POWER SYSTEM RELIABILITY IN THE MIDWEST FOR HIGH WIND AND SOLAR LEVELS

Organization:
Midcontinent Independent System Operator (MISO)

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Study Goal

As the cost of renewables recedes and the efficiency increases, the power industry will begin to see a shift from traditional power plants to renewable sites. With this increase in renewable generation being integrated into the system, it is important for power producers to know how to respond to this change in the grid. This study will provide insight by examining the reliability of the grid at different penetration levels and for different mixes of wind and solar generation.

Functional/Non-Functional Requirements

Functional Requirements:

- Working 50/50 and 75/25 models in PLEXOS
- Working PASA simulations
- Automation of LOLE and ELCC calculations

Non - Functional Requirements:

- Separate virtual machines for the 50/50 and 75/25 models

Project Overview

Create Siting Criteria
Thoroughly research and determine high-quality sites to place wind and solar generation within the MISO region.

Create Generation Profiles
For every hour for every bus, the capacity factor was found and multiplied by the rated maximum capacity from the established siting criteria.

Put Scenarios and Generation into PLEXOS
PLEXOS is a simulation tool based on optimization. Putting the wind and solar generations in for different scenarios allows us to run various simulations to evaluate the data.

Evaluating the Results
There are two parameters we are particularly interested in: loss of load expectation (LOLE) and expected load carrying capability (ELCC).

Definitions

ELCC - expected load carrying capability

LOLE - loss of load expectation

Capacity Credit - ratio of the average energy production during peak net load conditions over the installed capacity for all hours of the year

Capacity Factor - ratio of actual energy production over the total installed capacity

Renewable Penetration - the percentage of renewable generation

Design Approach

System Inputs

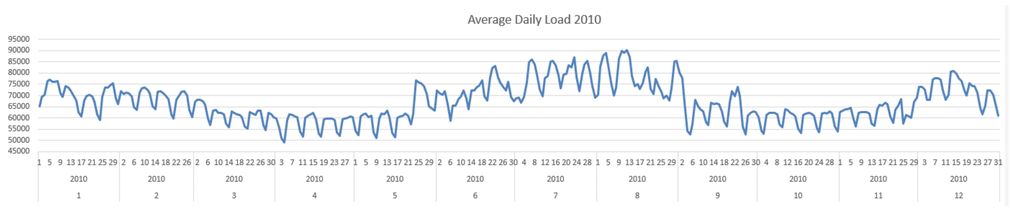
Scenarios ~ Siting

In order to evaluate the MISO system with more renewables integrated, extensive research needed to be done in order to determine desirable regions for new wind and solar energy to be built. The siting criteria examines:

- Utility Energy Goals and Incentives
- State Energy Goals and Incentives
- Cost of Renewables
- Location
- Population
- Capacity Factor and Capacity Credit

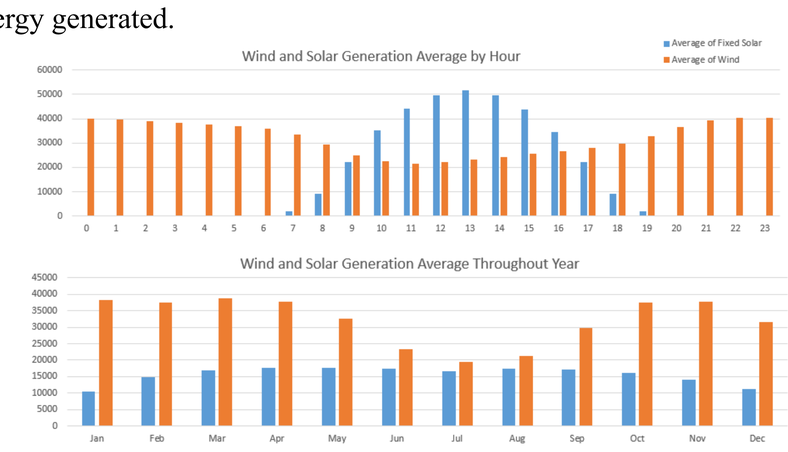
Load Profiles

In order to evaluate the system, MISO provided load profiles for six years (2007-2012). Since the team wants to evaluate the 2017 system, the data given by MISO was scaled to 2017 for each year. This means we can effectively evaluate the 2017 load for six different cases.



Generation Profiles

Since solar and wind operate at different levels during different times of the day throughout the year, it was necessary to create wind and solar profiles for each technology in order to properly reflect the energy generated.



Simulation Testing

- Using PLEXOS

  PLEXOS is a program that performs economic and reliability analysis of the power grid and returns useful information about how often the system will fail and what load it can support.

- Comparison Model LOLE

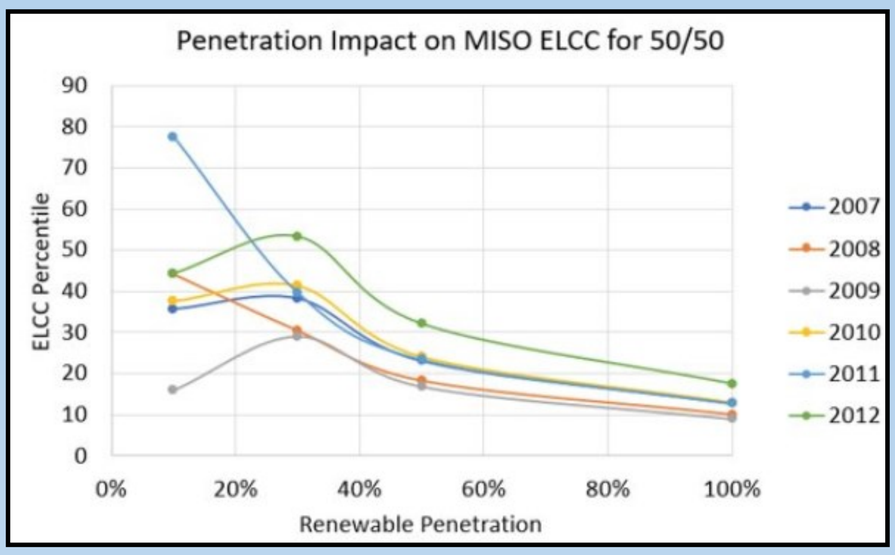
  This model has zero renewables and is simulated until an LOLE of 0.1 is achieved for each year.

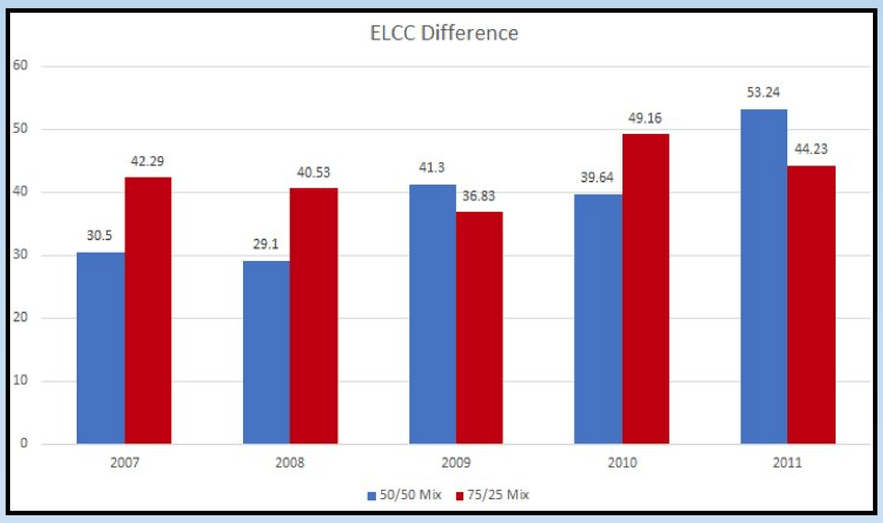
- 50/50 Model and 75/25 Model LOLE

  Each model is evaluated with 10, 30, 50, and 100 percent renewable penetration. Models are simulated and an LOLE of 0.1 is obtained for each year.

- ELCC

  The fixed load to achieve the LOLE in the 50/50 and 75/25 models is compared to the fixed load to achieve the LOLE in the comparison model. The difference between the fixed load of the mixed models and the comparison model is the ELCC in raw megawatts. This value gives insight on the reliability of the grid as various levels of renewable energy are integrated.





Applicable Standards

NERC - North American Electric Reliability Corporation

- *Bal-502-RF-03*: Must follow a “one day in ten years” loss of load expectation

Results

- As renewable penetration increases, more fixed load can be put onto the system.
- As seen in the Penetration Impact graph, as the level of renewable energy increases there is a decline in the percentile ELCC value.
- As seen in the ELCC Difference graph, the 75/25 model has a similar trend to the 50/50 model, but shows a higher percentile in ELCC values.

Conclusions

- The decline in ELCC, as more renewables are integrated on the grid, suggests that more renewable energy at higher penetration levels is necessary to maintain the 0.1 LOLE as required by NERC.
- The higher ELCC values for the 75/25 mix tells us that this model can reliably handle more load than the 50/50 model. This makes sense because wind generation is generally more reliable and has a higher capacity factor than solar.