The Effect of Demand Side Management on Reliability of Automated Distribution Systems

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Outline

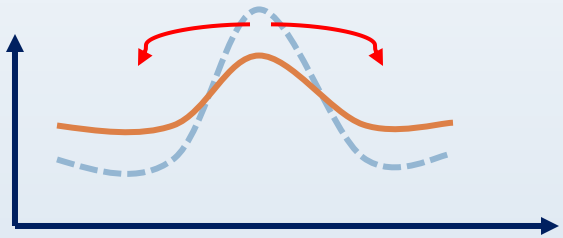
- Introduction
- Post-Contingency Model
- Reliability Evaluation Metrics
- Case Study
- Results
- Conclusion

Introduction

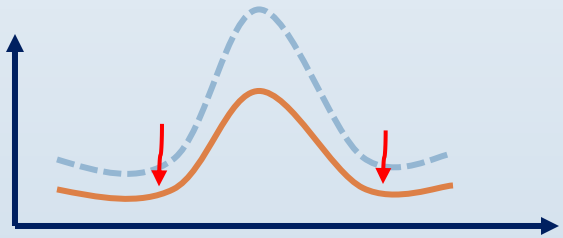
- Demand Side Management (DSM)
  - Modification of Customers' Energy Use Patterns
  - Began in 1970s
- DSM Activities
  - Energy Efficiency
  - Load Profile
    - Peak Reduction
    - Energy Conservation
    - Load Shifting
    - Valley Filling
- DSM in a Smart Grid

Introduction

- DSM Examples
  - Load Shifting:



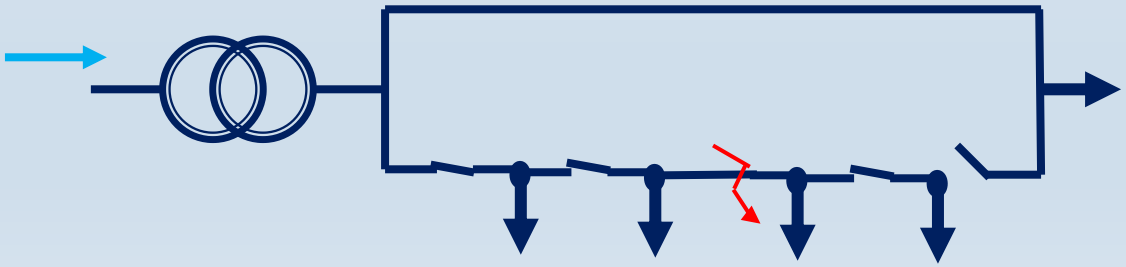
  - Energy Conservation:



- DSM and Reliability Improvement
  - Reduction of Loading Stress on System Components
  - Reduction of Overload Probability in a Case of a Contingency

Post-Contingency Model

-
- Fault Clearance
- Fault Isolation
- Power Restoration
- Load Shedding for Overload Elimination $(Loading_{max} = 100\%)$
- Load Shedding to Remove Voltage Violations $(0.95\ p.u < V < 1.05\ p.u)$
- Taking the System Back to the Prefault Configuration After the Repair



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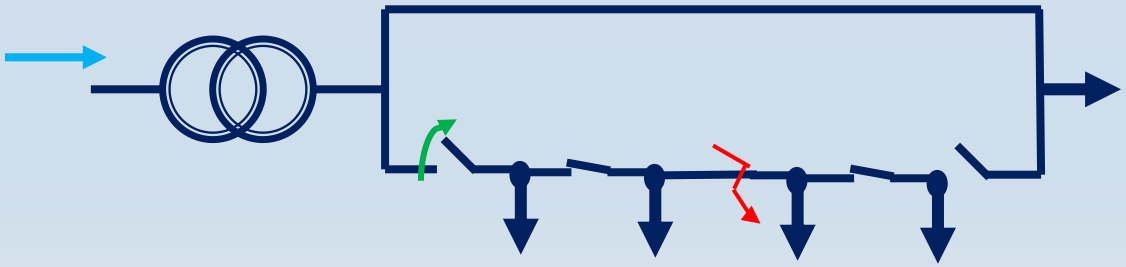

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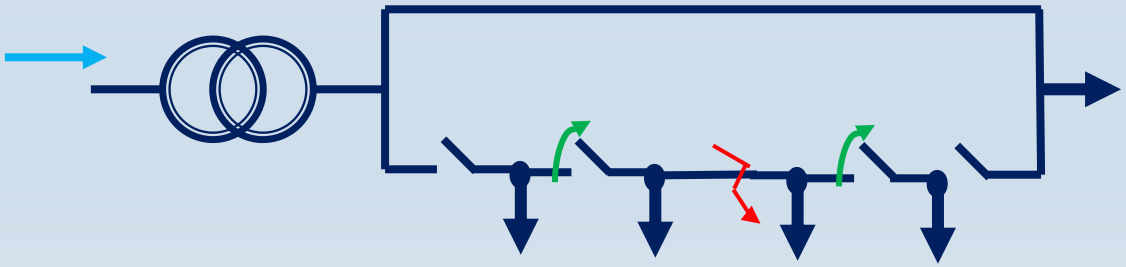

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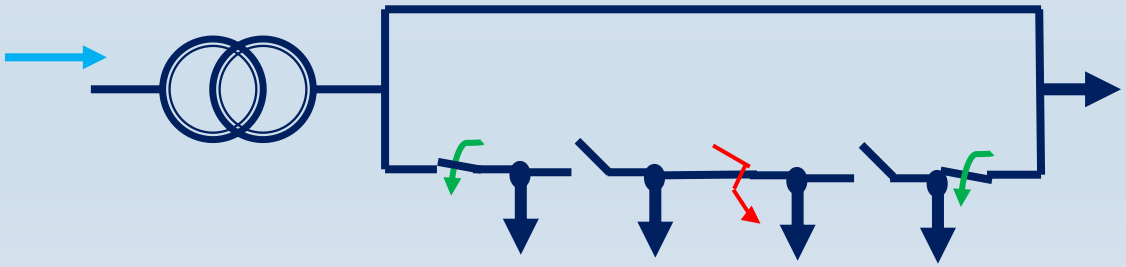

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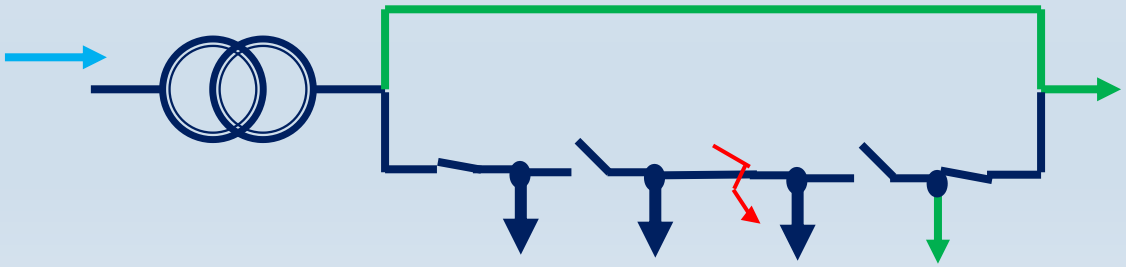

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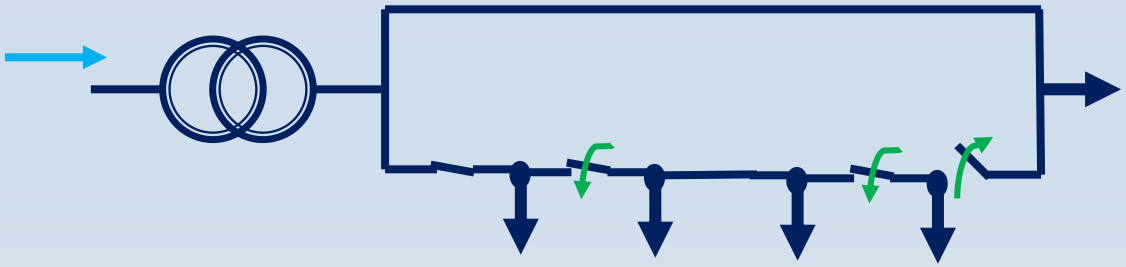
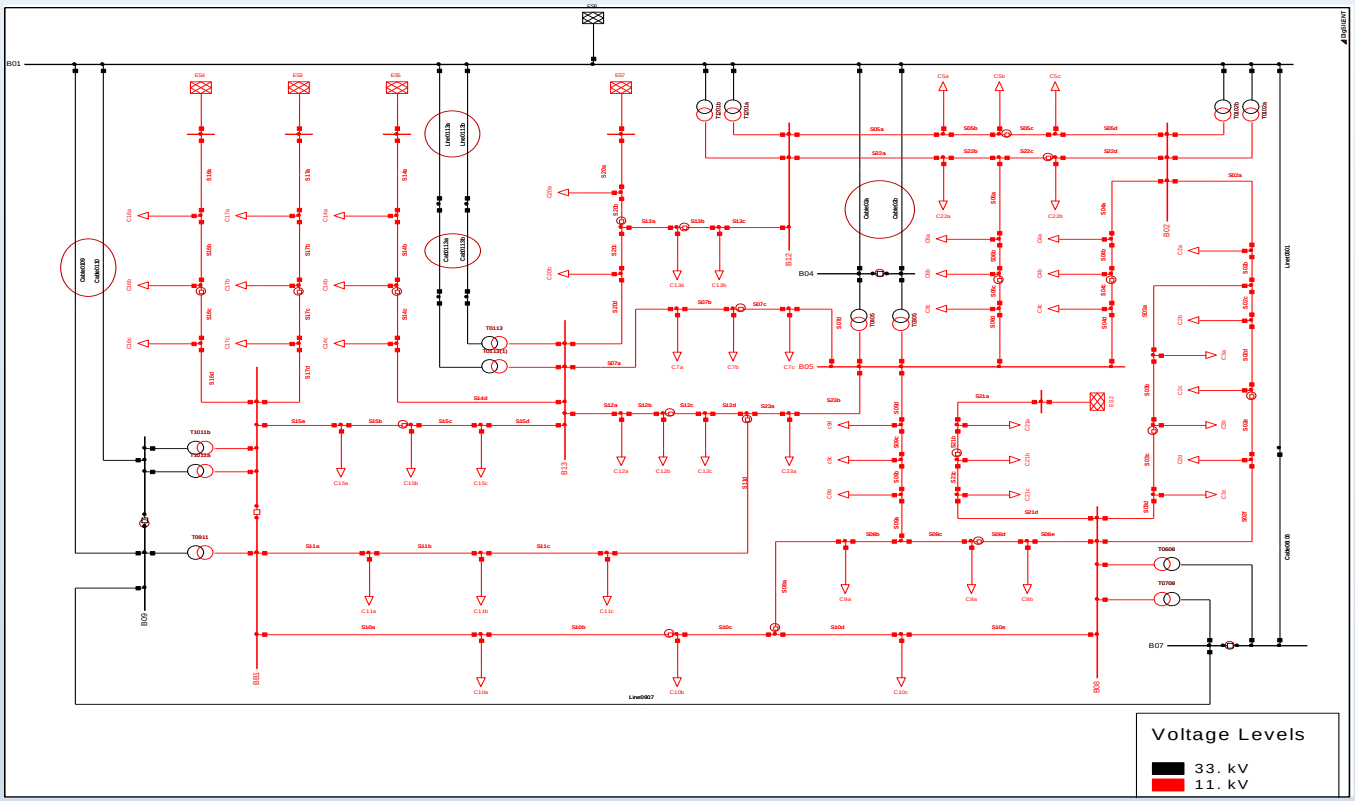


Reliability Evaluation Metrics

- System Average Interruption Frequency Index (SAIFI)
- System Average Interruption Duration Index (SAIDI)
- Customer Average Interruption Duration Index (CAIDI)
- Expected Energy Not Served (EENS)
- Average Service Availability Index (ASAI)

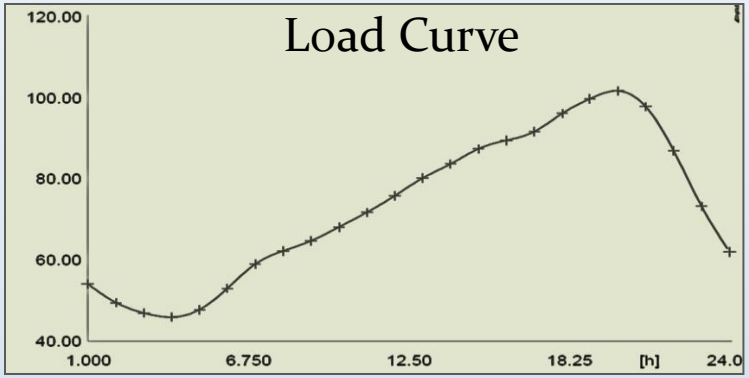
Case Study

- Distribution System Model:



Case Study

- Input Data:



System Data

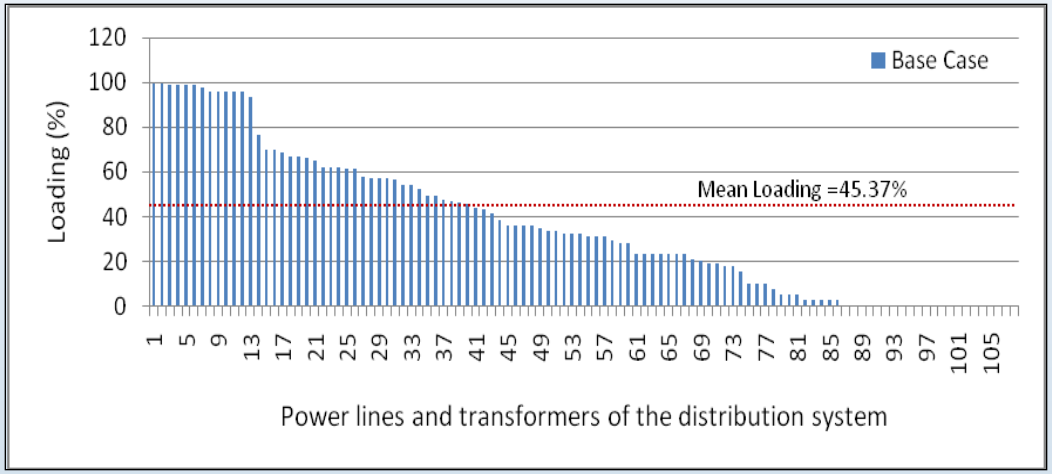
No. of busbars	86
No. of lines	92
No. of transformers	13
No. of loads	56
Avg. No. of customers per load	186
Total peak load	52.08 MW
Total grid power losses	130 kW

Failure and Repair Data

Component	Failure rate	Repair duration
Underground Cables	0.01/(km, year)	72 hours
Overhead Lines	0.015/(km, year)	50 hours
Power Transformers	0.008/year	96 hours
11kV Busbar	0.008/year for terminal; 0.015/year per connection	7 hours
33kV Busbar	0.005/year for terminal; 0.015/year per connection	10 hours

Results

- Base Case:
  - Loading of Components

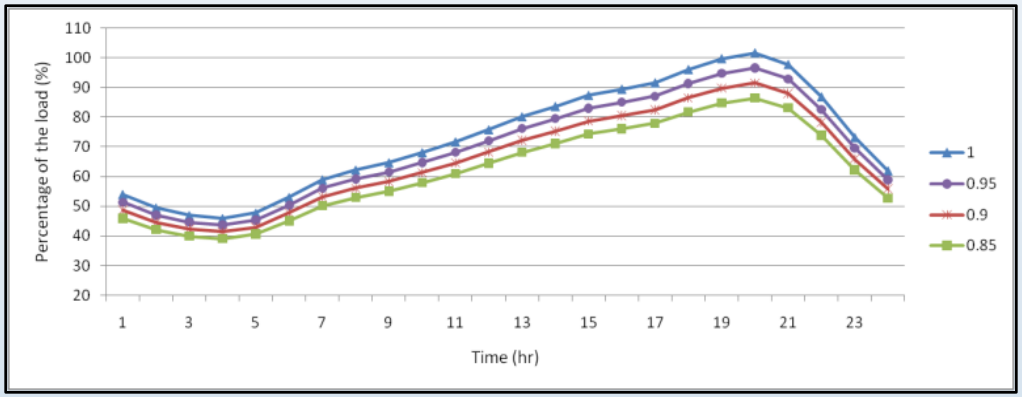


  - Reliability Study

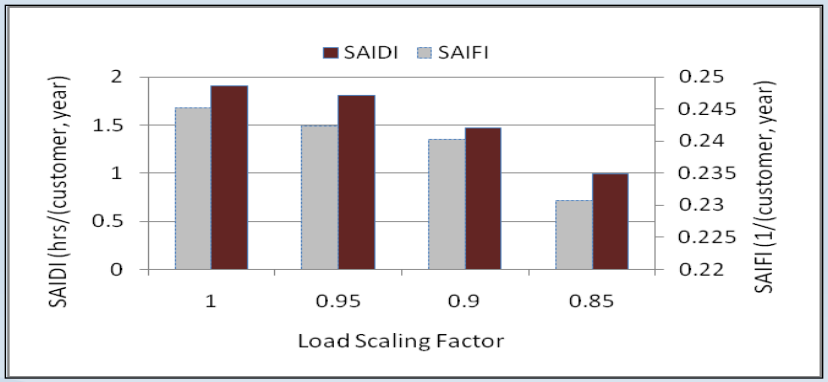
SAIFI 1/(Customer, Year)	SAIDI Hr./(Customer, Year)	CAIDI (Hr.)	EENS (MWh/Year)	ASAI
0.245187	1.904	7.767	76.369	0.9997826

Results

- Energy Conservation:
  - Load Curves

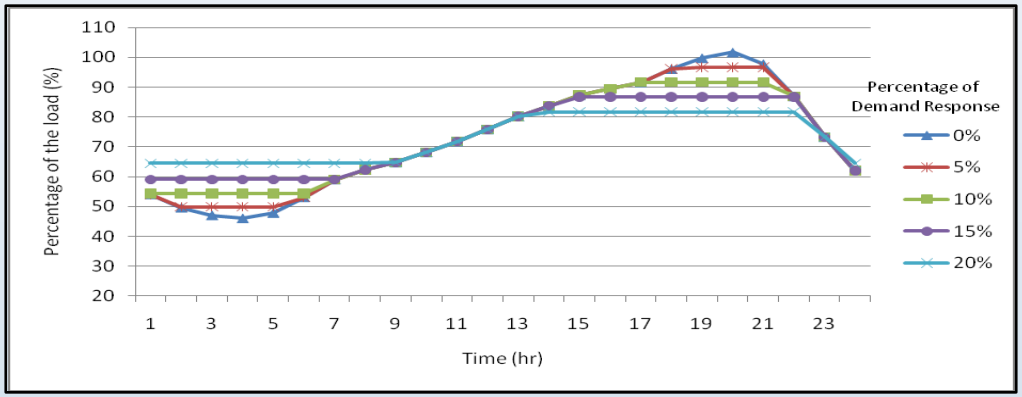


  - Reliability Study



Results

- Load Shifting:
  - Load Curves



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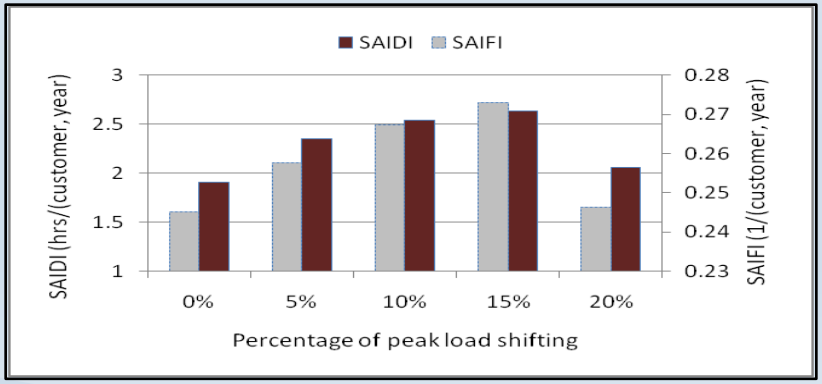
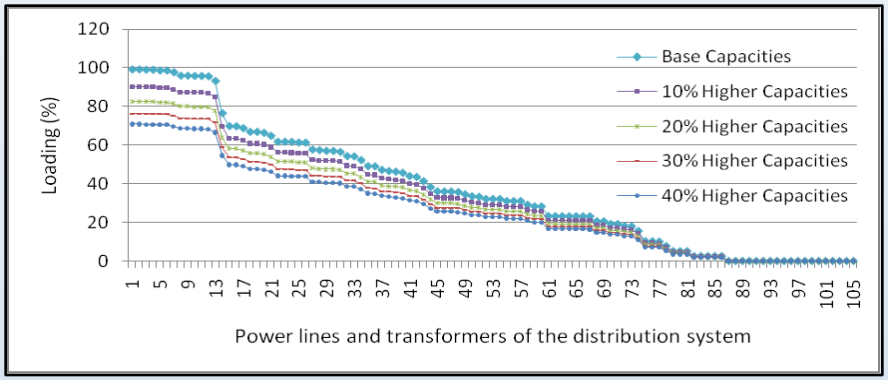
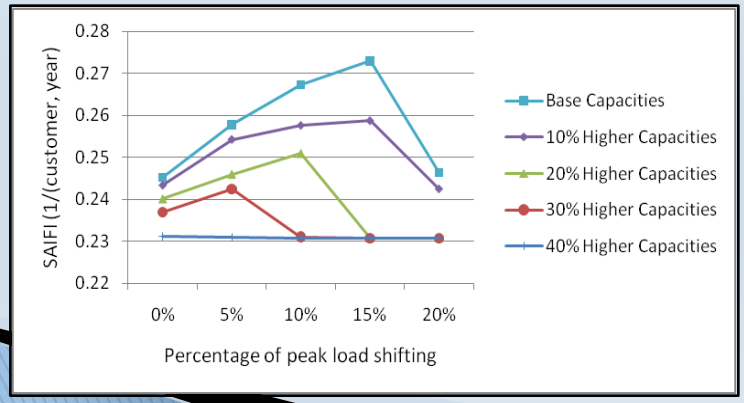


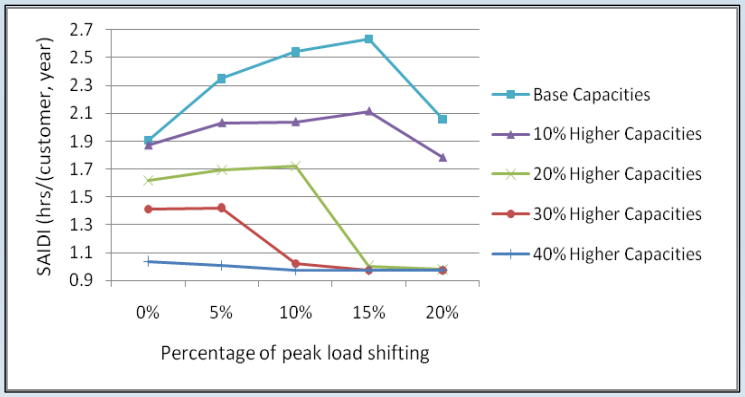
Results

- Sensitivity Analysis with Different System Capacities:
  - Loading of Components



  - Reliability Study





Conclusions

- Impacts of DSM on the Reliability of an Automated Distribution System
  - Energy Conservation
  - Load Shifting
- Energy Conservation Improves Reliability
- Load Shifting May Improve, Weaken, or Have no Significant Effect on System Reliability
- Peak Load Shaving Vs. Valley Filling
- Impact of System Loading

Thank You

- Question ?