Impact of imbalance costs on stochastic unit investments

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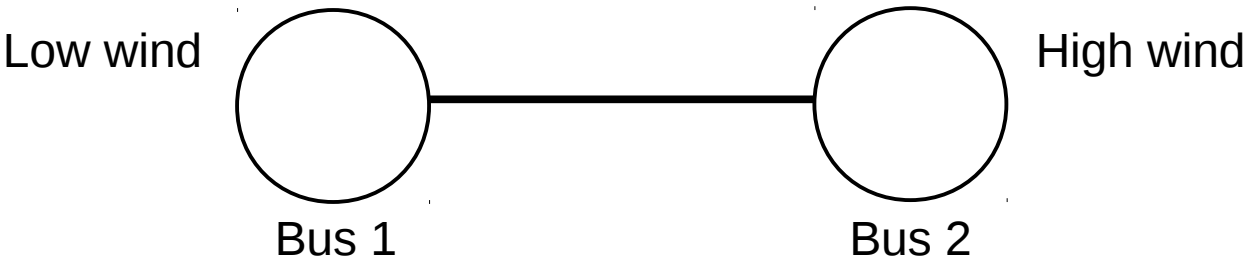
Workshop on Modelling Investment in Power Systems (27/03/2014)

Work supported by 5s project (http://www.futureelmarket.dk/)

Assumptions

- Static investment model (one target year)
- Long-term uncertainties disregarded
- Energy-only markets (no capacity or CO2 payments)
- No support scheme for renewables
- No competition at investment level
- Perfect competitive market (offers = marginal cost)

Expansion of stochastic units



Location of wind turbines?

Imbalance costs of wind

“The three study cases show that the error prediction costs can reach as much as 10% of the total WP incomes from selling energy.” [1]

“The predictions were analysed together with the electricity market prices for Denmark, using actual data from year 2001 (...) Costs from the regulation market for the prediction errors for 12–36 h ahead market were 2.3 Eur/MWh total wind power production, resulting in net income of 20.1 Eur/Mwh” [2]

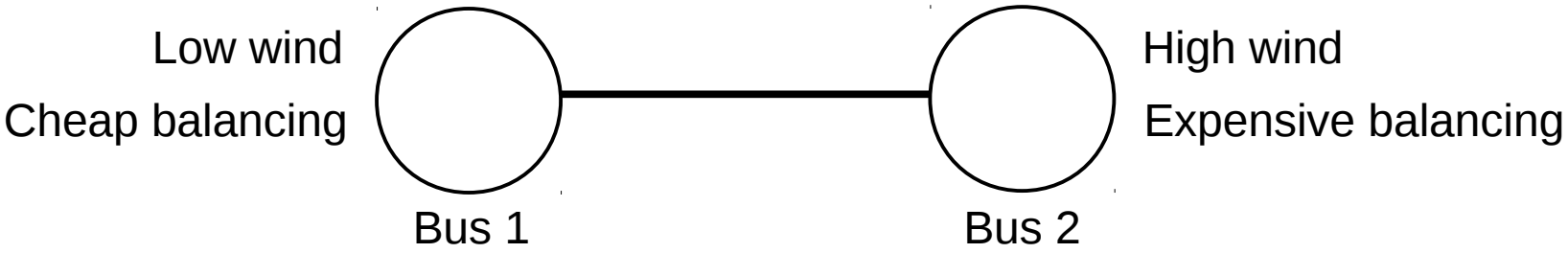
“Over 2002, the average spot price of APX is 29.99 euros/Mwh (…) Even if using perfect predictions, the average price per produced Mwh by a wind power producer equals 28.37 euros/Mwh (…) When considering regulation costs, the average price per produced MWh lowers to 24.68” [3]

[1] Fabbri, A.; Román, T.G.S.; Abbad, J.R.; Quezada, V.H.M., "Assessment of the Cost Associated With Wind Generation Prediction Errors in a Liberalized Electricity Market," Power Systems, IEEE Transactions on , vol.20, no.3, pp.1440,1446, Aug. 2005

[2] H. Holttinen, “Optimal electricity market for wind power”, Energy Policy, Volume 33, Issue 16, November 2005, Pages 2052-2063

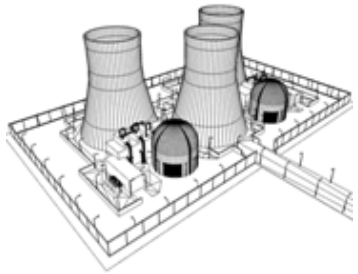
[3] Pinson, P.; Chevallier, C.; Kariniotakis, G.N., "Trading Wind Generation From Short-Term Probabilistic Forecasts of Wind Power," Power Systems, IEEE Transactions on , vol.22, no.3, pp.1148,1156, Aug. 2007

Expansion of stochastic units



Location of wind turbines?

Expansion of thermal units



Power producer

Decide new units

Maximize profit

Capacities & location

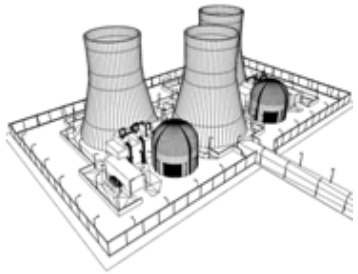
Dispatch & prices

Day-ahead market

Decide dispatch

Minimize cost

Expansion of thermal units



Power producer

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Capacities & location

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Decide dispatch

Minimize cost

Bilevel model

Maximize profit

Investment constraints

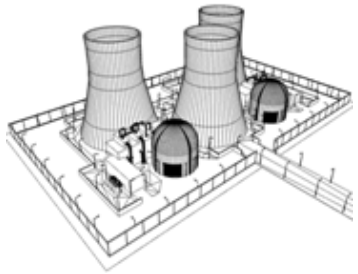
Day-ahead market

Decide dispatch

Minimize cost

Solve replacing lower-level problem by its KKT conditions

Expansion of stochastic units



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Power producer

Decide new units

Maximize profit

Capacities & location

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Day-ahead market

Decide dispatch

Minimize cost

Market design

- Day-ahead vs. balancing markets

Day-ahead market

- Power producers submit offers for the next 24 hours
- The demand and stochastic production are forecast
- The cheapest offers are accepted first

Balancing market

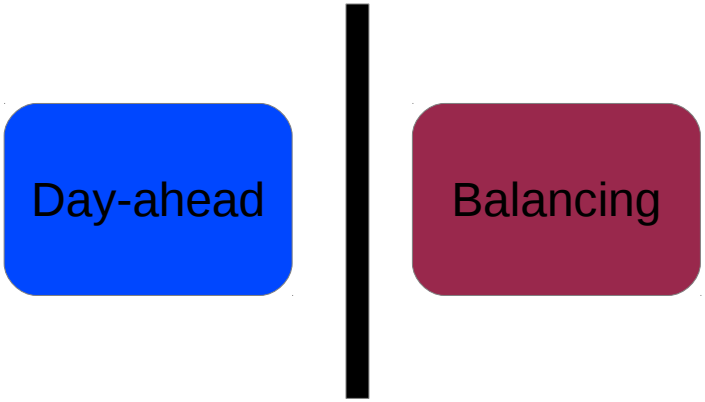
- Power producers submit offers to deviate from schedule
- The demand and wind realize at this stage
- The cheapest offers are accepted until deviations are balanced out

Market design

- Coordination between day-ahead and balancing

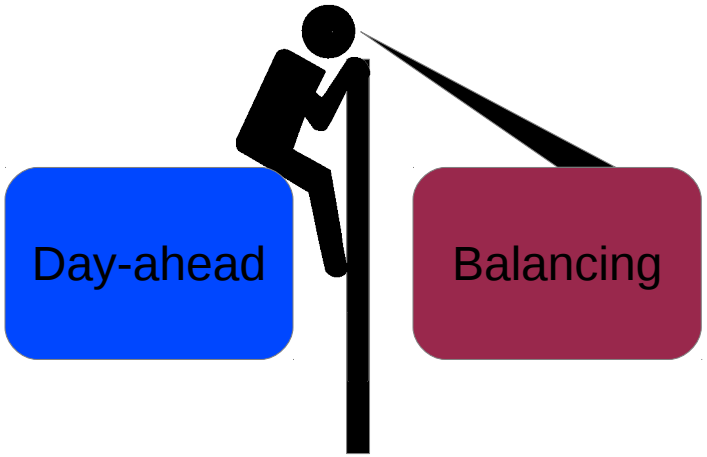
Conventional MC

Day-ahead dispatch compute disregarding balancing operation



Stochastic MC

Day-ahead dispatch takes into account balancing operation

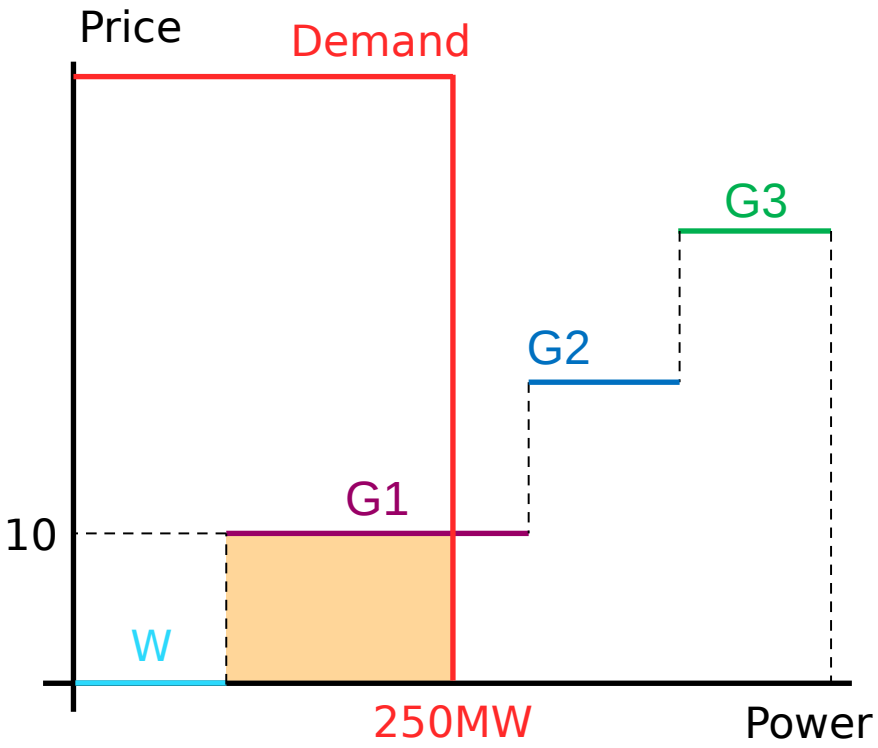


Market design

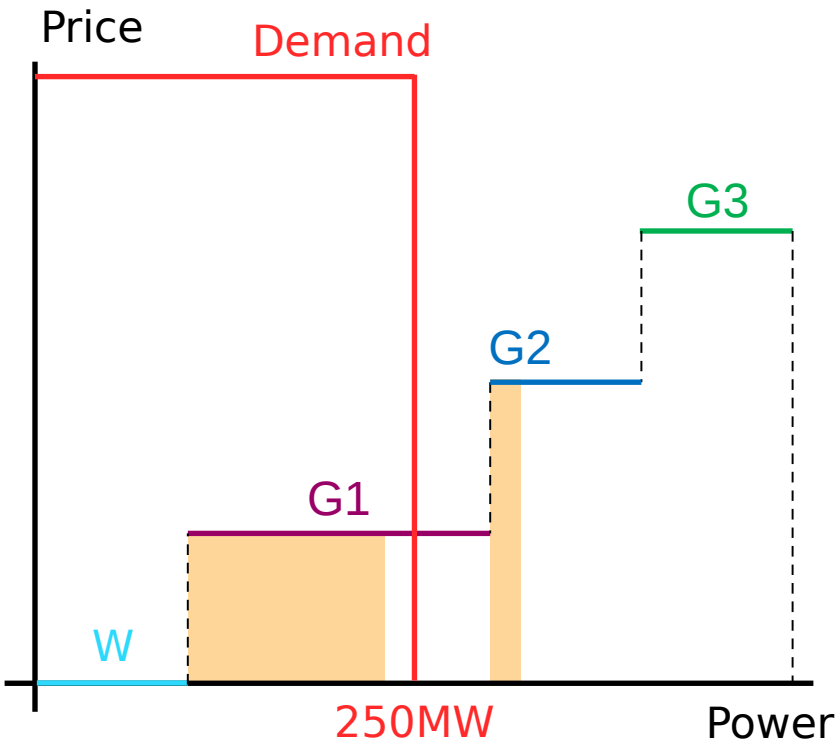
Forecast=100 MW

Wind(30%)=130 MW

Conv MC

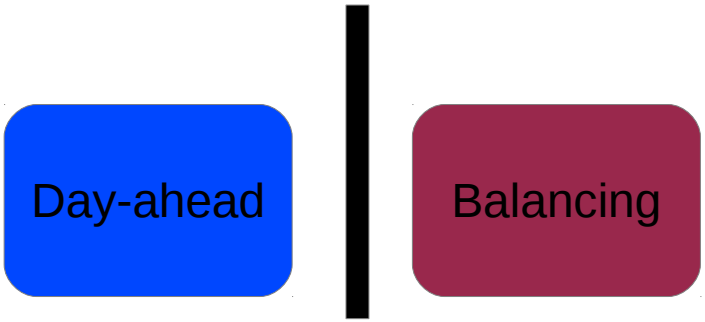


Stoc MC



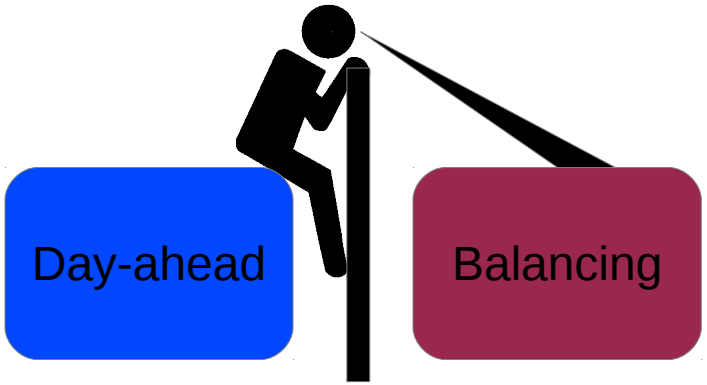
Market design

Conv MC



- DA dispatch: cheaper go first
- Balancing operation not included
- Minimizes day-ahead cost
- Higher imbalance cost
- All units obtain profits

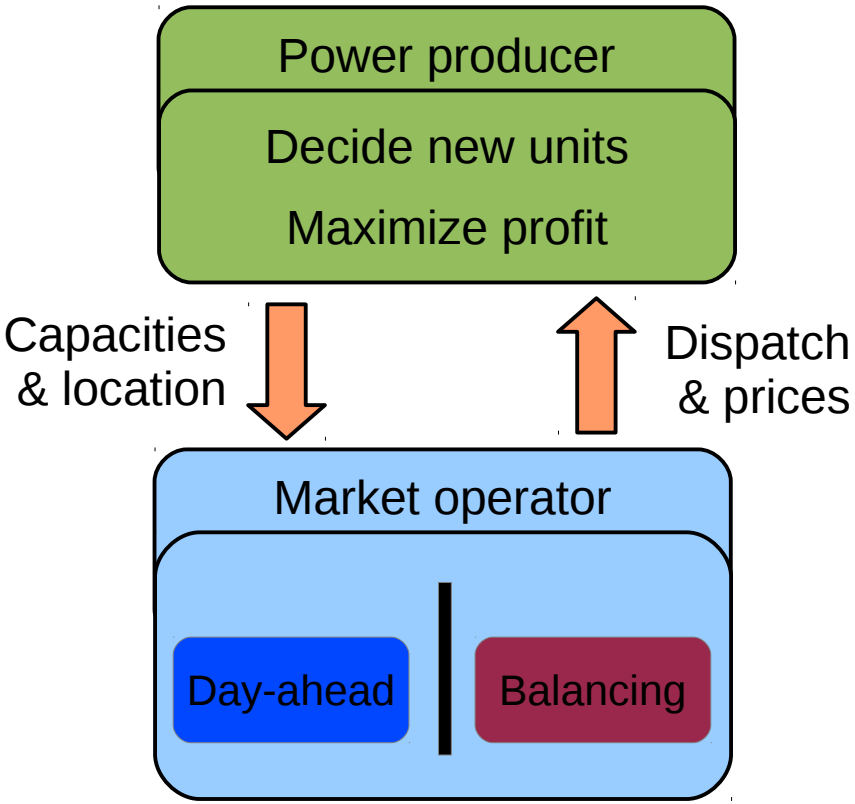
Stoc MC



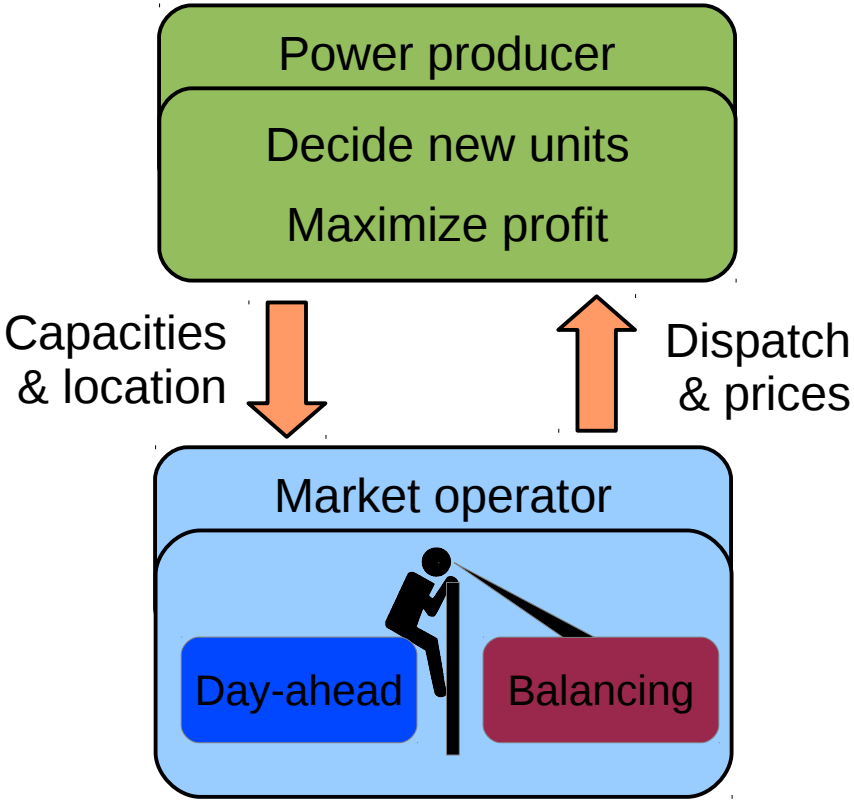
- DA dispatch: out of merit-order
- Balancing operation included
- Minimizes total cost
- Reduces imbalance cost
- Flexible units may incur losses

Expansion of stochastic units

Investment under Conv MC

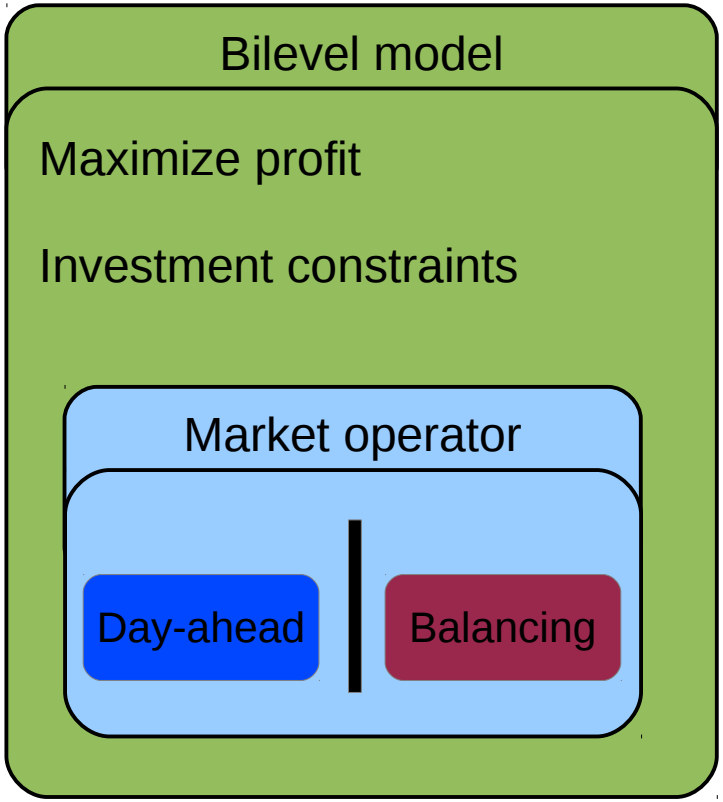


Investment under Stoc MC



Expansion of stochastic units

Investment under Conv MC



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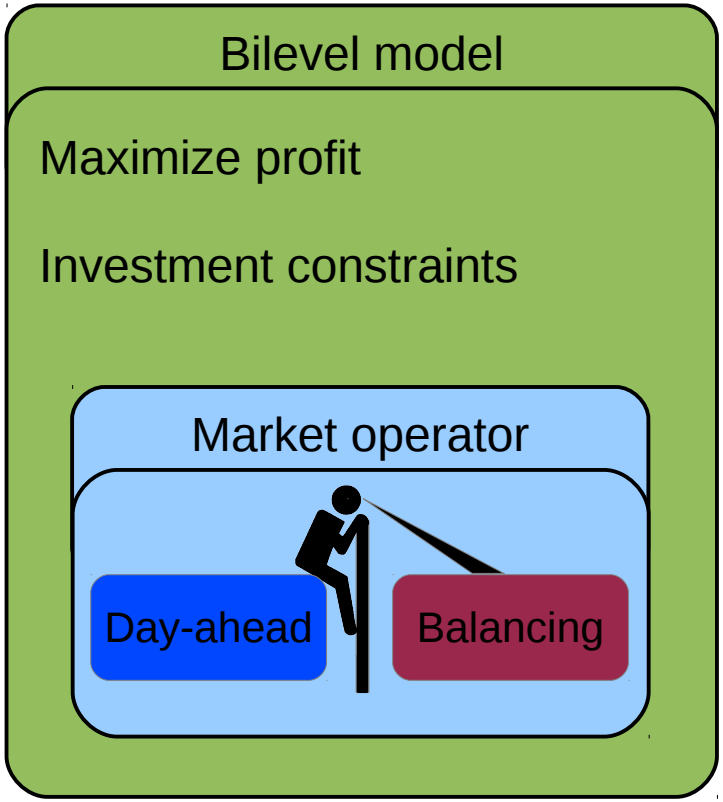
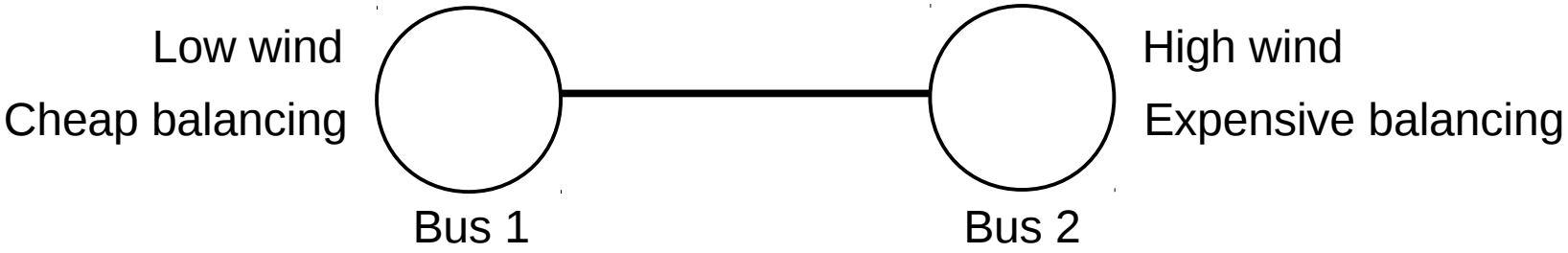
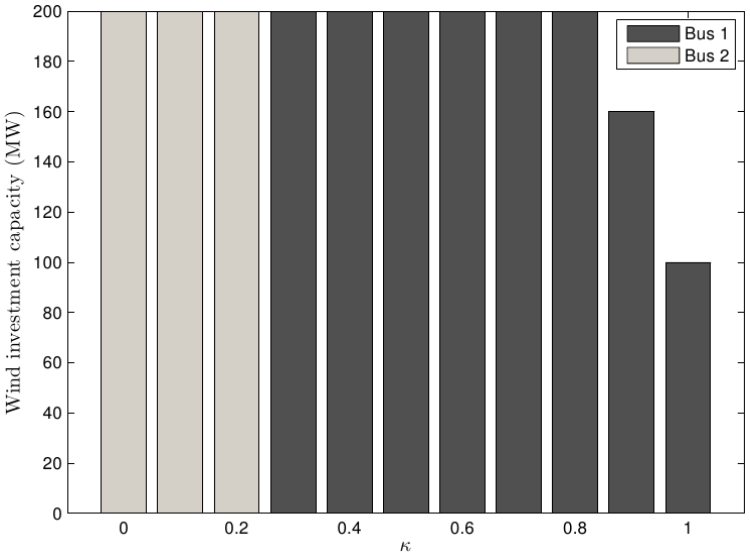


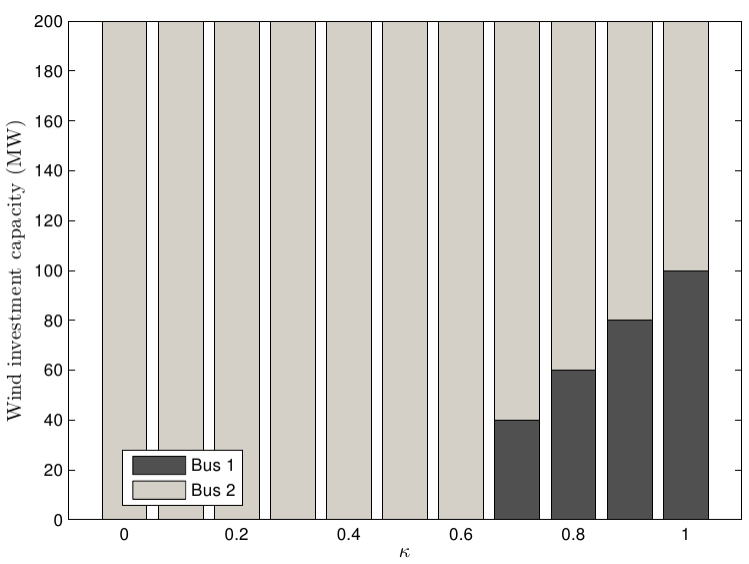
Illustrative example



Conv MC



Stoc MC



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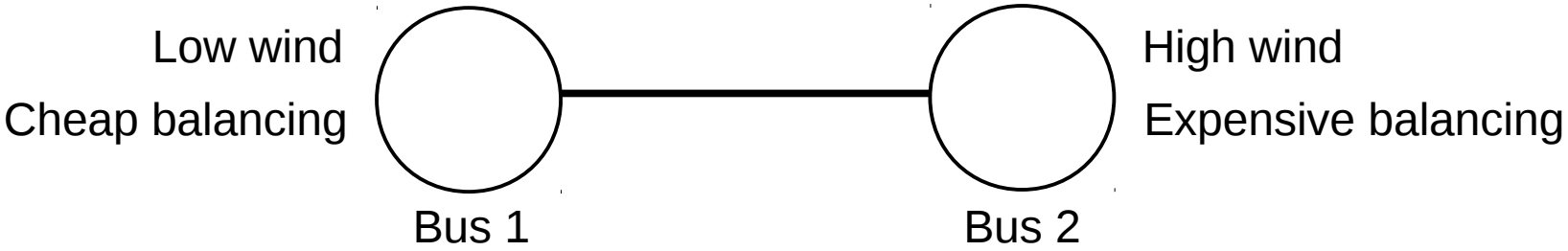

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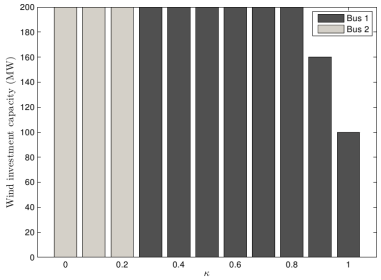

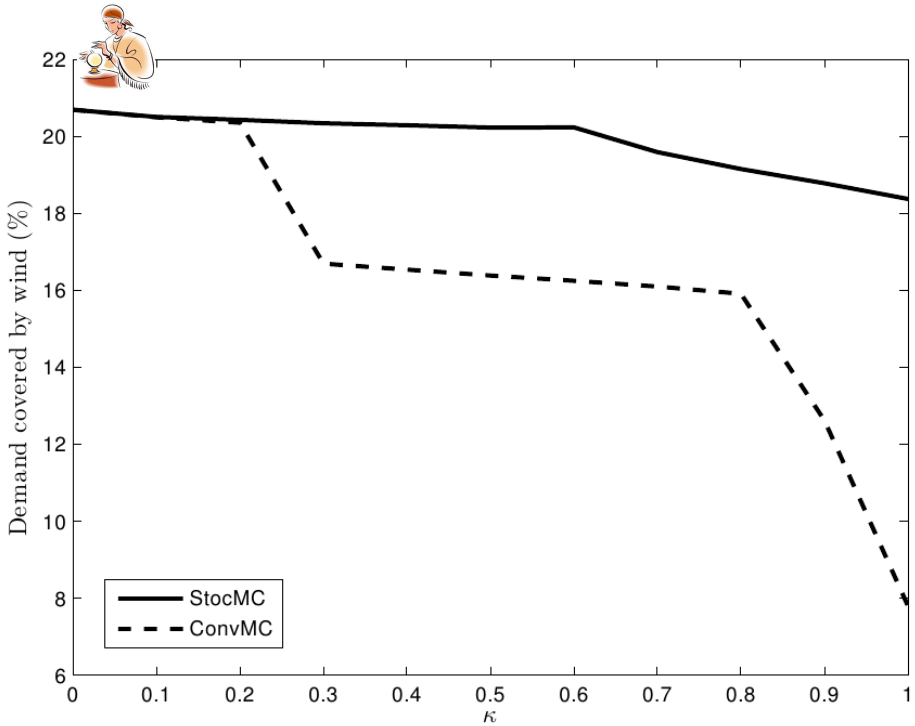

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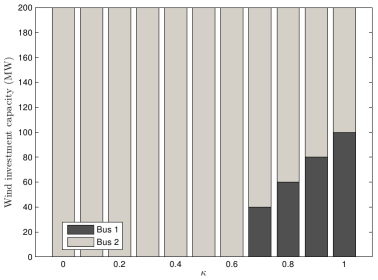
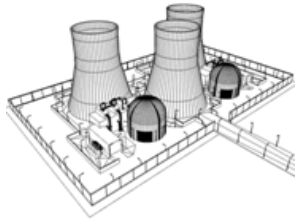


Conclusions

Investment model

Maximize profit

Day-ahead



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Investment model

Maximize profit

Day-ahead

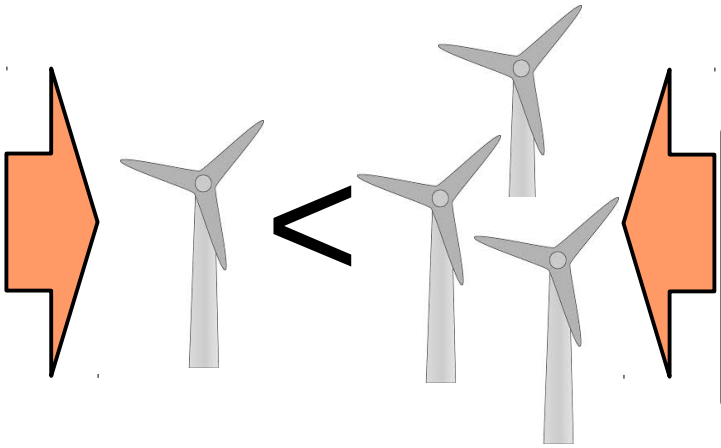
Balancing

Investment (Conv MC)

Maximize profit

Day-ahead

Balancing



Investment (Stoc MC)

Maximize profit

Day-ahead

Balancing

Thanks! Questions??

Submitted to *Operations Research*
manuscript (Please, provide the manuscript number!)

Modeling the Impact of Imbalance Costs on Generating Expansion of Stochastic Units

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Impact of Forecast Errors on Expansion Planning of Power Systems with a Renewables Target

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