Market Coupling Steering Committee

MCSC Co-Optimisation workshop following the informal survey

Workshop

19/12/24 10:00 – 12:30

Agenda

	TOPIC	WHO	TIMING
1	**Welcome and Workshop Objectives**	Com TF conveners MCSC Co-chair	10:00 – 10:10
2	**High-Level Overview of Key Design Challenges of Co-Optimised Markets & Q&A**	Christoforos Zoumas Gerard Doorman N-side	10:10– 11:10
3	**Survey Responses and Main Findings & Q&A**	Oliver Hedegaard Gerard Doorman	11:10 – 12:10
4	**R&D Roadmap and Next Steps & Q&A**	Timo Suhonen, Marja Eronen	12:10 – 12:25
5	**Closure**	Com TF conveners MCSC Co-chair	12:25 – 12:30

Welcome and Webinar Objectives

Provide a high-level overview of co-opt design challenges

Discuss survey responses and main findings

Provide an overview of steps ahead based on the R&D roadmap

Reminder

Informal survey

- Informal survey *run 07/10 - 06/11/2024, via the ENTSO-E public consultation platform [LINK],*
- *introduced to market participants on 11/10/24 through an online webinar [PPT], [RECORDING].*

Bilateral interviews

- Structured interviews with market parties, conducted by NEMO and TSO representatives with the focus on technical discussion of the representation of constraints, cost structures, bidding language needs, etc.

Why Co-Optimization?

Balancing capacity is a product and the market is the best way to procure it

Electricity Balancing GL

Art. 40 of EBGL lists co-optimised allocation process as one of three **alternatives for two or more TSOs to exchange balancing capacity or sharing of reserves**.

Co-optimisation shall apply for the exchange of cross-zonal balancing capacity or sharing of reserves with a contracting period of not more than one day and where the contracting is done not more than one day in advance of the provision of the balancing capacity.

Co-Optimisation Methodology & Algorithm Methodology

The **process shall be integrated, after a successful R&D providing proof of performance, with the SDAC algorithm** and allocate cross-zonal capacities for exchange of balancing capacity or sharing of reserves.

Algorithm methodology amendment took place in 2024 and focused on the required R&D and the introduction of a basic set of requirements for Co-optimisation.

Conceptual Design

Implementation of Co-Optimization in SDAC requires:

1. Extensive **R&D to specify the final set of requirements** for implementation
2. Adaptation of relevant **methodologies**
3. Industrialization and introduction into production

MCSC NEMOs and TSOs initiated work on the **conceptual study as the initial step of the R&D work** to research bidding alternatives and basic design considerations. Aim is to analyse as many impacts as possible of different models.

What Is Co-Optimization?

Allocation in one (co-optimised) step

Clearing based on the same bids or based on separate bids

Market liquidity and efficient process

Co-optimization is a process where the cross-zonal capacity for Balancing capacity is **allocated as part of the SDAC market coupling calculation process** – with potential for higher economic efficiency.

In theory, both day-ahead and balancing capacity markets can be cleared based on the same bids **assuming that balancing capacity prices are mainly defined by the opportunity costs** resulting from the day-ahead market profits. As an alternative, separate bids for day-ahead energy and balancing capacity may be used.

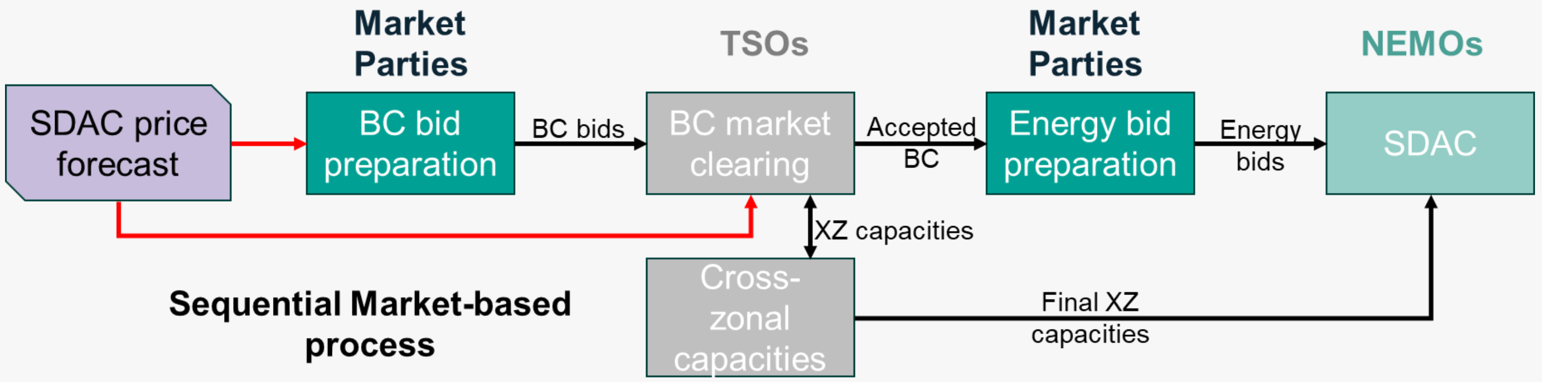
Co-optimisation can overcome the drawbacks of market-based allocation concerning forecast errors and coordination inefficiencies and allows the **liquidity of the day-ahead market to also be directly accessible to balancing capacity markets**.

The objective optimisation function is the maximization of the sum of the economic surplus for energy and balancing capacity per trading day.

Procurement of Balancing Capacity

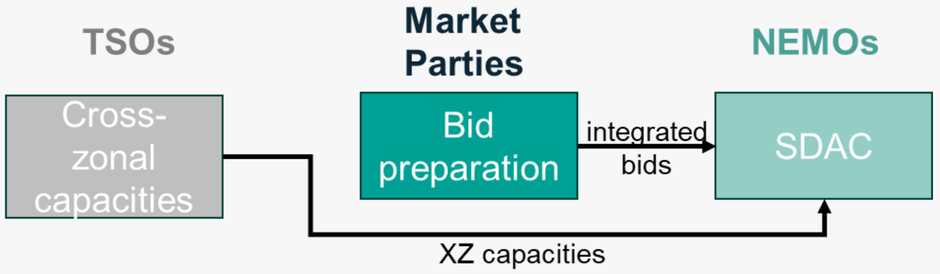
- Balancing **Capacity** is procured by TSOs to ensure the ability to activate Balancing **Energy** in real time
- Today, Balancing Capacity is mainly procured on a national basis
- However, trade in general reduces costs, and this is not different for Balancing Capacity

Two models for exchange of balancing capacity are relevant:



Used in the Nordics since December 2022

Co-optimized Process
w/integrated bids



Model with "explicit bids" is also considered

Current Context

Scope of the (ongoing) SDAC Co-optimization Study II

- Conceptual phase on the design of the bidding language, pricing approach, and network management
- Large-scale simulations will be performed in a follow-up study once main design options will have been shortlisted.

Conceptual Phase: Current efforts are on the analysis of two axes

- Bidding Language: linked bids versus combined bids and cost representations
- Pricing options in the presence of “non-convexities” (bids with indivisibilities and fixed costs, e.g. block or complex orders).

Co-optimization is a challenging topic: keeping everyone onboard and ensuring a continuous engagement requires to take sufficient time to disentangle various facets of the concepts

Co-optimization Impacts Many Market Coupling Requirements and Processes

We focus on the bidding language and pricing requirements in the ongoing work

N-SIDE

Focus in the ongoing work

Bidding Language

- Linked bids versus combined bids (for different technologies)
- Cost representation: implicit bidding versus explicit bidding (premium + opportunity cost vs. absolute limit price)
- Substitution between BC products and price reversals

Bidding of the BC Demand

- Elasticity (price-sensitivity and possibility of curtailment)
- Substitutability of aFRR and mFRR demands (≈ avoidance of price reversals)
- Location of procured FRR: ensure that FRR is not procured from too far away (in a flow-based configuration)
- Exchange of BC vs. sharing of BC
- Other specific requirements (e.g. indivisibilities)

Pricing

- Coherence of BC and Energy Prices
- Coherence of the CZC valuation and allocation
- Non-convexities: paradoxes & side-payments
  - Increased BC prices despite paradoxical rejection
  - Avoid completely paradoxically accepted bids
  - Paradoxically accepted bids + sidepayments
- Coherence of the Energy and BC Price?
- Price setting with supply or demand orders
- Pricing and volume indeterminacies interractions
- ...

Network Requirements

- Reserve deliverability:
  - Deterministic requirement (100%)
  - Probabilistic requirement (≥x%)
- Netting & counter-intuitiveness
- Relations with LTTRs

Algorithm

- Scalability
- Reproducibility
- Rounding procedures

IT Systems

- Governance, Technical Feasibility and Robustness
- Explicit bid linking IT aspects

Key Complexities of the Design Being Currently Addressed

Designing an effective bidding language that provides the right set of trading tools and accommodates both portfolio bidding and asset-specific bidding (thermal, storage, demand response, …)

1. Enabling market participants to accurately represent their asset's ability to deliver energy and balancing capacity services.
2. Allowing to effectively represent assets' costs (including the non-trivial ones) when jointly bidding for energy and balancing capacity products.

Designing adequate pricing mechanisms suitable to the co-optimization setup

1. Marginal Pricing in a co-optimization setup ensures that costs created within the auction due to bid linking are naturally recovered through the market prices of the various products (see next slide).
2. In the presence of complex bids introducing indivisibilities and fixed costs ('non-convexities'), various pricing options can be contemplated.

Other design topics include

1. Adequately representing the demand for balancing capacity (e.g. elasticity, substitutability,…).
2. Locational procurement constraints for balancing capacity (e.g. supplying from "not too far away").
3. Reserve deliverability constraints (deterministic versus probabilistic requirements).
4. …

Price Formation with Linked Bids for Energy and Balancing Capacity

Marginal prices perfectly align with the profit-maximization problem of the market participants

No need to forecast the (opportunity) costs implied by bid linking → These are automatically recovered through optimal marginal prices

Energy Demand

BC-up Demand

Energy Demand
400 MW @ 5000€/MWh

Upward BC Demand
150 MW @ 5000€/MWh

Energy Supply Bid B
500 MW @ 100 €/MWh

Upward BC Supply Bid C
200 MW @ 70 €/MWh

Energy Supply Bid A1
250 MW @ 60 €/MWh

Upward BC Supply Bid A2
250 MW @ 5* €/MWh

Exclusive group of 2 fully divisible orders:
→ *Sum of acceptance ratios can not exceed 100%*
→ Equivalent to: Energy Volume + BC - up Volume ≤ 250 MW

Market Results	Energy	Upward Balancing Capacity
Market Prices	100 €/MWh	45 €/MWh
Bid A1 Accepted Vol.	100 MWh	-
Bid A2 Accepted Vol.	-	150 MWh
Bid B Accepted Vol.	300 MWh	-
Bid C Accepted Vol.	-	0

*The reservation price, or premium, cover all possible types of costs which are not caused by bid linking

1. There is inelastic demand for energy and for balancing capacity.
2. Bid B offers expensive energy.
   Bid C offers expensive upward Balancing Capacity.
3. Bid A is composed by two linked bids: an energy bid A1 and an upward balancing capacity bid A2, connected by an exclusive condition.
4. The most cost-effective solution is to satisfy the upward Balancing Capacity demand with Bid A2, and the energy demand with a combination of Bid A1 and Bid B.
5. Bid B is fractionally accepted.
   Bid B sets the energy market price at 100 €/MWh.
6. The price of upward Balancing Capacity is set to 45€/MWh, to account for the opportunity cost of bid A: Bid A1 is facing an opportunity cost in the energy market of 40€/MWh because it provides instead upward BC. With an upward balancing capacity price of 45€/MWh, Bid A makes an equivalent profit in the balancing market.
7. All bids are optimally allocated given the clearing prices.

Co-Optimization Simultaneously Allocates Scarce Resources to Multiple Energy and Balancing Capacity Products

Two types of asset to optimally allocate between BC and energy: generation and transmission

1. Co-optimized allocation of joint offers for different products (energy & ancillary services)

2. Co-optimized allocation of CZ transmission capacity

Enforcement of **robust network requirements for cross-border balancing capacity procurement** → make sure that the network can support *any reserve activation pattern*

Future Challenges

The current R&D phase has a **narrowed scope, already addressing several conceptual and design challenges.**

Future R&D and work in the Co-optimisation context shall however tackle several other areas that are currently out of scope:

- Gaming
- Market operation and governance issues
- Challenges to system operation
- Allocation of cross-zonal capacity for balancing capacity
- Algorithm performance

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Q&A

Introduction to the Informal Survey and Its Goals

The objective was to collect inputs about market parties costs structures and their impact on bid designs

- **Get overall insight** into the characteristics of balancing service providers with both conventional and future technology portfolios/units **via an informal survey (voluntary initiative)**
- **Go in-depth** on specific technical/costs/bidding/optimization issues raised by a selection of market parties **via interviews**

INPUTS

- 31 informal survey responses
- 7 in-depth interviews

TO PROVIDE INSIGHTS ON

RESULTS

- Co-optimisation in general
- Requirements for new products considering:
  - Technology constraints
  - Link between costs and bid factors
  - Cost elements
  - Continuous portfolio optimisation

TO COMPLEMENT

NEXT STEPS

Next R&D phases defined by the Algorithm Methodology

**Slides 15-19 are based on market participant feedback from the survey and interviews and do not necessarily represent NEMO and TSO positions.*

Market Parties Identify Possible Challenges

IN R&D SCOPE

Representation of **inter-unit and inter-temporal links** & cost structures

Possibilities for **portfolio optimization**

Relative **insignificance of DA outcomes for the realised dispatch** of large market participants

Impacts on **current systems/practices**

Market signals for forward markets + investments

Market **transparency**, price formation

Remaining requirements for **price forecasts** for inter-temporal and inter-unit interactions modelling

Hindrance of utilizing trade flexibility between DA and balancing markets due to single bid nature of co-optimisation

Attractiveness of balancing capacity market

OUT OF R&D SCOPE

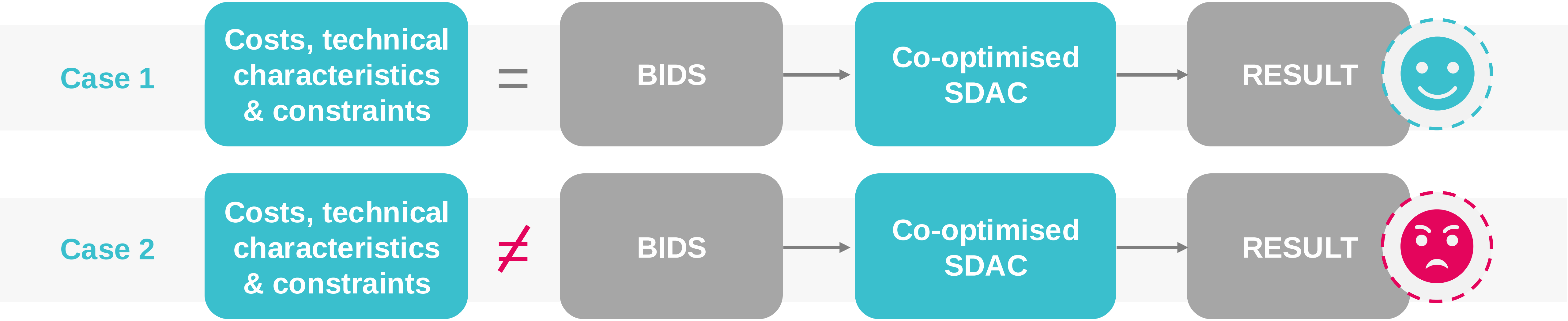
Complexity implementation phase

Computational **burden for market algorithm**

Increase of complexity, influencing e.g. possibility for **cross-optimisation** with heat markets

Algorithmic complexity and possible **risks**, e.g.; for decoupling, delayed results, inferior result, paradoxical results

Representation of Assets



- The quality (real optimality) of the co-optimised SDAC solution critically depends on the **bid formats being able to represent the cost structures and constraints** of the underlying assets.
- **If bids do not represent real costs, the SDAC solution may be optimal with respect to the bids, but not with respect to real costs.** In this case, the solution is only "quasi-optimal".
- Market participants will re-optimise their portfolios, but an **inadvertent BC allocation cannot be corrected.**
- In this case, the value of a co-optimised solution is doubtful.

Cost Elements Related to the Provision of Balancing capacity

Bid formats should allow market participants to adequately represent the underlying costs as well as technical constraints since good inputs are a necessity for good market results

**Non-exhaustive list of the most frequently mentioned cost elements*

Variable Costs

- Fuel costs, emission costs, subsidies
- Depend highly on the operating point of an asset

Fixed Costs

- Costs related to starting up/shutting down or maintaining a minimum operational level

Other Cost elements

- Many other cost elements were mentioned that often are specific to certain asset types (e.g., State of charge management for small storages)

Opportunity Costs

- Lost revenue of not participating in other markets like Day-ahead energy, intraday trading, or other ancillary services

Conclusions:

1. Some cost elements for Balancing Capacity might be endogenous to the market clearing algorithm
2. Other cost elements are unknown from an algorithm perspective and need to be included in the bid formats

Examples of Challenging Constraints

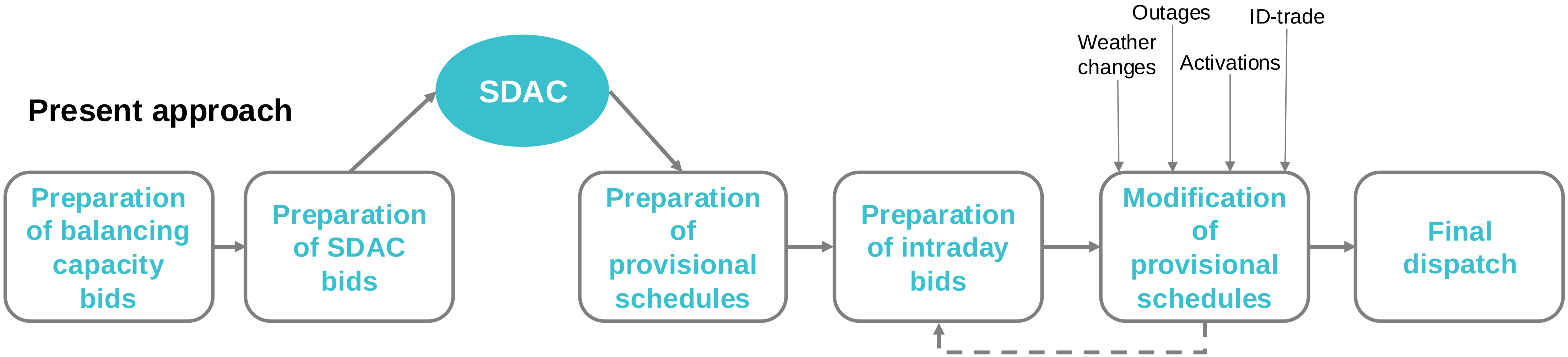
Thermal

- Startup costs, including dependency hot/cold
- Links with gas network/contracts
- Links with heating demand (CHP)
- Maximum number of startups during a day
- State-dependent duration of startup sequences
- Choice of plant state – CCGT/OCGT
- Min up- and down-times
- Increasing efficiency as function of output
- Ramping limits
- Coupling to FCR market

Hydro

- Links between plants in same river with small reservoirs
- Complex relations between water values and reservoir levels
- Time delays
- Ramping limits
- Dependency between reservoir level and plant maximum capacity and efficiency
- Non-convex plant efficiency curves
- Reservoir overflow characteristics

Continuous Optimisation of Portfolio



- SDAC market clearing is just **one step in a continuous sequence**
- Utilisation of the asset **portfolio is optimised in each step**
- Dedicated IT solutions handle relevant (non-)linear problems
- "Optimal" SDAC result can be perceived as less important due to **subsequent re-optimisation**.

▶ Because of this, a sequential solution may be just as good as co-optimisation

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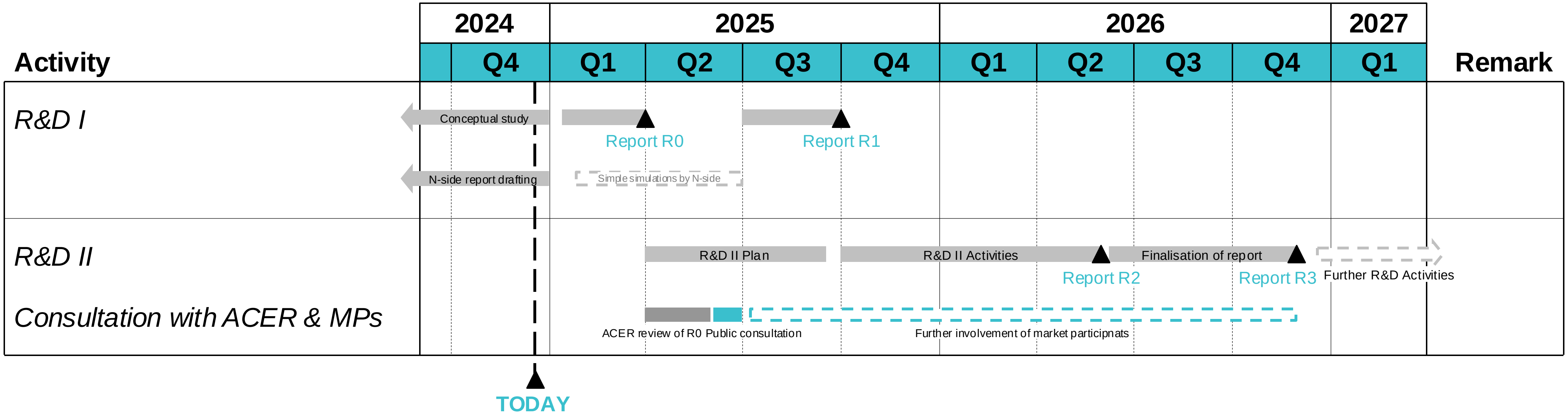
Q&A

Co-Optimization R&D Roadmap and Next Steps

Several stages of R&D are planned before implementation:



Newly approved Algorithm methodology [LINK] provides the basis for the introduction of co-optimisation and sets out a basic timeline for the R&D for the upcoming two years.

Involvement of Market Participants

Regular information on co-optimisation activities via MESC, MCCG and EBSG

Informal Survey & interviews to gain insights into the details of key co-optimisation market design concepts

Formal public consultation of reports, methodologies related to co-optimisation

Your opinion matters!

In the future, MCSC NEMOs and TSOs will seek regular alignment with MPs via:

- Formal public consultations of R&D reports in line with the Algorithm methodology provisions
- Informal surveys and further interview rounds focused on selected topics
- Active provision of information about next R&D phases - scope, content and co-optimisation challenges.

Q&A

Thank you for your attention!