Simulating the effect of cyber attacks on a Power Grid

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Introduction

- Simulating cyber-attacks on a power grid
  - PandaPower for grid formation and underlying Pandas library
  - False data injections and smart-home attacks
- Users will have interface to create grid
  - Removes the need for them to know Python in order to use our tool
- Results from simulation will be outputted in a map of grid showing location and severity of attacks

Implementation Architecture

- Python used for creating the grid and attack files

- PandaPower libraries for grid simulation
  - Main Functions
    - Allows the create of different grid components
  - Plotly
    - Used for plotting points on the grid
  - Pandas
    - Open-source library used for data manipulation and cleaning
  - Pickle files (.p)
    - Generated from converging grid and used in attack simulation

Work Accomplishments

- Successfully simulated a power grid
  - Built based off of schematics of an actual grid, which are not disclosed
- Implemented cyber attack framework against power grid
  - False Data Injection that targets transformers throughout grid
  - IoT attack that randomly targets different areas of buses located on the grid
- Main program
  - Program that lets users simulate cyber attacks against a grid
- Grid Creation Shell
  - Implemented shell for users to automatically generate a power grid

Key Contributions

- **Noah Peake**
  - Created IoT attack script, assisted with the creation of the FDIA script, co-wrote attack script documentation, assisted with creating sections of the power grid
- **Jake Stanerson**
  - Created false data injection script, made main program, implemented time series, created time series output for each attack, created grid creation bash environment
- **Hrijul Balayar**
  - Preparation of attack taxonomy, grid creation, assisting of project documentation, team website creation and maintenance
- **Cole Medgaarden**
  - Helped to scale up the power grid to the desired size, project documentation and ongoing tasks
- **Michael Gierek**
  - Created a spreadsheet regarding buildings on campus and their electric usage for time series
- **Conner Spainhower**
  - Created grid creation bash environment

Challenges and Solutions

- Array out of bounds error during False Data Injection simulation
  - Corrected calculation for number of transformers on grid

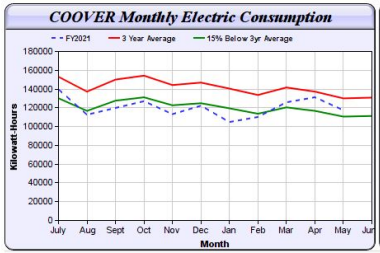
- Infinite loop in IoT Attack
  - Added a check to see if all parts of the grid had been attacked to exit loop

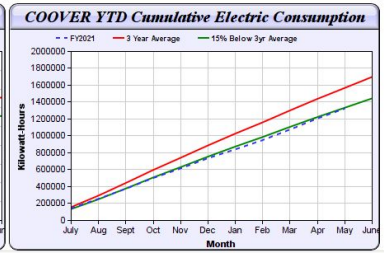
Load Values

- Found our values through an Iowa State website that documents building's kilowatt-hour usage
- Has every building on campus documented with in depth charts and analysis
- Took these values and put them into a spreadsheet to import into our project.

Load Values

Chart Size: Small Large





Consumption									YTD Consumption		
Month	FY2018	FY2019	FY2020	3yr Average	FY2021	Unit Savings	Savings $	Savings % of Hist. Ave	3 YR YTD	FY2021	15% Below 3yr Ave
July	153,600	167,400	136,800	152,600	139,200	13,400	$1,249	8.8%	152,600	139,200	129,710
August	144,000	144,000	122,400	136,800	112,200	24,600	$2,293	18.0%	289,400	251,400	245,990
September	147,000	148,200	153,600	149,600	119,400	30,200	$2,815	20.2%	439,000	370,800	373,150
October	164,400	163,800	133,200	153,800	126,600	27,200	$2,535	17.7%	592,800	497,400	503,880
November	139,800	136,200	155,400	143,800	112,800	31,000	$2,889	21.6%	736,600	610,200	626,110
December	158,400	150,600	130,200	146,400	121,800	24,600	$2,293	16.8%	883,000	732,000	750,550
January	141,600	129,000	149,400	140,000	104,400	35,600	$3,318	25.4%	1,023,000	836,400	869,550
February	136,800	133,200	129,600	133,200	109,800	23,400	$2,181	17.6%	1,156,200	946,200	982,770
March	147,600	151,200	124,800	141,200	125,400	15,800	$1,473	11.2%	1,297,400	1,071,600	1,102,790
April	171,600	137,400	101,400	136,800	130,800	6,000	$559	4.4%	1,434,200	1,202,400	1,219,070
May	151,200	125,400	112,200	129,600	117,000	12,600	$1,174	9.7%	1,563,800	1,319,400	1,329,230
June	138,000	142,800	110,400	130,400					1,694,200		1,440,070
Totals:	1,794,000	1,729,200	1,559,400	1,694,200	1,319,400	244,400	$22,778				

Buildings on Campus	3 Year Average	Yearly Average	Monthly Avg	Weekly Avg	Daily Avg
Administrative Services Building	1,397,568	465,856	38,821	8,945.01	1,278
Advanced Machinary Systems Lab	53,573	17,858	1,488	342.89	49
Advanced Teaching and Research Building	2,887,457	962,486	80,207	18,480.91	2,640
Agronomy Greenhouse	419,387	139,796	11,650	2,684.25	383
Agronomy Hall	4,117,867	1,372,622	114,385	26,356.04	3,765
Alumni Center	573,312	191,104	15,925	3,669.43	524
Armory	534,800	178,267	14,856	3,422.94	489
Atanasoff Hall	543,133	181,044	15,087	3,476.27	497
Barton Residence Hall	61,974	20,658	1,722	396.66	57
Beardshear Hall	416,833	138,944	11,579	2,667.90	381
Bessey Hall	2,819,600	939,867	78,322	18,046.59	2,578
Beyer Hall	973,253	324,418	27,035	6,229.22	890
Biorenewables Research Lab	1,798,144	599,381	49,948	11,508.86	1,644
Birch Residence Hall	99,147	33,049	2,754	634.58	91
Black Engineering	1,867,907	622,636	51,886	11,955.37	1,708
Carver Hall	851,840	283,947	23,662	5,452.12	779
Catt Hall	203,776	67,925	5,660	1,304.25	186
College of Design	1,569,600	523,200	43,600	10,046.08	1,435
Communications Building	684,500	228,167	19,014	4,381.08	626
Coover Hall	1,694,200	564,733	47,061	10,843.57	1,549
Crop Genome Informatics Lab	137,051	45,684	3,807	877.18	125
Curtiss Hall	571,733	190,578	15,881	3,659.33	523
Durham Center	4,190,400	1,396,800	116,400	26,820.28	3,831
East Hall	113,107	37,702	3,142	723.93	103
East Parking Deck	66,430	22,143	1,845	425.18	61
Eaton Residence Hall	781,333	260,444	21,704	5,000.85	714
Enrollment Services Center	240,000	80,000	6,667	1,536.10	219
Enviromental Health / Saftey Services	438,880	146,293	12,191	2,809.01	401
Extension 4-H Building	231,840	77,280	6,440	1,483.87	212
Farm House	10,094	3,365	280	64.61	9

Future Work

- Optimize the attack scripts and compiling of grids
  - Right now it's pretty slow and can use a speed-up
  - Might involve writing a lot of the code in c because of the limitations of python

- Make a GUI for each side of the program
  - Grid creation
  - Main program

- Figure out a way to interface the time series implementation without overcomplicating
  - Very confusing process
  - GUI will help

Conclusion

- Successfully created attack vectors to be used against a simulated grid
  - Grid ressemblent of Iowa State's infrastructure
- Developed a main program to be used for simulation of these attacks
- Grid shell interface
  - Allows for users unfamiliar with python to generate a grid for themselves
- Improvements
  - Optimizations
  - GUI