Estimating the value of demand response for resource adequacy

Hamid Aghaie

AIT Austrian Institute of Technology, Austria

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Introduction

- Resource Adequacy Problem
  - Insufficient investment in new non-renewable generation capacity
  - Generators have difficulty to recover their investment cost
- 3 main reasons
  - I. Political or regulatory price interventions
    - Bid cap or price cap suppresses scarcity (high) prices
  - II. Increasing investment risks
    - Uncertainty in future market regulation and design
  - III. Integration of large share of variable renewables
    - Lower prices
    - Less utilization of conventional generators

Introduction

- Resource Adequacy Value:
  - The contribution to the generation fleet during peak load

- Higher resource adequacy of a generation technology results in differ/postponing investment in new power plants (mainly peaking units such as CCGT)

- The resource adequacy value of intermittent renewables is relatively low
  - In the last three years in Germany, this value for wind and PV was between 4% to 8% of their total installed capacity

Motivation

Research Question:

- How much is the resource adequacy value of DR in the German electricity market?

- In other words, how much DR is available during peak load (as a percentage of total DR capacity)

- System operators need to consider the risk of exceeding DR constraints by estimating resource adequacy value of DR.

Motivation

- Resource adequacy value of DR mainly depends on:
    - Type of DR and DR dispatch constraints
    - Share of RES in the market
    - DR penetration
    - Reserve margin
    - Peak load season

Model

- Generation Capacity Expansion Model
  - Probabilistic Model
    - Uncertainty from variable RES, DR, …
    - Resource inadequacy events are infrequent
- Approach
  - Modeling generation and load uncertainty
  - Monte Carlo samples from generation and load by considering the uncertainties.
      - Capacity Credit of RES
      - Forced outage of conventional generation
      - Demand growth rate
      - Load forecast error
      - Weather-related uncertainty

Model

- Simulation:

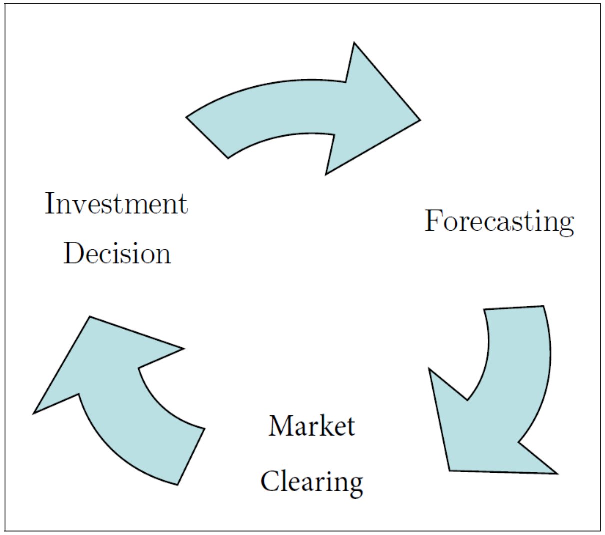

Fig. 6. Simulation algorithm flowchart

Model

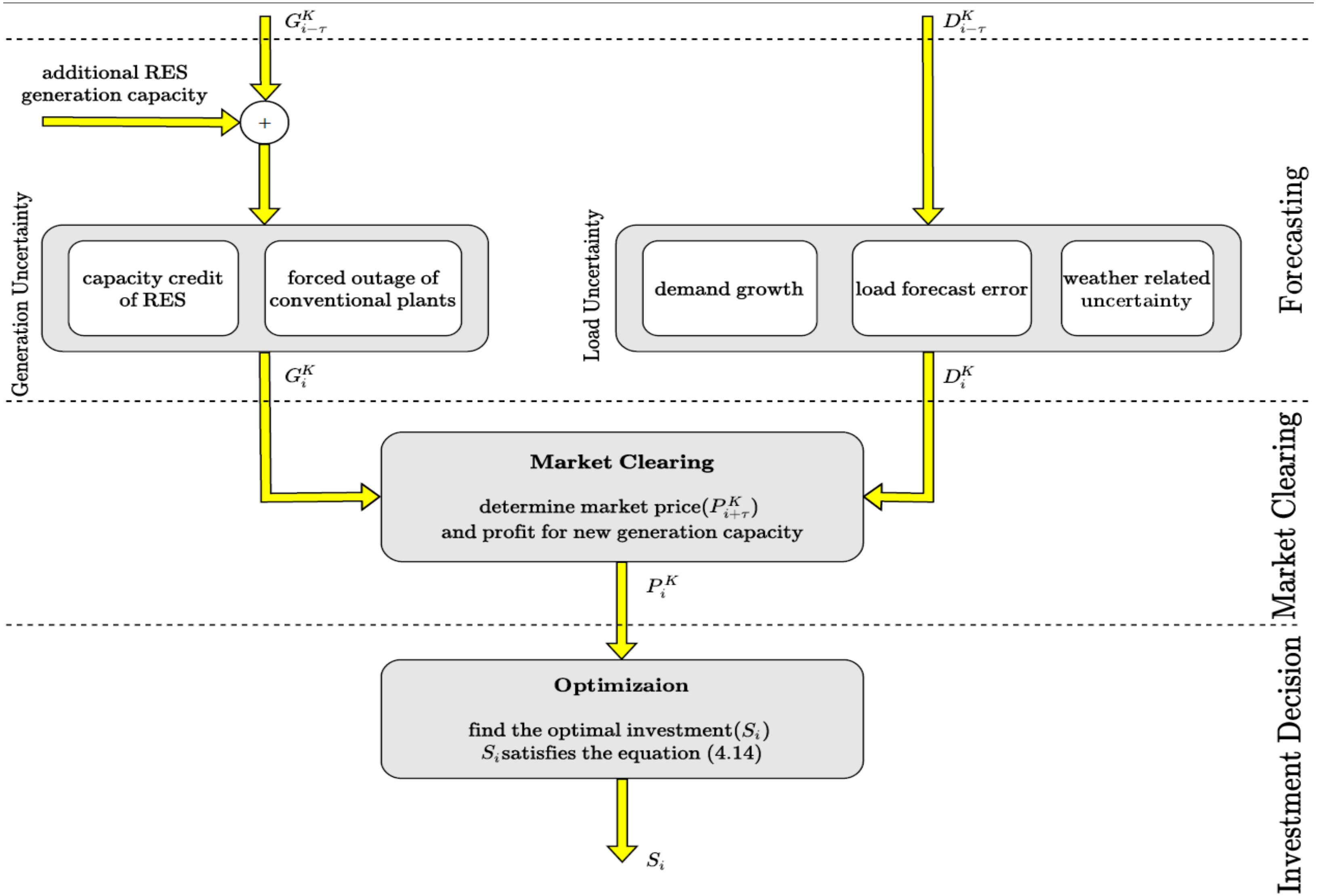

Fig. 7. Simulation flowchart for one year

Model

- DR capacity would be dispatched if the load exceeds the reserve margin.

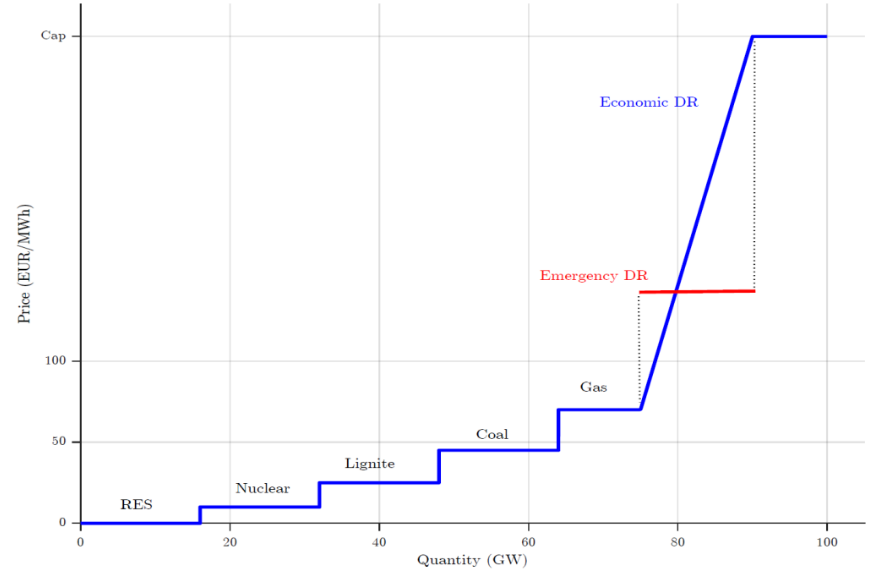

Fig. 5. Typical supply curve

- DR constraints:
  - Maximum DR-call hours per day
  - Maximum DR-call hours per year
  - Maximum MWh dispatched DR per day

- Data: Day-ahead German electricity market

Results

- DR utilization values reflect the probability-weighted average of DR utilization over a large number of scenarios.

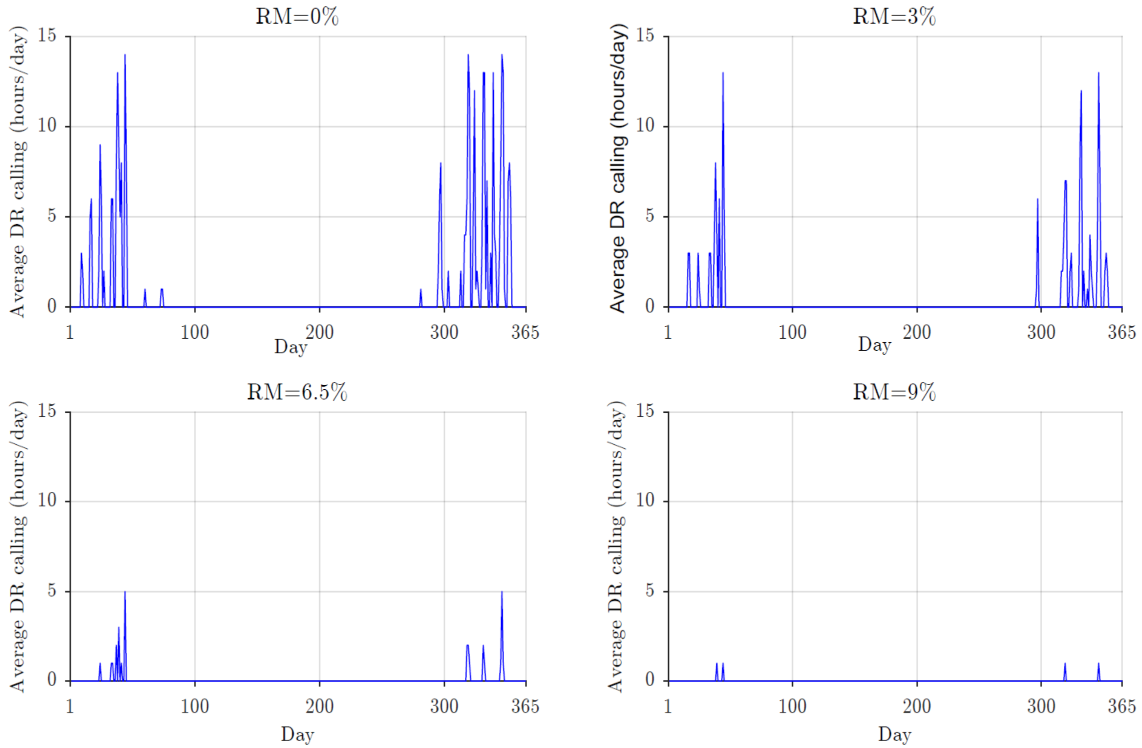

Fig 6. Average DR Dispatch hours per day at different reserve margins

Results

- At 6.5% reserve margin and in presence of 20% generation by variable RES
  - total annual DR call is 29 hours
  - maximum DR call hours per day : 5 hours
  - maximum amount of dispatched DR per day : 1,760 MWh/day
- In order to maintain 100 % resource adequacy value for DR, the call limit should be as high as 5 hours per day at 6.5 % reserve margin.

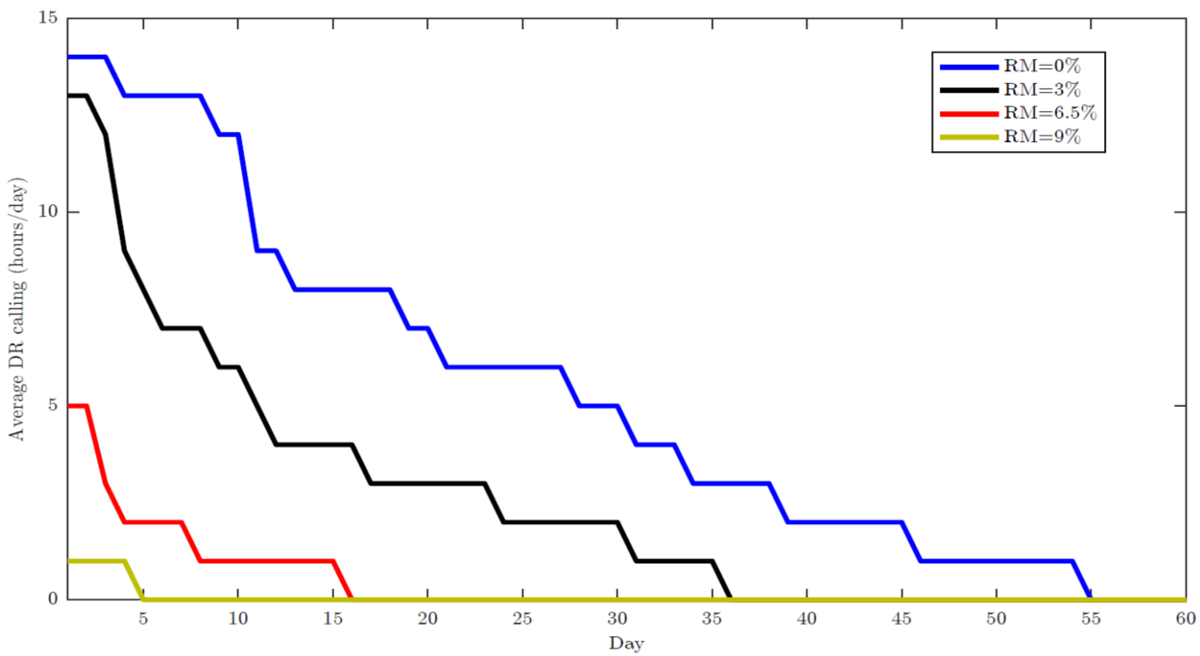

Fig. 7. Sorted average DR dispatch hours per day (hours/day)

Results

- By assuming a maximum 4 hours call per day limit, the resource adequacy value of DR is approximately 16 % at the 0 % reserve margin, and 65 % at 6.5 % reserve margin.

- At the same dispatch limit (4 hours/day): resource adequacy of DR in Germany is 65% and in Colorado 70%.

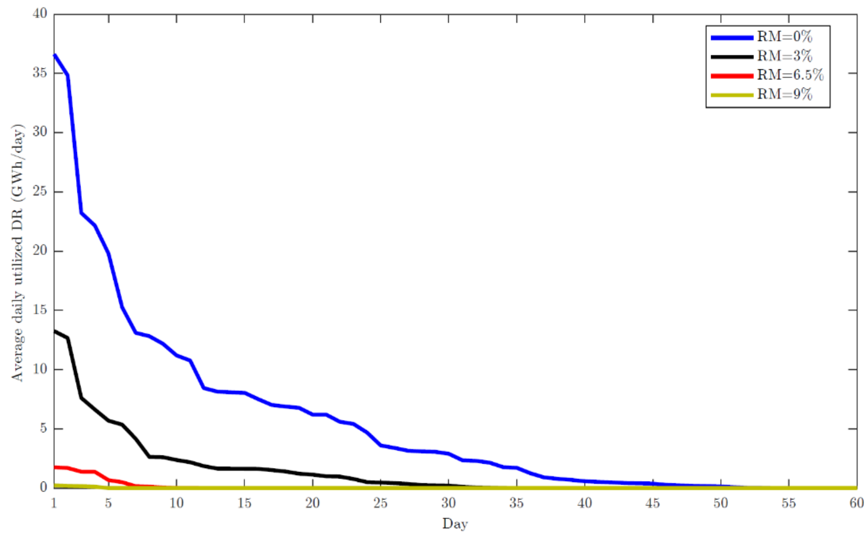

Fig 8. Average volume of dispatched DR per day at different reserve margins

Conclusion and Policy Implications

- At 6.5% reserve margin and in presence of 20% generation by variable RES
  - total annual DR call is 29 hours
  - maximum DR call per day is 5 hours
  - maximum amount of dispatched DR per day is 1,760 MWh/day

- Any DR dispatch constraint lower than these numbers will result in resource adequacy value of less than 100% for DR.

- System operators need to consider the risk of exceeding DR constraints by estimating resource adequacy value of DR.

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Thank You!

Result

- Capacity credit of variable RES
  - Generation by variable RES during peak load
  - Peak load in Germany occurs in cold winter evenings
  - Capacity credit of PV is almost zero

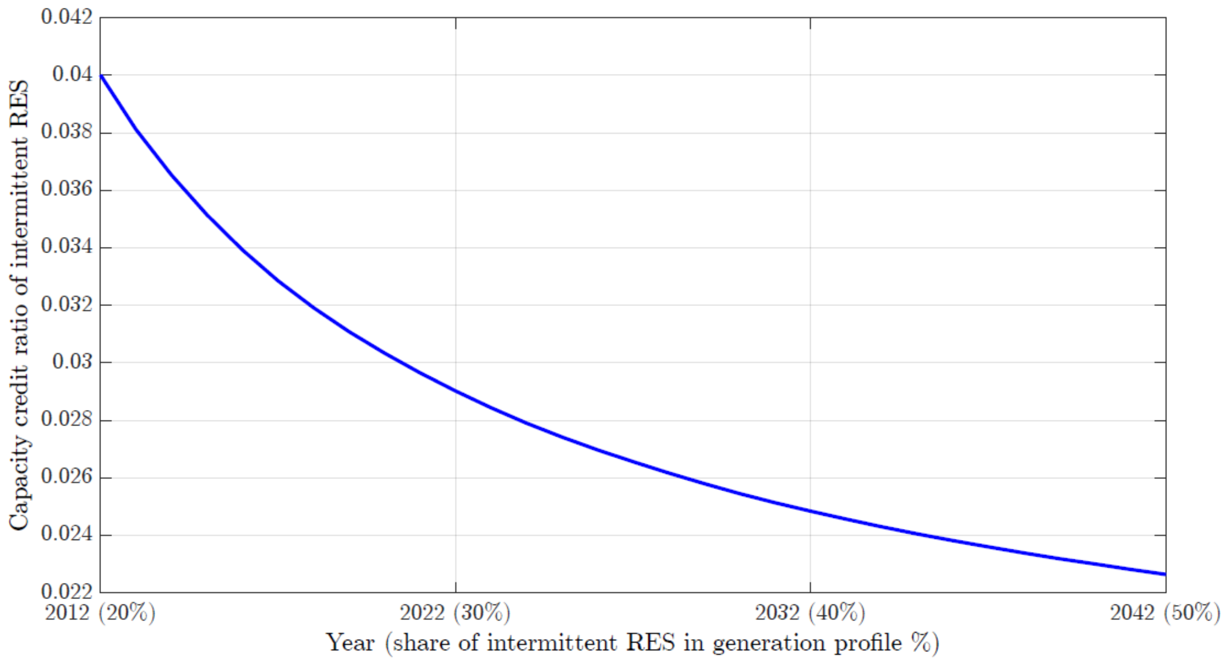

Fig. 8. Capacity credit ratio of variable RES versus RES penetration