LOAD PROFILES OF CUSTOMER CLASSES AND FEEDER VOLTAGE PROFILES

Forest Atchison [forestatchison@gmail.com], Kaylor Garcia [kaylor.myron.garcia@hotmail.com],
Jared McVeigh [jrod_mcveigh@bellsouth.net], Bryan Trawick [bstrawick@yahoo.com], Srikar Vavilala [srikarvavi@gmail.com]
Faculty Mentors: Nan BouSaba, Valentina Cecchi, Sukumar Kamalasadan
Industry Supporters: Joe Lavalliere, Shelby Tomassi

UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

PROBLEM STATEMENT

The team was in collaboration with Duke Energy to create an automated tool that would determine customer load schedules that improved on the existing load estimates and to detect the presence of BTM resources and modern loads. This analysis was to be enabled by analyzing customer meter measurements and the tool was to be written in Python.

RESEARCH QUESTION

Can analyzing AMI data improve load schedules and detect BTM resources and modern loads such as PVs and EVs?

SPECIFICATIONS

- Create automated tool to do the following:
  - Analyze existing DMS load schedules for accuracy
  - Create improved DMS loads schedules that increase accuracy
  - Create reactive power schedules to complement the active power load schedules
  - Detect the presence of BTM resources and modern loads
- The tool is to accept a substation data file and an AMI data file and automatically output improved load schedules and detected customer PV and EV loads
- Create detailed reports depicting the analysis

KEY TERMS

- AMI (Advanced Metering Infrastructure) –architecture for automated 2-way communication between a utility meter and utility company
- BTM (Behind the Meter) – refers to any energy generation on the customer's side of the meter
- DMS (Distribution Management System) – a collection of applications designed to monitor and control the entire distribution network

GRAPHICAL USER INTERFACE

1 FILE SELECTION

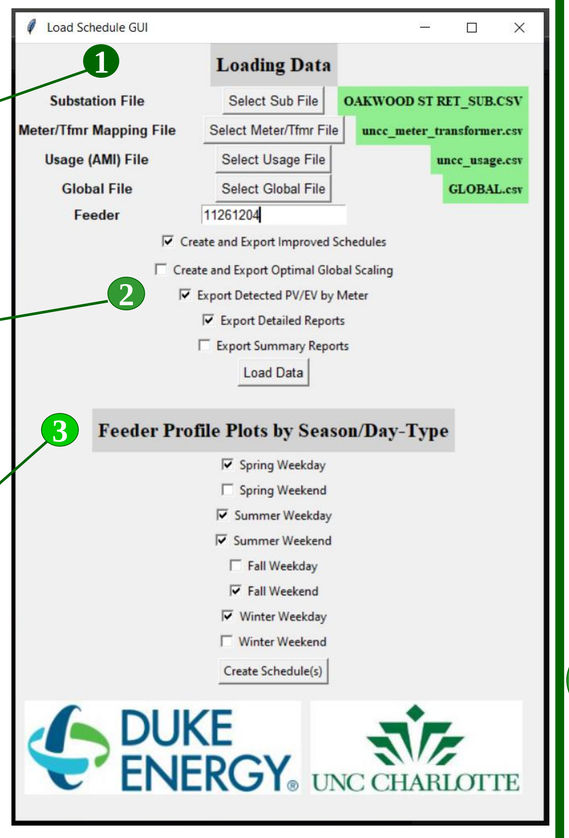
- Each Button widget opens a file explorer window that allows the user to select a relevant .csv file for each field
- The Textbox widget next to "Feeder" allows the user to enter the specific feeder that will be analyzed from the provided data files

2 FILE GENERATION

- Each Checkbox widget allows the user to decide which analysis to perform on the selected data files and which output files to generate

3 FEEDER PROFILE VISUALIZATION

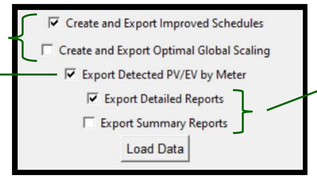
- Each Checkbox widget allows the user to decide for which season and day type to plot a visualization of the aggregated original DMS profiles, the aggregated improved DMS profiles, and the aggregated AMI profile for the feeder being tested



GUI Concept of Operations

Selection → Generation → Visualization

FILE GENERATION FUNCTIONS



2A IMPROVED LOAD MODELING

- The first Checkbox widget allows the user to generate new customer class load schedules based on the analysis of customer load data that reduces the feeder error characteristics
- The second Checkbox widget allows the user to create a new universal scaling factor that retains the original schedules, but reduces error
- These analyses account for data errors such as missing data, non-conformities in file structure, and data judged to be abnormal and thus to be excluded

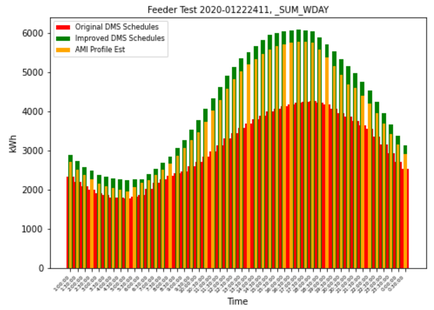
2B MACHINE LEARNING BTM DETECTION

- This Checkbox widget runs the selected feeder profiles through the created BTM detection tool. Powered by Gaussian Naïve Bayes Machine Learning, the BTM detection tool is trained with synthetic BTM load profiles for every season and day type to detect PV and EV present
- When the Checkbox is selected, a list of meters is exported to Excel which details BTM resources and modern loads that are detected for every season and day type

2C DETAILED REPORTS

- When selected, the final two Checkbox widgets export detailed reports to Excel
- These reports summarize the errors in magnitude and profile shape indicated by the average profiles both for each transformer and each load class on the feeder under test
- Reports are generated for both conditions: pre-improvement and post-improvement

2A VALIDATION: LOAD MODELING



		MAPE (%)	MSE (kWh^2)	COS
Fall Weekday	Improved	8.09	39035.72	0.999842
	Original	11.66	87615.10	0.993621
Fall Weekend	Improved	12.24	89388.76	0.999512
	Original	12.36	91130.06	0.991549
Spring Weekday	Improved	7.53	35246.55	0.999641
	Original	18.23	243862.82	0.991272
Spring Weekend	Improved	10.49	84438.12	0.999359
	Original	22.37	435539.03	0.988611
Summer Weekday	Improved	7.11	84867.05	0.999907
	Original	24.49	929960.85	0.997033
Summer Weekend	Improved	9.46	148309.25	0.999828
	Original	27.31	1147757.06	0.99592
Winter Weekday	Improved	8.98	48485.12	0.99899
	Original	26.84	724666.52	0.990821
Winter Weekend	Improved	13.39	118680.08	0.999433
	Original	26.32	690484.00	0.993346

2B VALIDATION: BTM DETECTION