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Review on Unit Commitment under Uncertainty Approaches

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Presenatation Guidelines

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- Unit Commitment
- Uncertainty Impact
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- Stochastic UC formulation
- Robust UC formulation
- Interval UC formulation
- Hybrid formulations
- Conclusion

Introduction

- **Meeting the demand for electricity at all times!**
- **Distributed, volatile generation, large-scale price responsive demand, electric vehicles – UNCERTAINTY!**
- **Integration of wind power – CHALLENGE - flexibility**
- **Computationally effective approach to optimally select the units and their output level to preserve the operational reliability of the system**
- **UNIT COMMITMENT - optimization problem**

Unit Commitment

- **Input Data**
  - **Load profile**
  - **Set of available units**
- **Objective**
  - **When to start or stop the unit and how much it should generate to meet the load at a minimum cost**
- **Constraints**
  - **Generator minimum and maximum generation limits, ramping limits, minimum up and down time constraints, time-dependent start up costs, transmission capacity limits**

Uncertainty Impact

- **NET LOAD = ACTUAL LOAD – UNCONTROLLED RENEWABLE GENERATION**
  - **Controllable generation**
- **Load shedding or Wind curtailment**
- **Minimize cost of scheduled generation**
- **Maintain feasibility without load shedding and wind spilling**

Deterministic UC formulation

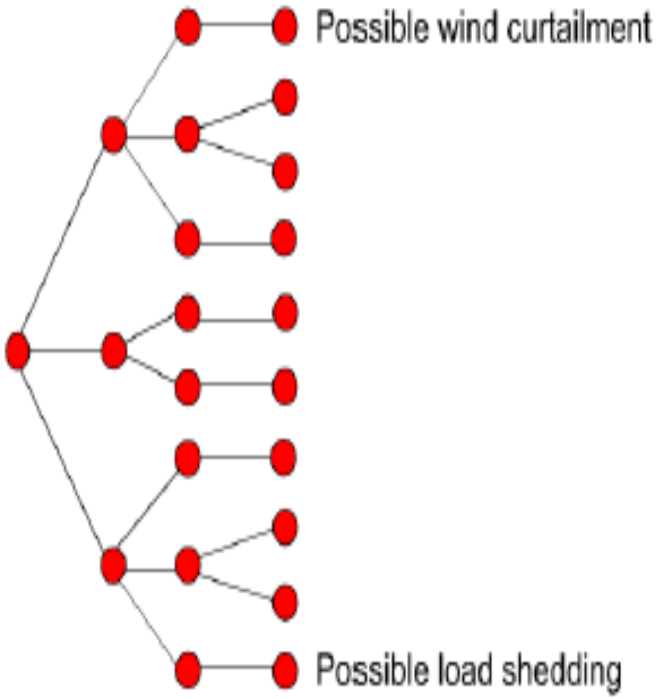
- Traditional solution
- Generating units are committed to meet the deterministic forecast and the uncertainty is handled by imposing reserve requirements
- Easy to implement in practice
- Reserve requirements
  - Economically inefficient
  - Possibility of the capacity inadequacy

Stochastic UC formulation

- **Net load modeled by probabilistic scenarios**
- **Determine the generation schedule that minimizes the expected cost over this set of scenarios while meeting the constraints for each scenario**
  - **Unique commitment decision**
  - **Scenario dependent dispatch decision**

Stochastic UC formulation

- **Large number of scenarios – computationally demanding**
  - **Scenario reduction techniques**
- **Possible issues**
  - **Loss of information**
  - **Low probability scenarios with high impact**
  - **Data availability**
  - **Probabilities**

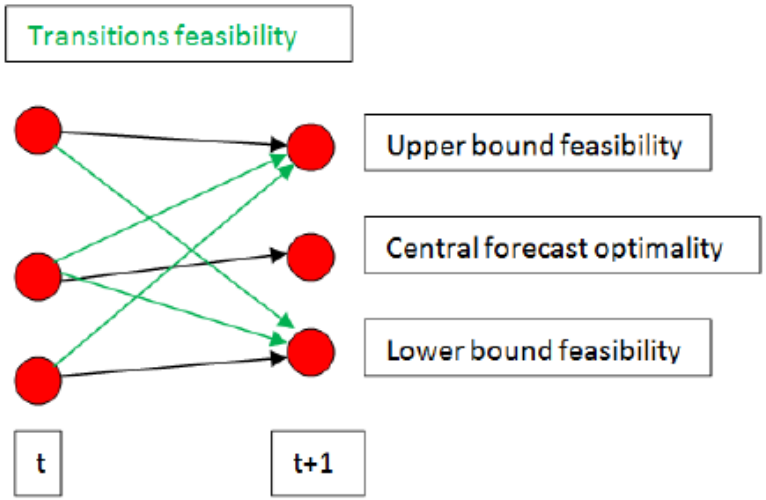


Robust UC formulation

- The range of uncertainty defined by the upper and lower bounds on the net load in each time period
- Solution
  - Feasible over the entire deterministic uncertainty set
  - Minimizes the cost of the worst case realization within the uncertainty set
- Conservativness – budget of uncertainty
  - The number of nodes where net load deviates from central forecast

Interval UC formulation

- **Schedule that minimizes the cost of serving the most probable net load forecast while guaranteeing feasibility in the entire uncertainty range**
- **Steep ramp requirements in between all consecutive time periods**



Summa summarum

	Stochastic	Robust	Interval
Uncertainty	Scenarios	Uncertainty range	Uncertainty range
Objective function (min)	The expected cost of the scenarios considered	The highest cost among all realizations	The cost of the most likely wind forecast
Solution	The most cost effective	Tends to be more conservative	Tends to be more conservative
Robustness	Increases with the number of scenarios	High	High
Computational burden	Higher	Depends on the worst scenario searching process	Lower

Hybrid formulations

- Exploiting the advantages and eliminating the disadvantages of the previously presented models
- Unified stochastic and robust formulation
  - The objective function contains stochastic and robust parts
  - Uses heuristics for balancing – suboptimality
- Hybrid stochastic/interval unit commitment
  - Stochastic model at the beginning (more accurate forecasts), then switching to interval (more security)
  - Switching time optimized

Conclusion

- **Research direction**
  - **Combining the existing models in order to exploit the advantages**
  - **Scenario generation and reduction techniques**
  - **Monte Carlo method testing**

Thank you for your attention!

Questions?