Introduction

- **Terminology: the *spot algorithm* is the algorithm used to calculate the spot prices and the market coupling flows.**
- **At www.houmollerconsulting.dk, from the sub-page Facts and Findings, you can download the PowerPoint presentation *Market coupling – European price coupling***
  - **Appendix 1 of this presentation explains block bids.**
- **Practicalities: this presentation is animated**
  - **It is recommended to run the animated version when viewing the presentation.**
  - **On most computers, you can start the animation by pressing *F5***
    - **Now the presentation moves one step forward, when you press *Page Down*. It moves one step backward, when you press *Page Up*.**

Spot algorithm's block bid selection – 1

- **An off-the-shelf solver is used as the basis for the spot algorithm's calculation kernel.**
- **It's an off-the-shelf solver doing linear optimization.**
- **The solver will handle the linear constraints and the criterion function:**
  - **Linear constraints (linear equations)**
    - ***Example: For a given bidding area and a given hour***
      - ***(the sum of accepted sales bids) - (the sum of accepted buy bids) + (import) - (export) = 0.***
  - **The criterion function (CF): maximizing the economic value of the spot trading ("welfare criterion").**
- **Binary constraint (not handled by the solver)**
  - ***A block bid is either completely accepted or completely rejected.***

Spot algorithm's block bid selection – 2

- In addition to the linear and binary constraints, the spot algorithm must fulfil one additional constraint:
  - No block bid must be loss-giving.
- This condition can <u>not</u> be handled by the off-the-shelf solver.
- *Example of a block sales offer: "In bidding area A, I will sell 100 MWh each hour during the period from 7am to 11am, if the average price during this period is 40 EUR/MWh or higher".*
- *Unfortunately, the solver may choose to include this block offer in the solution, even if the average price during the period is lower than 40 EUR/MWh*

  (ie, the block is included as a loss-giving block bid)
  - The solver will include the block, if this maximises the criterion function
    - Even if the block is loss-giving.

Spot algorithm's block bid selection – 3
The branch & bound algorithm

- **Hence, one option for the spot algorithm is to proceed the following way:*)**
- **At the outset, all block bids are unconditionally sent to the solver. The solver finds a solution maximising the criterion**
  - **Referring to some of the following slides: this is the calculation performed at node N_{00} at the root of the decision three.**
- **The N_{00} solution is checked for loss-giving blocks**
  - **Normally, there are lots of loss-giving blocks in solution N_{00}.**
- ***Assume block bid B_1 is loss-making. Now the process carries on as follows:***
  - ***In one branch of the decision three, B_1 is forced to be part of the solution. In the other branch, B_1 is forced out of the solution.***
- ***The process now continues as sketched on the following slides.***

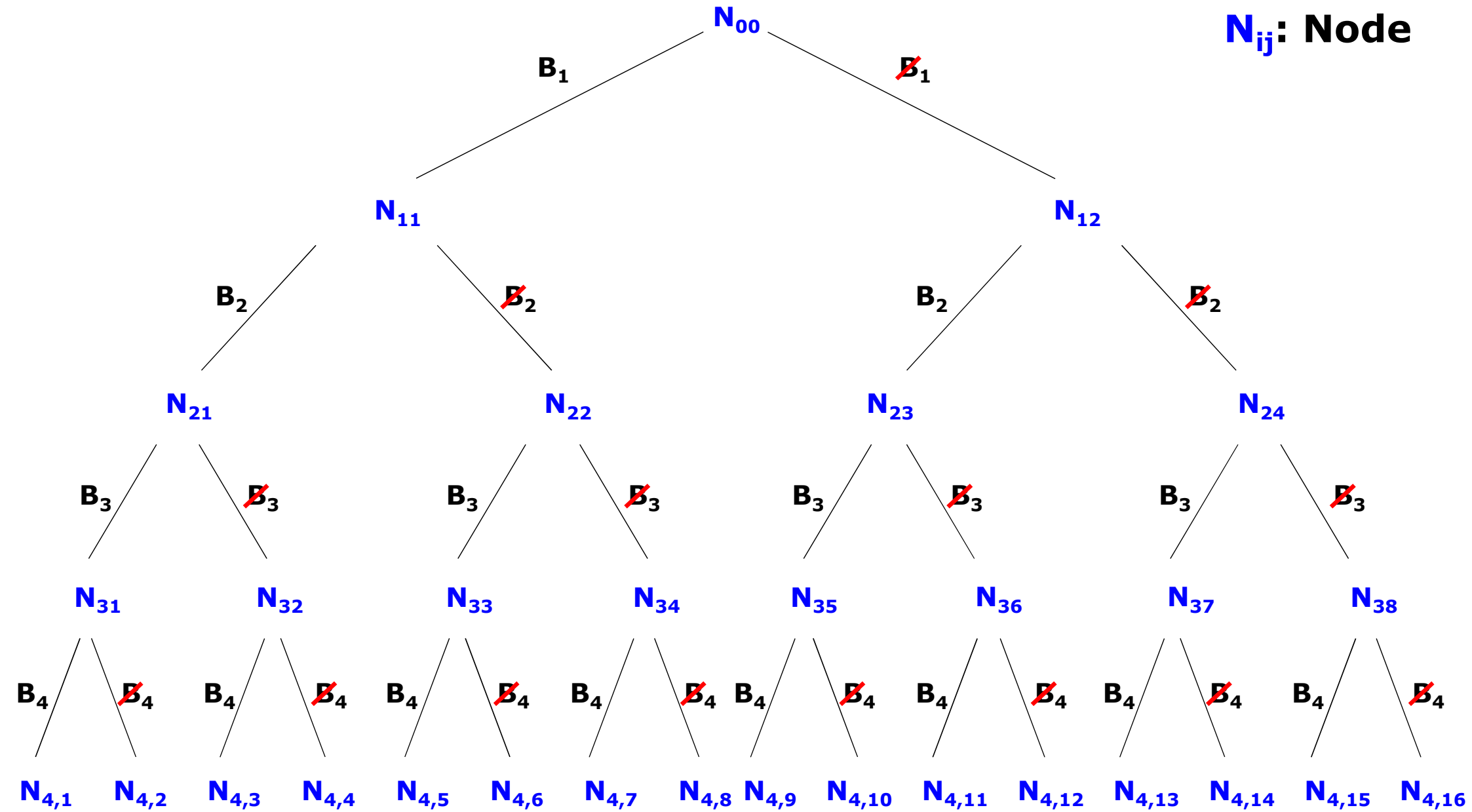
) Note: the search for the optimal combination of block bids may be designed in other ways.

Block bid selection

Branch & bound – simple example

- In the simple example on the next slide, the initial calculation yields only four loss-giving block bids: B_1, B_2, B_3 and B_4.
- Actually, the calculation performed at a sub-node may yield new loss-giving block bids. This possibility is ignored on the next slide
  - When this possibility is ignored, the complete decision three has 5 rows. At the bottom row, there are 16 nodes.
- Terminology:
  - If B_i is associated with a path, this indicates B_i is forced to be included in the solution in all the nodes below.
  - If B_i with a strikethrough is associated with a path, this indicates B_i is forced to be excluded from the solution in all the nodes below.

Complete decision tree with four loss-giving block bids



Example with three block bids – 1

- In this example, only three block bids B_1, B_2 and B_3 have been submitted to the exchange.
- For simplicity, it's assumed there is a valid solution no matter which blocks are forcibly included in or excluded from the solution.
- For a given node N_{12}, assume the value of the criterion function is 88 (ie, CF = 88).
- In this case, for all the nodes in the sub-three under N_{12}: the value of the criterion function can be at most 88
  - In all the nodes in N_{12}'s sub-three, the solver has fewer block bids, among which the solver can choose freely.
  - This limitation of the solver's options will cause 88 to be a ceiling for the criterion function in N_{12}'s sub-three.

Example with three block bids – 2

Terminology

- **Included** is the set of block bids forced to be included in the solution.
- **Excluded** is the set of block bids forced to be excluded from the solution.
- **CF** is the value of the criterion function.
- **Ø** is the empty set.
- **B_i ... [also] included** lists blocks which are included in the solution by the solver (ie, these block were not <u>forcibly</u> included in the solution).
- **B_i ... excluded** lists blocks which are excluded from the solution by the solver (ie, these block were not <u>forcibly</u> excluded from the solution).

Example with three block bids – 3
Terminology

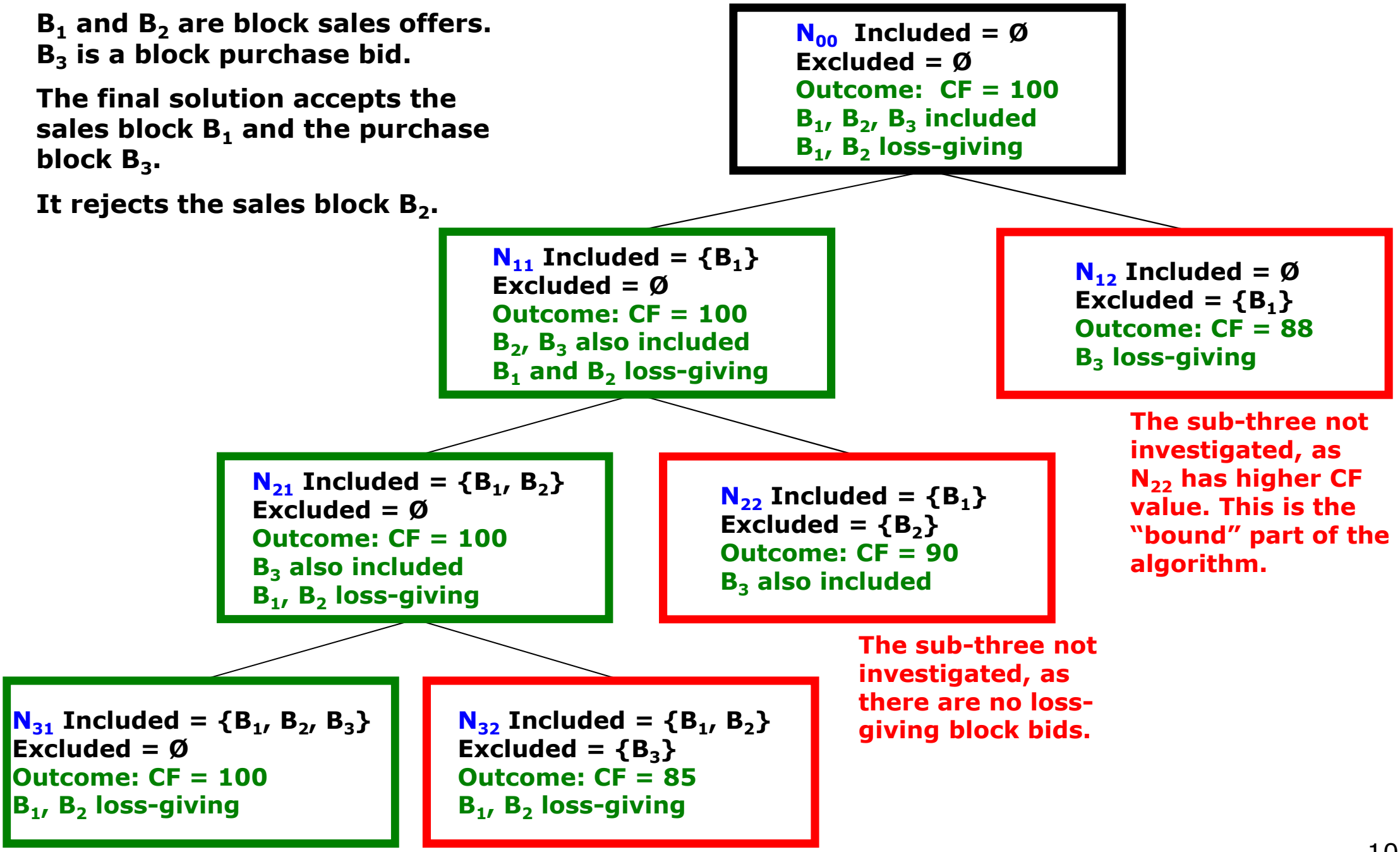
- A green frame indicates a node, where no new calculation is carried out
  - As the result at the parent node make a new calculation redundant.
- A red frame indicates a node, where the sub-tree is not investigated due to one of the following two reasons:
  - Either the node's calculation result does not contain loss-giving block bids.
  - Or another node has been found, which has both the following properties:
    - A higher value of the criterion function.
    - A calculation result without loss-giving block bids (ie, a valid solution).

Example with three block bids – 4

B_1 and B_2 are block sales offers.
B_3 is a block purchase bid.

The final solution accepts the sales block B_1 and the purchase block B_3.

It rejects the sales block B_2.



The sub-three not investigated, as N_{22} has higher CF value. This is the "bound" part of the algorithm.

The sub-three not investigated, as there are no loss-giving block bids.

Thank you for your attention!

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