Q3.

a.With the function calculate\_ic we calculated the OPTIMAL LENGTH FOR A VAR FOR THE VARIABLES for the given dataset.From the results we can see that the IC results are decreasing as the number of lags keeps going up, which suggests that more historical data does help the model to better capture the dynamics between the data, thus improving the model's fit to the data.

At the same time, it is noted that the BIC decreases more slowly compared to the AIC, which suggests that while a higher number of lags may reduce the value of the information criterion, it also increases the risk of model overfitting. At a lag number of 19, the HQIC stops decreasing and the IC value gradually stabilizes, suggesting that 19 lags may be a better number of lags.

b. We ran the Granger Causality Test on the data using granger\_causality\_tests and obtained an N x N F-statistic. Where we focus on the part of each variable that interacts with the other variables, the F-statistic for Zonal\_COMED\_price vs. System\_load\_forecast is 151.268283, indicating that "System\_load\_forecast" significantly Granger Causality Tests "Zonal\_COMED\_price" to "Zonal\_COMED\_price". to "Zonal\_COMED\_price"; the F-statistic of "Zonal\_COMED\_load\_forecast" to "System\_load\_forecast" is 151.268283 indicating that "System\_load\_forecast" is significantly Granger-induced. The F-statistic of "Zonal\_COMED\_load\_forecast" is 324.049866, which indicates that "Zonal\_COMED\_load\_forecast" significantly Granger causes "System\_load\_forecast The F-statistic of "System\_load\_forecast" to "Zonal\_COMED\_load\_forecast" is 2555.598165, which indicates that "System\_load\_forecast" significantly Granger leads to "System\_load\_forecast". indicating that "System\_load\_forecast" significantly Granger causes "Zonal\_COMED\_load\_forecast".

In summary, each pair of variables shows significant Granger causality. This means that, based on statistical criteria, the past value of each variable is predictive of the future value of the other variable.

c. We plot the corresponding plots of each variable against Zload shocks over the next 12 cycles. We can see from the plots how each variable changes over time in response to the Zload shock.

The response to the "Zonal\_COMED\_load\_forecast" shock starts off with a rapid decline and tends to a negative value instead of going back to zero within 12 periods. This means that the impact of the shock is long-lasting and remains significant at the end of the 12 periods of the simulation.

The second figure shows the response of "System\_load\_forecast" to the "Zonal\_COMED\_load\_forecast" shock. In this figure, we see that the response curve starts off with a rapid increase, and then after about 5 periods the growth rate starts to decay towards 0, indicating a relatively short-lived response.

The response of Zonal\_COMED\_load\_forecast to its own shock rises rapidly at first and then stabilizes at a high level, which also indicates a longer-lived response.

So the response of "System\_load\_forecast" to the "Zonal\_COMED\_load\_forecast" shock is a relatively short-lived positive shock.