Hunter Browning-Smith

Electrical Grid Stability: A Regression Analysis

Background

The world is transitioning at an accelerating rate to renewable energies – most of which is derived from solar and wind

The Problem

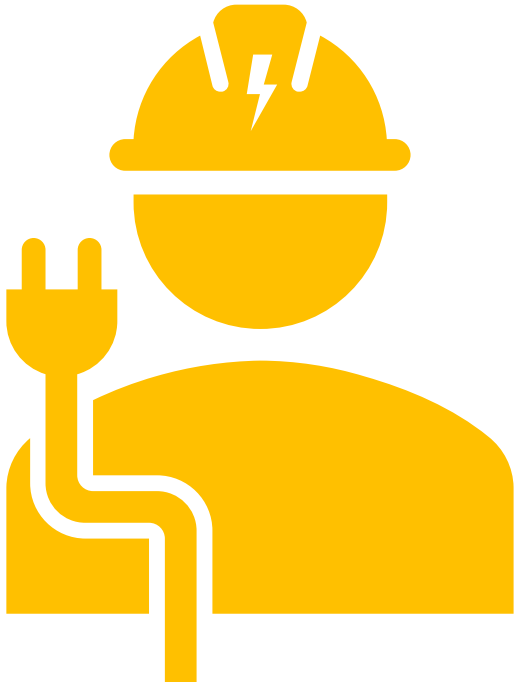
Renewable energies are “intermittent”

Intermittent energy sources put stress on the grid

The Solution

Decentralized Smart

Grid Control (DSGC)



Who benefits?

Energy providers

Energy policy makers

Energy consumers

How it works

Logistic Regression utilizes selected inputs to evaluate grid stability

Result is a model which quantifies impacts (like accurate pricing) of variable energy production sources (like solar and wind)

DSGC manages electrical grid and optimizes grid stability while minimizing blackouts and inefficient distribution practices

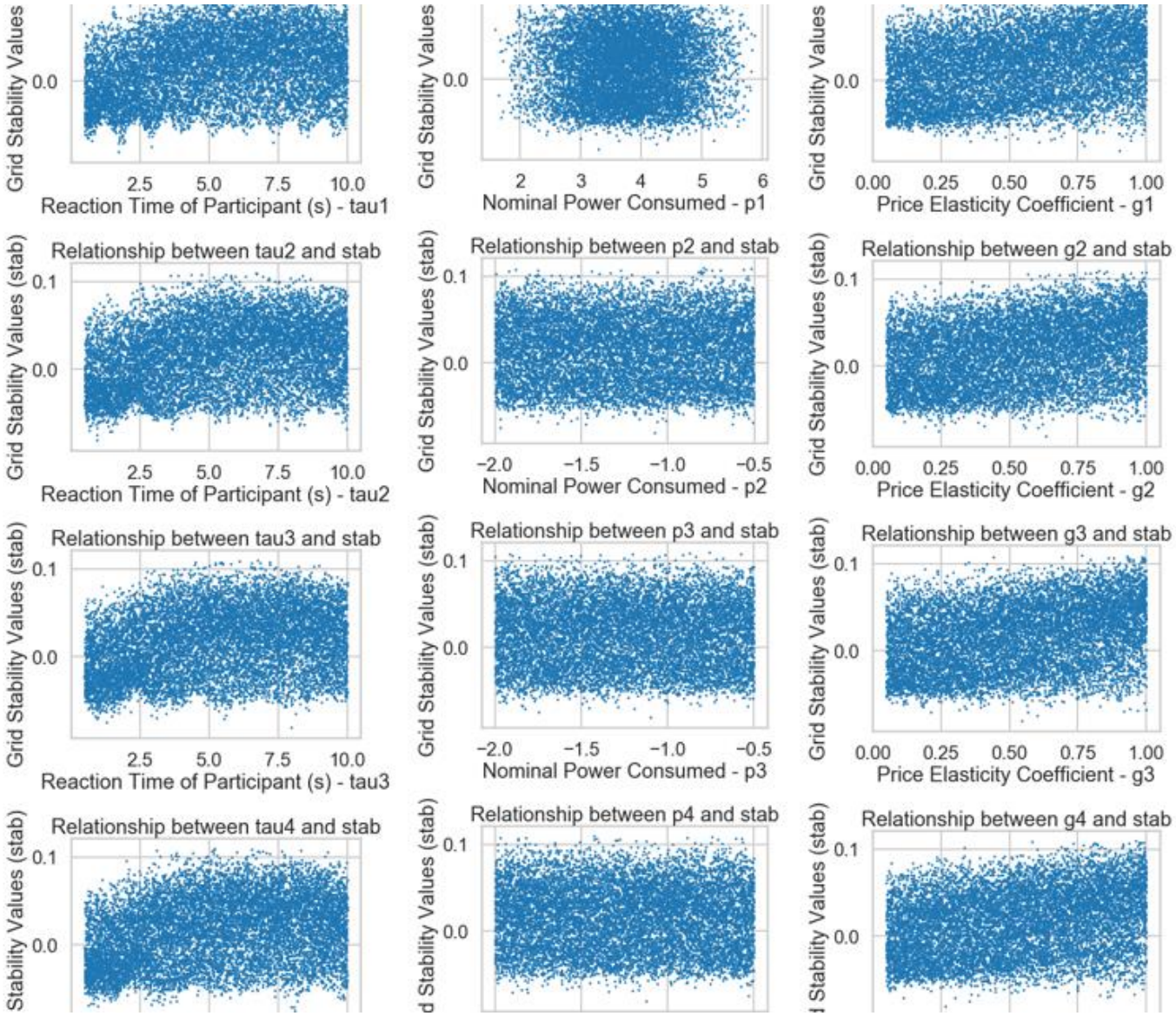
The Data

Independent Variables of Decentralized Smart Grid Control

P_x	Mechanical power produced/consumed
τ_x	Reaction time, the delay between a price change and adaptation to it
γ_x	Coefficient, proportional to price elasticity

See the following paper for more detail about the variables used:
Arzamasov, Vadim, Klemens Böhm, and Patrick Jochem. 'Towards Concise Models of Grid Stability.' Communications, Control, and Computing Technologies for Smart Grids (SmartGridComm), 2018 IEEE International Conference on. IEEE, 2018
(Section V-A)

EDA


Grid Stability Values
0.0
2.5
5.0
7.5
10.0
Reaction Time of Participant (s) - tau1
Grid Stability Values
0.0
2
3
4
5
6
Nominal Power Consumed - p1
Grid Stability Values
0.0
0.00
0.25
0.50
0.75
1.00
Price Elasticity Coefficient - g1
Relationship between tau2 and stab
Grid Stability Values (stab)
0.1
0.0
2.5
5.0
7.5
10.0
Reaction Time of Participant (s) - tau2
Relationship between p2 and stab
Grid Stability Values (stab)
0.1
0.0
−2.0
−1.5
−1.0
−0.5
Nominal Power Consumed - p2
Relationship between g2 and stab
Grid Stability Values (stab)
0.1
0.0
0.00
0.25
0.50
0.75
1.00
Price Elasticity Coefficient - g2
Relationship between tau3 and stab
Grid Stability Values (stab)
0.1
0.0
2.5
5.0
7.5
10.0
Reaction Time of Participant (s) - tau3
Relationship between p3 and stab
Grid Stability Values (stab)
0.1
0.0
−2.0
−1.5
−1.0
−0.5
Nominal Power Consumed - p3
Relationship between g3 and stab
Grid Stability Values (stab)
0.1
0.0
0.00
0.25
0.50
0.75
1.00
Price Elasticity Coefficient - g3
Relationship between tau4 and stab
Stability Values (stab)
0.1
0.0
Relationship between p4 and stab
Stability Values (stab)
0.1
0.0
Relationship between g4 and stab
Stability Values (stab)
0.1
0.0

Results

Top 10 Logistic Regression Models and Accuracy Scores	
Independent Variables	Accuracy Score
[tau1, tau2, tau3, tau4, p2, p3, p4, g1, g2, g3, g4]	0.815915
[tau1, tau2, tau3, tau4, p3, p4, g1, g2, g3, g4]	0.81583
[tau1, tau2, tau3, tau4, p2, p3, g1, g2, g3, g4]	0.815275
[tau1, tau2, tau3, tau4, p4, g1, g2, g3, g4]	0.814865
[tau1, tau2, tau3, tau4, p2, p4, g1, g2, g3, g4]	0.81472
[tau1, tau2, tau3, tau4, p2, g1, g2, g3, g4]	0.81429
[tau1, tau2, tau3, tau4, g1, g2, g3, g4]	0.81289
[tau1, tau2, tau3, tau4, p2, p4, g2, g3, g4]	0.798405
[tau1, tau2, tau3, tau4, p2, p3, g1, g2, g3]	0.794655
[tau1, tau3, tau4, g1, g2, g3, g4]	0.79453

Top 5 Linear Regression Models Based on OLS R-Squared, OLS F-Statistic, and OLS AIC			
Independent Variables	OLS R-Squared Value	OLS F-statistic	OLS AIC
[tau1, tau2, tau3, tau4, p2, p3, p4, g1, g2, g3, g4]	0.46396	785.981	-42147.8
[tau1, tau2, tau3, tau4, p2, p3, p4, g1, g2, g3]	0.44653	805.974	-41829.8
[tau1, tau2, tau3, p2, p3, p4, g1, g2, g3, g4]	0.446041	804.383	-41821
[tau2, tau3, tau4, p2, p3, p4, g1, g2, g3, g4]	0.445351	802.141	-41808.5
[tau1, tau3, tau4, p2, p3, p4, g1, g2, g3, g4]	0.445242	801.786	-41806.6

Conclusions

Logistic regression technique is superior to linear regression techniques given the dataset

Logistic regression model accurately predicts grid stability greater than 80% of the time