INTEGRATING AMI WITH GIS FOR ELECTRIC DISTRIBUTION TRANSFORMER LOAD MANAGEMENT

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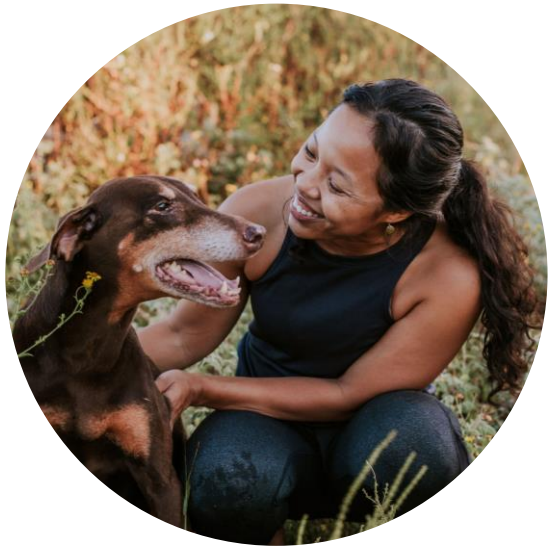
GEOG 596A | Fall 2020
Advisor | Pat Kennelly

Pennsylvania State University

Education
BS | *Wildlife Ecology and Conservation*
MS | *Organismal Biology*

Certificate | Geographic Information Systems
Certificate | Geospatial Programming and Web Map Development

Work
Local Government GIS | 10 years
Electric Utility GIS | 5 years



Family
Moxie | Rescue Doberman
Corwin | Leopard Gecko
Bryan | Husband Extraordinaire

Interests
Traveling | *Anywhere & Everywhere*
Florida Activities | *Camping, Hiking, All The Water Things*

Sue Ann Panton

GIS Analyst | Kissimmee Utility Authority

AGENDA

BACKGROUND

OBJECTIVES

STUDY AREA

WORKFLOW

ANTICIPATED RESULTS and DELIVERABLES

PROJECT TIMELINE

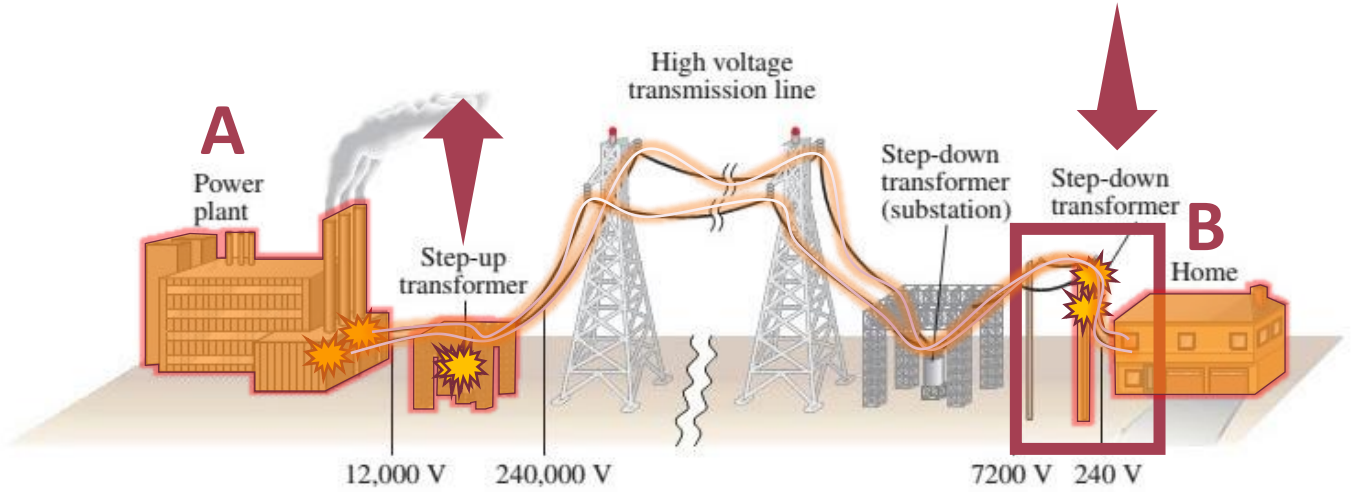
BACKGROUND

STEP-UP TRANSFORMER

Increase voltage and reduce current

STEP-DOWN TRANSFORMER

Reduces voltage before reaching end-user



Source : https://www.servostabilizer.org.in/what-is-step-down-transformer/

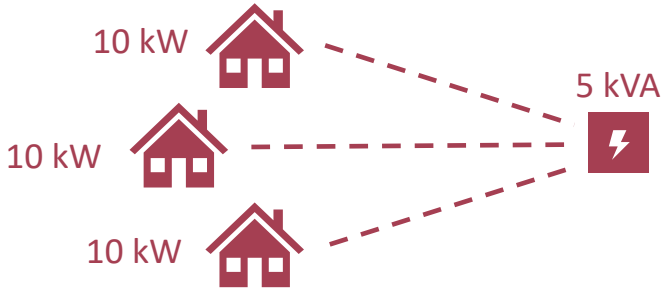
BACKGROUND

transformer load analysis

Analyze transformer consumption data against transformer capacity

OVERSIZED TRANSFORMER

- Excess fuel costs to the utility = $$



UNDERSIZED TRANSFORMER

- Life of the transformer is reduced
- Causes system outages
- Requires replacement = $$$$

Source: https://articles.utegration.com/case-study-sap-ami-implementation-transforms-a-multi-service-utility-for-the-future

BACKGROUND

electric meters

ANALOG ELECTRICITY METER

Energy consumption is collected manually on a monthly basis by a meter reader.

SMART METER

Utility can read, start, and stop services remotely.

Advanced Metering Infrastructure (AMI)

Smart meters record and transmit energy consumption to the utility throughout the day via a secure wireless network

BACKGROUND

Technology Limitations Stated in Literature	Work
Cost of software and other components, requires investment in hardware and IT equipment	Ashkezari, et al. (2018)
Requires frequent data collection resulting in protocol errors and bandwidth constraints	Balakrishna & Swarup (2020)
Consolidation of big data was a time-consuming task	Guerrero-Prado, et al. (2020)
Large volumes of data lead to increased potential of data errors and confusion	Lo, Huang & Lu (2014)
Requires robust methods for managing big data and quality models	Peppanen, et al. (2015)
Big Data challenge is efficiently managing data flows	Peppanen, et al. (2016)
Hardware and software limitations exist; storing and managing data	Triplett, Rinell & Foote (2010)

Table 1. Technologies and their limitations used to incorporate Advanced Metering Infrastructure (AMI) data within a GIS.

OBJECTIVES

comparative analysis

Determine if distribution engineering design standards used are still valid based on actual customer usage within areas of single-family residence.

spatial analysis

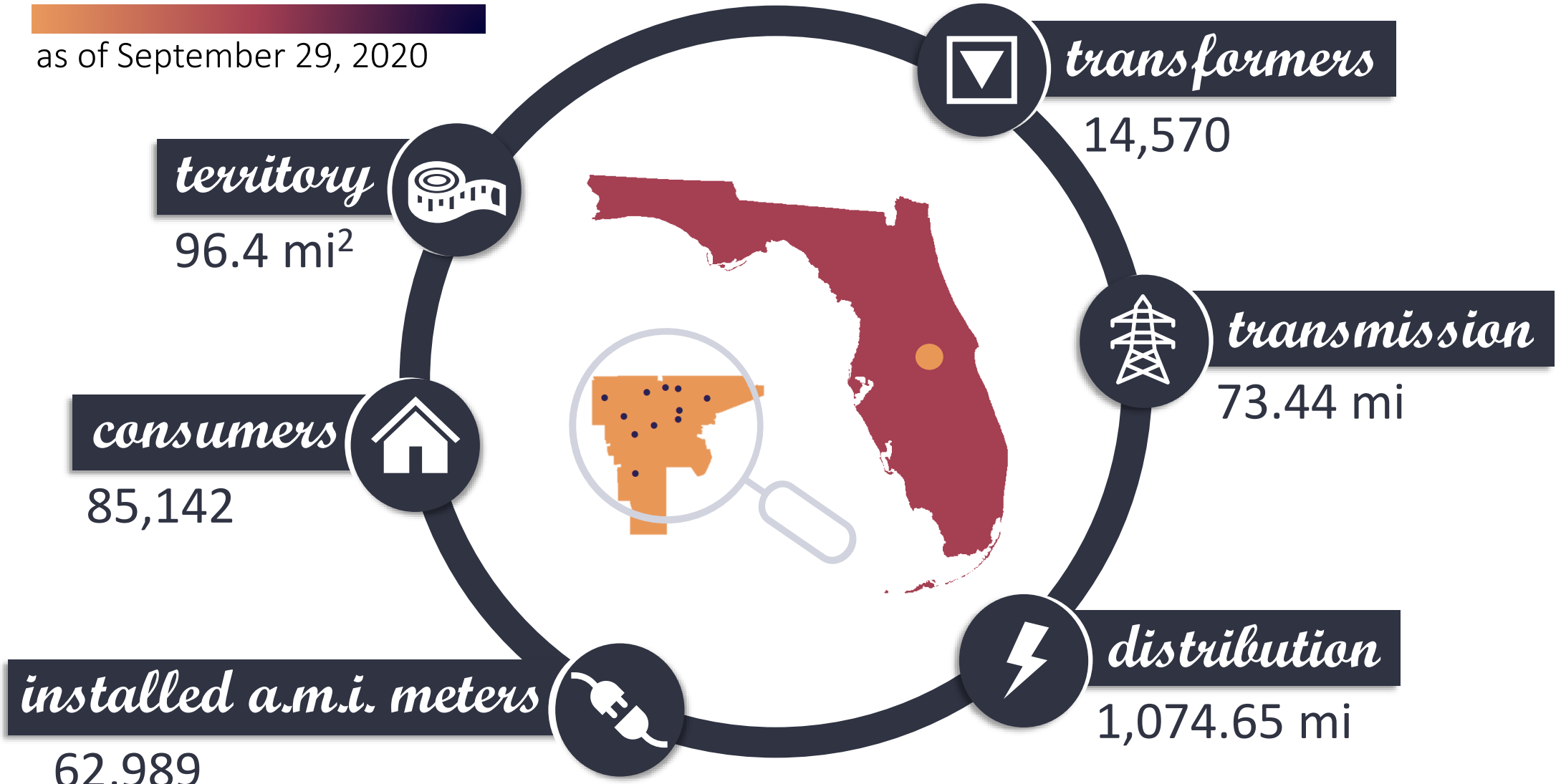
Improve criteria used when placing an appropriately sized transformer.

custom application

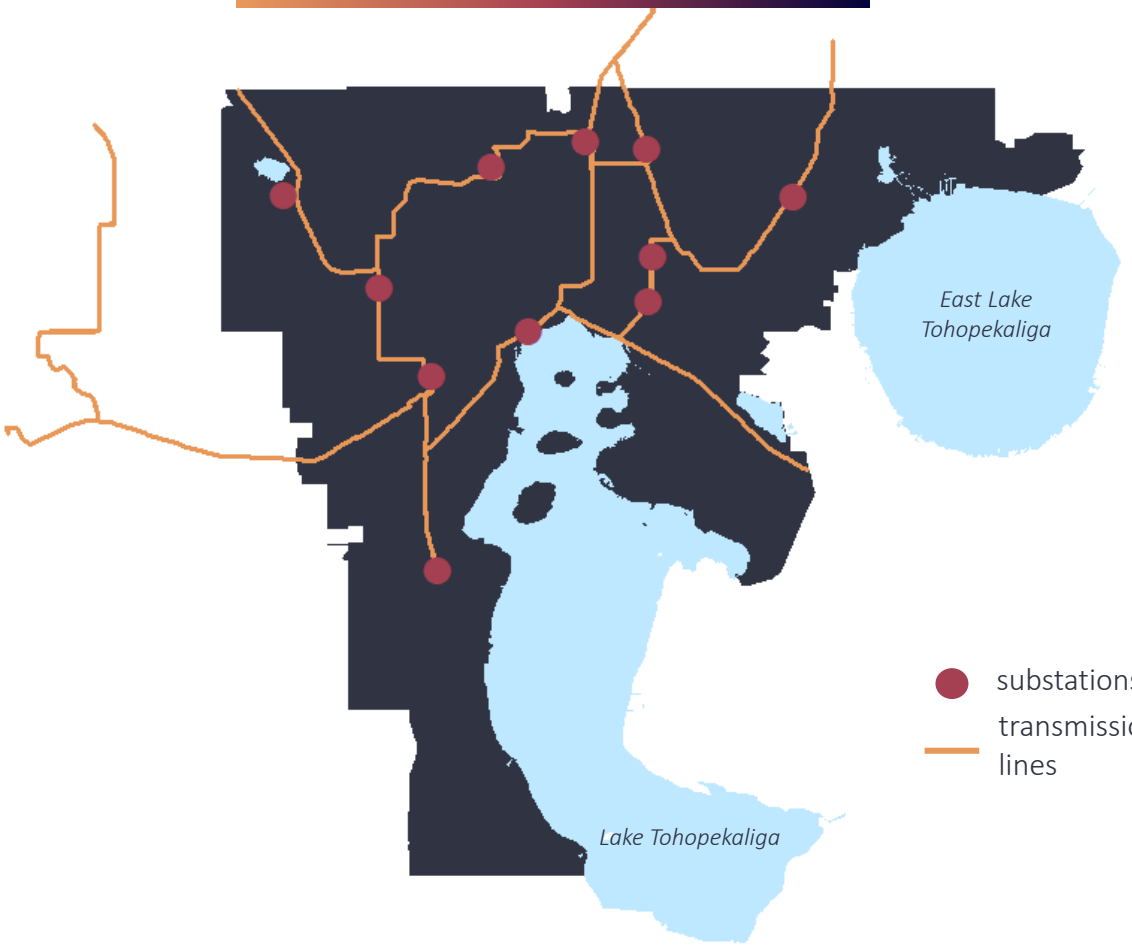
Aid our engineers in identifying areas which may require electric reconstruction to avoid future power-related issues.

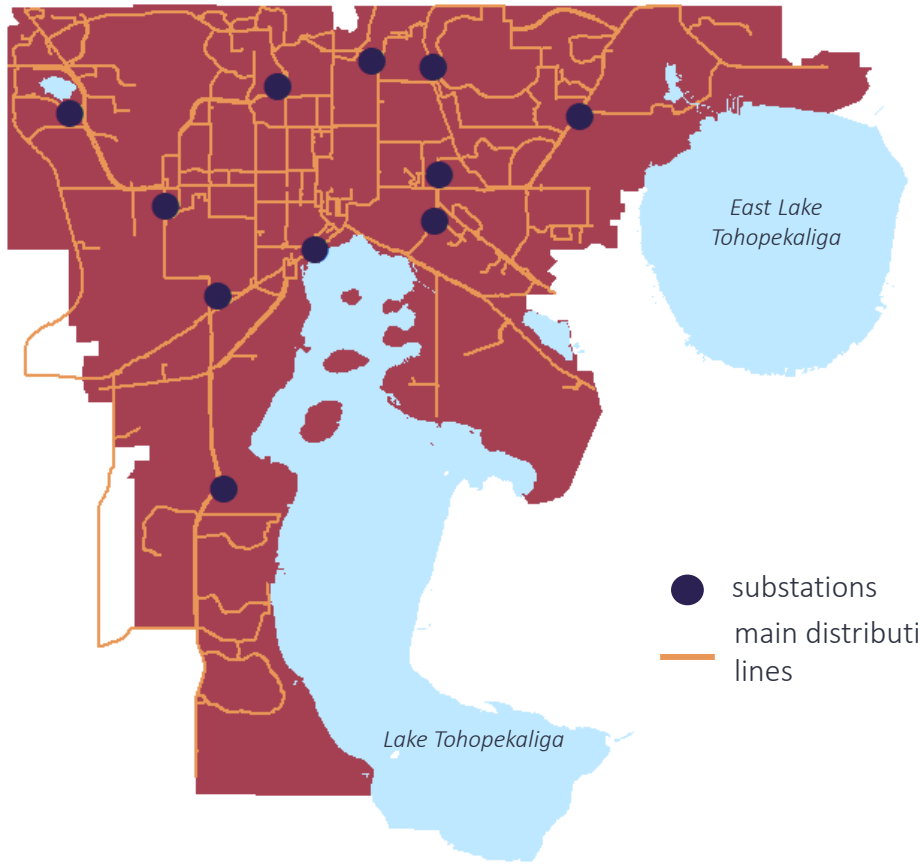
STUDY AREA

as of September 29, 2020



STUDY AREA





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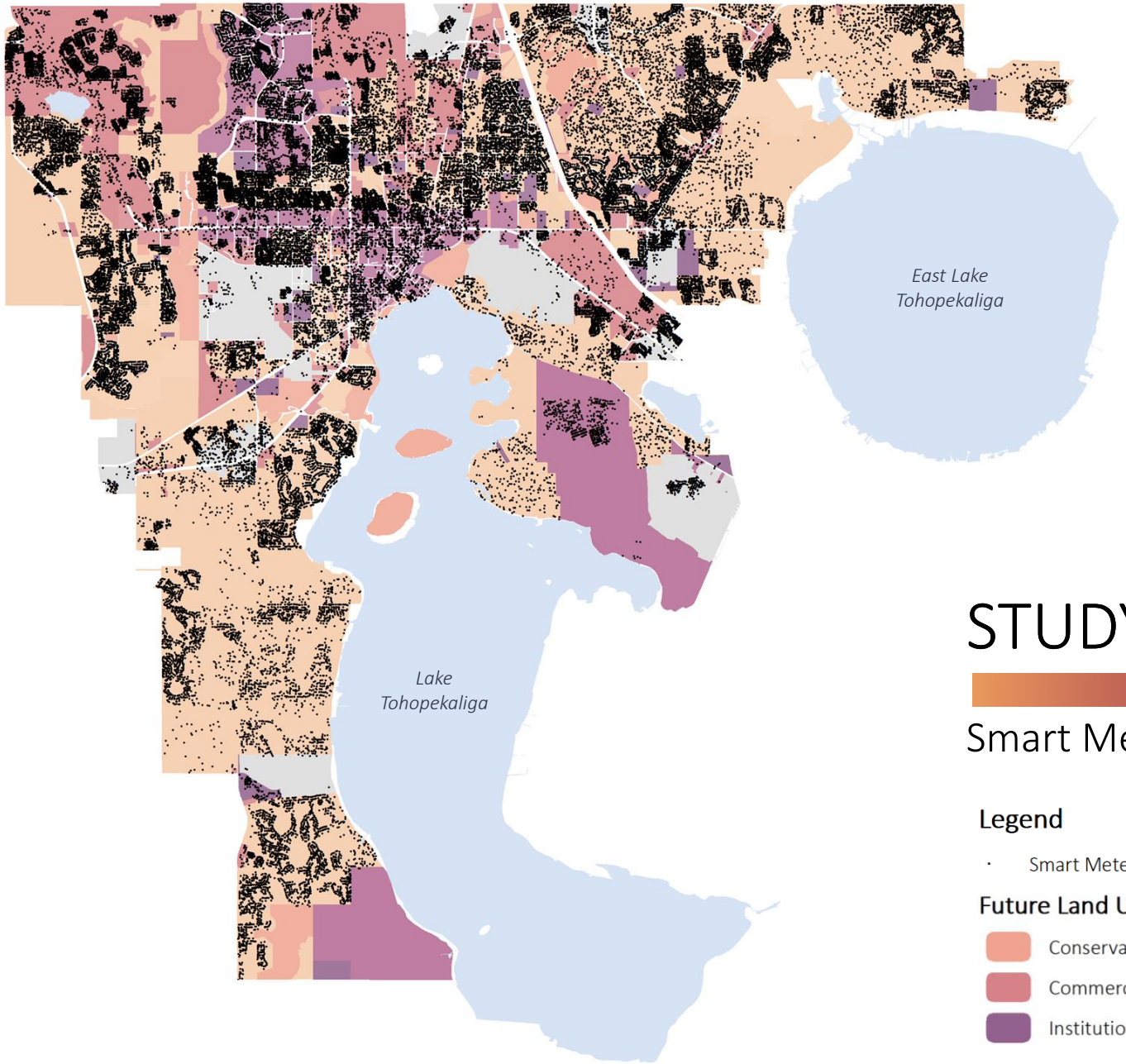


STUDY AREA

Smart Meters Overlaid on Future Land Use

Legend

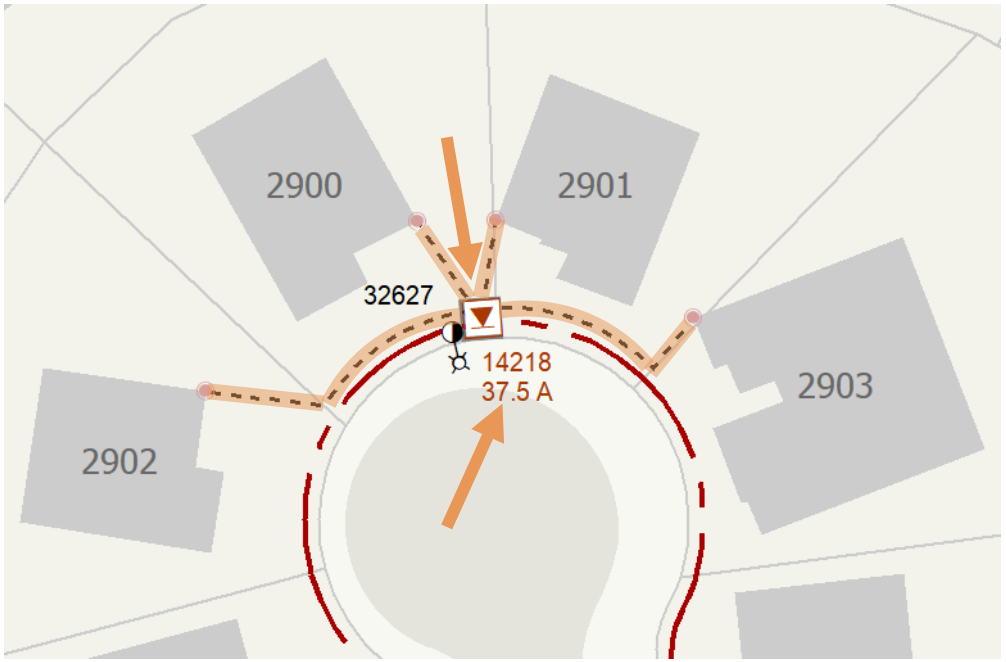
- Smart Meter Installed

Future Land Use

- Conservation
- Commercial
- Institutional
- Mixed Use
- Residential
- Other

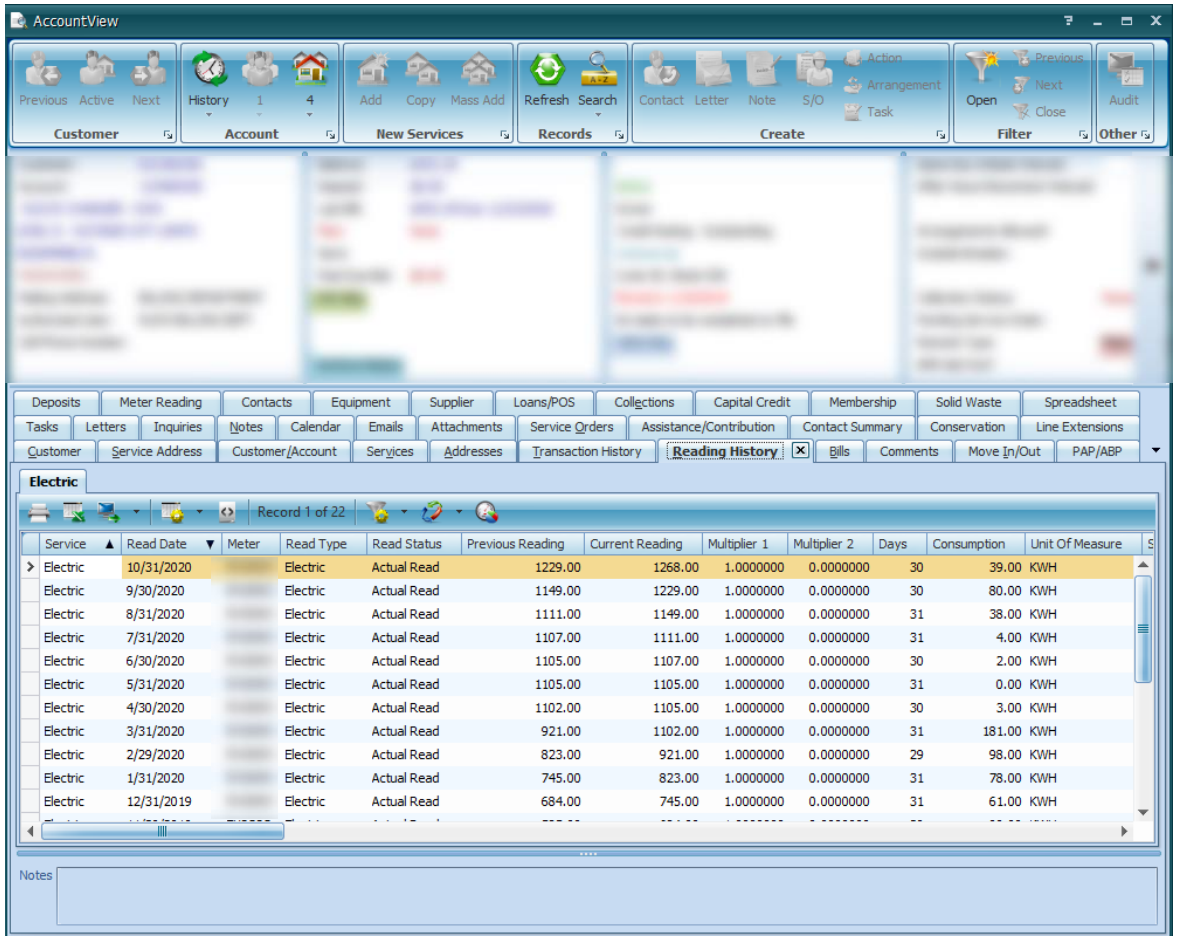
CURRENT SYSTEM

GIS



CURRENT SYSTEM

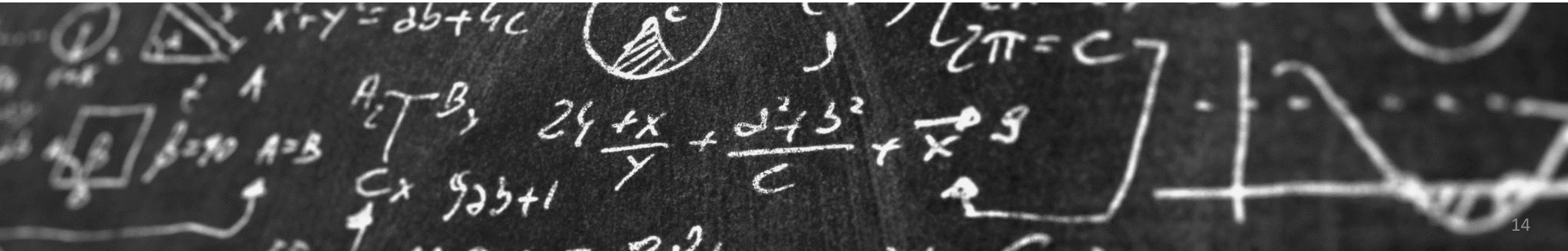
CIS (Customer Information & Billing Software)



Service	Read Date	Meter	Read Type	Read Status	Previous Reading	Current Reading	Multiplier 1	Multiplier 2	Days	Consumption	Unit Of Measure
Electric	10/31/2020		Electric	Actual Read	1229.00	1268.00	1.0000000	0.0000000	30	39.00	KWH
Electric	9/30/2020		Electric	Actual Read	1149.00	1229.00	1.0000000	0.0000000	30	80.00	KWH
Electric	8/31/2020		Electric	Actual Read	1111.00	1149.00	1.0000000	0.0000000	31	38.00	KWH
Electric	7/31/2020		Electric	Actual Read	1107.00	1111.00	1.0000000	0.0000000	31	4.00	KWH
Electric	6/30/2020		Electric	Actual Read	1105.00	1107.00	1.0000000	0.0000000	30	2.00	KWH
Electric	5/31/2020		Electric	Actual Read	1105.00	1105.00	1.0000000	0.0000000	31	0.00	KWH
Electric	4/30/2020		Electric	Actual Read	1102.00	1105.00	1.0000000	0.0000000	30	3.00	KWH
Electric	3/31/2020		Electric	Actual Read	921.00	1102.00	1.0000000	0.0000000	31	181.00	KWH
Electric	2/29/2020		Electric	Actual Read	823.00	921.00	1.0000000	0.0000000	29	98.00	KWH
Electric	1/31/2020		Electric	Actual Read	745.00	823.00	1.0000000	0.0000000	31	78.00	KWH
Electric	12/31/2019		Electric	Actual Read	684.00	745.00	1.0000000	0.0000000	31	61.00	KWH

WORKFLOW

1. connect AMI peak data to consumer feature class in GIS
2. populate summarized AMI data within transformer feature class
3. identify undersized transformers
4. create a webapp display of identified transformers
5. engineers to determine if current design standards require updating
6. spatial and statistical analysis to find potential patterns of use

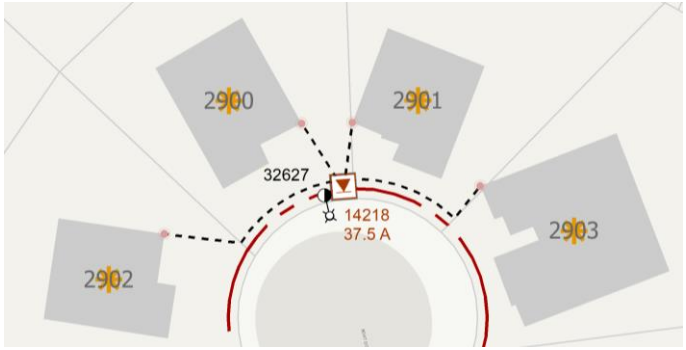


WORKFLOW

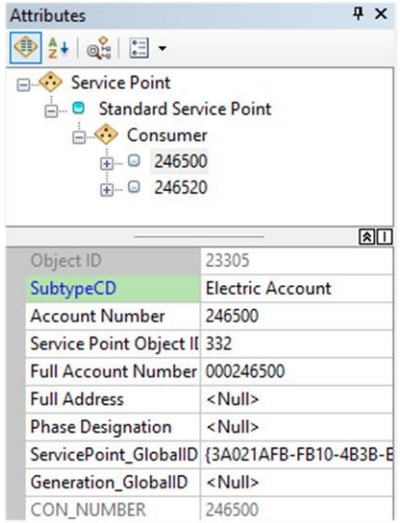
1 connect AMI peak data to consumer feature class in GIS

```
H|4324|1.0.0
D|0149925402|123462760A|0.8.15.6.1.1.8.0.0.0.0.0.0.0.0.3.38.0|3.0.0|20200921062100|127.99|
D|0149925402|123462760A|0.0.0.1.1.1.12.0.0.0.0.0.0.0.0.3.72.0|3.0.0|20200924000000|249708|
D|0149925402|123462760A|0.0.0.1.19.1.12.0.0.0.0.0.0.0.0.3.72.0|3.0.0|20200924000000|162163|
D|0149925403|123461310A|0.8.15.6.1.1.8.0.0.0.0.0.0.0.0.3.38.0|3.0.0|20200919153700|35.77|
```

Join MDMS extract data to Consumer



Populate data from joined Consumer into Service Points



Consumer to Service Point relationship

Copy Linked Record

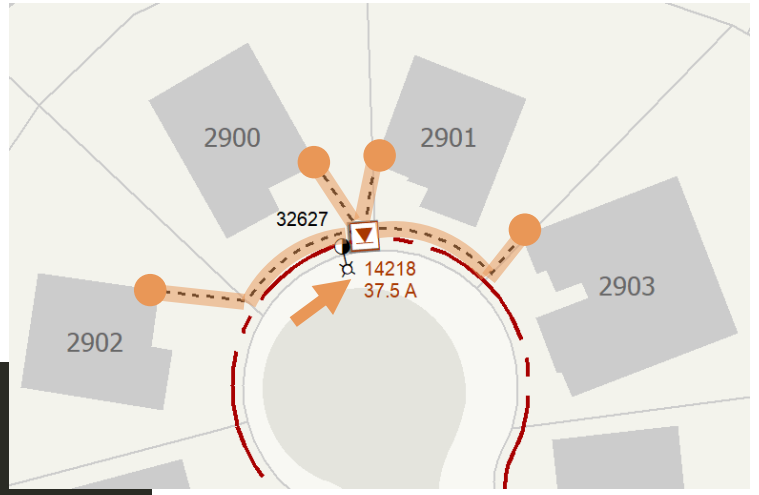
Updates an attribute of a feature with a value from a related table.

To configure this method, populate the following in the DynamicValue table:

Table Name	Field Name	Value Method	Value Info
Feature class to which value will be copied to from the source or related table	Field to store the copied value	COPY_LINKED_RECORD	Source|Source Field|Primary Key|Foreign Key

Attribute Assistant's Copy Linked Record function

WORKFLOW



2 populate summarized AMI data within transformer feature class

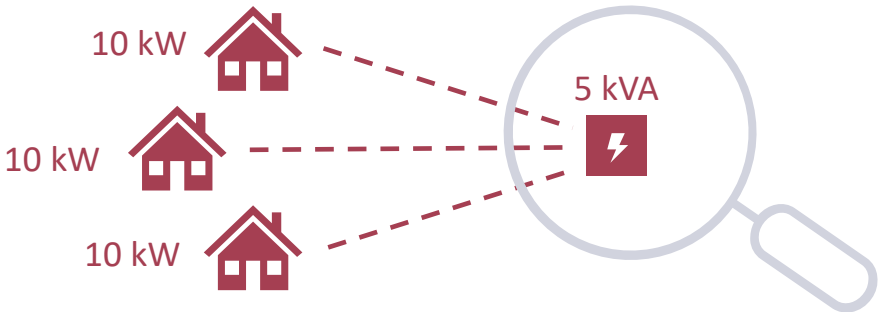
```
["List", "of", "transformers"]

Loop through list, for each transformer:
    Make Feature Layer tool of single transformer to be used as Flag
    Trace Geometric Network tool (result:  all service points downstream are selected):
        Flags - as created above | Trace Task Type - TRACE_DOWNSTREAM | Disable unneeded feature classes from trace
    Copy Features tool to create feature class of all downstream service points
    Summary Statistics tool to sum all peak data
    Update Cursor to populate transformer with peak data sum
```

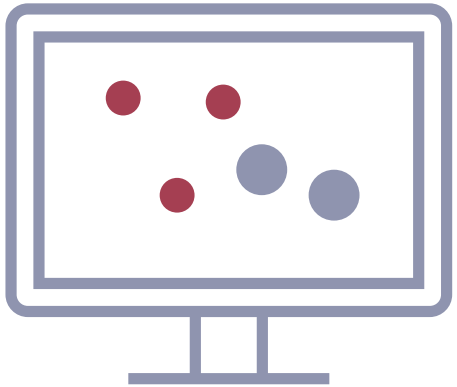
Pseudocode to populate peak data within transformer feature class

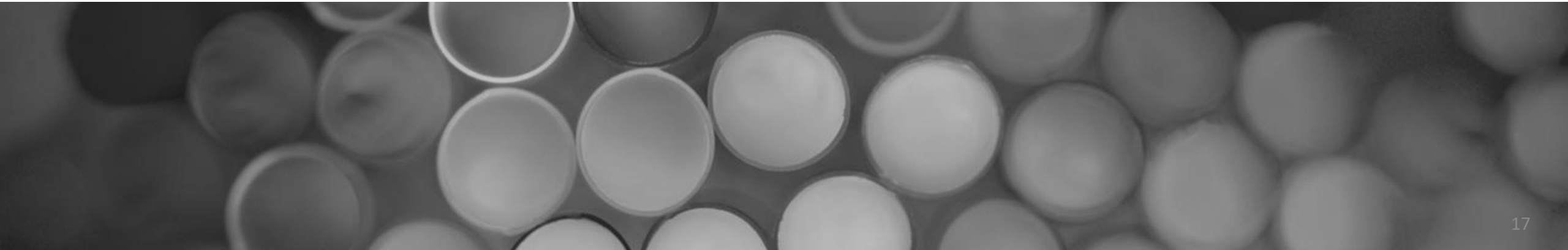
WORKFLOW

3 identify undersized transformers



4 create a web application display of identified transformers



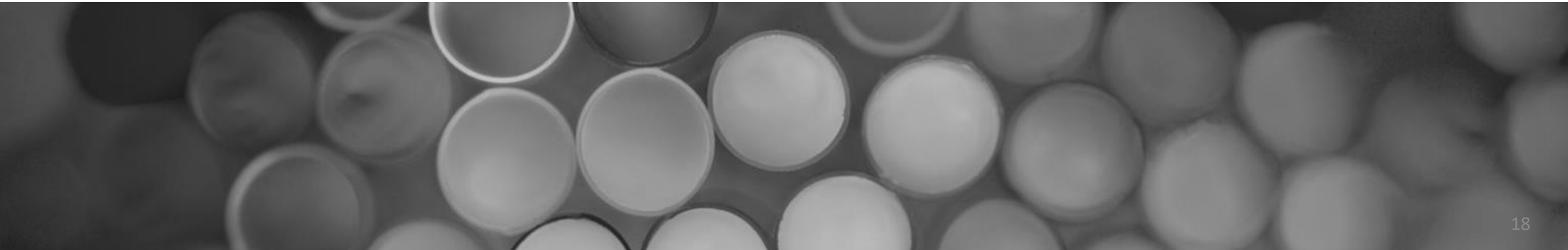


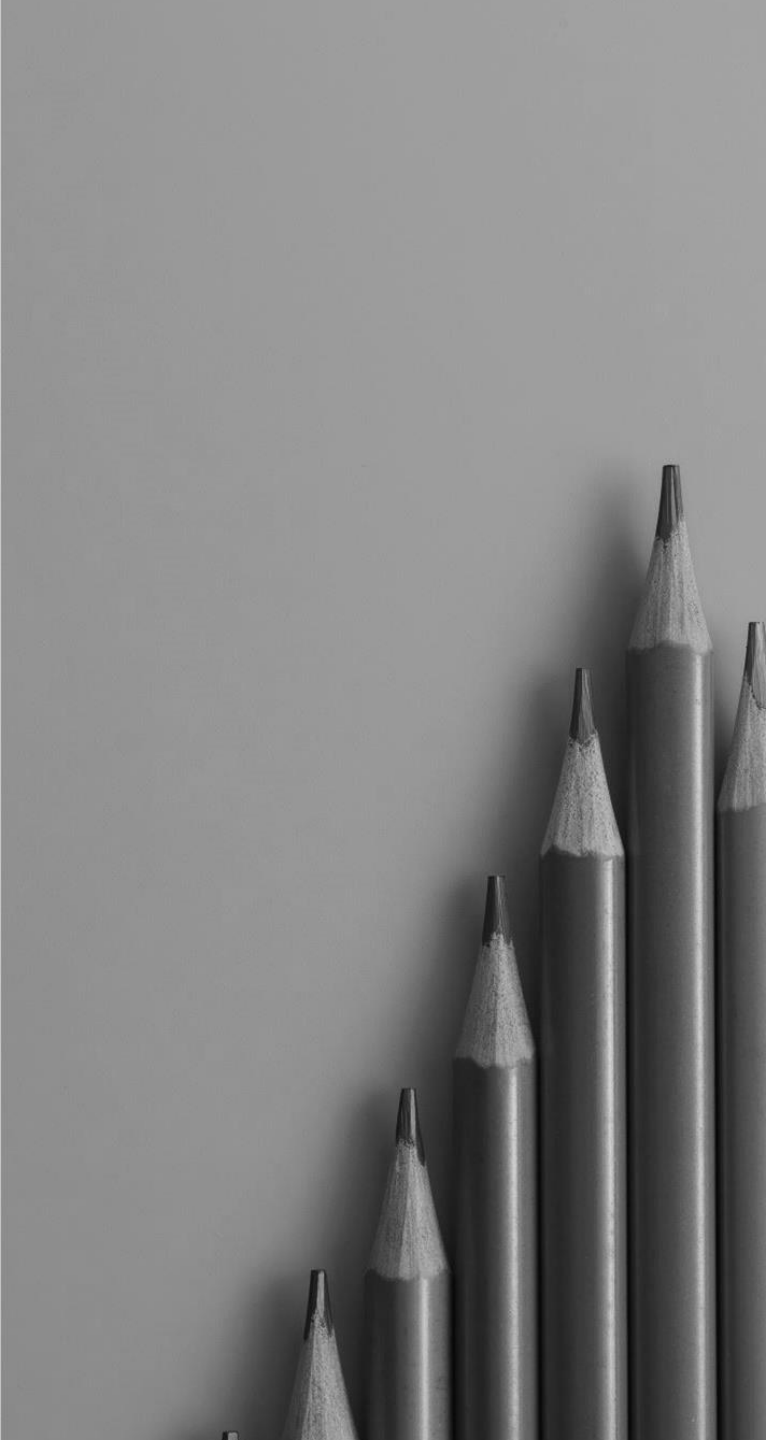
WORKFLOW

5 engineers to determine if current design standards require updating

6 spatial and statistical analysis to find pattern

- Kernel Density Estimation
- Distance Based Analysis with Monte Carlo Assessment
- Regression Analysis
- Chi-Square Test





WORKFLOW - DATA SETS

MDMS EXTRACT FILE

CONSUMER

TRANSFORMER

MISCELLANEOUS ELECTRIC DATASETS

ADDITIONAL DATASETS

ANTICIPATED RESULTS and DELIVERABLES

spatial & statistical analysis

Reveal patterns through exploratory analysis which will further improve criteria currently used when placing an appropriately sized transformer.

- Kernel Density Estimation
- Distance Based Analysis with Monte Carlo Assessment
- Regression Analysis
- Chi-Square Test

Map Graph Equation Table

ANTICIPATED RESULTS and DELIVERABLES

web application

- Color-coded (Table 2) thematic map
- Show patterns of peak use
  - Identify transformers that are at high risk of power-related failure
  - Pinpoint areas requiring reconstruction

Color	Percentage Loading	Representation
Green	< 80%	Safe operation
Yellow	80% - 90%	Heavily loading operation
Orange	90% - 95%	Noticing operation
Red	95% - 100%	Warning operation
Black	> 100%	Overloading operation

Table 2. Symbology established by Su et al. (2017) for symbolization of distribution transformer operation conditions.

PROJECT TIMELINE

PHASE 1	PHASE 2	PHASE 3	PHASE 4
JANUARY 2021	MARCH 2021	MAY 2021	JULY 2021
COMPILE & PREPARE DATA	ANALYZE DATA	BUILD APPLICATION & DEVELOP FINAL PROJECT	PRESENTATION | 2021 ESRI UC

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QUESTIONS

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THANK YOU