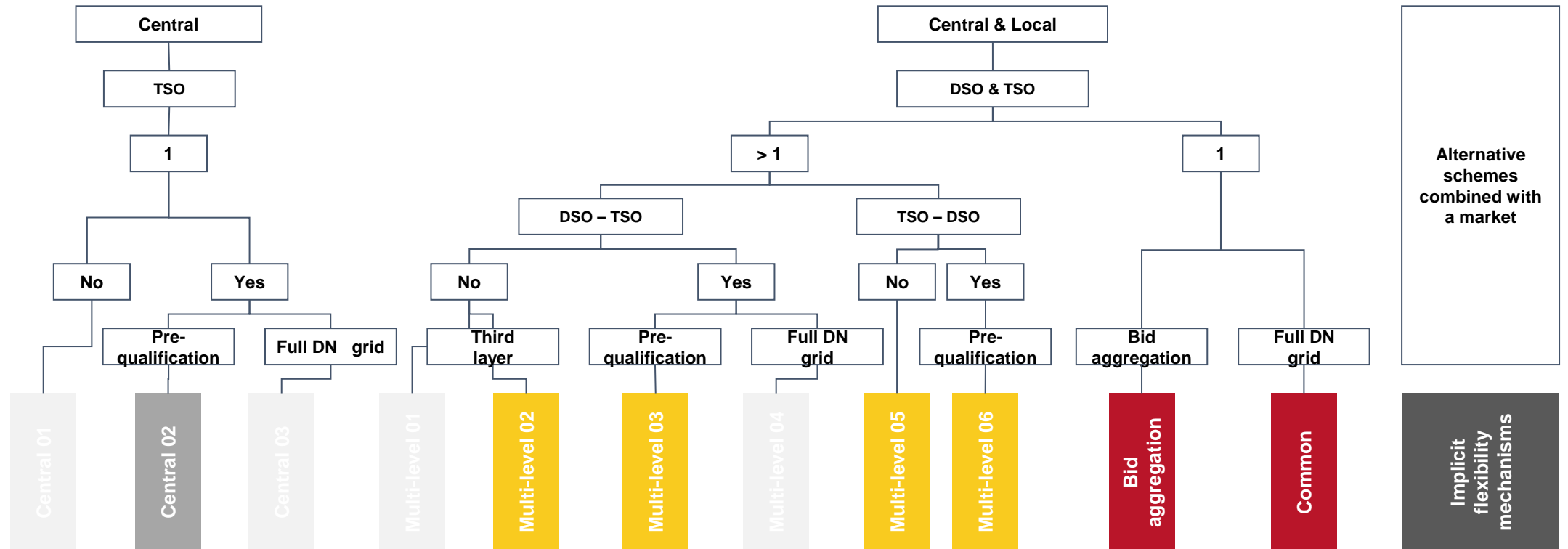
TSO-only procurement (Today)

- TSO-only balancing markets
  - NFS
  - iCAROS

DSO-TSO Separate procurement

- DSO-TSO or TSO-DSO market with pre / ex-post qualification

DSO-TSO Joint procurement

- Joint markets

(Combination with) implicit mechanisms
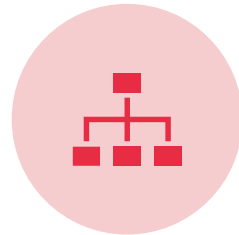
- Tariffs
- Connection agreements
- …

vito

exander

1

WHERE AND WHEN

2

OPTIONS

3

IMPLICATIONS

4

VISION

When and where is coordination needed? What are priority use cases to study?

What are all the coordination options?

What are the consequences in practice when implementing these options?

How to move forward?
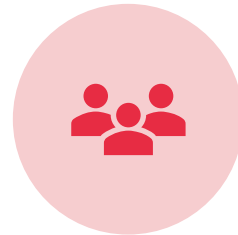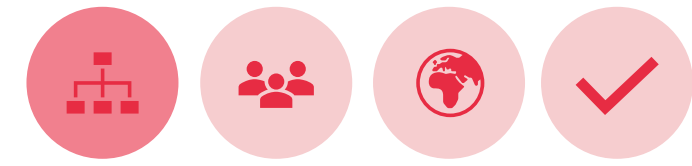
Set-up Coordination Scheme

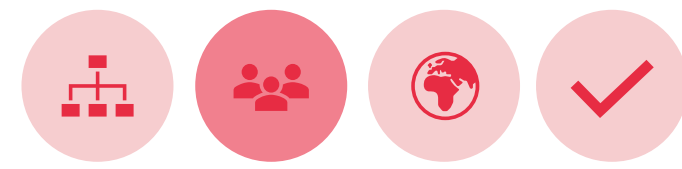| Set-up parameters	Description
Products & services	
Roles & responsibilities	
Prequalification & Grid security check	
Procurement/activation	
Remuneration & settlement	
Transparency on long-term, short-term and real-time SO's needs and constraints	
Operation Guidelines/ Process Mapping	
Data Management & Governance	
Elements not discussed today	
Consumer engagement & participation	
Interoperability & Standards	
Technological Components (Software)	

| BAU	(Close to being) implemented	Challenging to implement	Many significant changes needed	Needs to be adapted to market design + scalable
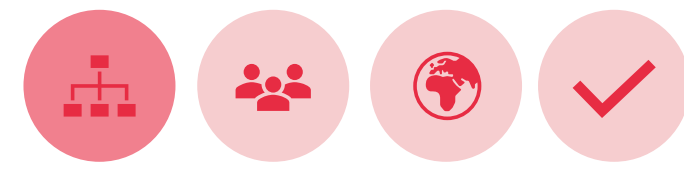
Set-up Coordination Scheme

Set-up parameters	Description
Products & services	Do current products need to be adapted? Do we need new products?
Roles & responsibilities	Who takes up new or adapted responsibilities? What are these responsibilities?
Prequalification & Grid security check	How do we ensure that flexibility is activated in a grid safe manner for all SOs?
Procurement/activation	How does the market clearing take place?
Remuneration & settlement	How do we verify whether flexibility is delivered and how do we incentivize FSPs?
Transparency on long-term, short-term and real-time SO's needs and constraints	Where is flexibility needed? Do we know outside our grid what grid constraints are?
Operation Guidelines/ Process Mapping	*What are the operational implications for each SO when implementing these schemes?*
Data Management & Governance	*Which data are needed, and which data need to be shared?*
Elements not discussed today	
Consumer engagement & participation	*How do we encourage the consumer to offer flexibility? Does this scheme decrease market access barriers?*
Interoperability & Standards	*How do we facilitate cooperation, replication and upscaling?*
Technological Components (Software)	*Which new or adapted technologies and/or software (components) are needed?*

BAU	(Close to being) implemented	Challenging to implement	Many significant changes needed	*Needs to be adapted to market design + scalable*

Performance

Performance parameters	Description
Total procurement cost	How much does the market procurement cost for the involved SOs?
Complexity of the market clearing	How complex it is, in terms of mathematical model and solving time, to implement the market clearing for the specific DSO-TSO coordination scheme?
Grid safety of distribution systems	How safe it is, for the local grid, to activate resources at distribution-level?
Market liquidity	What is the impact of the DSO-TSO coordination scheme on the overall liquidity and value stacking of resources?

Very positive performance

Medium performance

Bad performance
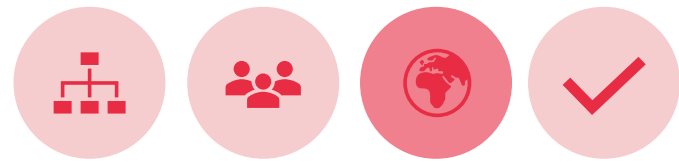
(Inter)national Examples
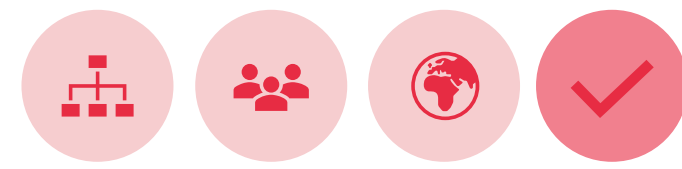
Feasibility

Criteria	Description
Ease of implementation in terms of adaptations needed (products, baselining…)	What adaptations are needed to implement the DSO-TSO coordination scheme?
Compatibility with existing DSO processes	How close to reality of the DSOs current practices the DSO-TSO coordination scheme is?
Feasibility in terms of timing	Can the different steps of the DSO-TSO coordination scheme be sequentially performed and aligned timewise?
Compatibility in terms of regulation	Is the DSO-TSO coordination scheme compatible with current regulation? Can it be directly implemented or does it need regulatory adaptations beforehand?
When do we need this model?	In what situation the DSO-TSO coordination scheme is applicable?
Priority areas of improvements	What steps should be taken first to implement the DSO-TSO coordination scheme?

High feasibility	Medium feasibility	Difficult feasibility

VITO

Alexander
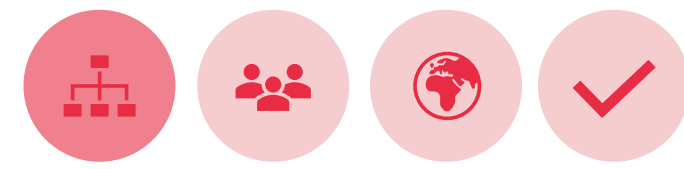
TSO-only procurement (Today)

Set-up Coordination Scheme

| DSO prequalification | → | TSO market procurement |

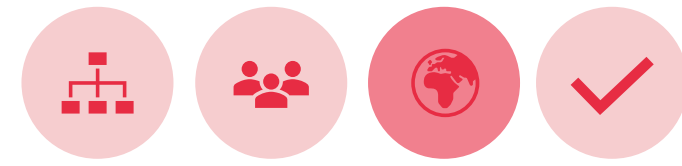| To accommodate or establish	DSO prequalification	TSO market procurement
Products & services	/	TSO opening market for LV
Roles & responsibilities	DSO as grid constraints forecaster and communicator of these to TSO (up to real-time when dynamic scheme) DSO as prequalification responsible DSO as responsible of the safety of the distribution	TSO needs to account for DSO grid constraints (for instance through NFS/traffic light/…) TSO as FRP and MO
Prequalification & Grid security check	Timing: Prior to market clearing Frequency: static (NFS), dynamic (iCAROS – DA)	Can only use prequalified DSO bids on top of its BAU prequalification
Procurement/activation	/	BAU
Remuneration & settlement	/	BAU (although ToE)
Transparency on SO's needs	Reduced network representation, partial data DSO communication of grid prequalification results to TSO and FSP	Provide information to FSPs on flex needs (especially when moving to localized provision for TSO, such as congestion management)
	Move towards more detailed network data/insights	
Operation Guidelines/ Process Mapping	NFS set-up Internal implementation system	Internal system to acquire information and to take it into account
Data management and governance	Sharing grid data is not required Prequalification results do need to be shared: how, when, frequency… ? DSO wants to understand asked TSO services to have better observability for its own system	
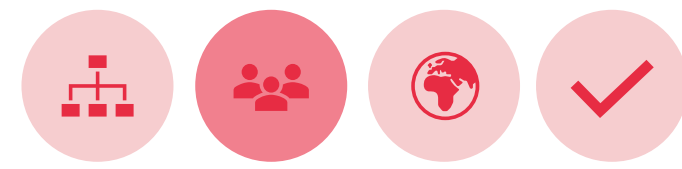
TSO-only procurement (Today)

Performance Coordination Scheme

Performance parameters	TSO-only procurement (Central 02)
Total procurement cost	Unpredictable: - Could be high in case of inefficiencies and **blocked flexibility** - Could accidentally be low, but not guaranteed
Complexity of the market clearing	BAU
Grid safety of distribution systems	High, often **worst-case scenario** is used
Market liquidity	**Not facilitating value stacking** Might **unnecessarily block flexibility** (depending on the prequalification method)

TSO-only procurement (Today)

National Examples

- Belgium: NFS
- iCAROS project
- But also: preparing for the future:
  - DSO-TSO coordination workshops/meetings
  - Common grid development meetings
  - Grid visibility tooling
  - Set-up Local Flex market
  - Flexibility roadmaps
  - Connection agreements
  - ...

The move away from the BAU has started
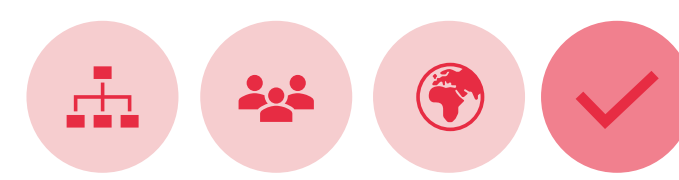
TSO-only procurement (Today)

Feasibility Coordination Scheme

Criteria	Description
Ease of implementation in terms of adaptations needed (products, baselining…)	Minimal effort Key challenge for LV remains baselining and ToE
	Although ideally: set-up of flexibility register for DER
Compatibility with existing DSO processes	High
Feasibility in terms of timing	High, as everything takes place before market bidding
Compatibility in terms of regulation	Non ambitious: - Draft NCDR requires coordination to ensure value stacking and system efficiency
When do we need this model?	• When only TSO is procuring flexibility. • When there are grid visibility challenges and/or not all data are available, a NFS is a good starting point. • When more detailed grid data is available, but cannot be shared, more advanced OE prequalification models are suited.
Priority areas of improvements	• Set-up friendly discussion environment to come to common vision on next steps: how to move away from this scheme? • Agree on priority areas of improvement and problems to tackle. • Establish proper data environment • Grid visibility!

Discussion round

Does the previous analysis align with your experience?

Do you agree/disagree?

What are challenges currently unsolved?

- Where do you believe consensus is possible?
- What are bottlenecks and barriers?
- What could be the timing of implementation?

TSO-only procurement (Today)

- TSO-only balancing markets
  - NFS
  - iCAROS

DSO-TSO Joint procurement

- Joint markets

DSO-TSO Separate procurement

- DSO-TSO or TSO-DSO market
  with pre / ex-post qualification

(Combination with) implicit mechanisms

- Tariffs
- Connection agreements
- …

DSO-TSO Separate procurement

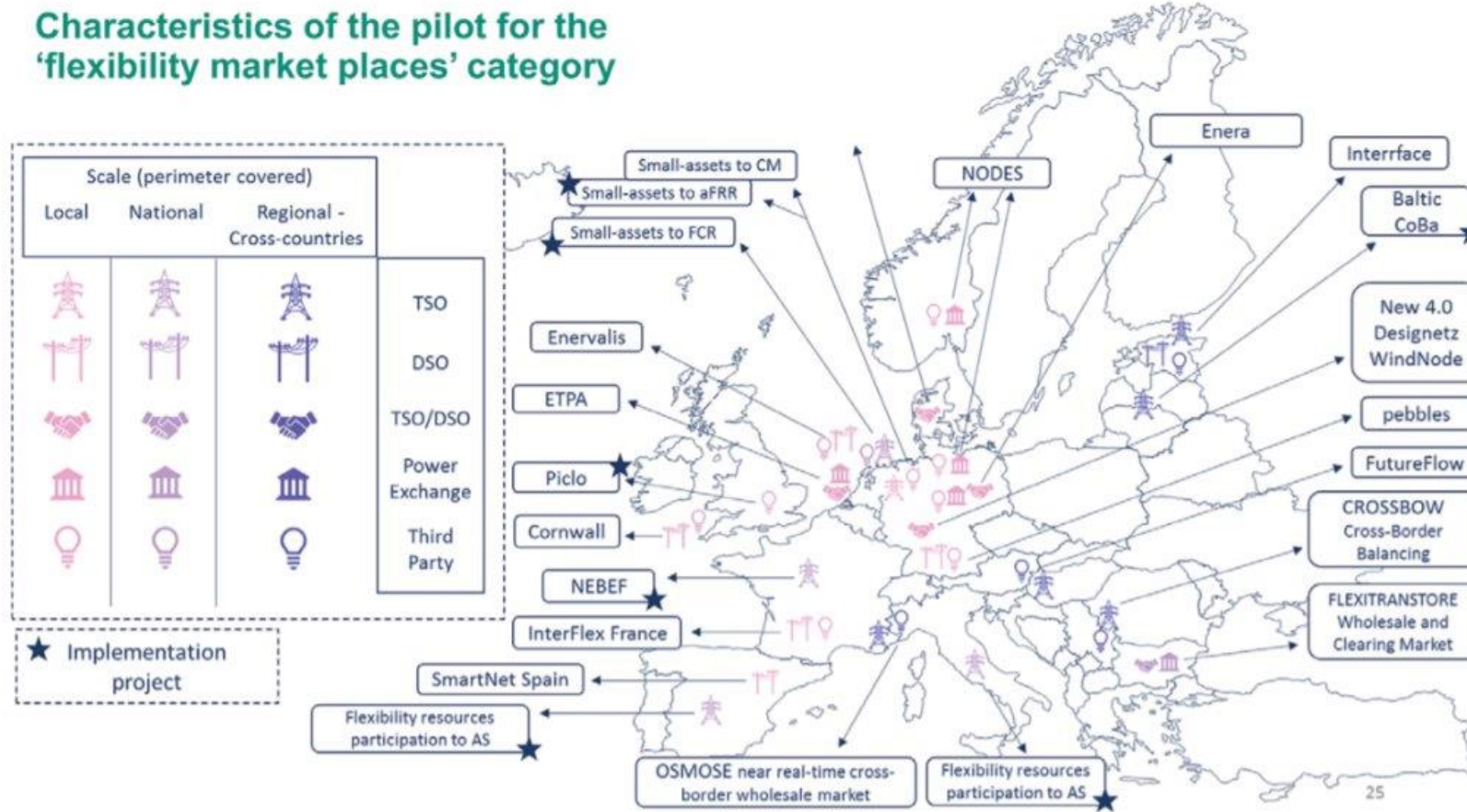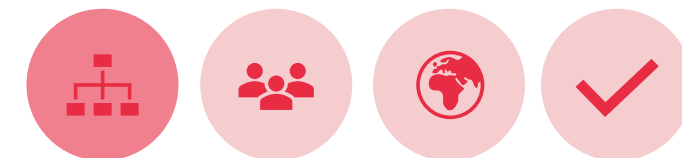- DSO-TSO or TSO-DSO market with pre / ex-post qualification

True story…

Figure 2: Emergence of flexibility platforms across EU member states

Source: ENTSO-E. Available at: *eepublicdownloads.entsoe.eu/clean-documents/events/2019/191205_Flexibility%20Framework_full_public.pdf?Web=1*

DSO-TSO Separate procurement

Set-up Coordination Scheme

| DSO market procurement | → | Either ex-ante — DSO prequalification | → | Bid forwarding (manual or automatic) | → | TSO market procurement | → | Or ex-post — DSO market procurement (for correction) |

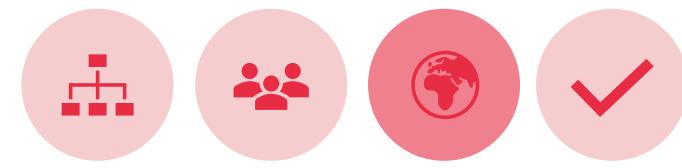|	DSO-market procurement	DSO prequalification	Bid forwarding	TSO market procurement	DSO correction market procurement
Products & services	Development of DSO product — DSO and TSO products to be aligned/harmonized to allow for bid forwarding. That is: Alignment on product requirements + Aggregation				
Roles & responsibilities	DSO = flex buyer — Other (3rd) party: MO	DSO as need forecaster (up to real-time for dynamic schemes) — DSO as prequalification officer — DSO as communicator of grid constraints to TSO	Other (3rd party): Bid forwarder, possibly bid aggregator	BAU — • TSO needs to account for DSO grid constraints — • TSO as FRP and MO	DSO = post-qualifier — Other (3rd) party: MO
Prequalification & Grid security check	To be developed, ideally in line with TSO qualification	Timing: Prior to TSO market clearing — Frequency: static (NFS), dynamic (iCAROS – DA)	DSO communication of grid constraints to TSO — Aggregation rules in line with prequalification req.	• Only use PQ DSO bids on top of its BAU PQ — • PQ process aligned with DSO!	To ensure TSO bid activation is DSO grid safe: method and timing to be selected.
Procurement/activation	To be developed	/	/	BAU	To be developed
Remuneration & settlement	To be developed	/	/	BAU	To be developed
Transparency on SO's needs	Reduced or full network representation — DSO communication of grid prequalification results to FSP and TSO			Same as previous scheme	
Operation Guidelines/ Process Mapping	Set-up, Implementation — Timing challenges				
Data management and governance	No grid data sharing is required — Prequalification results do need to be shared: how, when, frequency… ? — Sharing of market clearing results and updated grid data for DSO ex-post				
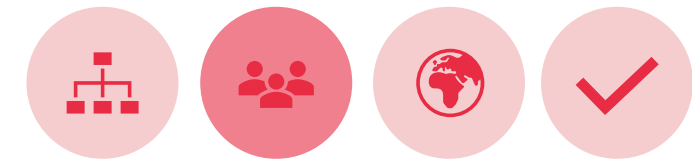
DSO-TSO Separate procurement

Performance Coordination Scheme

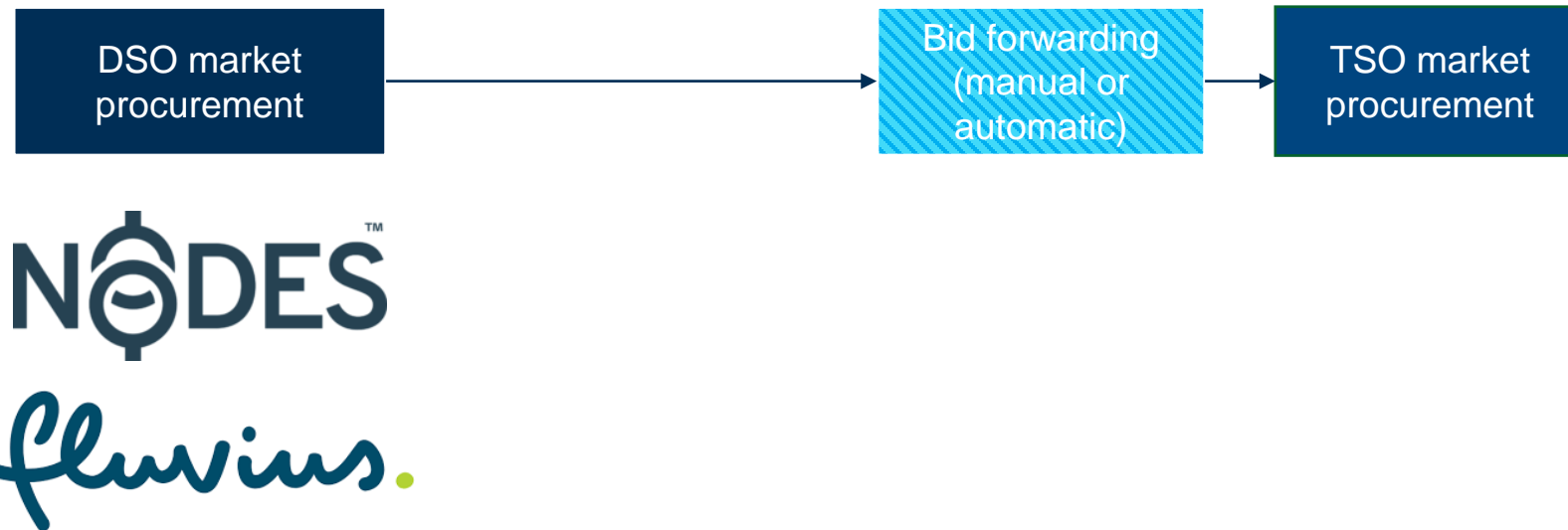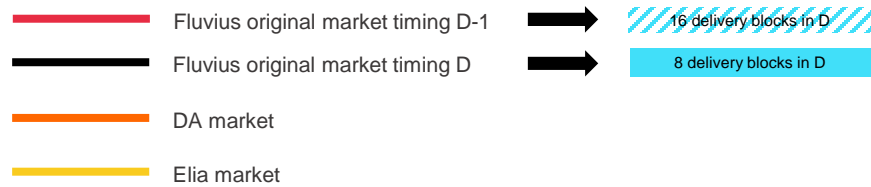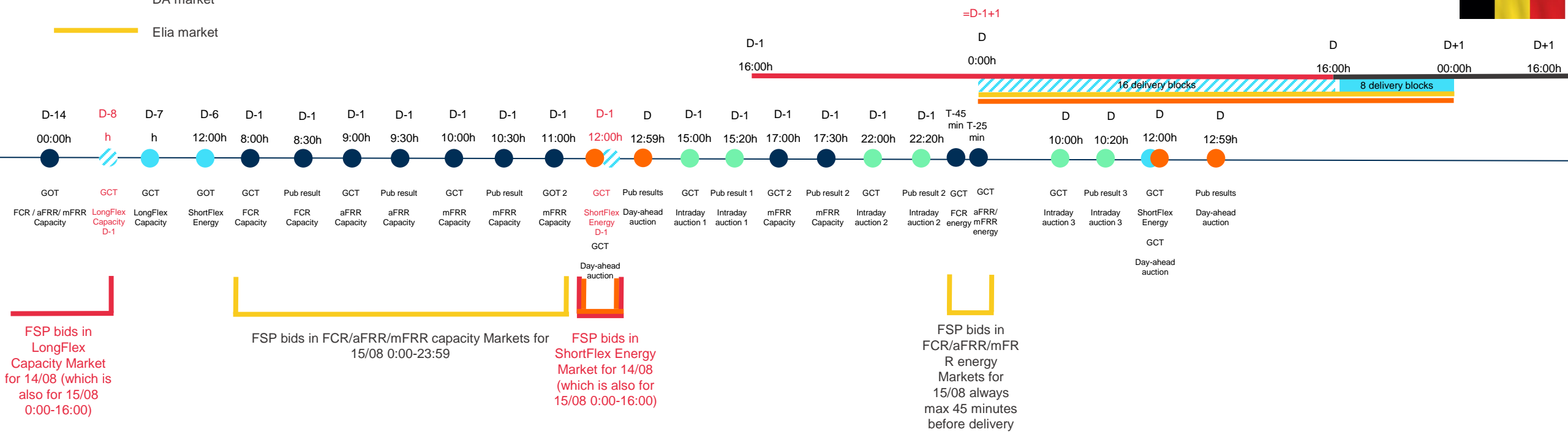| Performance parameters	DSO-TSO with prequalification (Multilevel 03)	DSO-TSO with ex-post correction (Multilevel 02)
Total procurement cost	Could be high due to **separate procurement** and prequalification **blocking flexibility**	Could be high due to **negative impact of one level in another level**
Complexity of the market clearing	**Prequalification** adds complexity Separating problems reduces solving time	**No prequalification at every round needed.** Only ex-post when something goes wrong **Additional level** of market clearing adds complexity Separating problems reduces solving time
Grid safety of distribution systems	Can be **guaranteed**	Can **not be guaranteed**, requires market liquidity Yet, **more accurate real-time data** available to make proper decisions
Market liquidity	**Partial value stacking of DERs** Separating markets reduces liquidity of each level Might unnecessarily block flexibility (depending on the prequalification method)	Partial value stacking of DERs Separating markets reduces liquidity of each level **Feasibility depends on market liquidity**

DSO-TSO Separate procurement

International Examples

- Belgium: Fluvius Flexibility Market

Legend:
- Fluvius original market timing D-1
- Fluvius original market timing D
- DA market
- Elia market
- 16 delivery blocks in D
- 8 delivery blocks in D

FSP bids for D = 15/08

=D-1+1

D-1 16:00h — D 0:00h — D 16:00h — D+1 00:00h — D+1 16:00h

16 delivery blocks — 8 delivery blocks

Time	Event	Market
D-14 00:00h	GOT	FCR / aFRR/ mFRR Capacity
D-8 h	GCT	LongFlex Capacity D-1
D-7 h	GCT	LongFlex Capacity
D-6 12:00h	GOT	ShortFlex Energy
D-1 8:00h	GCT	FCR Capacity
D-1 8:30h	Pub result	FCR Capacity
D-1 9:00h	GCT	aFRR Capacity
D-1 9:30h	Pub result	aFRR Capacity
D-1 10:00h	GCT	mFRR Capacity
D-1 10:30h	Pub result	mFRR Capacity
D-1 11:00h	GOT 2	mFRR Capacity
D-1 12:00h	GCT	ShortFlex Energy D-1; GCT Day-ahead auction
D 12:59h	Pub results	Day-ahead auction
D-1 15:00h	GCT	Intraday auction 1
D-1 15:20h	Pub result 1	Intraday auction 1
D-1 17:00h	GCT 2	mFRR Capacity
D-1 17:30h	Pub result 2	mFRR Capacity
D-1 22:00h	GCT	Intraday auction 2
D-1 22:20h	Pub result 2	Intraday auction 2
T-45 min	GCT	FCR energy
T-25 min	GCT	aFRR/ mFRR energy
D 10:00h	GCT	Intraday auction 3
D 10:20h	Pub result 3	Intraday auction 3
D 12:00h	GCT	ShortFlex Energy; GCT Day-ahead auction
D 12:59h	Pub results	Day-ahead auction

FSP bids in LongFlex Capacity Market for 14/08 (which is also for 15/08 0:00-16:00)

FSP bids in FCR/aFRR/mFRR capacity Markets for 15/08 0:00-23:59

FSP bids in ShortFlex Energy Market for 14/08 (which is also for 15/08 0:00-16:00)

FSP bids in FCR/aFRR/mFRR energy Markets for 15/08 always max 45 minutes before delivery

FSP wants to submit for D = 15/08.

For the Fluvius market, D is split in 00:00-15:59 and 16:00-23:59.

For D 00:00-15:59, the FSP can submit the following: 16 delivery blocks in D: 00:00-15:59

1. Long Flex Capacity on D-8 (which is D-7 for D = 14/08)

2. In case of non-acceptance, bids from can be forwarded to the TSO capacity markets for D = 15/08. Conclusion: DSO capacity market closes in all cases before TSO market.

3. Unless a second GOT for mFRR capacity is opened, all non-selected energy bids from 00:00-15:59, can be forwarded to the Short Flex energy market or the DA market. This means that DA market and ShortFlex market for D 0:00-16:00 run in parallel.

4. Further non-selected energy bids can join the TSO energy market
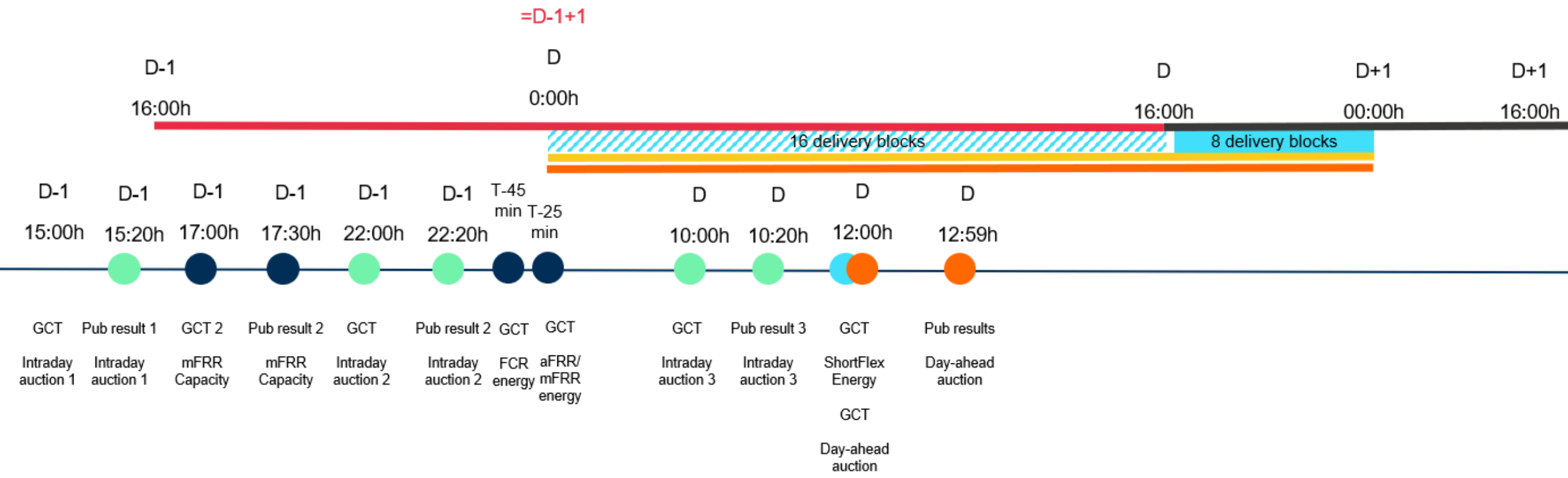
DSO-TSO Separate procurement

International Examples

- Belgium: Fluvius Flexibility Market
- UK: Standardized products and processes over all DSOs
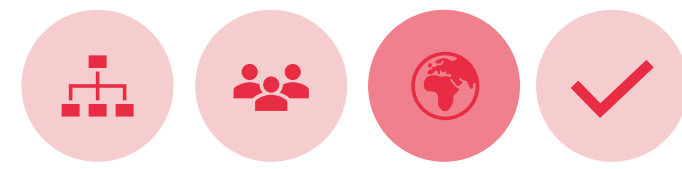
# UK: standardized flexibility products over all DSOs

Standardised products

| Product name	Network Requirement	Example of how it may be used (other uses are possible)	Payment Structure
Scheduled Utilisation	Advanced planning for the management of the forecasted seasonal demand on the network	Network Asset reinforcement deferral	Utilisation payment only
Operational Utilisation	Supplement (in nearer-real time) the management of the seasonal demand on the network	Network maintenance requiring planned outage management	
Peak Reduction	To manage an ongoing requirement to reduce peak demand	Energy Efficiency	
Operational Utilisation + Scheduled Availability	To support the network during fault conditions, often during planned maintenance work	Unplanned fault management	Availability and Utilisation payments
Operational Utilisation + Variable Availability	To support the network during faults that occur as a result of equipment failure and unplanned maintenance	Network restoration	

UK: standardized flexibility products over all DSOs
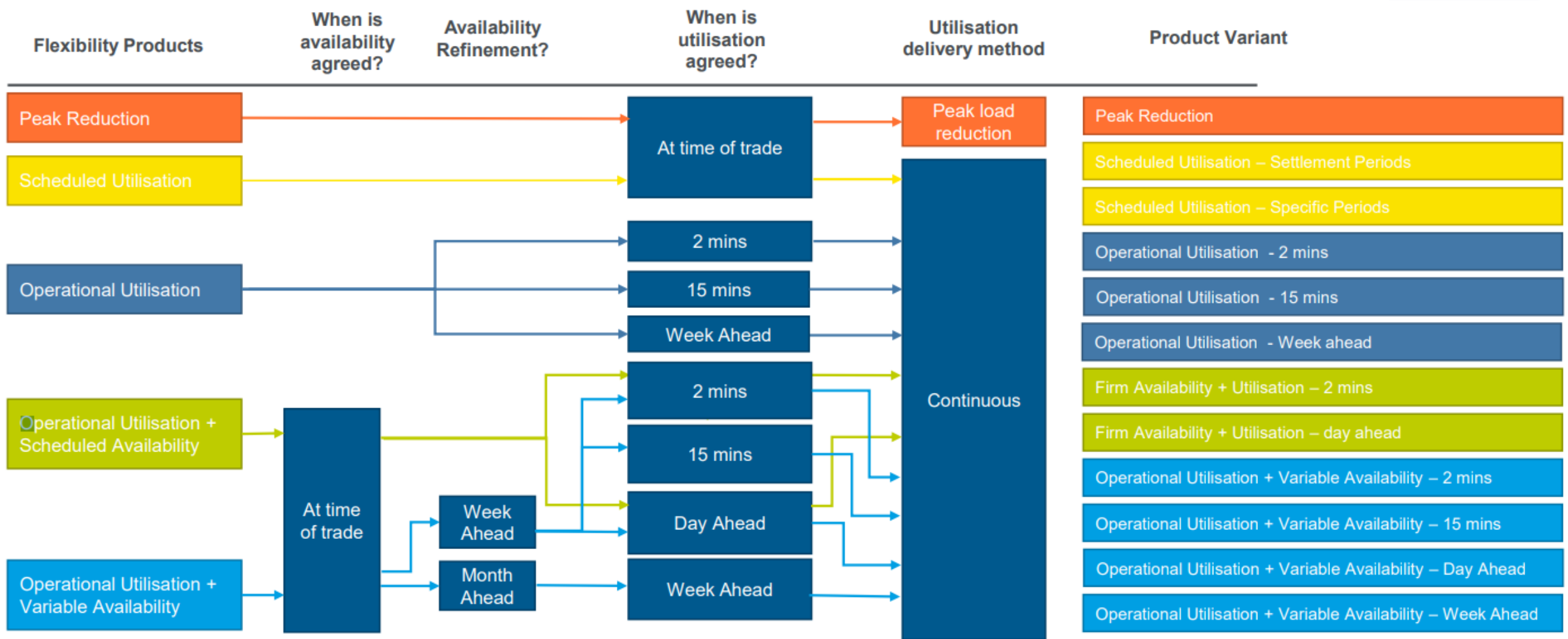
UK: Standardization of other processes

Overview of outcomes

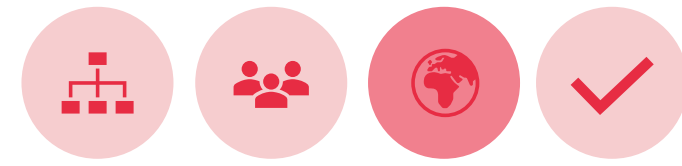| Main outcomes	Target Date	Description of result	Stakeholder impact
Standardisation of Flex products	By Apr 2024	80% of total volume of flexibility tendered by DNOs will be with common products having common technical specifications	Flexibility service providers will have consistent user experience accessing the DSO market with a consistent product specification across the country
Standardisation of Pre-qualification	By Apr 2024	All assets registering for distribution flexibility services will use standard data for technical and commercial pre-qualification	Simplified and standardised pre-qualification process will ensure easy sign-up to DSO flexibility markets and a consistent user experience across the country
Standardisation of Flexibility contracts	By Apr 2024	All DNOs will use common T&Cs and schedule headings for all flexibility contracted.	Moving towards a framework agreement, flexibility providers will have minimal legal costs when engaging with the market across all DSO and relevant ESO flexibility services,
Standardisation of Dispatch API	By Apr 2024**	All DNOs adopt common API specification for dispatch of flexibility.	DSO flexibility market platforms will provide an optimal end-to-end experience, saving flexibility service providers from needing to develop multiple interfaces
Standardisation of Settlement process	By Apr 2024	All DNOs adopt a common settlement approach for flexibility.	Simplified and standardised settlement process will ensure a consistent user experience across the country
Implementation of Primacy rules	By Apr 2024**	All DNOs and ESO implement designed processes and information flows to implement primacy rules (increments 1 and 2).	Clear and consistent rules to manage conflicts arising within and across flexibility markets will help service providers improve their DSO flexibility offerings, whilst ensuring secure operation of the networks
Harmonisation of data shared between DNO-ESOs	By Apr 2024**	Consistent bilateral operational data exchange between all DNOs and ESO.	Markets will benefit from improved efficiencies with network company processes and confidence in their operational forecasting
Harmonise DER visibility Information	By Dec 2023**	All DNOs use consistent DER visibility specifications ('Go' or 'No go' decision to be taken in Sep 2023).	Requirements for new DER connections will be streamlined and network visibility will be improved through the consistent information flow from DER to DNOs
Consistent Network development plans	By Jun 2023	All DNOs report using the agreed Network Development Plan (NDP) format	Consistent reporting and regulatory submissions across network companies will allow stakeholders to be better informed of major network developments, with a sufficient level of detail to aid their planning and forecasting activities
Consistent Network co-ordination activities	By Jun 2023	All DNOs report using the agreed whole electricity system co-ordination register format.	
Consistent Carbon Reporting	By Jun 2023	All DNOs report using the agreed carbon reporting methodology for 2023 & 2024 SLC 31E submissions.	
Consistent Flex Reporting	By Aug 2023	Publication of flexibility figures collated from SLC 31E submissions (including technology break down).	
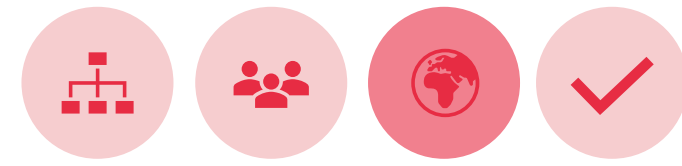
DSO-TSO Separate procurement

International Examples

- Belgium: Fluvius Flexibility Market
- UK: Standardized products and processes over all DSOs
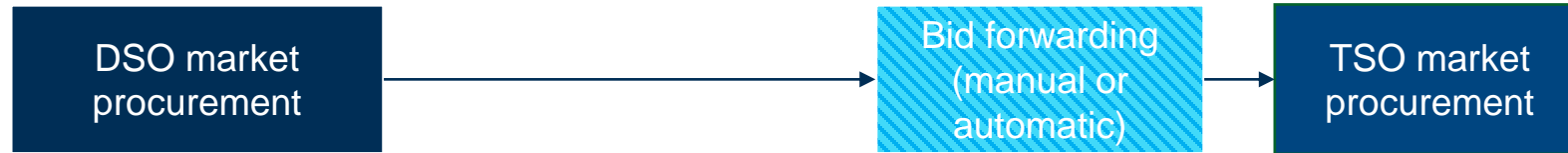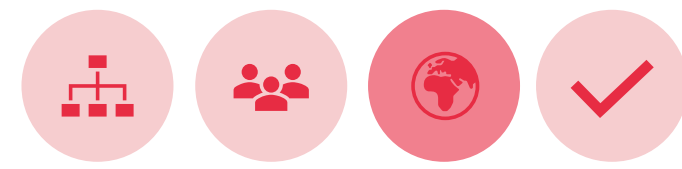- Norway: NorFlex project – aggregation of forwarded bids by the market operator

DSO-TSO Separate procurement

International Examples

```
┌──────────────┐              ┌──────────────┐     ┌──────────────┐
│ DSO market   │─────────────▶│ Bid forwarding│────▶│ TSO market   │
│ procurement  │              │ (manual or   │     │ procurement  │
│              │              │ automatic)   │     │              │
└──────────────┘              └──────────────┘     └──────────────┘
```

NODES NorFlex example:

- Local DSO market with minimum bid size of 1 kW.
- NODES as independent market operator
- NODES aggregates uncleared flexibility not bought by the DSO
- And forwards this to the Statnett mFRR market in minimum block sizes of 1 MW

DSO-TSO Separate procurement

International Examples

- Belgium: Fluvius Flexibility Market
- UK: Standardized products and processes over all DSOs
- Norway: NorFlex project – aggregation of forwarded bids by the market operator
- Portugal: EUniversal – bid selection by the DSO
- Sweden: Coordinet – bid selection by the DSO

DSO-TSO Separate procurement

EUniversal Portuguese demo and Coordinet demo:

→ ex-post bid validation for validating grid safety (Euniversal), or validating market results (CoordiNet)

The Portuguese demo developed a framework where the market was cleared by an independent market operator (for instance NODES). However, after the clearing, the DSO validated the flexibility bid selection first before the market results were confirmed.

EUniversal concluded that this kind of validation could be appropriate for more complicated meshed grids.

The Swedish demo in CoordiNet relied on an automated market clearing process for congestion management, in which a market clearing engine generates bid selection recommendations for the DSO. The market clearing recommendation is then checked by the DSO before approving it, to accommodate any forecast changes that had take place after the bid selection recommendation.

Such a process may face scalability challenges.

DSO-TSO Separate procurement

Feasibility Coordination Scheme

Criteria	Description
Ease of implementation in terms of adaptations needed (products, baselining…)	• New product and new processes at DSO level (DSO-market) • Ideally: harmonization of products, processes and market phases, even if there is no common market. • Important to decide upon how prequalification takes place to avoid counter balancing issues
	• Ideally: set-up of flexibility register for DER • Linked discussions: baselining, ToE
Compatibility with existing DSO processes	New to implement, but ORES and Fluvius are already setting up an LFM
Feasibility in terms of timing	• If DSO-TSO model (yes), although prequalification close to market clearing might still be challenging • If TSO-DSO model (challenge for DSO to run market after TSO and before real-time) • From FSP point of view: markets need to be aligned
Compatibility in terms of regulation	• Different regions and regulators in Belgium complicates harmonization
When do we need this model?	• When the DSO is also acquiring/procuring flexibility • When the market is not mature yet
What is needed to move forward?	• There is a lot of resistance for the common market model, however, for separate DSO-TSO flexibility procurement to be done efficiently, it is important to align many processes in any case • Communication and engagement of all stakeholders

Discussion round

Does the previous analysis align with your experience?

Do you agree/disagree?

What are challenges currently unsolved?

- Where do you believe consensus is possible?
- What are bottlenecks and barriers?
- What could be the timing of implementation?

DSO-TSO Joint Procurement
Set-up Coordination Scheme

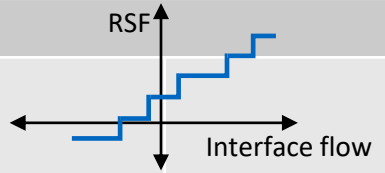|			Common market procurement	
			DSO-TSO market procurement	
Products & services			Common product	
Roles & responsibilities			MO and data manager	
Prequalification & Grid security check			In the market clearing	
Procurement/activation			To be developed	
Remuneration & settlement				
Transparency on SO's needs			Full grid transparency is needed from both SOs	
Operation Guidelines/ Process Mapping			To be developed	
Data and governance			All data and grid constraints to be shared with MO	

DSO-TSO Joint Procurement
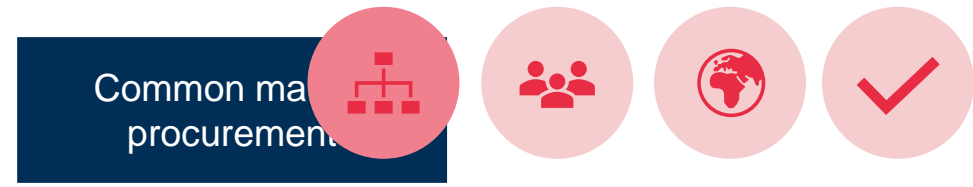## Set-up Coordination Scheme

Common market procurement

	DSO bid aggregation	DSO-TSO market procurement		DSO bid translation

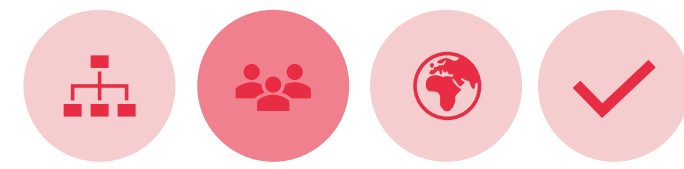|			DSO-TSO market procurement	
Products & services			Common product	
Roles & responsibilities			In case of common market: - MO - Data manager	
Prequalification & Grid security check			Prequalification: / Grid security check: in the market clearing	
Procurement/activation			To be developed	
Remuneration & settlement			To be developed – e.g. split of cost question in case procurement is for both	
Transparency on SO's needs			Full grid transparency is needed from both SOs	
Operation Guidelines/ Process Mapping			To be developed	
Data and governance			All data and grid constraints to be shared with the market clearing responsible	

RSF

Interface flow

DSO-TSO Joint Procurement
Set-up Coordination Scheme

	DSO bid aggregation	DSO-TSO market procurement	DSO-TSO market procurement	DSO bid translation
Products & services	Highly harmonized products	Highly harmonized products	Common product	
Roles & responsibilities	To be defined	Market Operator	- MO - Data manager	To be defined
Prequalification & Grid security check			Prequalification: / Grid security check: in the market clearing	
Procurement/activation		To be developed	To be developed	
Remuneration & settlement		To be developed	To be developed – e.g. split of cost question in case procurement is for both	To be developed
Transparency on SO's needs	Insights own DN data	MO requires: - data of TSO-level bids - aggregated bids from DNs - TSO needs (e.g. balancing) and possibly grid constraints	Full grid transparency is needed from both SOs	
Operation Guidelines/ Process Mapping	To be developed	To be developed	To be developed	
Data and governance	DSO must provide its grid information, constraints and needs to the responsible party (can also be itself)	All bids, including aggregated bids, and TSO needs must be shared to the responsible party	All data and grid constraints to be shared with the market clearing responsible	Market clearing results and aggregation results must be shared to the responsible party

Common market procurement

DSO-TSO Joint Procurement

Performance Coordination Scheme

Performance parameters	Market with bid aggregation	Common Market
Total procurement cost	Can **approximate optimal cost** of common market	**Lowest** of all schemes
Complexity of the market clearing	**High**, due to: - calculation of aggregated bid curve - introduction of complex variables in TSO market	**High**, due to: - full representation of all involved SOs in market clearing - data sharing
Grid safety of distribution systems	Guaranteed	Guaranteed
Market liquidity	**High**, all bids made available to both SOs (through aggregation)	**High**, all bids made available to both SOs (though joint market)
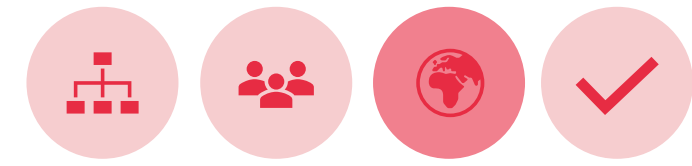
DSO-TSO Joint Procurement
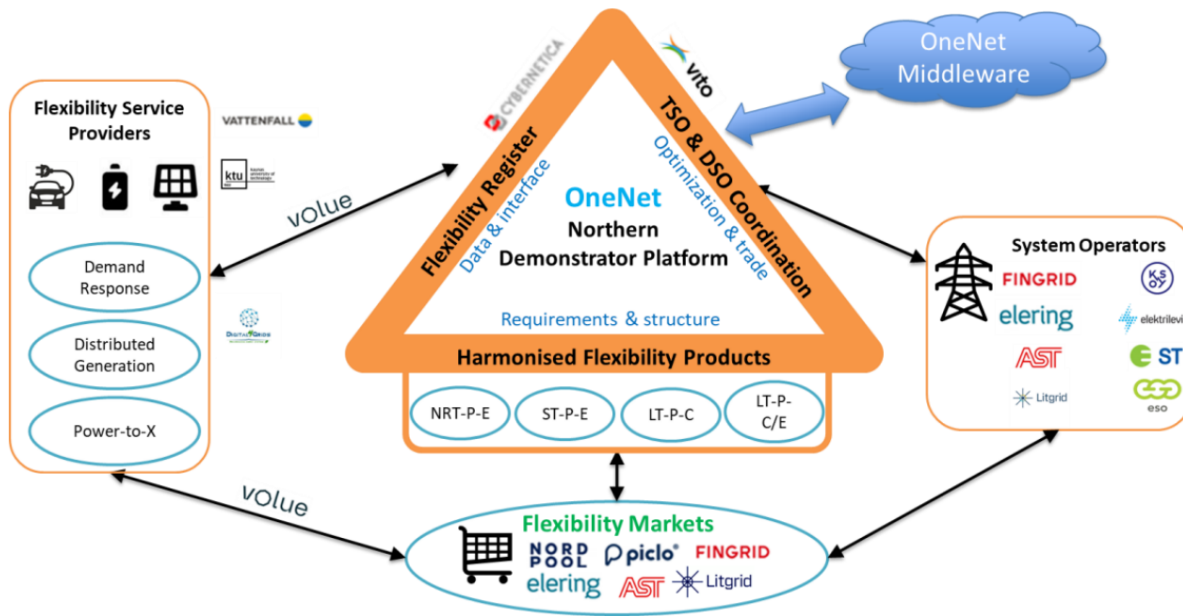
International Examples: OneNet Northern Demo

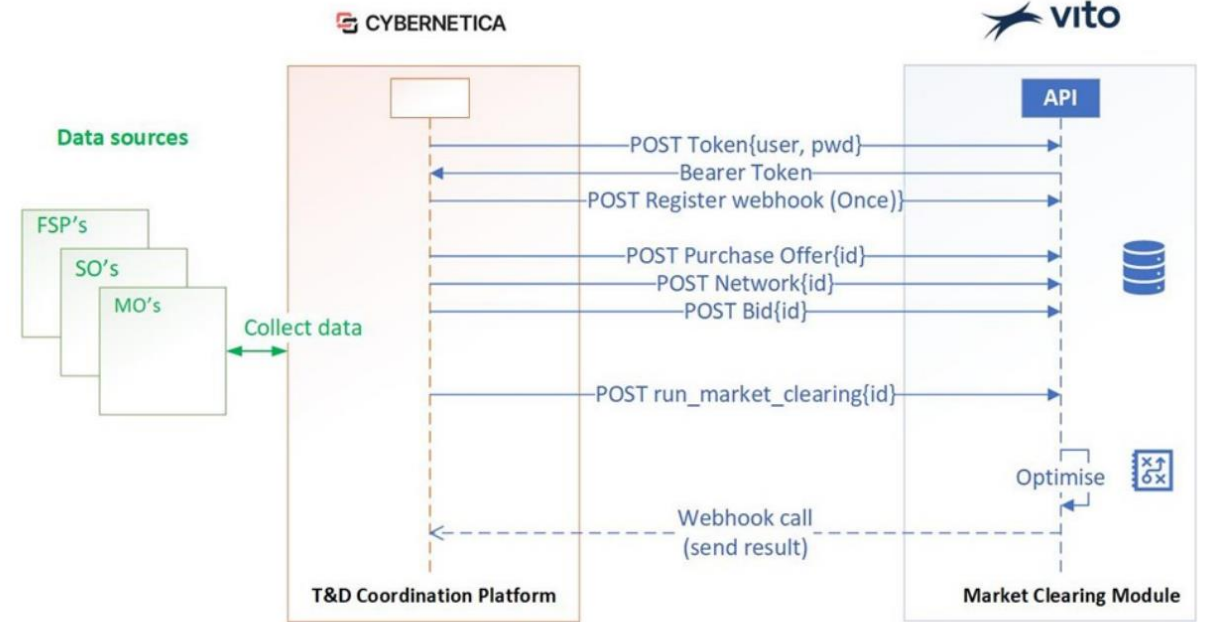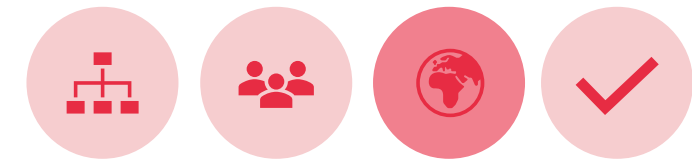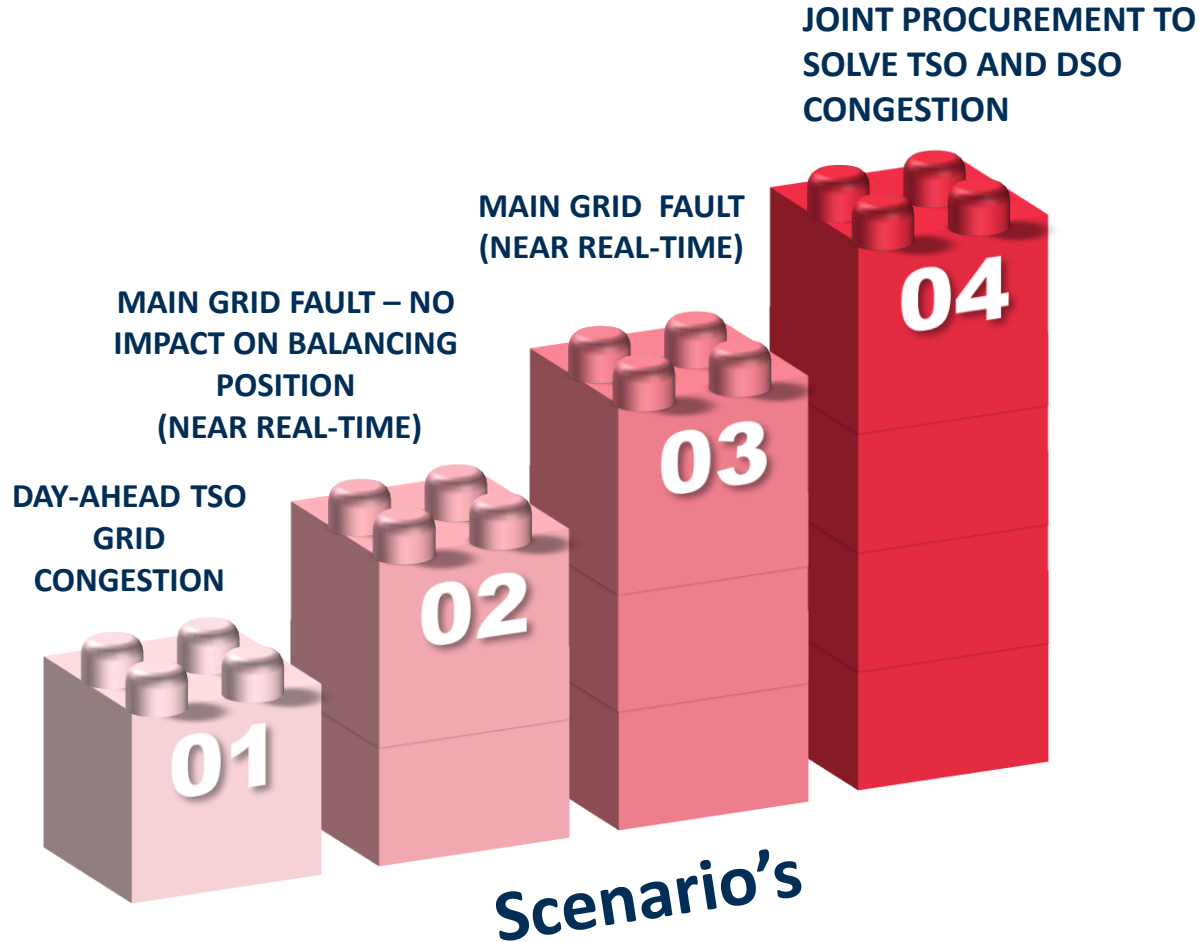Figure 2.1: Northern Cluster architecture

Figure 5.10: API Integration between the Market Clearing (Optimization) Module and the T&D-CP

Source: OneNet D7.6

DSO-TSO Joint Procurement

International Examples: OneNet Finish Demo

JOINT PROCUREMENT TO SOLVE TSO AND DSO CONGESTION

MAIN GRID FAULT (NEAR REAL-TIME)

MAIN GRID FAULT – NO IMPACT ON BALANCING POSITION (NEAR REAL-TIME)

DAY-AHEAD TSO GRID CONGESTION

01

02

03

04

Scenario's

Supporting mature and innovative use cases

Common design 'no regret'

Complexity of models are evolving in line with the market needs

vito

Alexander

Scenario 01

System	Node	Direction	Price (€/MWh)	Offered Q (MW)	Cleared Q (MW)
KSOY	D8	Up	600	1.0	1.0
KSOY	D10	Up	700	0.5	0.5
FINGRID	206	Up	900	3.0	1.5
FINGRID	209	Down	-700	5.0	3.0

Fully divisible bids submitted and market results

- Congestion is resolved with bids from both systems (no balancing impact)

- Bids selected while **respecting DSO-grid constraints** (grid-safe)

- Joint procurement increases liquidity by 50%, reducing cost by 67%

- **Considers merit-order costs while allowing bids from multiple locations**
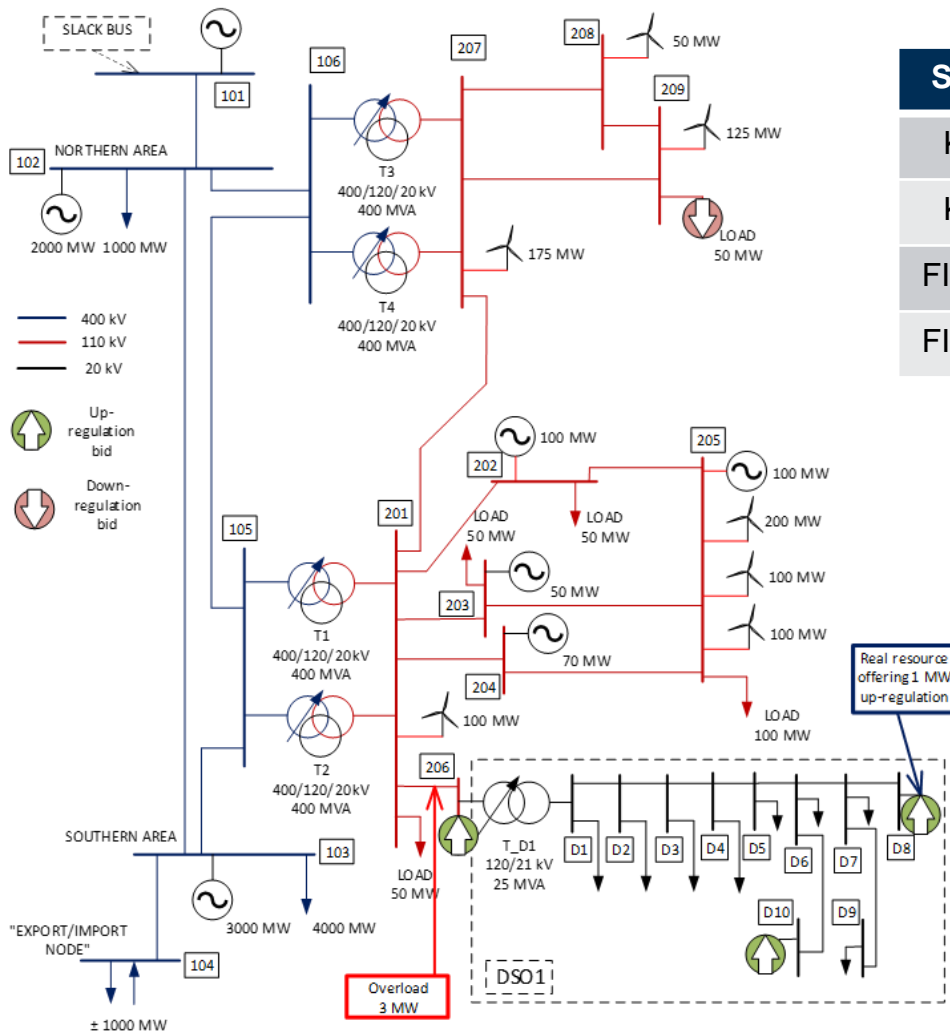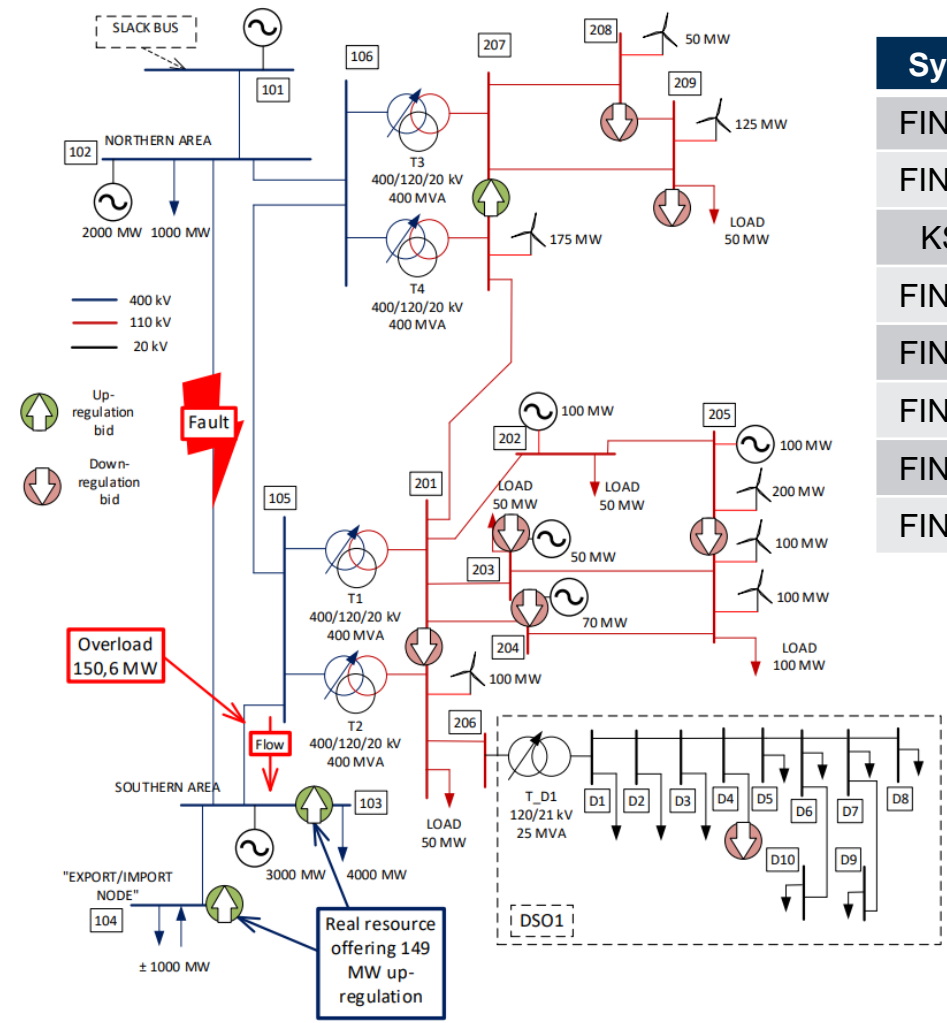
Grid Representation – Flex Scenario 1
ST-P-E Finnish Demo -- OneNet
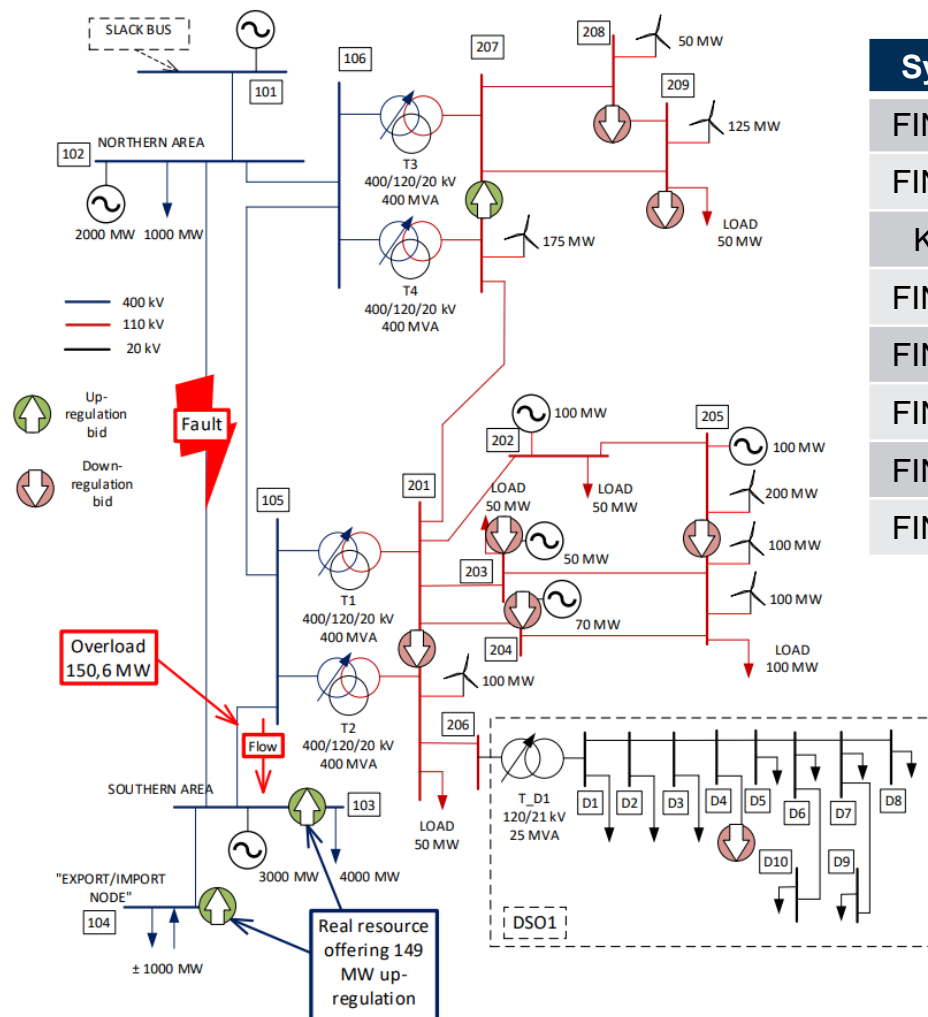
Scenario 02

Grid Representation – Flex Scenario 3 (adapted)
NRT-P-E Finnish Demo -- OneNet

System	Node	Direction	Price (€/MWh)	Offered Q (MW)	Cleared Q (MW)
FINGRID	209	Down	35	85.0	85.0
FINGRID	208	Down	40	50.0	50.0
KSOY	D4	Down	45	2.0	-
FINGRID	203	Down	50	60.0	16.0
FINGRID	205	Down	70	20.0	-
FINGRID	207	Up	150	10.0	-
FINGRID	103	Up	220	188.0	-
FINGRID	104	Up	230	151.0	151.0

Fully divisible bids submitted and market results

- Considering grid-impact (PTDF) reduces procurement costs by 18% (as compared to only MOL) OR resolves 24% more congestion (as compared to not considering PTDF)

- **Considers grid-impact of bids while minimizing procurement costs**

Scenario 03

Grid Representation – Flex Scenario 3 (adapted)
NRT-P-E Finnish Demo -- OneNet

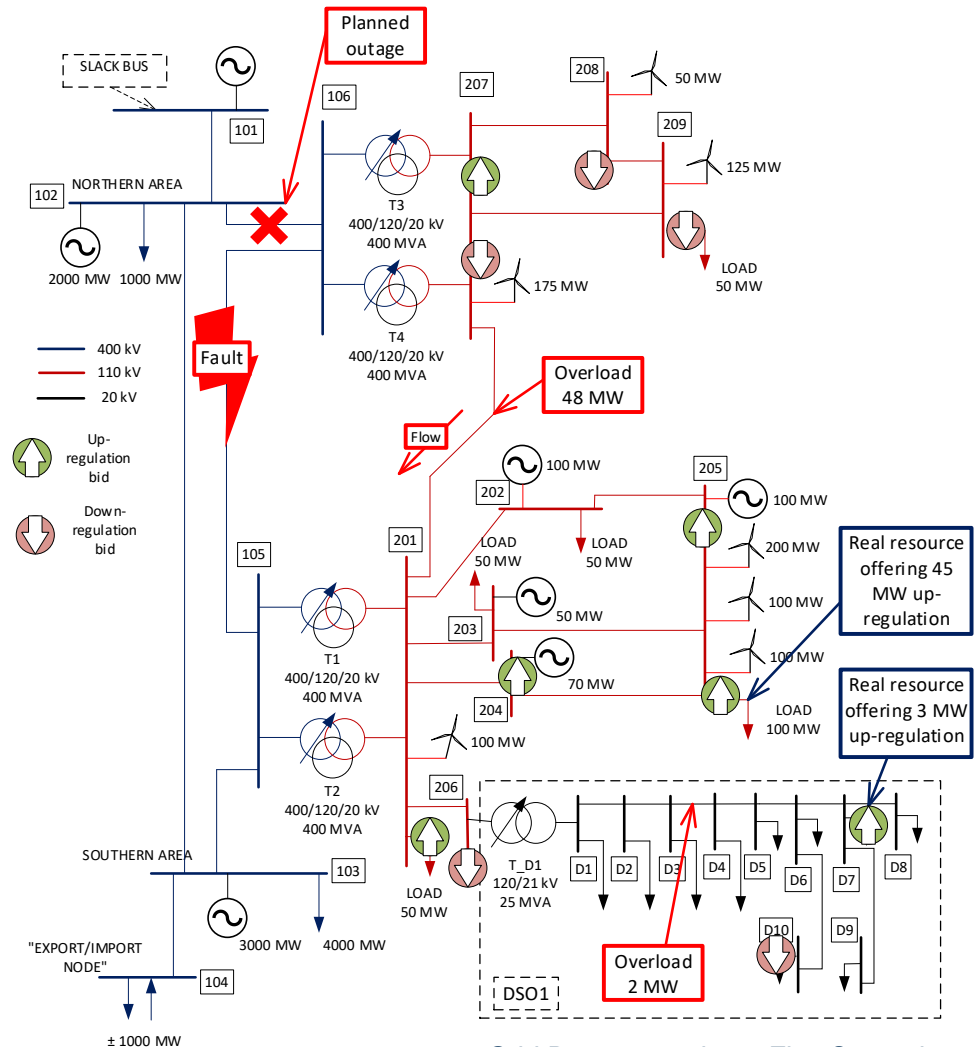| System	Node	Direction	Price (€/MWh)	Offered Q (MW)	Cleared Q (MW)
FINGRID	209	Down	35	85.0	-
FINGRID	208	Down	40	50.0	-
KSOY	D4	Down	45	2.0	-
FINGRID	203	Down	50	60.0	-
FINGRID	205	Down	70	20.0	-
FINGRID	207	Up	150	10.0	-
FINGRID	103	Up	220	188.0	-
FINGRID	104	Up	230	151.0	151.0

Fully divisible bids submitted and market results

- Solving congestion reduces the imbalance of the interconnected system by 99,7%

- Including imbalance optimization when procuring congestion services can reduce overall procurement cost by 15% while reducing the balancing need of the TSO

- **Resolves congestion while controlling/resolving the imbalance of the system, enhancing the value stacking potential of bids**

Scenario 04

Grid Representation – Flex Scenario 4
NRT-P-E Finnish Demo -- OneNet

System	Node	Direction	Price (€/MWh)	Offered Q (MW)	Cleared Q (MW)
FINGRID	209	Down	70	30.0	-
FINGRID	206	Down	60	15.0	-
FINGRID	208	Down	50	30.0	30.0
KSOY	D10	Down	25	2.0	-
FINGRID	207	Up	35	45.0	45,0
FINGRID	205	Up	98	48.0	48,0
KSOY	D7	Up	100	3.0	3.0
FINGRID	204	Up	180	15.0	-
FINGRID	201	Up	195	10.0	10.0
FINGRID	207	Up	200	10.0	10.0

Indivisible bids submitted and market results

➢ Value stacking of bids: procurement cost of jointly purchasing flexibility can be reduced by 2% to 95% if compared to separate markets for DSO and TSO needs

➢ Negative impact on congestion TSO (worsened by 5%) in case where DSO resolves own congestion locally

➢ **Considers joint procurement of TSOs and DSOs as well as different bid types (simple, complex)**
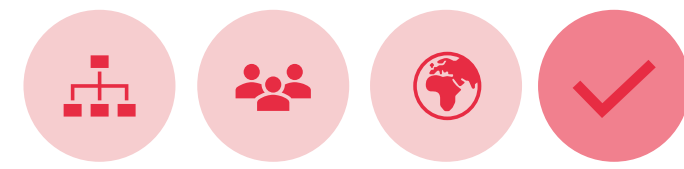
DSO-TSO Joint Procurement

Feasibility Coordination Scheme

Criteria	Market with bid aggregation	Common market
Ease of implementation in terms of adaptations needed (products, baselining…)	**Less efforts** needed: - Harmonized product accommodating DSO and TSO needs - No grid data sharing needed	**Many efforts** needed: - Joint product accommodating DSO and TSO needs - Data sharing with market operator
Compatibility with existing DSO processes	Could **lead to a close proxy** without all the process difficulties	Incompatible
Feasibility in terms of timing	The bid aggregation needs a translation step near-real time (challenge)	Can fit with existing TSO-level flexibility markets
Compatibility in terms of regulation	Bid aggregation process is not defined: **roles needs to be specified**	Foreseen in regulation, however role definition can be challenging
When do we need this model?	When more coordination is needed between SOs to ensure flexibility is used efficiently from a system perspective Variations in terms of this model are possible depending on possibilities for data sharing	
What is needed to move forward?	• This model is currently not the end-goal • All steps defined before are needed before discussing this • Important to understand that there is not just "one common market" and the variations are possible to facilitate it: it all depends on what needs to be achieved	

Discussion round

Does the previous analysis align with your experience?

Do you agree/disagree?

What are challenges currently unsolved?

- Where do you believe consensus is possible?
- What are bottlenecks and barriers?
- What could be the timing of implementation?

Workshop Agenda

Time	Item
09:00 - 09:30	🧀 Welcome and coffee
09:30 - 09:40	👥 Why DSO-TSO coordination?
09:40 – 12:20	🔀 4 steps to set up DSO-TSO coordination
09:45 - 09:50	✔ Step 1
09:50 – 10:05	🔱 Step 2
10:05 – 11:30	🌍 Step 3
10:05 – 10:25	① DSO-TSO coordination type 1
10:25 – 10:45	② DSO-TSO coordination type 2
10:45 – 11:05	③ DSO-TSO coordination type 3
11:05 – 11:30	🧀 COFFEE BREAK
11:30 – 11:50	🔱 Model explanation
11:50 – 12:10	④ DSO-TSO coordination type 4
12:10 – 12:30	🥽 Step 4 and conclusions

vito

Alexander

Modeling methods

Modeling Methods

Simulating Different Market Designs

Market Simulator

Run sequence

Market Participants (FSPs)

- Technologies
- Appliances
- Behavior
- Consumption
- Generation
- (…)

Techno-Economic Parameters

Historical Data

Generate Bidding Strategies

Market Participants (SOs)

- Number SOs
- Type SOs
- Parameters
- Topology
- Capacities
- (…)

Grid Data/Model

Demand/ Supply

Calculate Grid Constraints

Calculate Flex Needs

Market Operator

Market Configuration

Market Set-up

Market Clearing

Publish results

- Timing
- Frequency
- Hierarchy
- Sequence
- Phases
- Products
- (…)

- Grid status
- Grid safety
- Liquidity
- Prices
- Activations
- Cost
- Complexity
- (…)

Test Case

TN: IEEE 14-bus (meshed)
DN_69: Matpower 69-bus (radial)
DN_141: Matpower 141-bus (radial)

TN: PTDF model
DNs: Linearized branch flow model

Overall imbalance in the interconnected system (generation > load): solved with downward flexibility

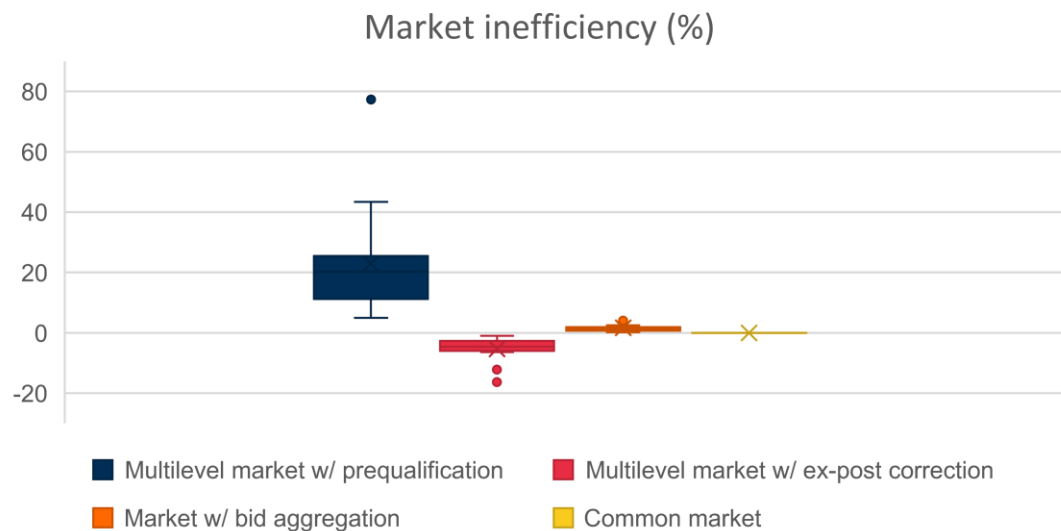DNs are heavily loaded and have congestion

Flexibility was allocated to the buses according to their base offtake/injection

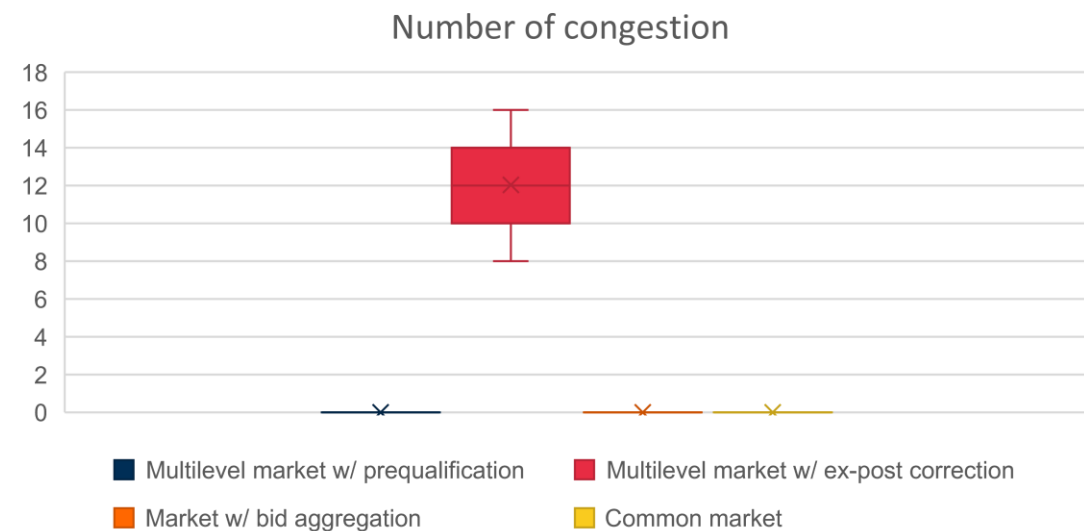A price for the allocated flexibility was also defined:
- DOWN (cost for FSP) cheaper than UP (cost for SO)
- DN resources cheaper than TN resources

Multiple instances of the case were generated

Performance comparison of different market models

Market inefficiency (%)

Legend:
- Multilevel market w/ prequalification
- Multilevel market w/ ex-post correction
- Market w/ bid aggregation
- Common market

The cost difference from the common market's (normalized)

Number of congestion

Legend:
- Multilevel market w/ prequalification
- Multilevel market w/ ex-post correction
- Market w/ bid aggregation
- Common market

Market model	Simulation time*
ML prequalification	6.8x
ML ex-post correction	4.3x
Market w/ bid aggregation	61x

compared to common market

Prequalification can cause a loss in market efficiency but ensures safe activation of resources in distribution systems. Blocked bids: 20-60% (depending on DN situations)

Ex-post corrective market cannot always resolve congestion especially when DNs are heavily loaded and almost congested.

Market with bid aggregation can approximate the performance of the common market while ensuring grid-safe activation of distributed resources. But it is computationally demanding.

VITO

Alexander

TSO-only procurement (Today)

- TSO-only balancing markets
  - NFS
  - iCAROS

DSO-TSO Joint procurement

- Joint markets

DSO-TSO Separate procurement

- DSO-TSO or TSO-DSO market with pre / ex-post qualification
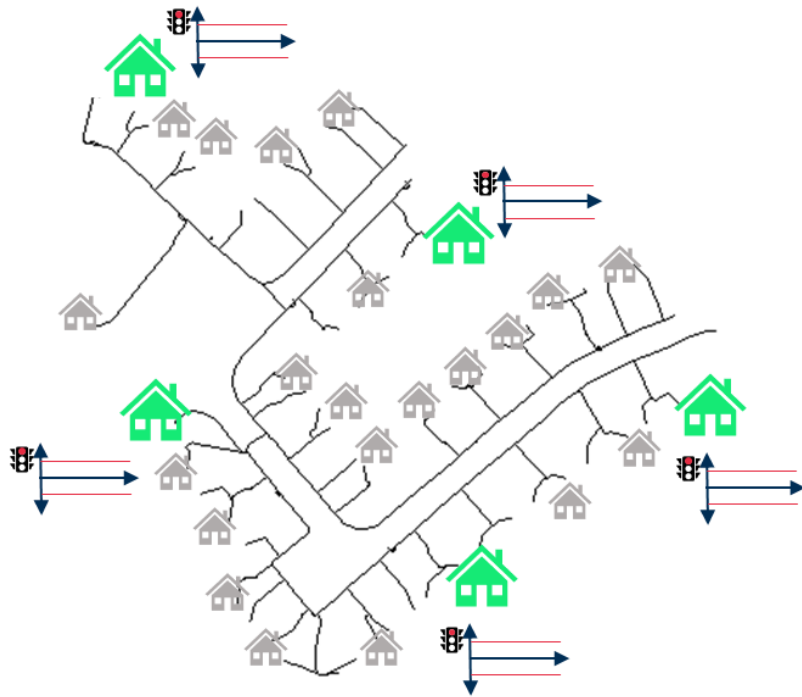
(Combination with) implicit mechanisms

- Tariffs
- Connection agreements
- …

Operating Envelope

Concept

- **Definition** - Maximum (minimum) power that can be injected (consumed) per end-user without exceeding congestion on the LV distribution grid.

- **Principle** - Some end users with flexible assets may contract with the DSO and when there is a high risk of congestion, these end users are limited to the OE for a reward (= non-firm connection agreement).

- **Applications** – In Australia with the EDGE project, in Germany, Austria (but not for DSO congestion management), Hungary, Sweden and the Netherlands.
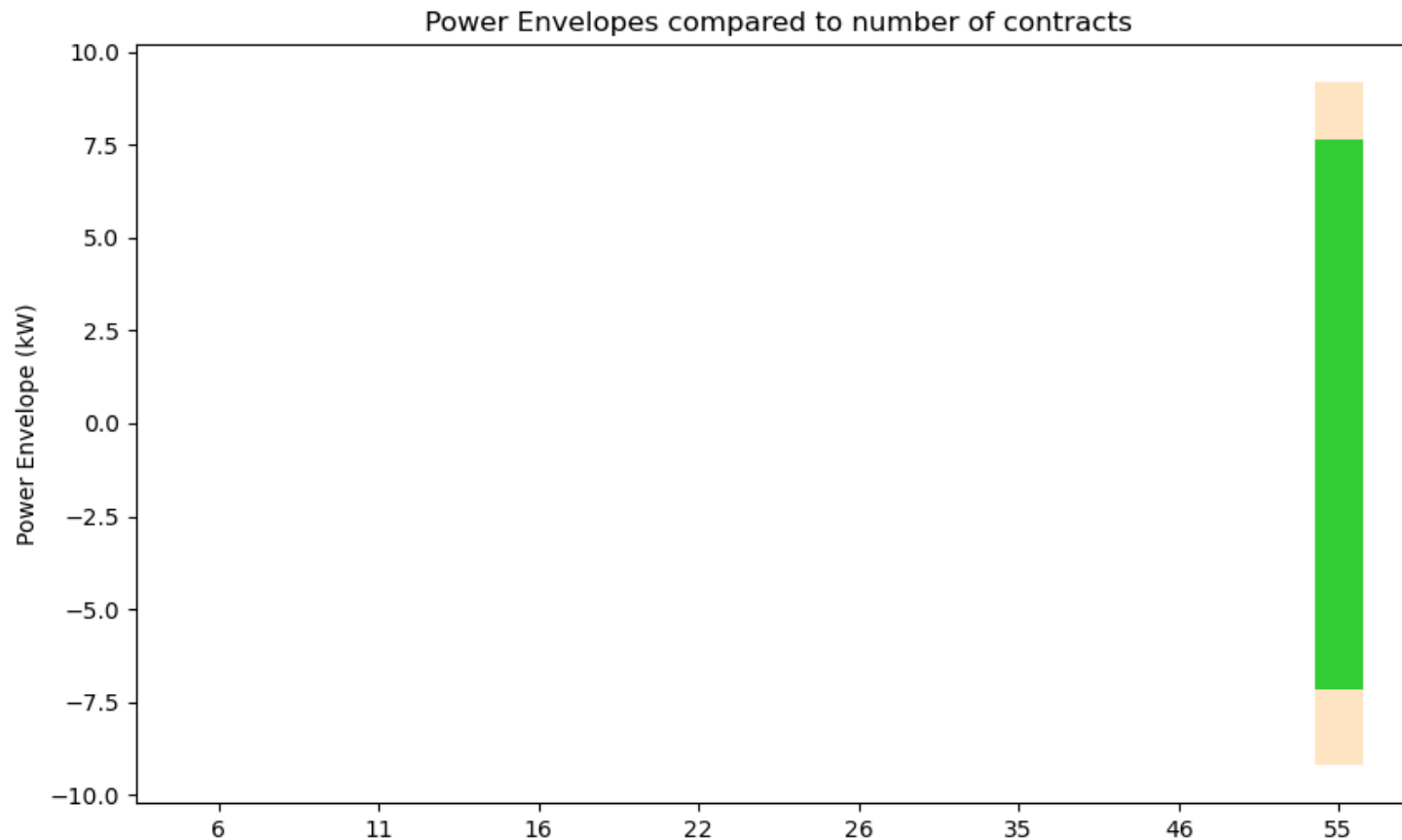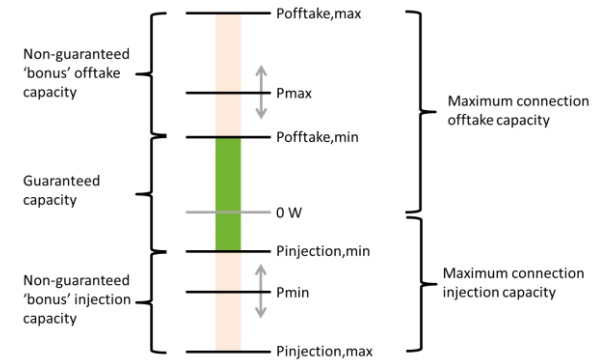
Power envelopes

Applications on an unbalanced LV distribution feeder with 55 end-users

Power Envelopes per end-user
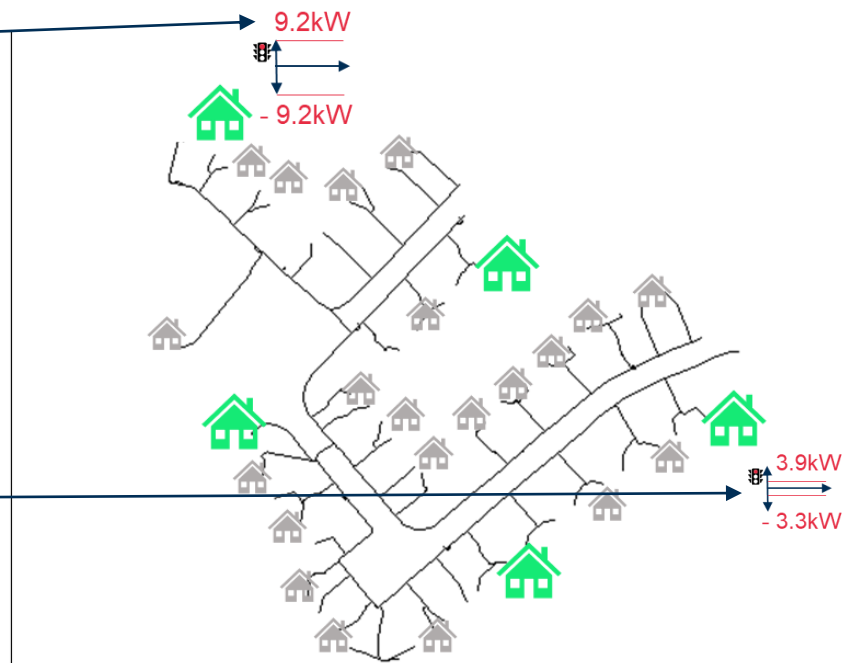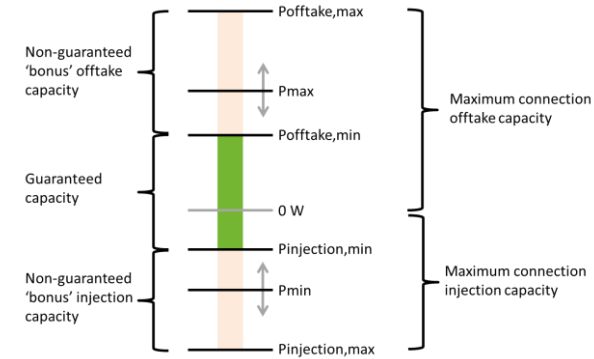
➤ Complementary rules should be added to consider end-users in a non-discriminatory manner

Operating envelope

Power limits are similar for all end-users and depend on number of contracts
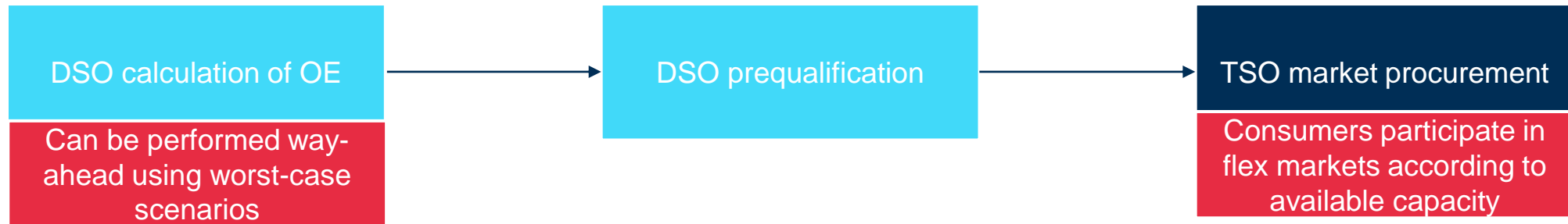

Power Envelopes compared to number of contracts

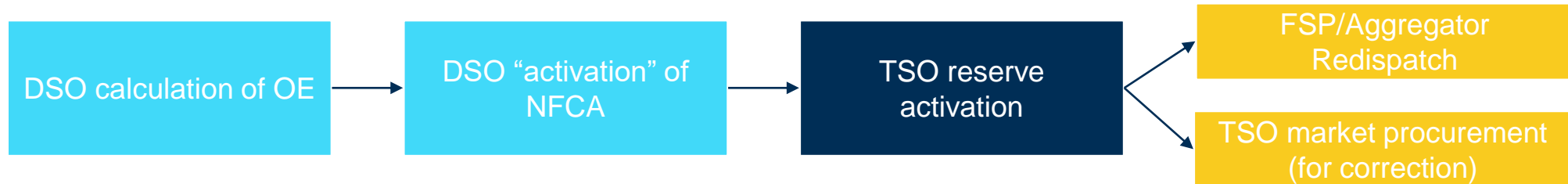➢ The more end-users adhere to a non-firm connection agreement, the less they need to be constrained

Combination with Implicit Mechanisms

Non-Firm Connection Agreements (NFCAs) & DSO-TSO Coordination

- **Prequalification method**

DSO calculation of OE	→	DSO prequalification	→	TSO market procurement
Can be performed way-ahead using worst-case scenarios				Consumers participate in flex markets according to available capacity

- **Ex-post correction (TSO or FSP)**

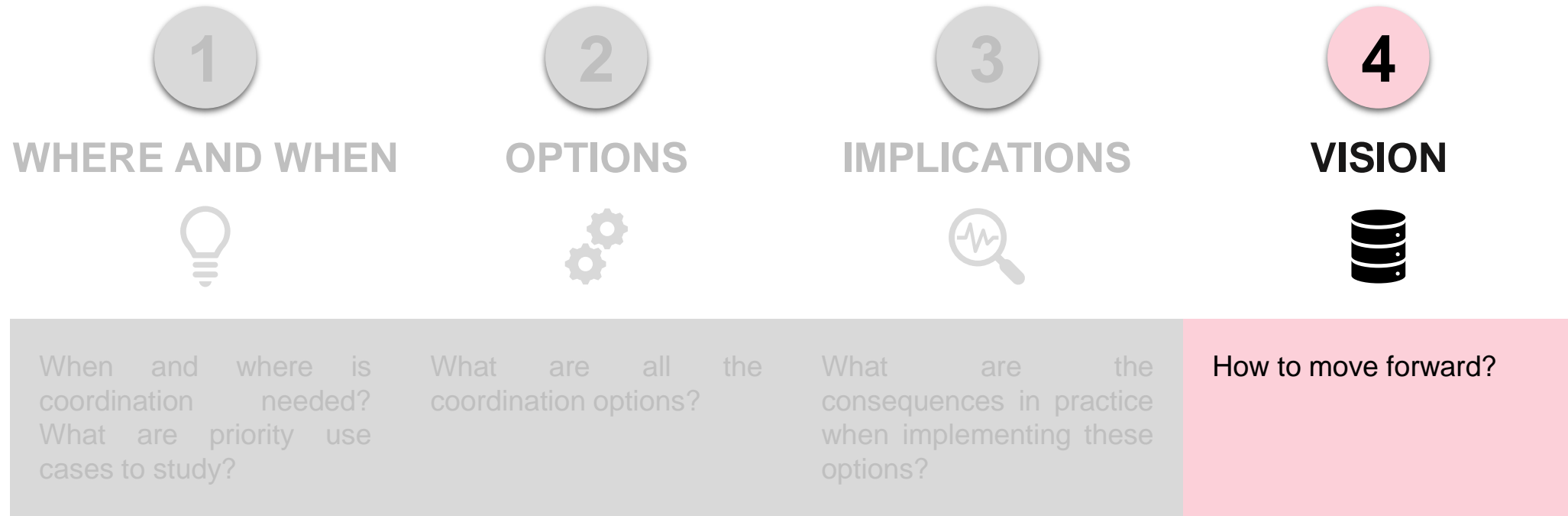| DSO calculation of OE	→	DSO "activation" of NFCA	→	TSO reserve activation	→	FSP/Aggregator Redispatch
						TSO market procurement (for correction)

Discussion round

How do you currently see the tradeoff and alignment between different flexibility acquisition mechanisms?

1

WHERE AND WHEN

2

OPTIONS

3

IMPLICATIONS

4

VISION

When and where is coordination needed? What are priority use cases to study?

What are all the coordination options?

What are the consequences in practice when implementing these options?

How to move forward?

VITO

4lexander

How to move forward?

Step 1:

When is it needed?

Where is it needed?

What are the uses cases?

Step 2:

Know what you are discussing:

What are options?

How do you compare them?

Step 3:

What are the consequences?

Many interlinked discussions:

Which ones should be prioritized now?

How intrusive are they compared to the BAU?

Step 4:

Regional differences and opinions:

• Which ones can be aligned?

• Which ones should be aligned?

Set up vision