IOWA STATE UNIVERSITY
College of Engineering

CG-2022: A tool for mining AMI data to model customer loads for small public power utilities

Funded by APPA DEED

Background

- Grant to Algona Municipal Utilities and Iowa State University
- Purpose: Extract AMI data, query it, and save query results:
  - Understand variability of load behavior
  - Contribution of different rate classes to peak load and energy consumption
  - Identify gaps or other errors in AMI data
  - Observe temperature/Cooling Degree Day/Heating Degree effects on load
  - Find mis-classified customers
  - Follow on work: explore new rate design impacts based on customer class clustering

Motivation

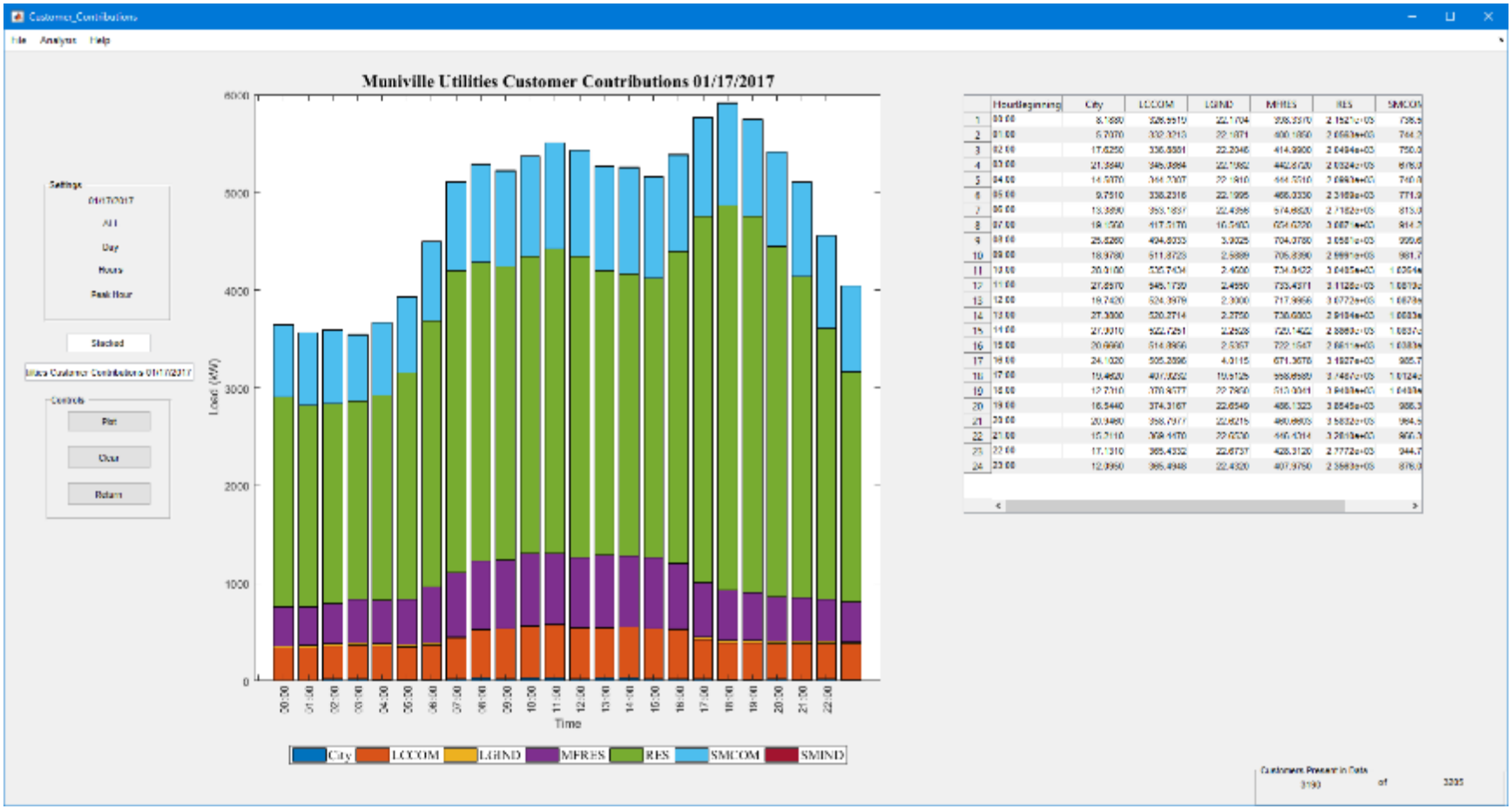
AMI metering generates very large customer usage data files. For small utilities these files can be difficult to work with; analysis may not be part of meter data management contract, which can be a lost opportunity to learn from the data

DEED awarded this project to develop a very simple-to-use tool to extract data from text files (.txt,.csv or .xlsx file extensions) in order to review AMI data sets for quality control, customer behavior, customer contribution to peak, and to provide “what if” analyses that are quick to run, for future rate design.

The tool:

1. Is a stand-alone tool developed in MatLab
2. Imports very large text files
3. Has option for importing temperature, cooling and heating degree days,
4. Provides menu for selecting subsets of data, by customer class, customer account number or meter number, or by feeder, for months, weeks or a selected day
5. Saves the data subsets in Excel for further analysis and plotting

Development Objectives cont.



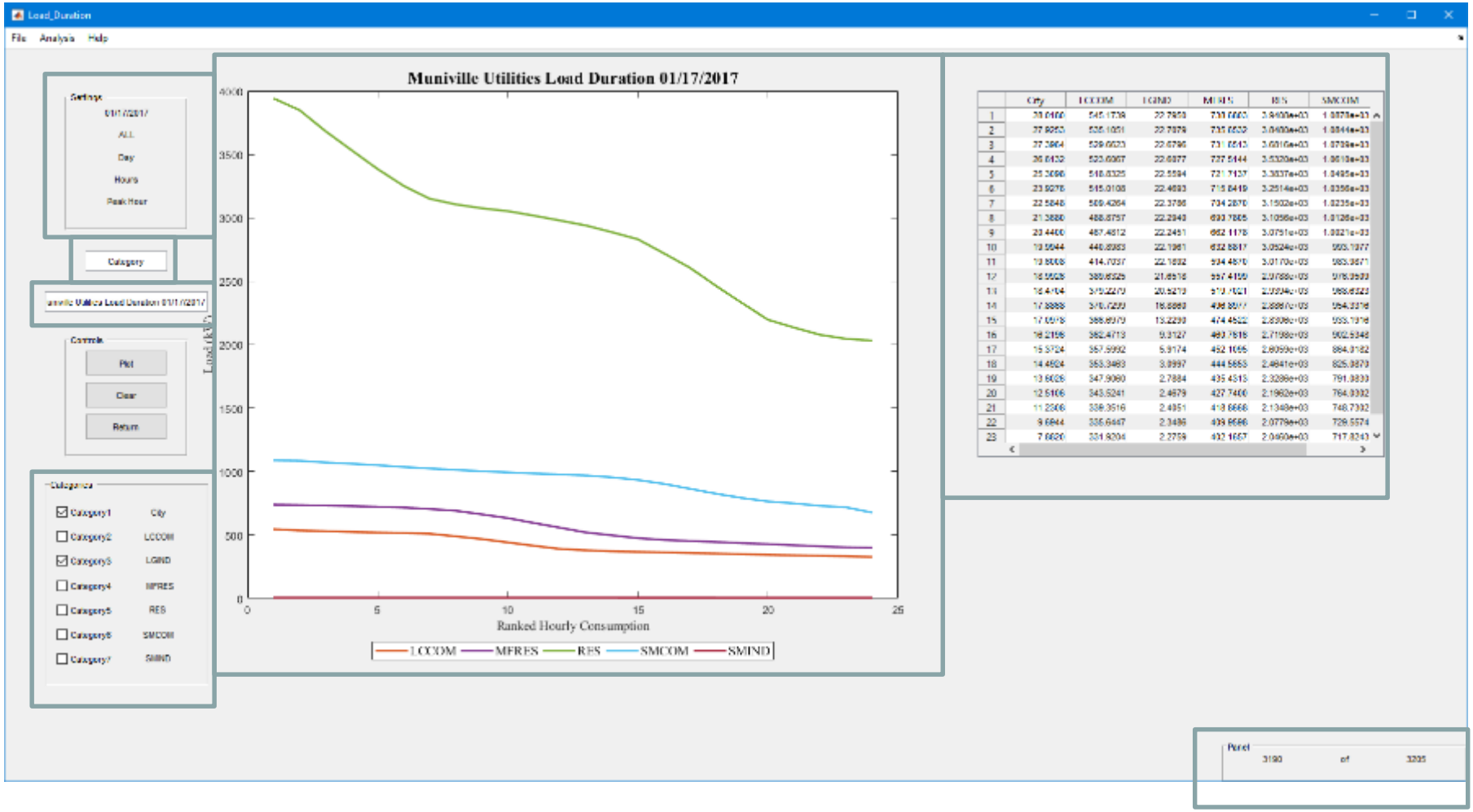
AMI data analysis advantages:

- Understand specific customer load profiles to help reclassify certain loads into new or revised rate classes.
- Understand the contribution of specific loads to the overall load and especially the contribution to peak load.
- Use load analyses to help in design of new demand response programs, and understand the costs and benefits of such programs.
- Use load analyses to help utilities determine the benefits and operational constraints of customer and utility installed PV, specifically PV output over the course of a day versus the load profile over the same period.
- Use AMI data to estimate the customer load profile of non-AMI meters on the same feeder or on similar feeders.

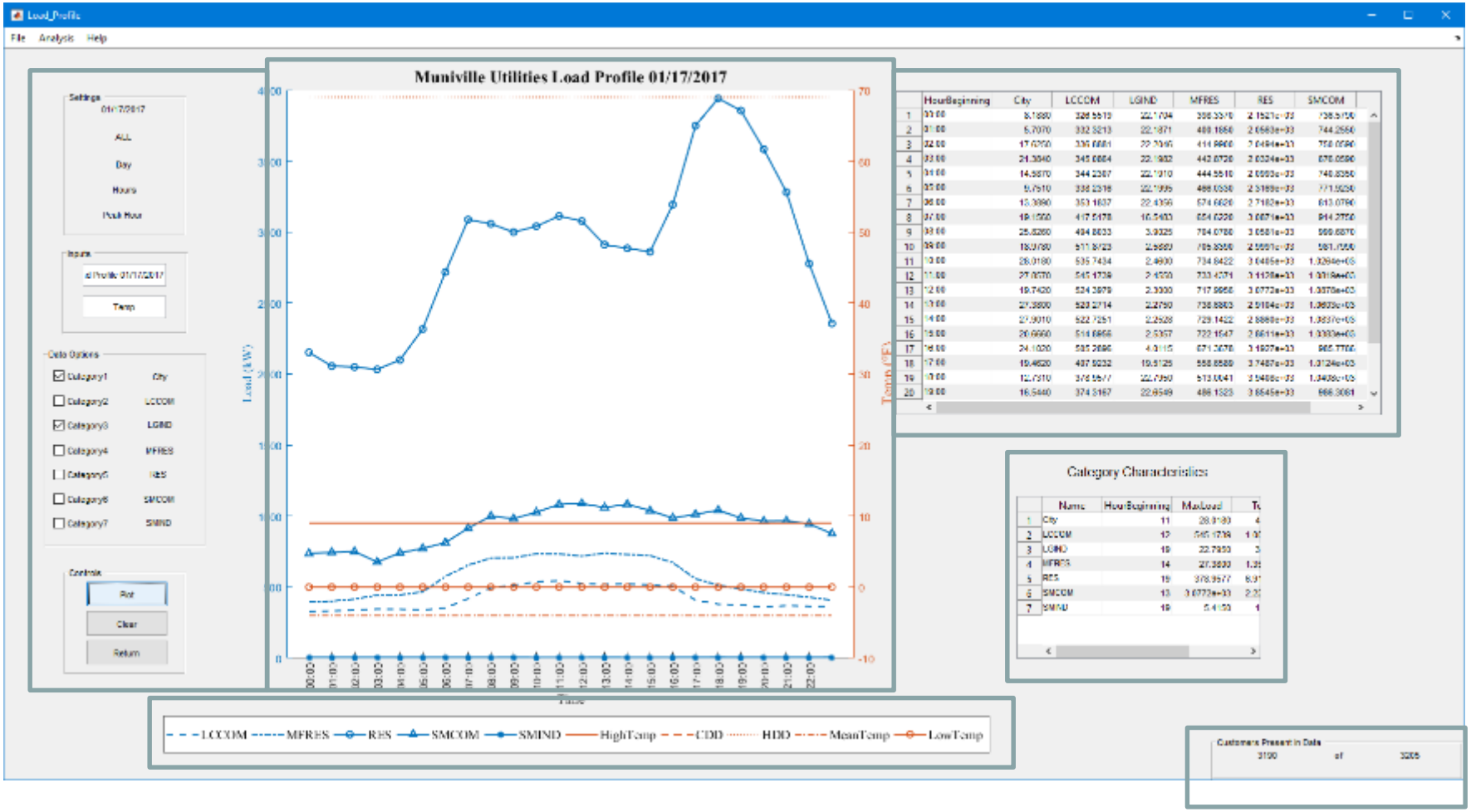
DEED Grant background: Algona

- Algona AMI data available
  - Data from 2014-mid 2018
  - Able to cluster by customer class, and by feeder
  - Most data is hourly load (kWh) data; there is also 15 minute data for subset of residential and industrial customers
  - Able to compare load data with AMU generated monthly reports from SCADA, to identify gaps, and incorrect meter data: independent error checking (especially useful when AMI meters first installed- can find communications errors)

Example Features from Motivation



Example Features from Motivation Cont.



Data Requirements:

1. Billing Provider data: An Excel file of customer account information:
    1. Account Number
    2. Customer Name
    3. Meter Number
    4. Location (street address)
    5. Latitude
    6. Longitude
    7. Rate Code
    8. Revenue Code
2. Meter Data Management contractor data
    1. Column A: Account Number
    2. Column B: Meter Number
    3. Column C: Date and time of reading
    4. Column D: consumption in kWh for the time interval. (either hourly data or 15 minute data)

DATA REQUIREMENTS CONT.

.CSV and .XLSX Example

Account	Meter	RateCode	Account
100002	1261899	RES	100002
100003	1261898	RES	100003
100004	1261906	RES	100004

Account Information

.TXT Example

```
Account,Meter,RateCode
100002,1261899,RES
100003,1261898,RES
100004,1261906,RES
```

Account	Meter	DateTime	KWHr
100284	1260717	1/1/2017 1:00	0.544
100284	1260717	1/1/2017 2:00	0.4
100284	1260717	1/1/2017 3:00	0.497

Consumption Data

```
Account,Meter,DateTime,Energy
100284,1260717,01/01/2017 01:00 AM,0.544
100284,1260717,01/01/2017 02:00 AM,0.4
100284,1260717,01/01/2017 03:00 AM,0.497
```

Meter	Feeder
1259001	Feeder2
1259002	Feeder25
1259003	Feeder3

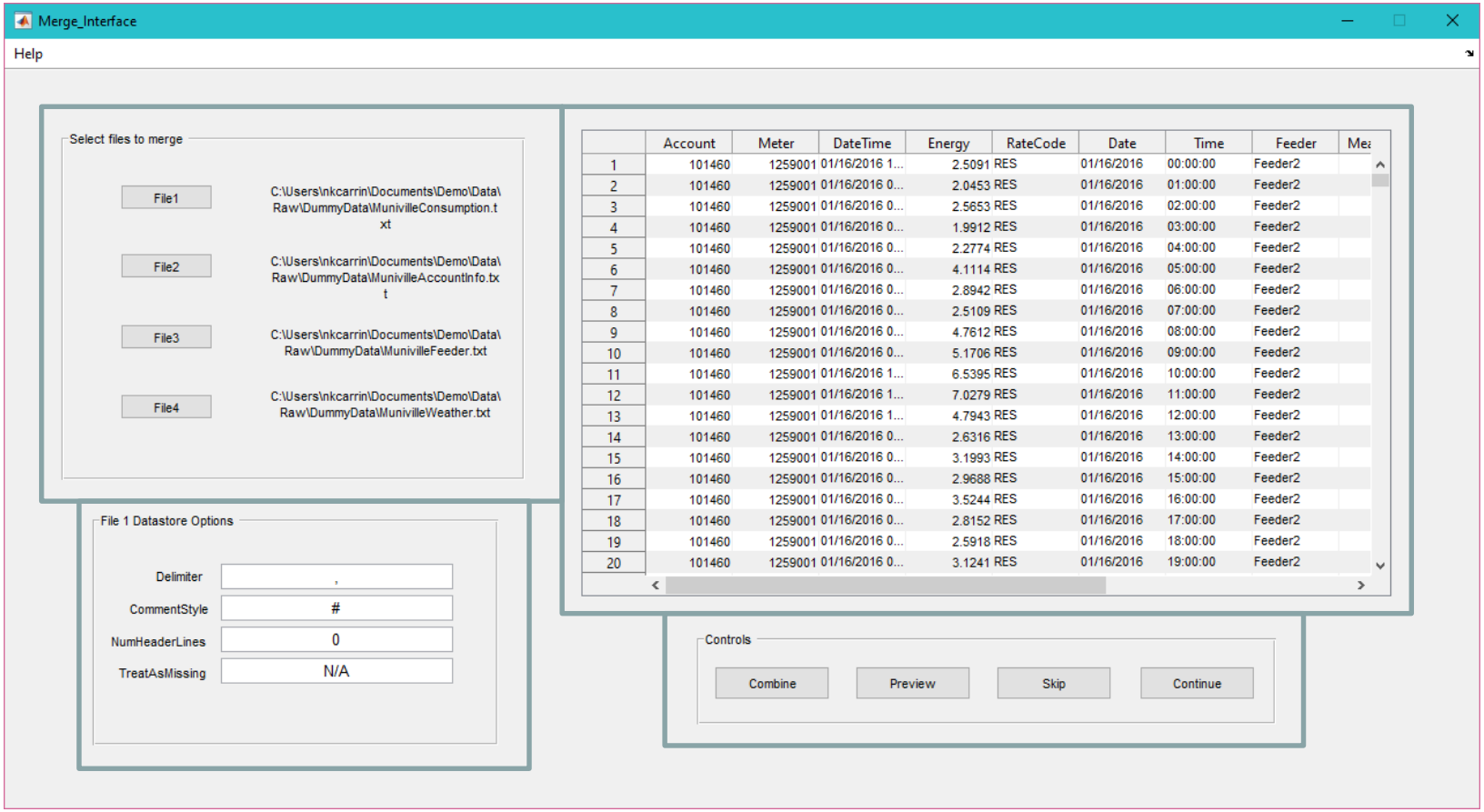
Feeder Information

```
Meter,Feeder
1259001,Feeder2
1259002,Feeder25
1259003,Feeder3
```

Date	MeanTemp	HDD	CDD
1/1/2017	3	62	0
1/2/2017	4	61	0
1/3/2017	-4	69	0

HDD/CDD Data

```
Date,MeanTemp,HDD,CDD,HighTemp,LowTemp
01/01/2017,3,62,0,1,-5
01/02/2017,4,61,0,3,-3
01/03/2017,-4,69,0,1,-1
```


Merge_Interface
Help
Select files to merge
File1
C:\Users\nkcarrin\Documents\Demo\Data\Raw\DummyData\MunivilleConsumption.txt
File2
C:\Users\nkcarrin\Documents\Demo\Data\Raw\DummyData\MunivilleAccountInfo.txt
File3
C:\Users\nkcarrin\Documents\Demo\Data\Raw\DummyData\MunivilleFeeder.txt
File4
C:\Users\nkcarrin\Documents\Demo\Data\Raw\DummyData\MunivilleWeather.txt
File 1 Datastore Options
Delimiter
,
CommentStyle
#
NumHeaderLines
0
TreatAsMissing
N/A
Account Meter DateTime Energy RateCode Date Time Feeder
1 101460 1259001 01/16/2016 1... 2.5091 RES 01/16/2016 00:00:00 Feeder2
2 101460 1259001 01/16/2016 0... 2.0453 RES 01/16/2016 01:00:00 Feeder2
3 101460 1259001 01/16/2016 0... 2.5653 RES 01/16/2016 02:00:00 Feeder2
4 101460 1259001 01/16/2016 0... 1.9912 RES 01/16/2016 03:00:00 Feeder2
5 101460 1259001 01/16/2016 0... 2.2774 RES 01/16/2016 04:00:00 Feeder2
6 101460 1259001 01/16/2016 0... 4.1114 RES 01/16/2016 05:00:00 Feeder2
7 101460 1259001 01/16/2016 0... 2.8942 RES 01/16/2016 06:00:00 Feeder2
8 101460 1259001 01/16/2016 0... 2.5109 RES 01/16/2016 07:00:00 Feeder2
9 101460 1259001 01/16/2016 0... 4.7612 RES 01/16/2016 08:00:00 Feeder2
10 101460 1259001 01/16/2016 0... 5.1706 RES 01/16/2016 09:00:00 Feeder2
11 101460 1259001 01/16/2016 1... 6.5395 RES 01/16/2016 10:00:00 Feeder2
12 101460 1259001 01/16/2016 1... 7.0279 RES 01/16/2016 11:00:00 Feeder2
13 101460 1259001 01/16/2016 1... 4.7943 RES 01/16/2016 12:00:00 Feeder2
14 101460 1259001 01/16/2016 0... 2.6316 RES 01/16/2016 13:00:00 Feeder2
15 101460 1259001 01/16/2016 0... 3.1993 RES 01/16/2016 14:00:00 Feeder2
16 101460 1259001 01/16/2016 0... 2.9688 RES 01/16/2016 15:00:00 Feeder2
17 101460 1259001 01/16/2016 0... 3.5244 RES 01/16/2016 16:00:00 Feeder2
18 101460 1259001 01/16/2016 0... 2.8152 RES 01/16/2016 17:00:00 Feeder2
19 101460 1259001 01/16/2016 0... 2.5918 RES 01/16/2016 18:00:00 Feeder2
20 101460 1259001 01/16/2016 0... 3.1241 RES 01/16/2016 19:00:00 Feeder2
Controls
Combine
Preview
Skip
Continue

Special Notes for Data requirements

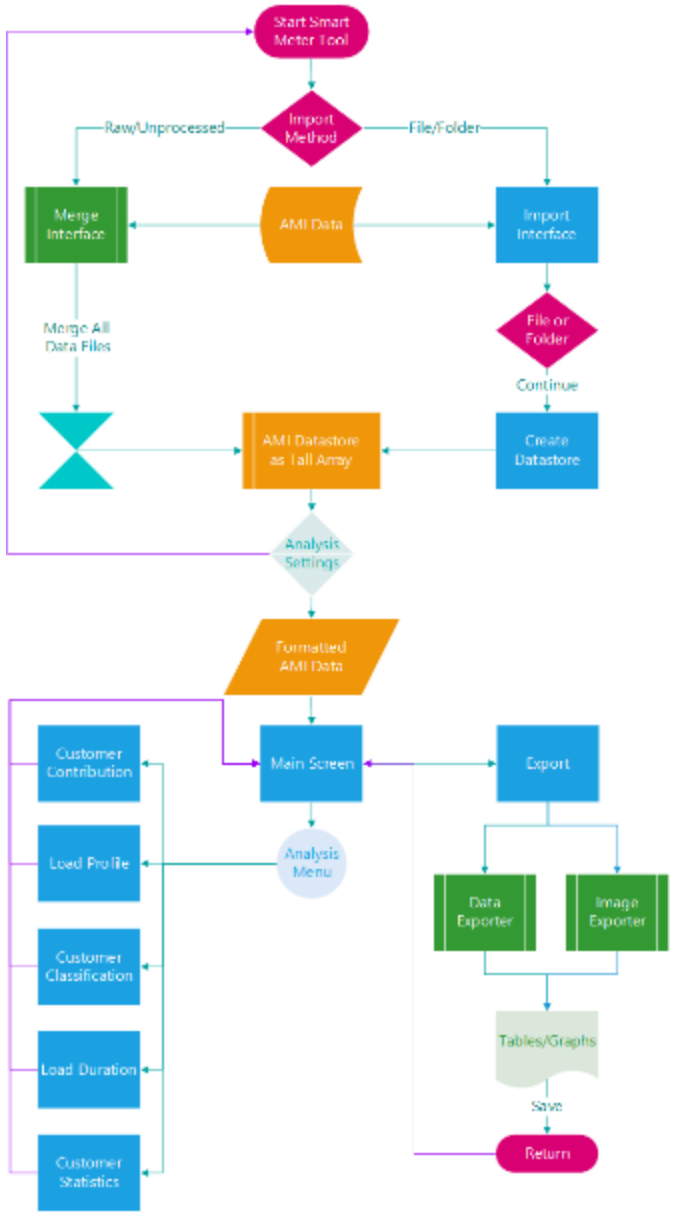
- Utility-provided data
  - Meter Data Multipliers. The program assumes that multipliers have been applied to the data.
  - Filter Customer-by-feeder information
- Other data sources
  - Publicly available data
- Troubleshooting
  - Several data files are merged together in the program.
  - For this to work correctly, spelling and capitalization must match across data files, and data also match in format. The requirements are detailed in the User Guide.

SOFTWARE ARCHITECTURE

Fundamental design for the flow of data throughout the tool.

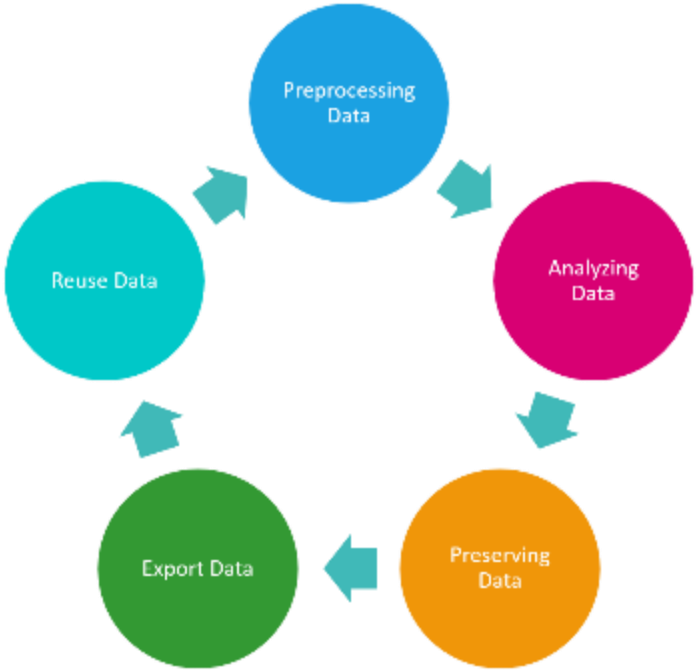
Overview of software design

The software architecture was modeled using a modified data management plan to ensure the user maintains uniform and complete data tables .
The software design is divided into four phases for data flow from import, filtering, analysis and exporting.
The graphical user interfaces (GUI) within the software tool simplify the handling of data from import to export.



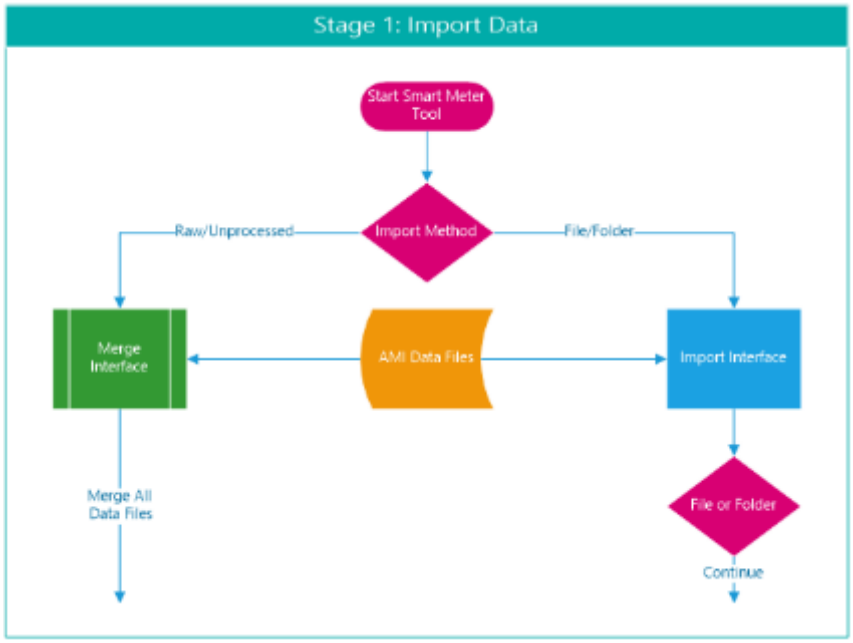
Modified Data Management Plan

- The preservation of the data during its use both within and outside of data is critical to maintain the integrity of the data.
- During the tool the data is preserved by calling from a global table and performing the analysis independently from one another.
- The tables are saved as Excel files that can be imported into Word, NotePad, WordPad, or Excel.



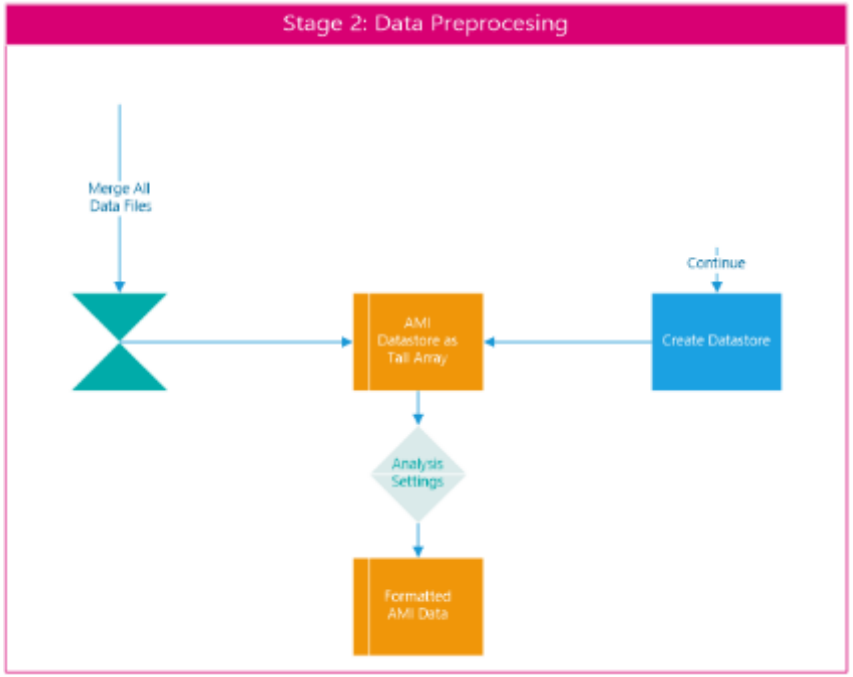
Stage 1: Import Data

- Data can be imported as either raw data files or data that has been previously formatted with the tool.
- The versatility of the import method between raw and preprocessed data was designed with the intended purposes of optimizing the integrity and uniformity of the AMI data.
- Reusing previously processed data increases efficiency by eliminating the need for a complete cleaning and formatting when reviewing data and results.



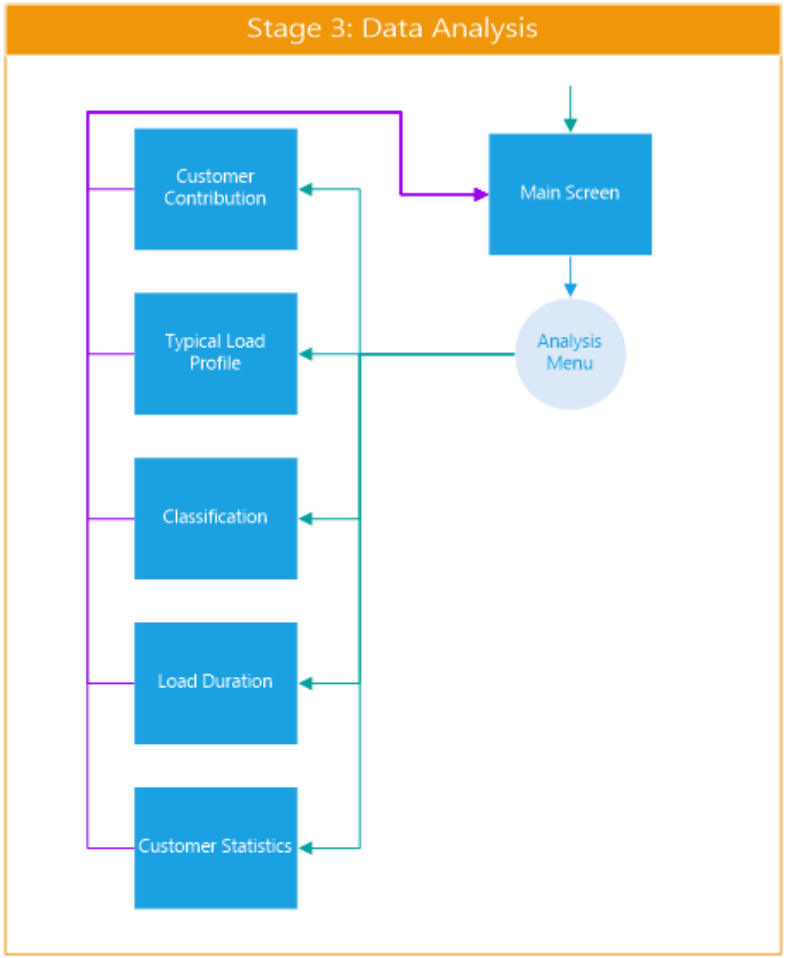
Stage 2: Data Preprocessing

- Data files are preprocessed using subroutines to format the data into a uniform information table which is then saved in a datastore internally within the tool, making the table a global variable.
- Global variables allow for all interfaces and processes to access the same table without changing the format or contents of the table.



Stage 3: Data Analysis

- There are 5 analyses available within the tool:
  - Load Duration
  - Customer Contribution
  - Typical Load Profile
  - Customer Classification
  - Customer Statistics
- Each GUI design include both a summary table of the analysis results to correspond to the graphical results provided.
- For the convenience of the utility, categories can be toggled on and off during selected analysis (such as Load Profile).
- This means that if the user wants to see only residential and industrial customers in an analysis they can turn off the results for all other categories.



Stage 4: Data Export

- The graphical and tabular results of all analyses and the formatting process can be exported for use of the utility.
- The user can select the format of the tabular results as .txt, .csv or .xlsx files.
- The graphical results can be saved as .png (Portable Network Graphics) images.