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Simulating investment decision making in the power sector under imperfect foresight

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University College Cork

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Myopic optimization: limited window of foresight

- Capture imperfect foresight and short-term focus of decision makers
  - More realistic decision making?
  - Simulation paradigm

- Reduce computational complexity
  - Allows to increase level of detail
  - Trade-off LT time horizon versus level of ST detail
  - Either optimization or simulation paradigm

Complementing optimization models

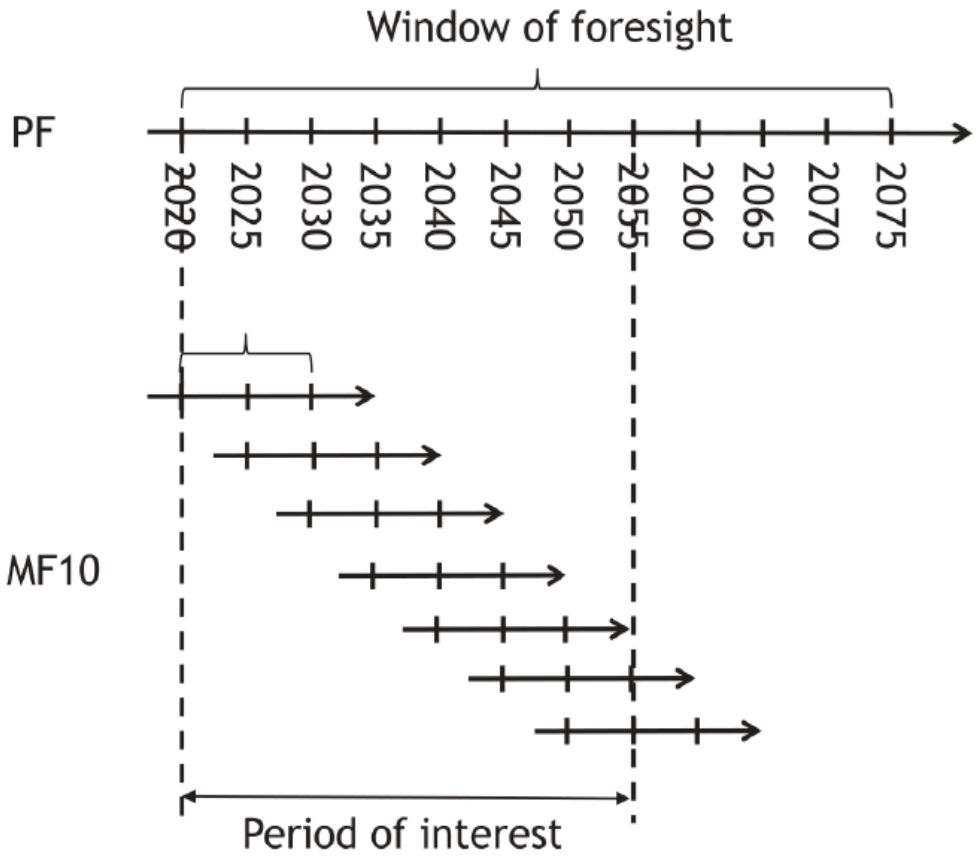
- Optimization: what is the cost-optimal transition pathway?
- Simulation: which policies are needed to realize this transition?
- Assess effectiveness and efficiency of policies

Liberalized electricity markets

- Investment decision makers are private utilities
- Invest if projected revenues allow a reasonable internal rate of return IRR (incl. risk premium)
- Generation assets have a long lifetime
- Future revenue streams are uncertain

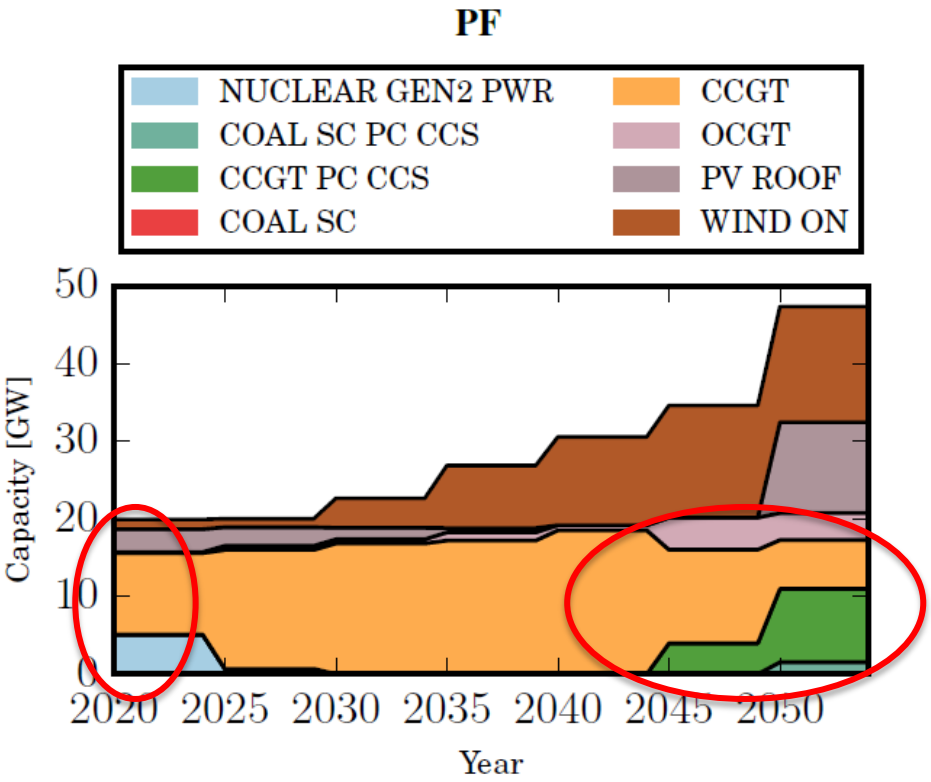
Methodological analysis

- 2 scenarios:
  - Perfect foresight (PF)
  - Myopic foresight (MF10)
- Focus on period 2020-2055
- 5-year periods
- Power system inspired by the Belgian system
- Increasing carbon price
- LUSYM Investment planning model:
  - Partial equilibrium
  - 8 representative days
  - Clustered unit commitment

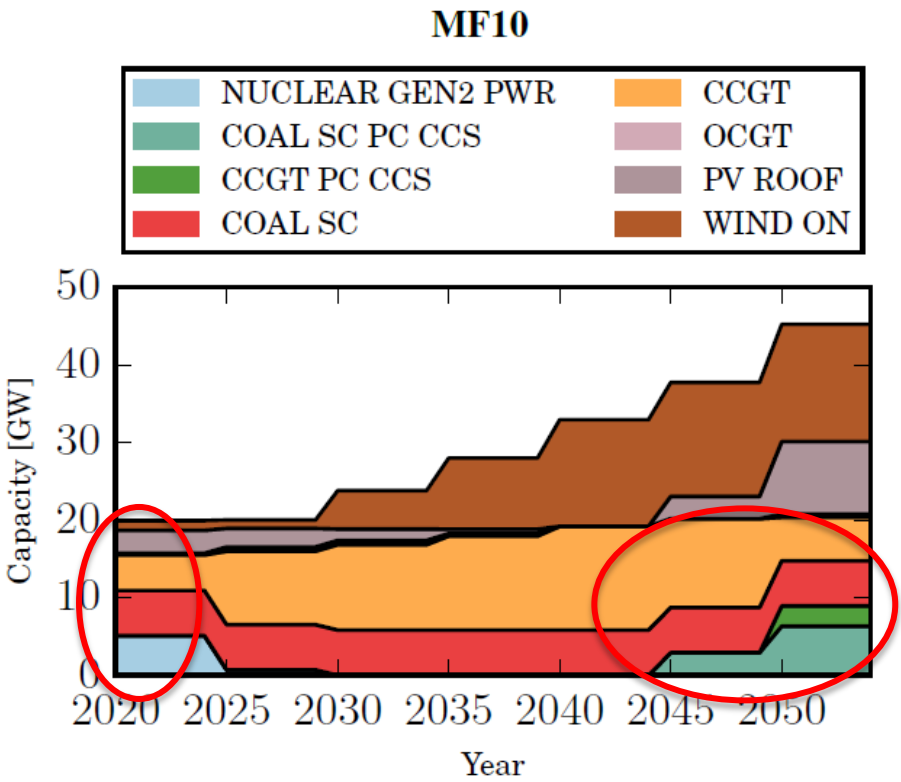


Impact on results

Perfect foresight



10-year foresight



Liberalized electricity markets

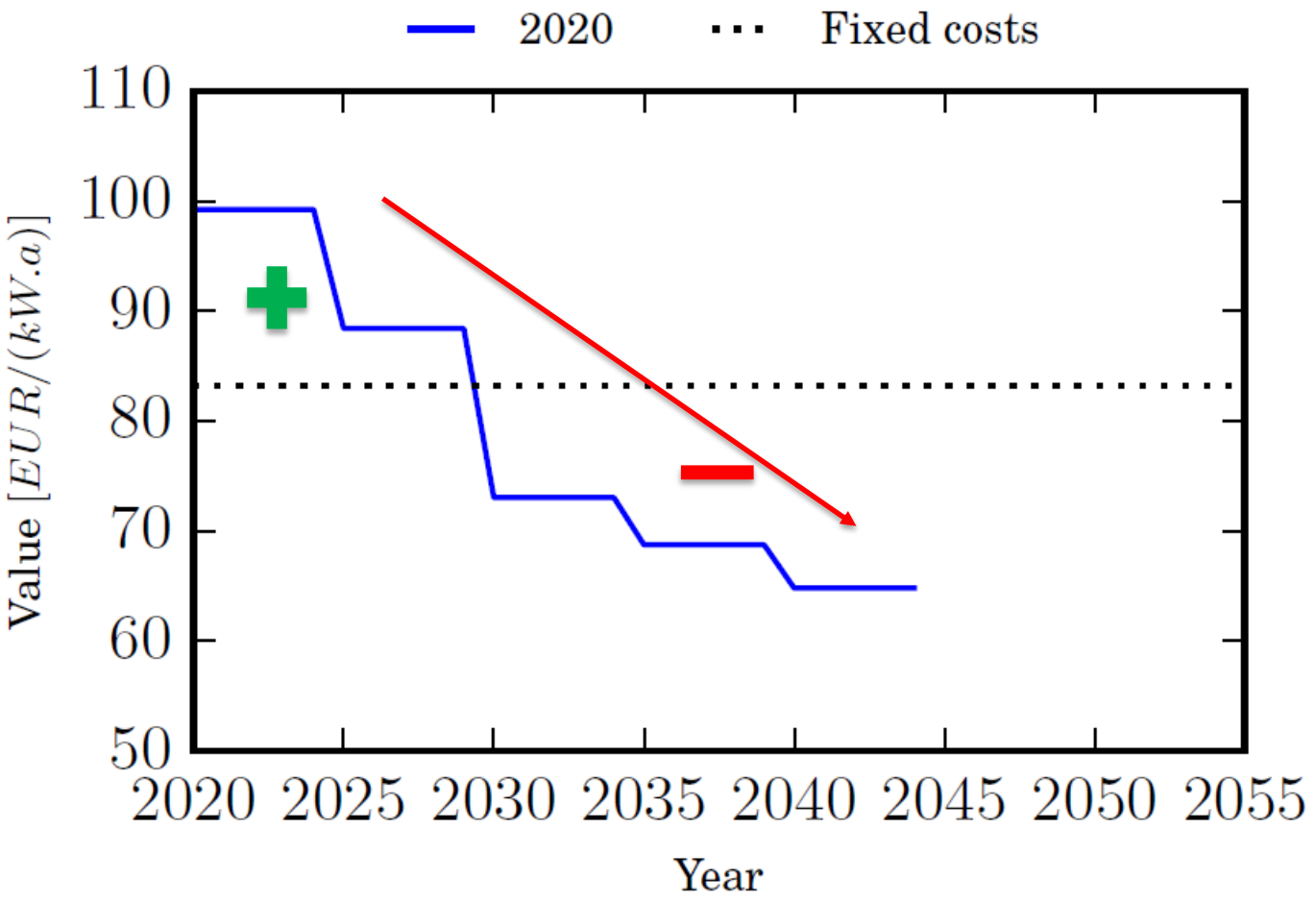
- Investment decision makers are private utilities
- Invest if projected revenues allow a reasonable internal rate of return IRR (incl. risk premium)
- SR profits = revenues – operational costs
- $\sum_y \{E[SR\ Profits_y] \times \frac{1}{(1+IRR)^{y-z}}\} \geq fixed\ costs$

Perfect foresight scenario

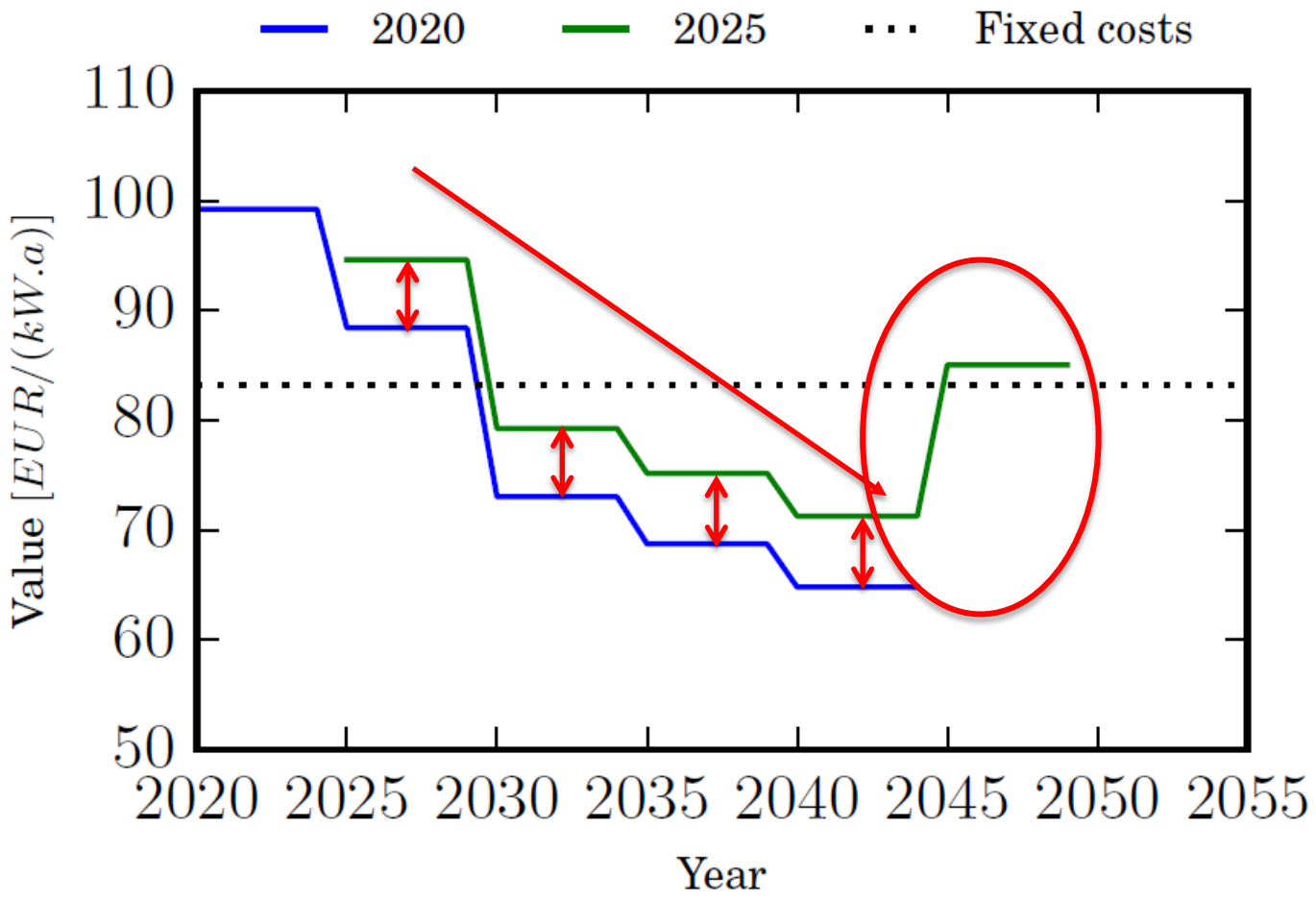
- Perfect foresight of:
  - Electricity prices (and capacity remuneration) in each time step and all years (implicit)
  - Generation during each time step and all years
  - Generation costs (fossil fuel prices, maintenance, etc.)
  - => Exactly know SR profits

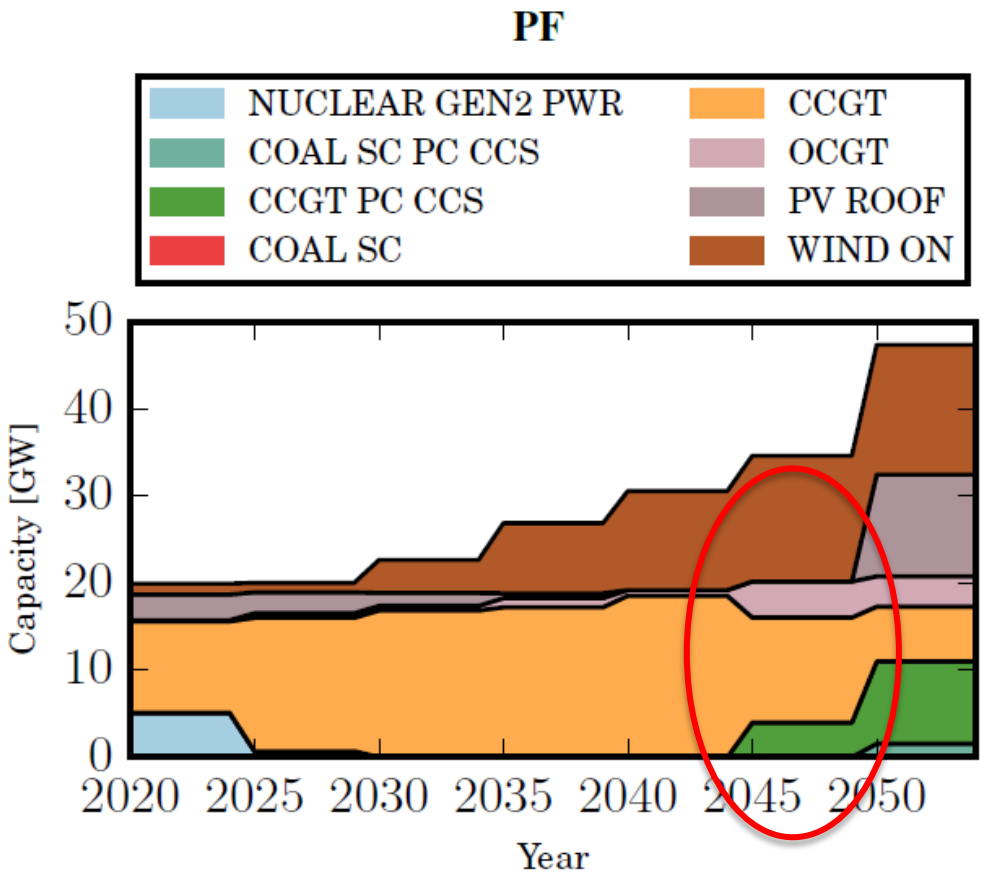
- => $\sum_y \{SR\ Profits_y \times \frac{1}{(1+IRR)^{y-z}}\} = fixed\ costs$

Perfect foresight scenario



Perfect foresight scenario

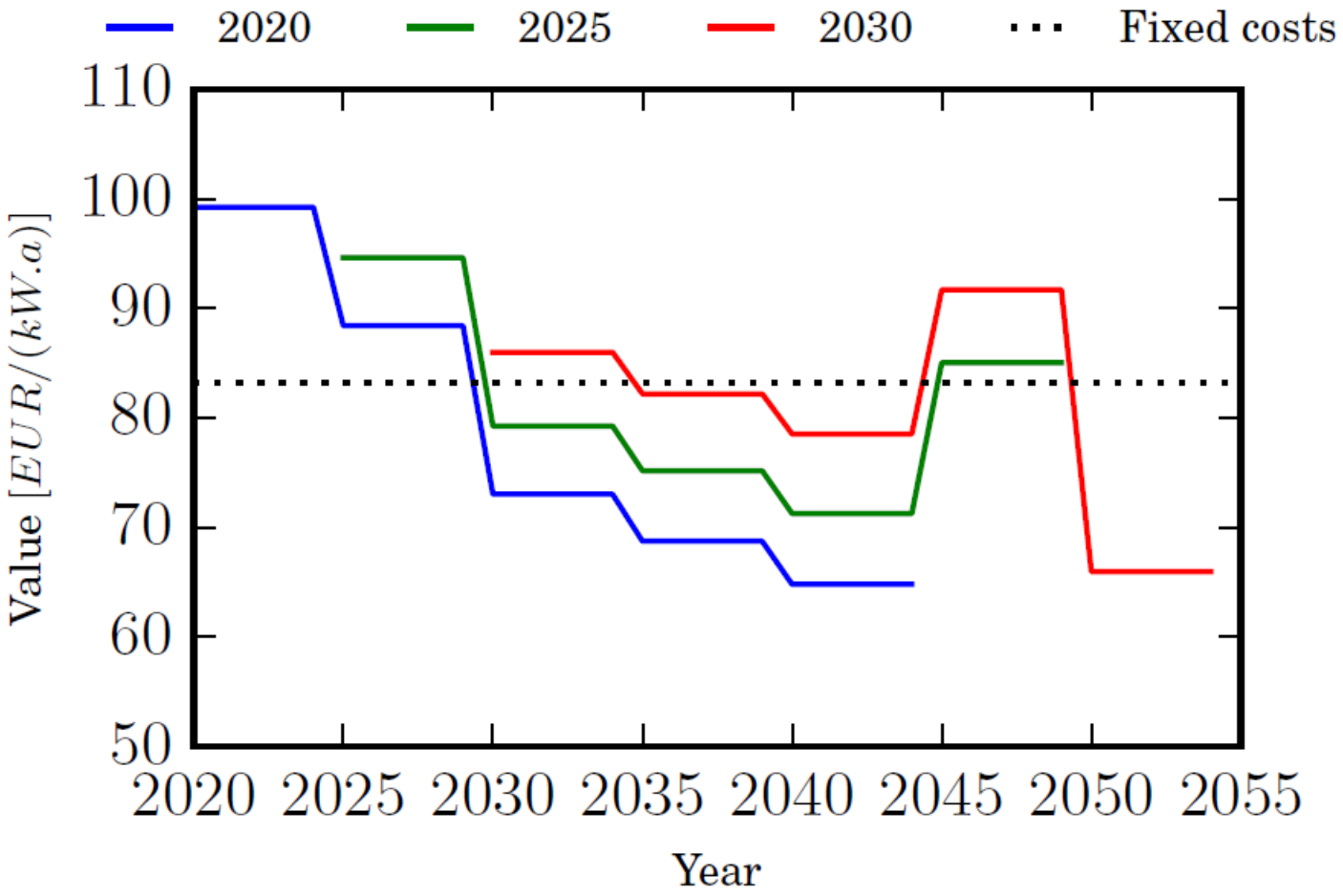



PF
NUCLEAR GEN2 PWR
COAL SC PC CCS
CCGT PC CCS
COAL SC
CCGT
OCGT
PV ROOF
WIND ON
Capacity [GW]
0
10
20
30
40
50
2020
2025
2030
2035
2040
2045
2050
Year

Perfect foresight scenario

- Factors which can impact the SR profits:
  - Fossil fuel prices
  - Carbon price
  - Timing of decommissioning existing plants
  - Type, timing and amount of newly built capacity
  - Technological progress
  - Evolution of the electricity demand
  - Policy interactions
  - Market design changes
  - Interconnections
- Private utilities do not have perfect information
  - The assumption of perfect foresight is not realistc

Perfect foresight scenario

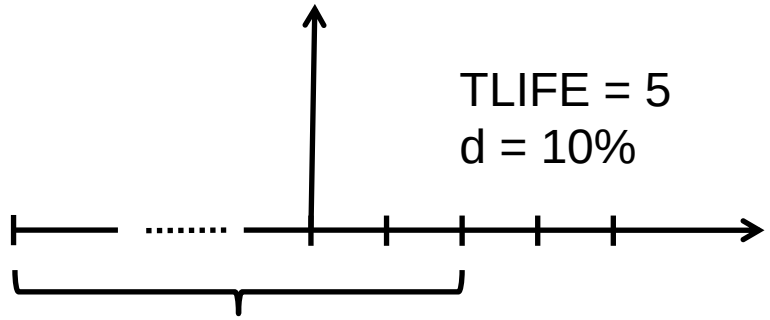


Perfect foresight scenario - conclusions

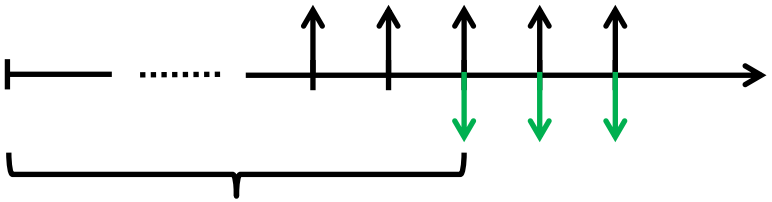
- $\sum_y \{SR\ Profits_y \times \frac{1}{(1+IRR)^{y-z}}\} = fixed\ costs$
- Perfect foresight for private utilities is unrealistic
- Can lead to unrealistic simulation of investment decisions

Myopic foresight model

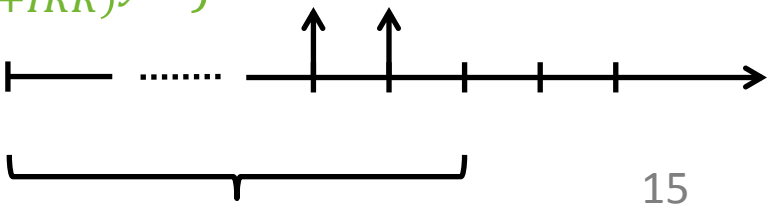
- $\sum_{y=a}^{a+MF-1}\left\{SR\ Profits_y \times \frac{1}{(1+IRR)^{y-z}}\right\} = fixed\ costs\ - salvage\ value$



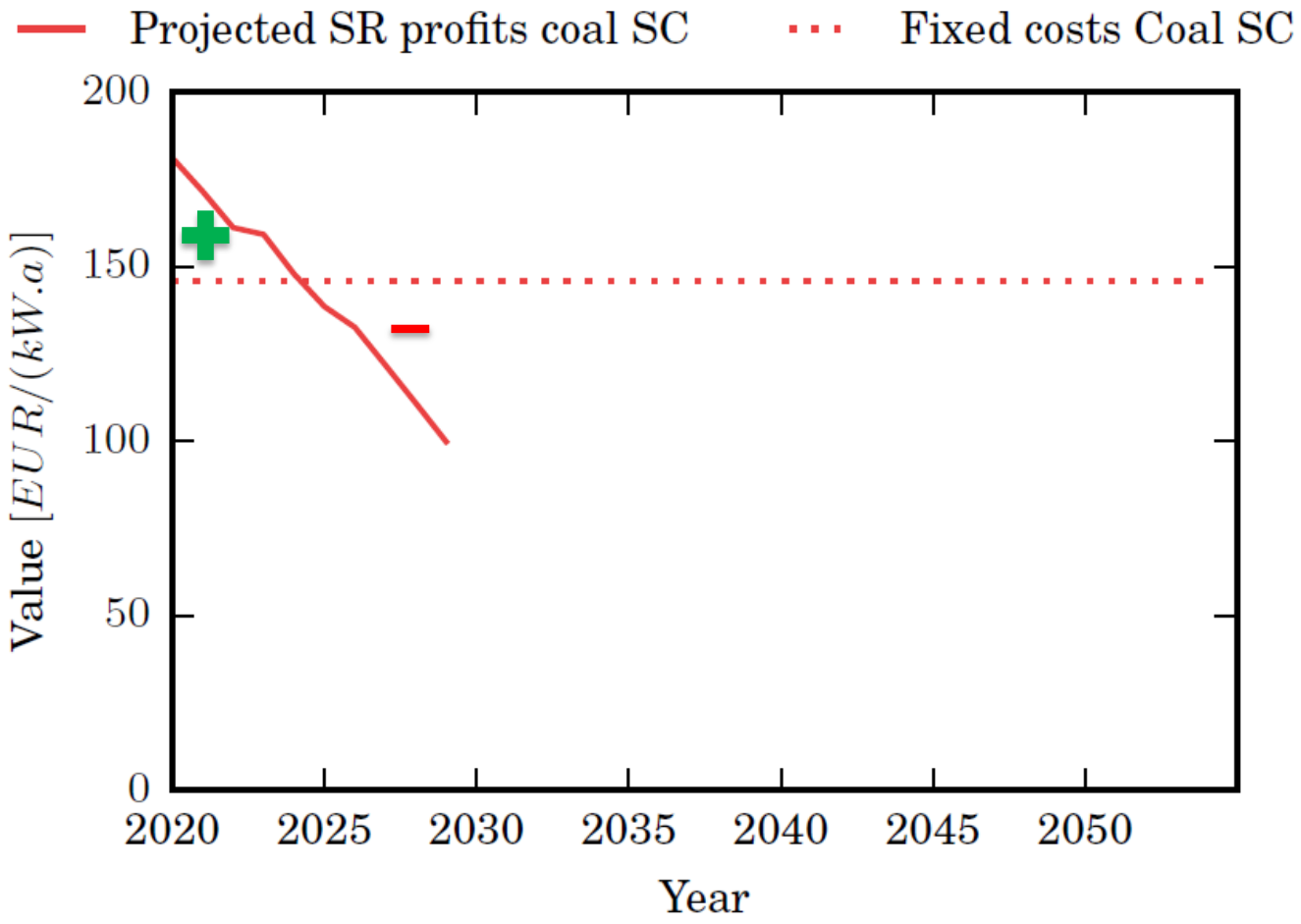
- Calculation of salvage value typically based on two assumptions:
  1. Total discounted value of an asset equals the total discounted cost
  2. value is distributed homogenously over the asset's life time



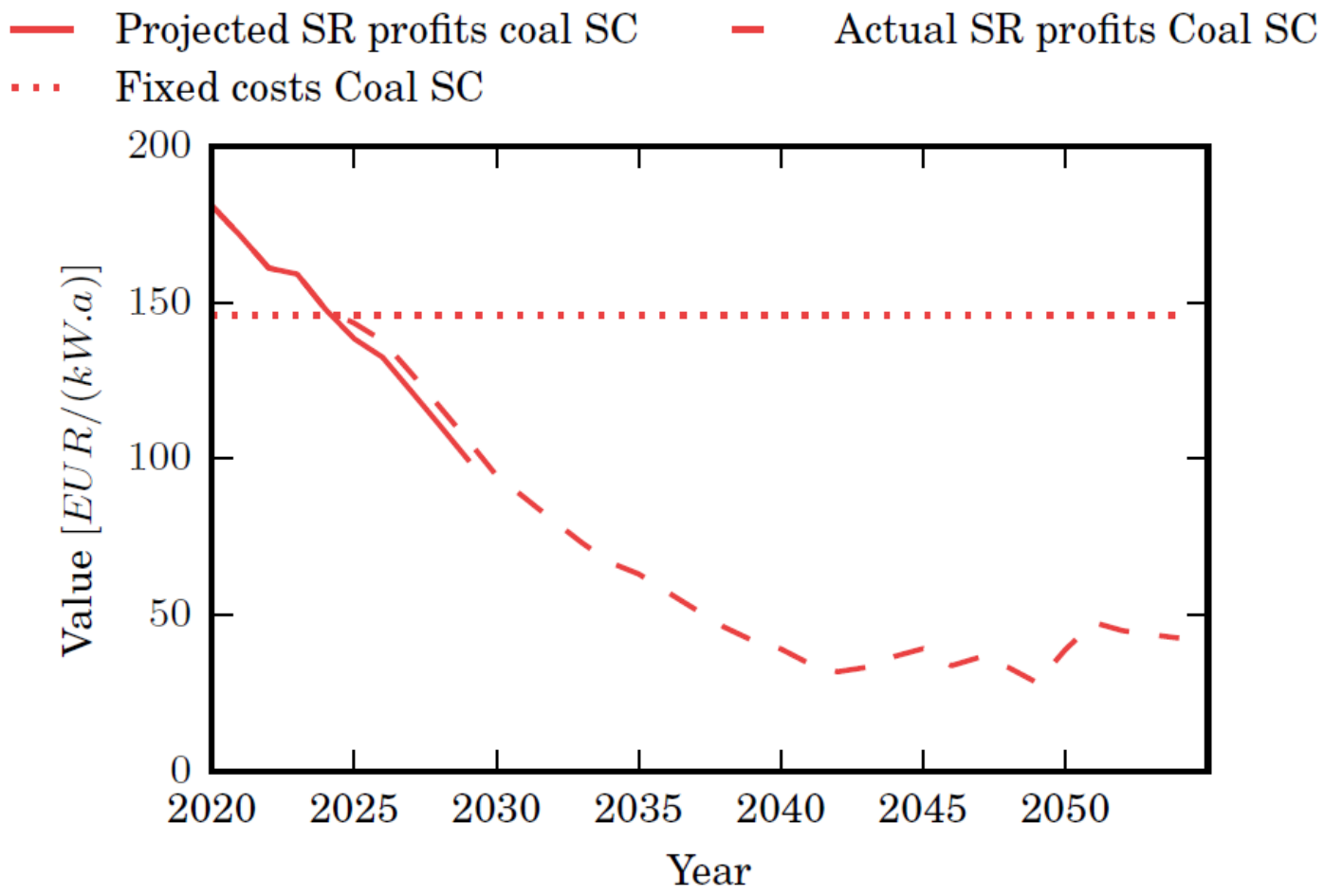
- $\sum_{y=a}^{a+MF-1}\left\{SR\ Profits_y \times \frac{1}{(1+IRR)^{y-z}}\right\} =$
  $\sum_{y=a}^{a+MF-1}\left\{annualized\ fixed\ cost\ \times \frac{1}{(1+IRR)^{y-z}}\right\}$



Myopic foresight scenario



Myopic foresight scenario



Myopic foresight scenario - conclusions

- $\sum_{y=a}^{a+MF-1}\left\{SR\ Profits_y \times \frac{1}{(1+IRR)^{y-z}}\right\} = fixed\ costs\ - salvage\ value$
- Salvage value is determined exogenously
- Homogeneous distribution of the value of an asset seems optimistic (implications for dynamic recursive models)
- => No extrapolation of observed trends
- Can lead to unrealistic simulation of investment decisions
- Additional issues:
  - What is the window of foresight?
  - Window of foresight identical for all uncertain parameters

Summary and conclusions

Investment criterion: $\sum_y \{E[SR\ Profits_y] \times \frac{1}{(1+IRR)^{y-z}}\} \geq fixed\ costs$

Perfect foresight

- $\sum_y \{SR\ Profits_y \times \frac{1}{(1+IRR)^{y-z}}\} = fixed\ costs$
- Private utilities do not have perfect foresight on short-run profits
- Can lead to unrealistic investment decisions

Myopic foresight

- $\sum_{y=a}^{a+MF-1} \left\{SR\ Profits_y \times \frac{1}{(1+IRR)^{y-z}}\right\} = fixed\ costs\ - salvage\ value$
- No extrapolation of observed trends in short-run profits
- Can lead to unrealistic investment decisions

Poncelet, K. et al., *Myopic Optimization Models for Simulation of Investment Decisions in the Electric Power Sector*. 13th International conference on the European Energy Market, 6-9 June 2016, Porto.

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Open questions

- Optimization Vs. Simulation:
  - should TIMES be used for simulation?
  - What are the alternatives?