Ambient Adjusted Ratings

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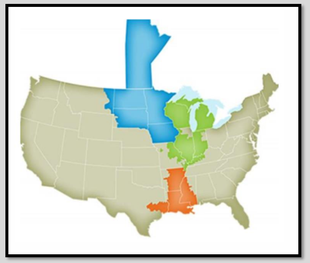
MISO

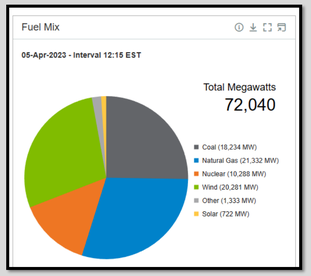
MISO, also known as Midcontinent Independent System Operator, is the regional transmission organization based in Carmel, Indiana.

They operate one of the largest energy markets encompassing 15 states and the Canadian province of Manitoba, providing 45 million people with energy.

They oversee the grid rather than operating any utility equipment on the ground.



Map of MISO's coverage.



The live energy generation of MISO's coverage.

MOTIVATION

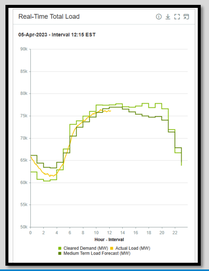
MISO must follow regulations put in place by the Federal Energy Regulatory Commission.

The primarily focus of FERC Order 881 is requiring ambient adjusted transmission line ratings.

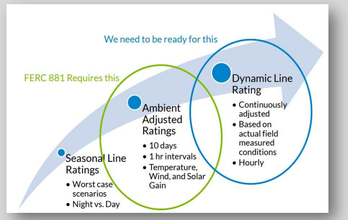
Ambient adjusted line ratings are produced from 240 hours of forecasted data.

One of the implications of FERC Order 881 is the need for large amounts of data stored in a reliable database solution.

The goal is to increase transmission efficiency across the grid.



Live forecast of energy demand and actual load from MISO's website.



Ambient adjusted ratings allow more electricity to be moved, increasing supply and decreasing price. We expect to shift to dynamic line ratings in the future.

DATA COLLECTION, ANALYSIS, AND RESEARCH

To look at efficiency, we looked at data from NOAA, and used line rating code based on the IEEE line rating equation that was on GitHub to compare to a general line rating value that we was given.

But the NOAA data was sparse, so we went searching for a new data source.

	startTime	endTime	temperature	windSpeed	windDirection
0	2022-11-07T14:00:00-05:00	2022-11-07T15:00:00-05:00	15.6	4.0	0.0
0	2022-11-07T15:00:00-05:00	2022-11-07T16:00:00-05:00	15.6	3.6	22.5
0	2022-11-07T16:00:00-05:00	2022-11-07T17:00:00-05:00	15.0	4.0	22.5
0	2022-11-07T17:00:00-05:00	2022-11-07T18:00:00-05:00	14.4	3.1	22.5
0	2022-11-07T18:00:00-05:00	2022-11-07T19:00:00-05:00	12.8	2.7	22.5
...	...	...	...	...	...
0	2022-11-13T21:00:00-05:00	2022-11-13T22:00:00-05:00	-1.1	2.7	270.0
0	2022-11-13T22:00:00-05:00	2022-11-13T23:00:00-05:00	-1.7	2.7	270.0
0	2022-11-13T23:00:00-05:00	2022-11-14T00:00:00-05:00	-2.2	2.7	270.0
0	2022-11-14T00:00:00-05:00	2022-11-14T01:00:00-05:00	-2.2	2.2	270.0
0	2022-11-14T01:00:00-05:00	2022-11-14T02:00:00-05:00	-2.8	2.2	270.0

We ended up choosing an NWS API for a 156-hour forecast, which provided most of our data except solar irradiation.

That source had too little data, because it fell short also fell short of our 240-hour requirement.

But it was enough to start with because it has temperature and wind forecasts. This was used to find R values with isolated value equations.

During the second semester, we found an API, Open-Meteo, that met all the criteria that we had.

Our criteria was 240 hours of forecasted temperature, wind speed, wind direction and solar irradiance.

With this we were able to find better line ratings and see the isolated effects of each type.

This idea led to our business case research goals because it was to find ways to save MISO money and resources and therefore increasing the efficiency of their operations.

A subset of this was to find an easy-to-use, scalable database that either used API or SQL.

	temperature_2m	windspeed_10m	winddirection_10m	direct_normal_irradiance
0	20.4	24.5	28	0.0
1	19.6	18.9	24	0.0
2	19.7	9.8	354	0.0
3	19.2	19.1	3	0.0
4	18.8	18.2	333	0.0
...	...	...	...	...
235	20.3	11.3	211	286.8
236	20.2	11.2	228	19.1
237	20.0	12.2	256	0.0
238	19.9	16.4	320	0.0
239	19.5	11.0	341	0.0

```
Start Date = 2nd April, 2023
End Date = 4th April, 2023

Only Temperature: Average Deviation from Base = -56.663
+ Wind Speed: Average Deviation from Base = 5.767
+ Wind Direction: Average Deviation from Base = -10.656
+ Solar Irradiance: Average Deviation from Base = -8.733
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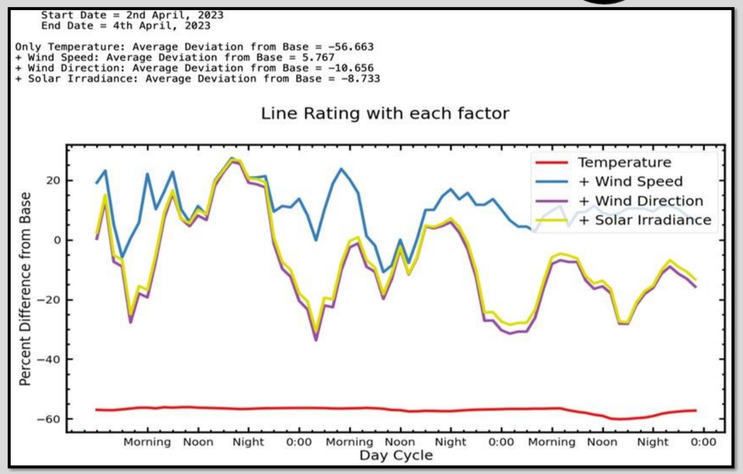
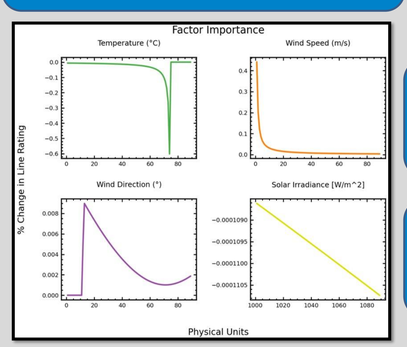


OUTCOMES

Azure's Cosmos DB has API support. The database research pointed out that something Azure based was the best option. This works out well because MISO recently entered a partnership with Microsoft over Azure. We went towards Cosmos DB because after research we decided that an API based database was better for MISO and its partners over an SQL database.

Originally, our analysis showed that temperature had the greatest influence, however after deeper analysis we discovered it was only partially true. While temperature starts negatively influencing the line rating for values over 40°C, wind speed has the largest positive influence out of all the factors.



Additionally, The R values had wind speed, without direction, as a linear relationship with line ratings assuming the other values were constants. This means that transmission lines should not be put into very hot areas, and they should be put into windy areas to cool them down a lot.

2 to 6 percent of energy is lost in transmission. This research led us to want to make it more efficient, so we lose less energy during transmission.

FUTURE WORK

Our future work would focus on progressing to dynamic line ratings.

For database, it would be testing data ingest speeds, so we can see how fast we can log data to have a way to check on the transmission lines.

The next steps for the business and data aspects would be to apply real world data from MISO and its partners to better understand line ratings, which would allow us a better understanding of where transmission lines thrive allowing infrastructure to improve.

DISCLAIMER: All analysis was based off simulated data, not data from MISO or its partners.

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