



A cost benefit analysis of transmission grid projects considering interdependencies within the power system

5<sup>th</sup> Mannheim Energy Conference | 20 May 2016

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## Overview

- Background
- Drawbacks considering overall system effects in currently applied methods and a proposal for its overcoming
- First exemplary results

## Background

### Strong demand on transmission grid expansion...

- > ...especially due to an increasing distance between the locations of supply and demand
- > ...could not be met to the overall economically sensible extent because of extensive approval procedures and public resistance
- > Focus on grid expansion projects with maximum benefits
- > EU<sup>1</sup>-Commission has established a list of PCI<sup>2</sup> and has requested an appropriate CBA<sup>3</sup> to solve the problem → still weaknesses

### Challenges of an appropriate CBA

- > Benefits of grid expansion projects are influenced by
  - » several economic and non-economic effects
  - » complex overall system effects
    - > interdependencies between grid and generation expansion as well as between existing and new grid projects themselves
    - > distribution effects within and between bidding zones

- > Complex overall system effects are not appropriately addressed
- Focus of this presentation are the overall system effects

1) EU := European Union  
2) PCI := Projects of Common Interest  
3) CBA := Cost Benefit Analysis

## Overview

Background

Drawbacks considering overall system effects in currently applied methods and a proposal for its overcoming

First exemplary results

## Status quo: Evaluation of grid expansion projects

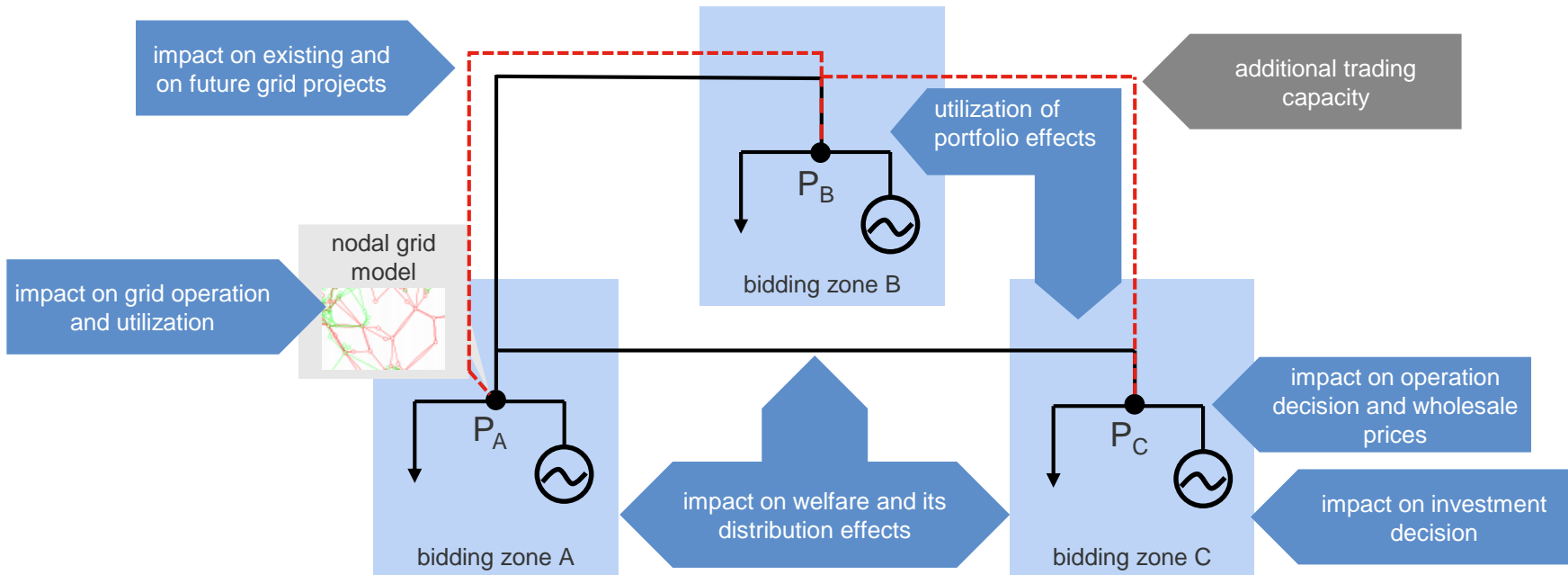
### Consideration of the overall system effects

- > Evaluations mostly based on predetermined generation expansion paths
  - » only consideration of operating decisions
  - » neglecting investment decisions
- benefit of grid expansion projects could heavily be influenced by interactions implying investment decisions in generation expansion
- > Evaluation solely based on a comparison between an individual grid expansion project and a predefined existing grid condition
- insufficient consideration of interactions between grid projects

- > Status quo neglects adjustment processes within the power system
  - » in particular interactions between individual grid expansion projects and between grid and generation expansion
- > Well-known example: ENTSO-E's CBA to derive the list of PCI within the Ten-Year-Network-Development-Plan (TYNDP) process

# Evaluation of grid expansion projects within the overall power system

## Overall system effects



- > Benefits of grid expansion projects especially show heavy interactions with future investment decisions
- > Welfare optimization is the basis for the benefit evaluation  
→ however, distribution effects can be used for further trade-offs

## Benefit evaluation

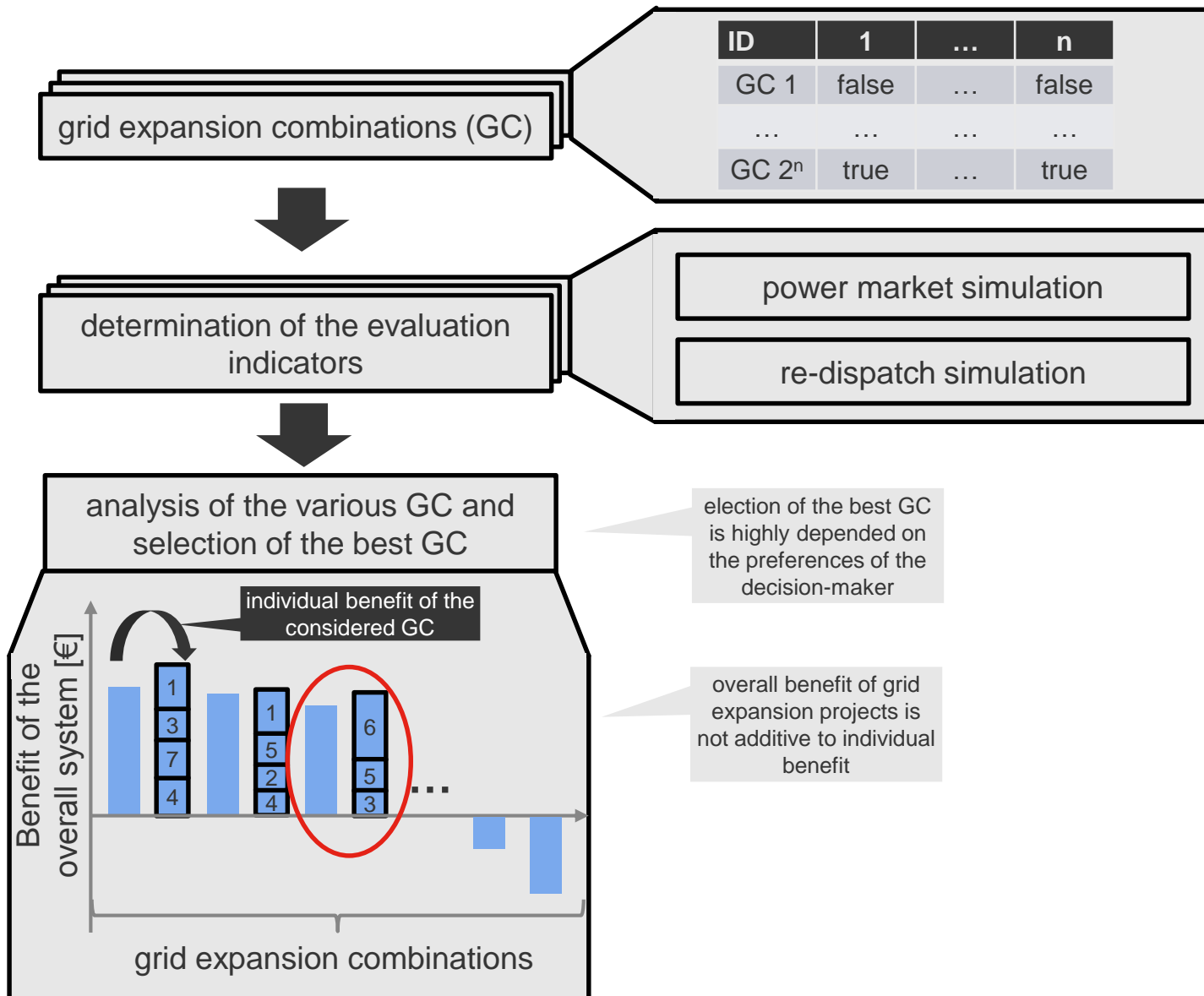
### Challenges

- > Evaluation of grid expansion projects requires the consideration of various grid expansion combinations, because
  - » a solely individual evaluation of grid expansion projects compared to the existing grid condition could not consider the shown interactions
  - » the economically optimal grid expansion combination may be accompanied by significant distribution effects

overall benefit of grid expansion projects are not additive to individual benefit

- > Comparison of the best grid-expansion combinations under consideration of overall system effects
- > Further analysis of resulting distribution effects to consider different preferences of decision-makers
- > Combinatorial problem requires long computation time → a full enumeration counts  $2^n$  grid expansion combinations

# Methodical approach





## Overview

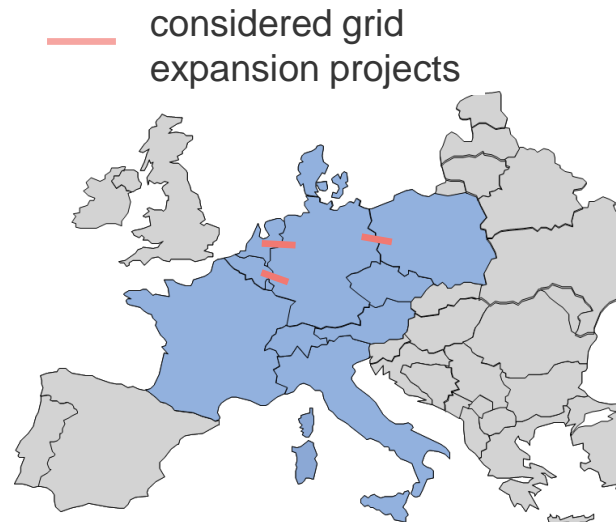
Background

Drawbacks considering overall system effects in currently applied methods and a proposal for its overcoming

Exemplary results

## First exemplary results

### Scope for the market and re-dispatch simulations



- > Time horizon: 2015-2055
  - » Divisions into representative years (each one represents 5 years)
- > Power plant fleet
  - » existing power plant fleet 2014
  - » endogenous expansion of thermal power plants
  - » exogenous expansion of RES, CHP, nuclear and hydro power plants<sup>1</sup>
  - » Infeed profiles of RES based on 2013

Consideration of generation investment decisions within the market simulation

### Grid expansion projects

- > Starting point: existing Day Ahead FTC<sup>2</sup> of the ENTSO-E 2014
- > The reference case is given by no realization of the considered grid expansion projects
- > Grid expansion: DE-NL (1400 MW), DE-BE (1000 MW), DE-PL (900 MW)

1) Trends To 2050; E3M-Lab; IIASA-GAINS; IIASA-GLOBIOM and EuroCARE, Brussel 2013

2) Forecasted Transfer Capacities (FTC)

# Present values of market and grid evaluation indicators

Grid expansion project BE-DE with an increase of the NTC value in the amount of 1000 MW

## Reference without compared to with grid expansion project



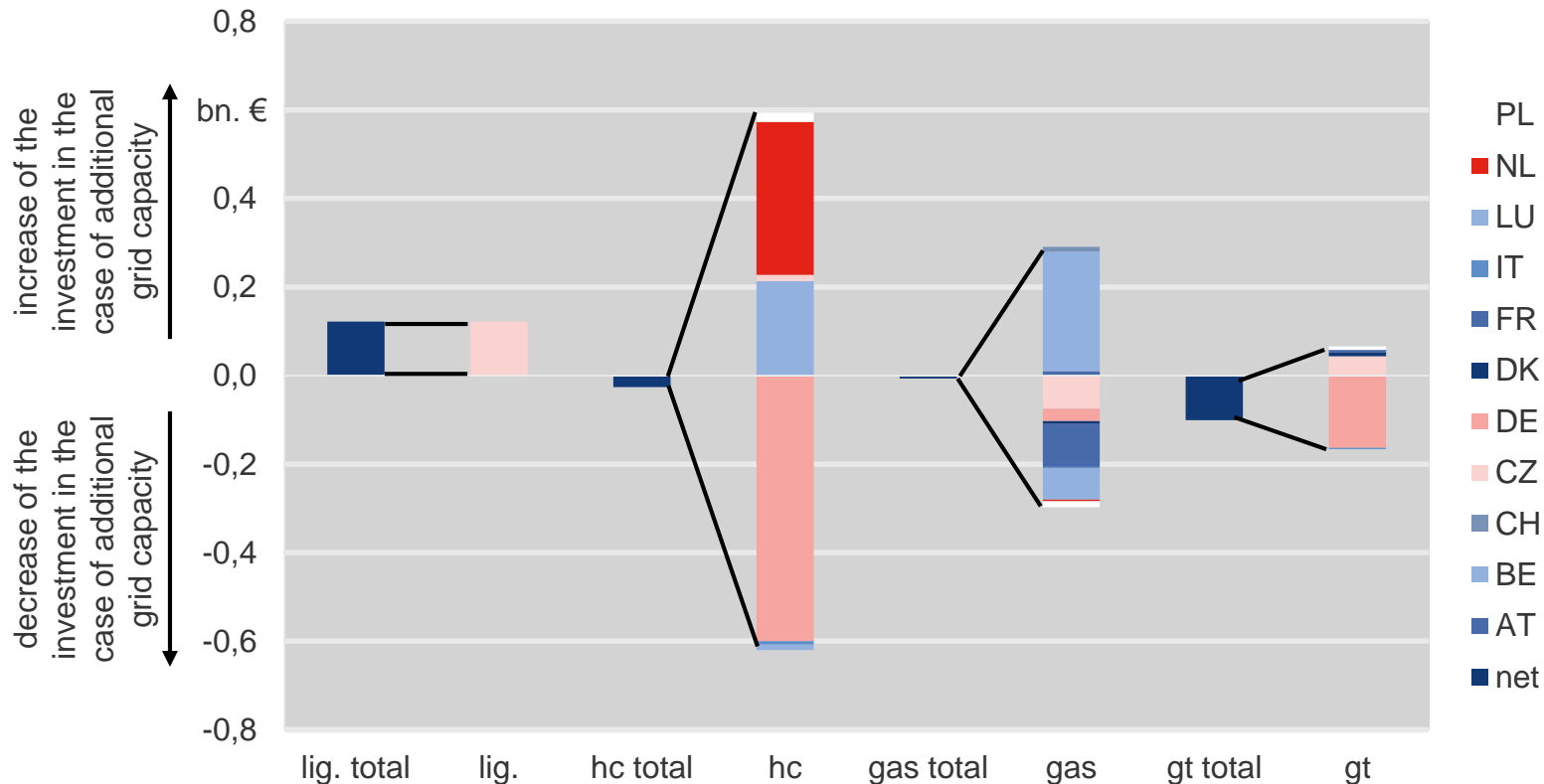
> Implementation of the grid expansion project leads to an overall system cost reduction of € 378 mio.

tc := total cost of the overall system, gic := generation investment costs, fgoc := fix generation operating costs, vgoc := variable generation operating costs, rdc := re-dispatch costs, cgl := cost of grid losses, gcc := grid combination costs

# Present values of generation investment decisions

Grid expansion project BE-DE with an increase of the NTC value in the amount of 1000 MW

## Integral generation investment decisions



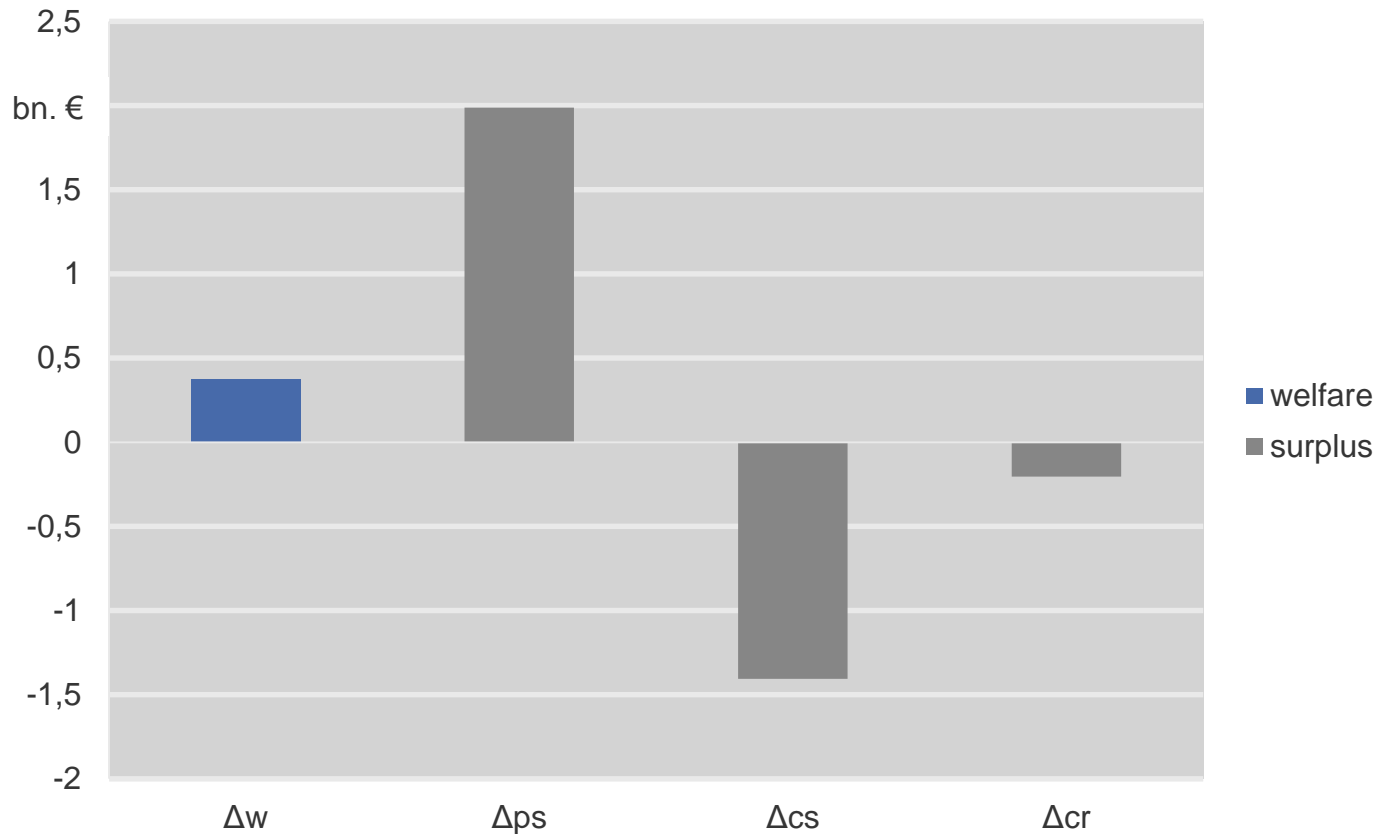
> Strong impact on regional cost allocation especially in countries with geographic proximity to the grid expansion project → could be observed for all benefit indicators

lig. := lignite, hc := hard coal, gt := gas turbine

## Welfare and its distributional effects

Grid expansion project BE-DE with an increase of the NTC value in the amount of 1000 MW

### Distribution of the welfare in producer, consumer and congestion rent

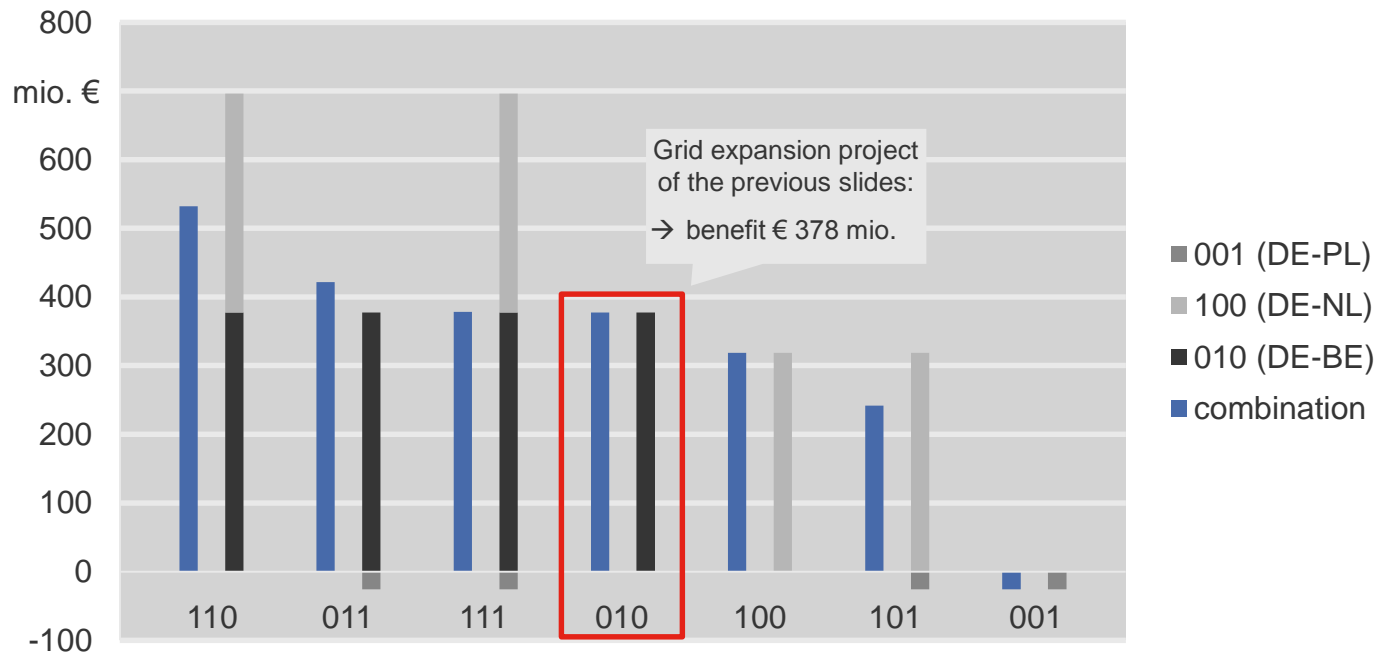


> The grid expansion project leads to significant distribution effects within the overall system

w := welfare, ps := producer surplus, cs := consumer surplus, cr := congestion rents

## Benefit of the observed grid expansion combinations

### Benefit of the grid expansion combinations compared to the individual grid expansion project benefits



- > Benefit of the grid expansion combination insufficiency as solely selection criterion → evaluation of distribution effects required
- > overall benefit of grid expansion projects are not additive to individual benefit

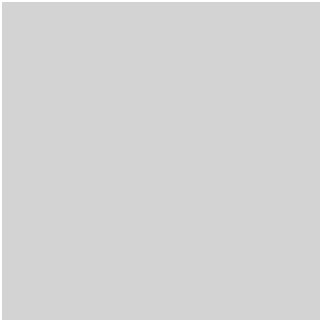
# Conclusion

## Summary

- > Status quo of CBA neglect interactions within the overall power system
  - » appropriate CBA requires interactions between grid and generation expansion as well as between grid expansion projects among themselves
- > Methodical approach shows a way to deal with interdependencies within the power system
  - » the exemplary results show the effects of the interdependencies and the importance of its consideration
  - » however, the computational time for a complete consideration of all interdependencies between existing and new grid projects acts as a limit

## Outlook

- > A more detailed analysis of the impact of interdependencies within the overall power system for example on derive rankings of grid expansion projects
- > Considerations on an appropriate way to include interdependencies in the CBA process for PCI → practical computation time



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