NREL
NATIONAL RENEWABLE ENERGY LABORATORY

“Realistic but not Real”: Comprehensive electrical distribution datasets of the future

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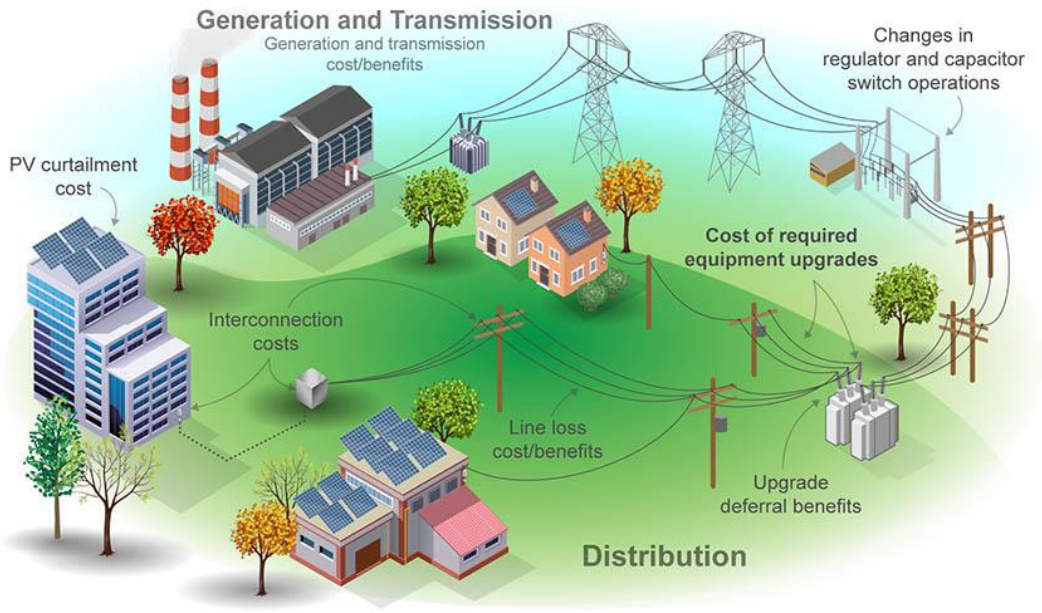
Bryan Palmintier, Nadia Panossian

PSERC Webinar
February 15th, 2022

PSERC

Distribution System Basics

- Substations: Drop the voltage to 4kV, 12.47kV, 13 kV etc. from transmission
- Feeders: Transport power from substation to customers. Normally around 4-8 per substation. Range between 1-24
- Primaries: Section of feeder connecting substation to service transformers. 1, 2 or 3 phase.
- Distribution transformers: Drop voltage to 480V, 240V or 120V. Many configurations (two phase input, one phase and neutral (center tap), three phase etc.)
- Secondaries: Section of feeder connecting low voltage customers to distribution transformers.



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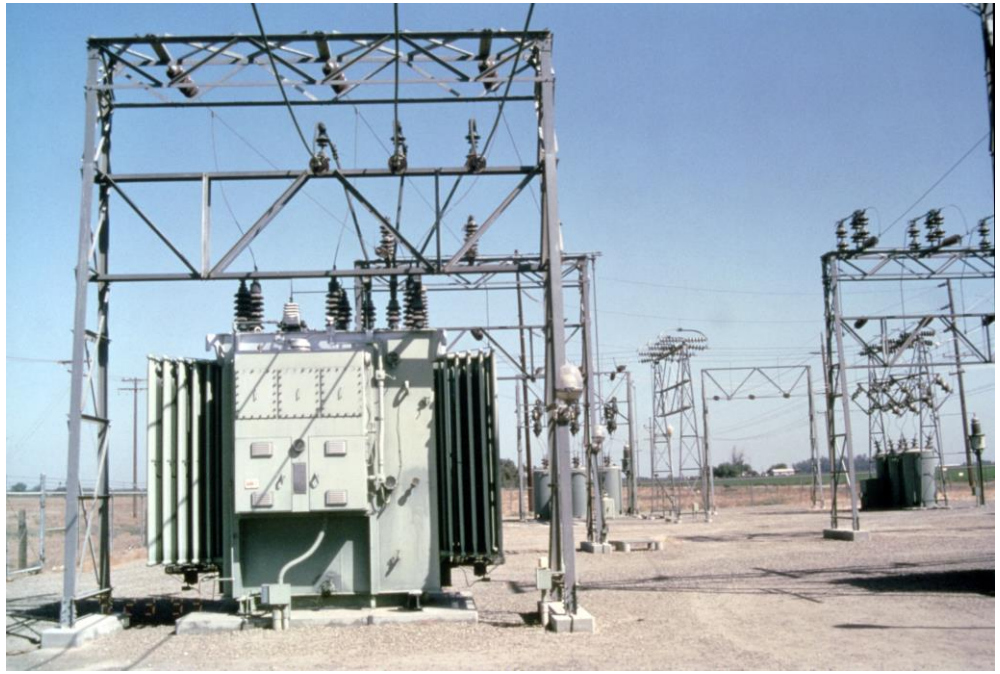

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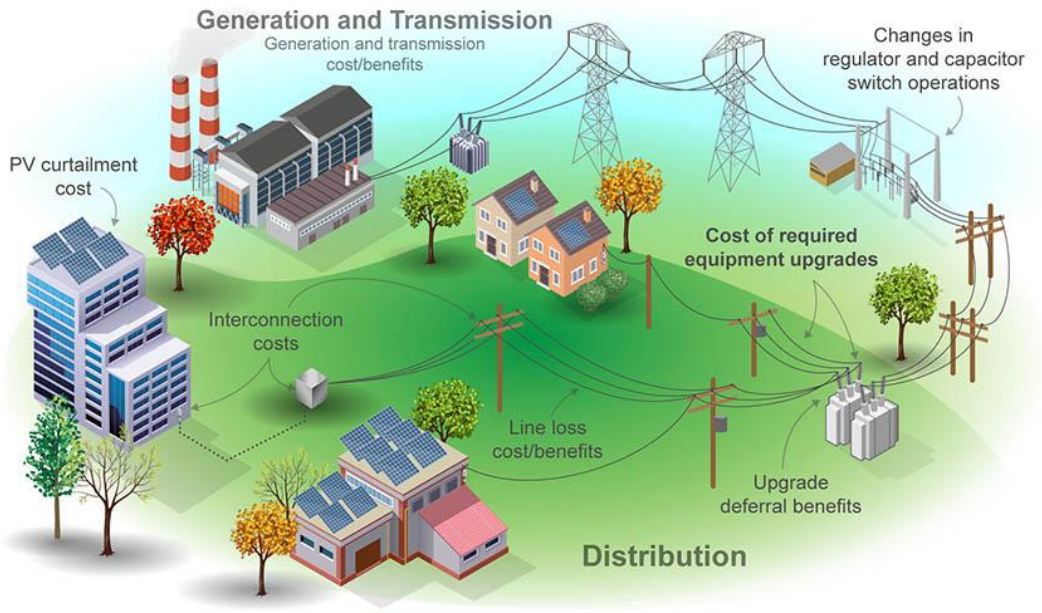

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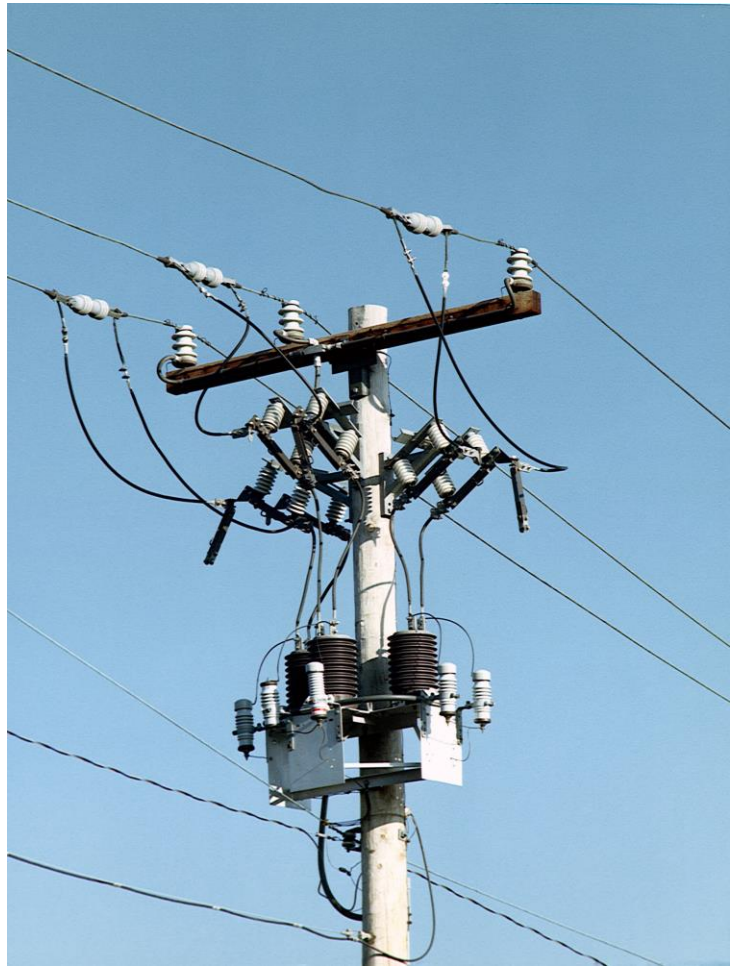

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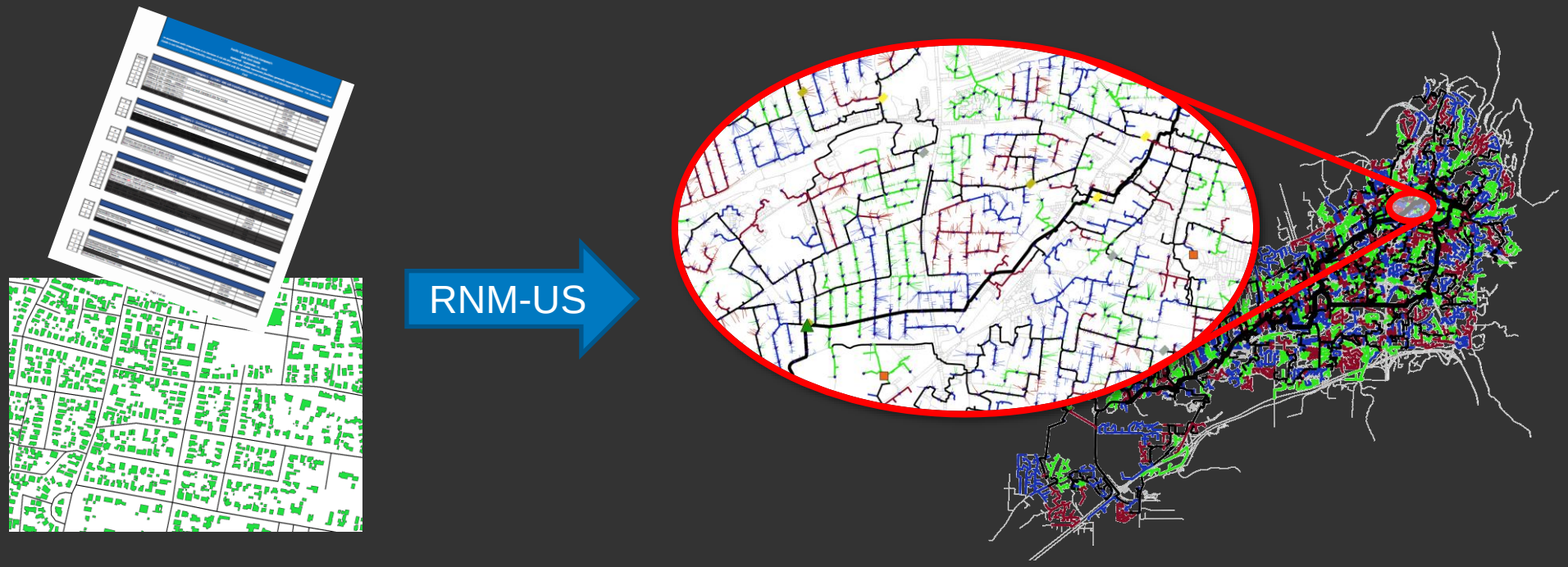
The Problem

- Distribution data is hard to obtain from utilities
- It can be incomplete
- Timeseries data is often not recorded
- Comparisons of utility studies are difficult
- Single feeder test systems lack the complexity and scale of utility-sized networks

The Smart-DS Solution:



Build large-scale, high-quality, open-source, “Realistic but not real” synthetic distribution* test systems from building/street map data and realistic equipment & design practices.

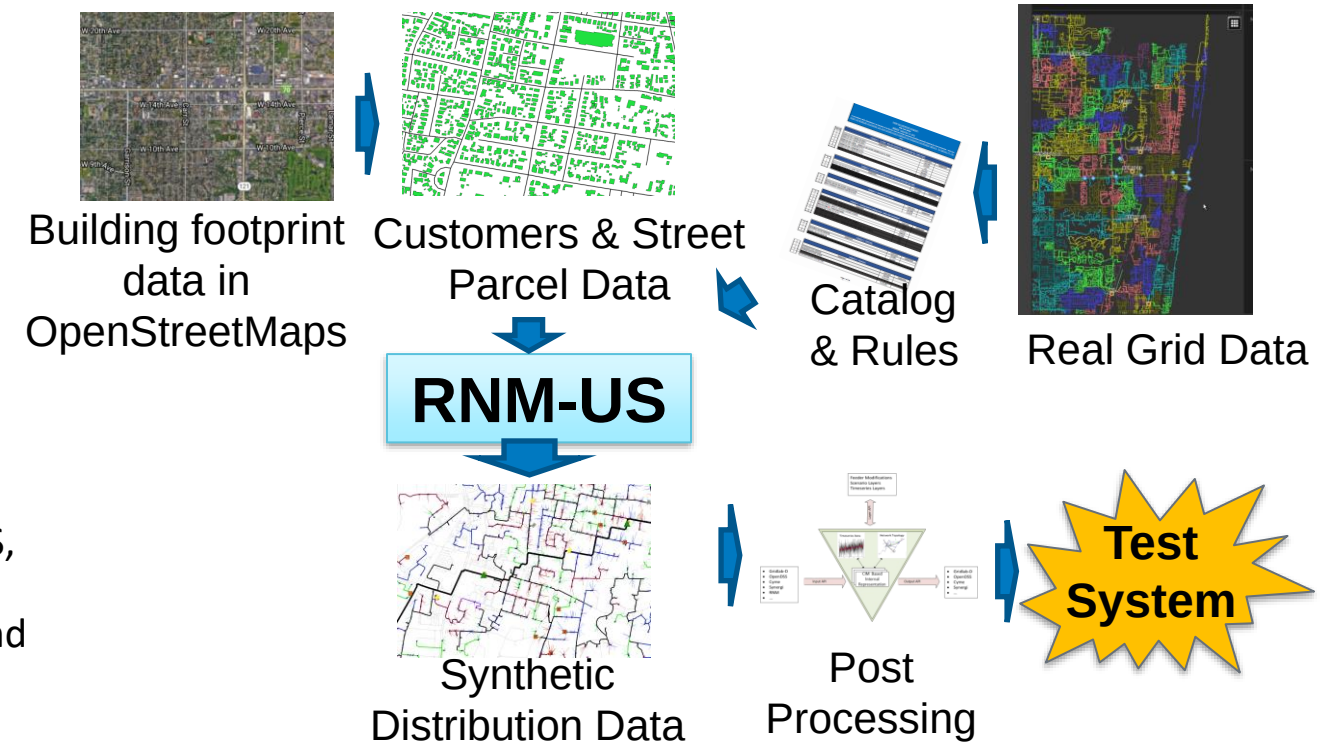
**Note: Other GRID DATA Projects are building open transmission data*

SMART-DS: Comprehensive, Large Scale Realistic Distribution Systems

"Realistic but not real" full-scale, high-quality synthetic distribution system dataset(s) for testing advanced grid algorithms and technology analysis

Containing:

- Substation internals
- Sub-transmission connecting substations
- Multiple feeders from substation with open switches between feeders.
- Secondaries
- Diversity in rural, urban configurations, voltage classes and delta vs/ wye configurations
- Multiple load customer types
- Fuses, Reclosers, Switches
- Regulators and Capacitors
- 100+ substations, 500+ feeders, **1M+ customers**
- Timeseries Load and Solar data
- Data in multiple formats (currently OpenDSS, CYME and Geojson)
- Feeder Metadata (including size, average land value, customer classes)
- Summary metrics of each feeder
- Selection of different locations for DERs, Electric Vehicles, faults etc.



Dataset Creation

Input data: Consumers & street map

Transmission substation
HV/MV Substation
Distribution transformer
Voltage regulator
Capacitor
Sub-transmission network
Three-phase medium voltage
Single-phase medium voltage (A/B/C)
Three-phase low voltage
Single-phase low voltage (A/B/C)

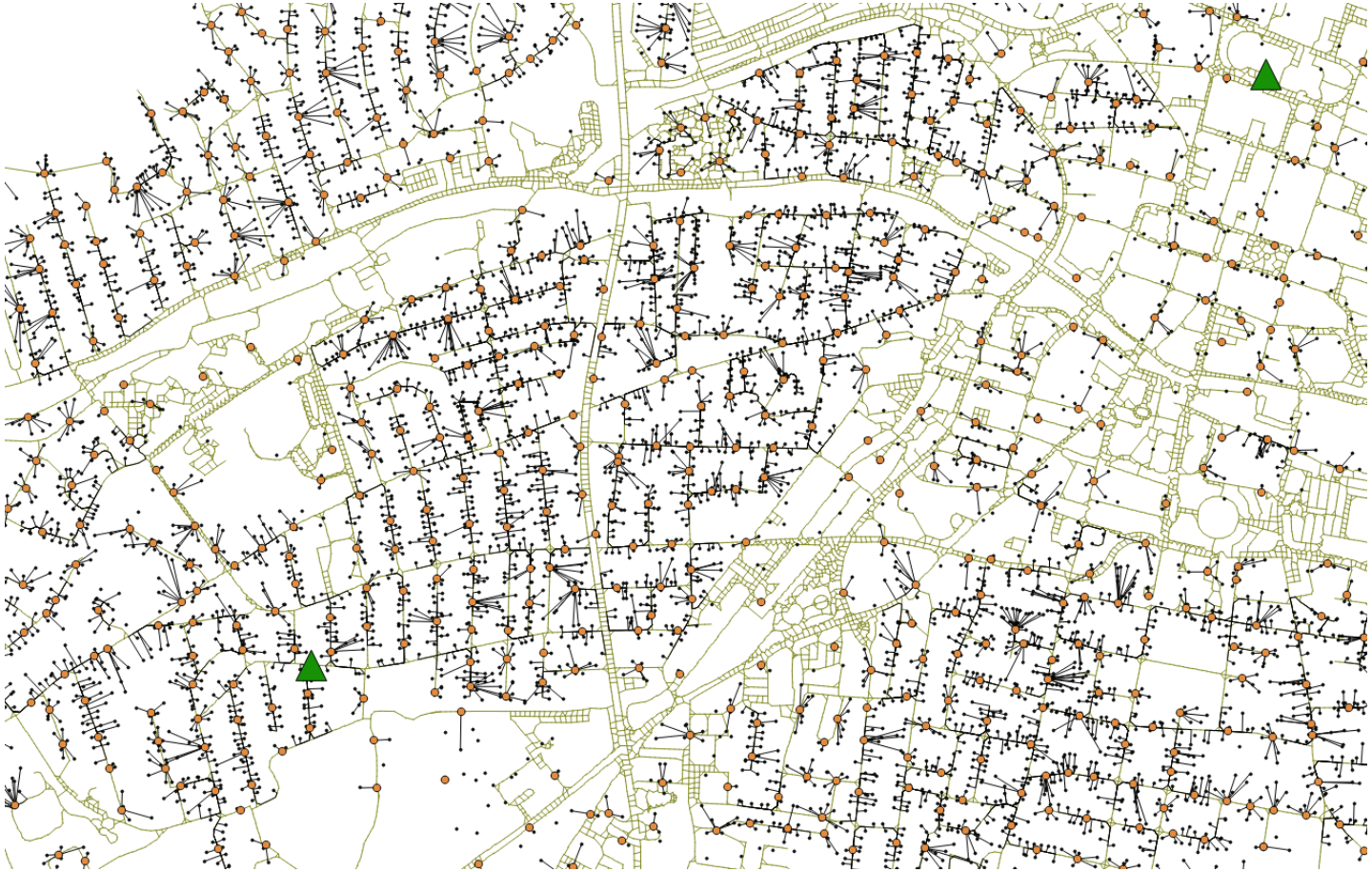
Distribution Transformers

Transmission substation
HV/MV Substation
Distribution transformer
Voltage regulator
Capacitor
Sub-transmission network
Three-phase medium voltage
Single-phase medium voltage (A/B/C)
Three-phase low voltage
Single-phase low voltage (A/B/C)

Low Voltage Network

Transmission substation
HV/MV Substation
Distribution transformer
Voltage regulator
Capacitor
Sub-transmission network
Three-phase medium voltage
Single-phase medium voltage (A/B/C)
Three-phase low voltage
Single-phase low voltage (A/B/C)

Distribution Transformers



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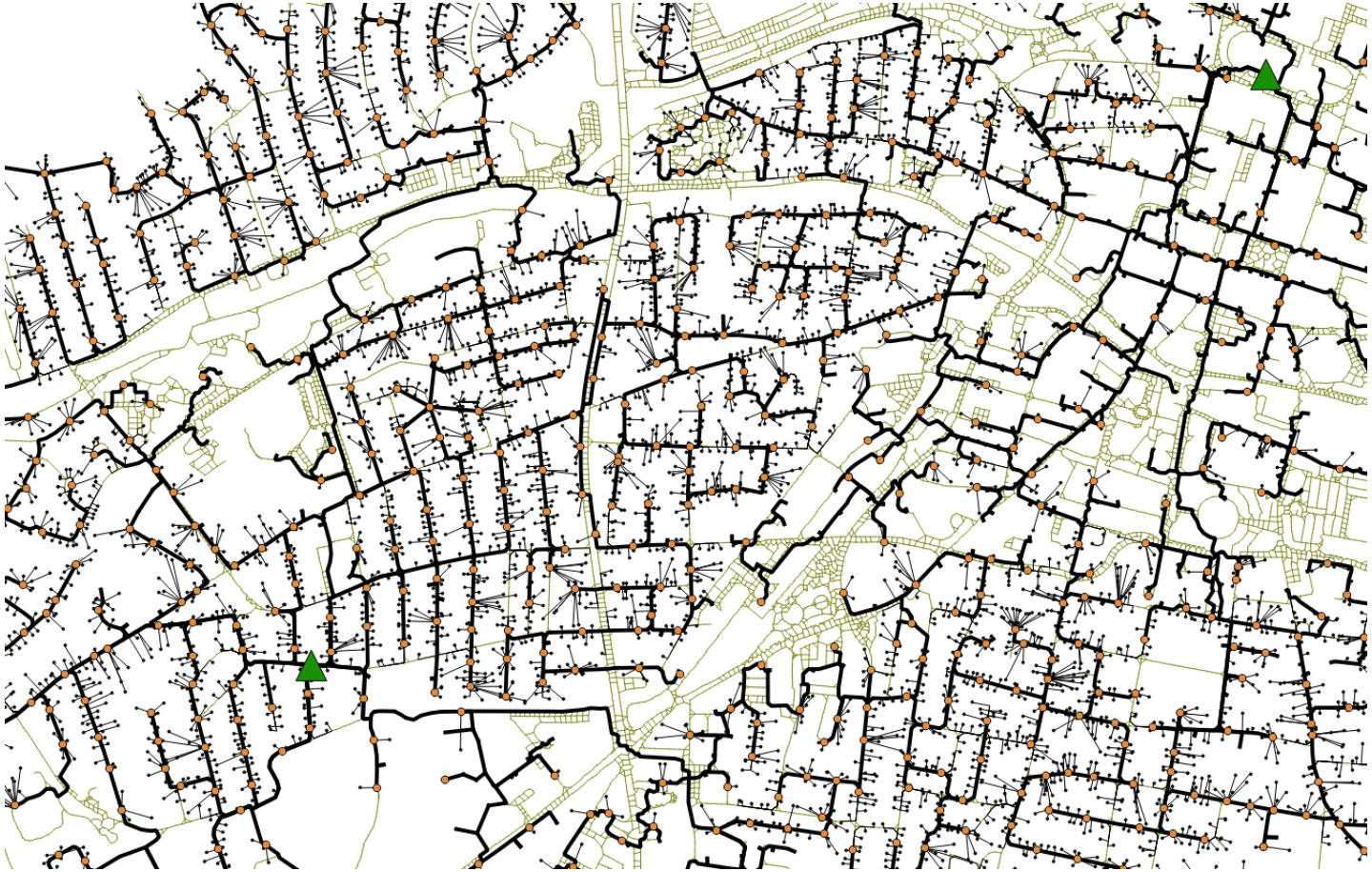
HV/MV Substation
Distribution transformer
Voltage regulator
Capacitor
Sub-transmission network
Three-phase medium voltage
Single-phase medium voltage (A/B/C)
Three-phase low voltage
Single-phase low voltage (A/B/C)

Medium Voltage Topology



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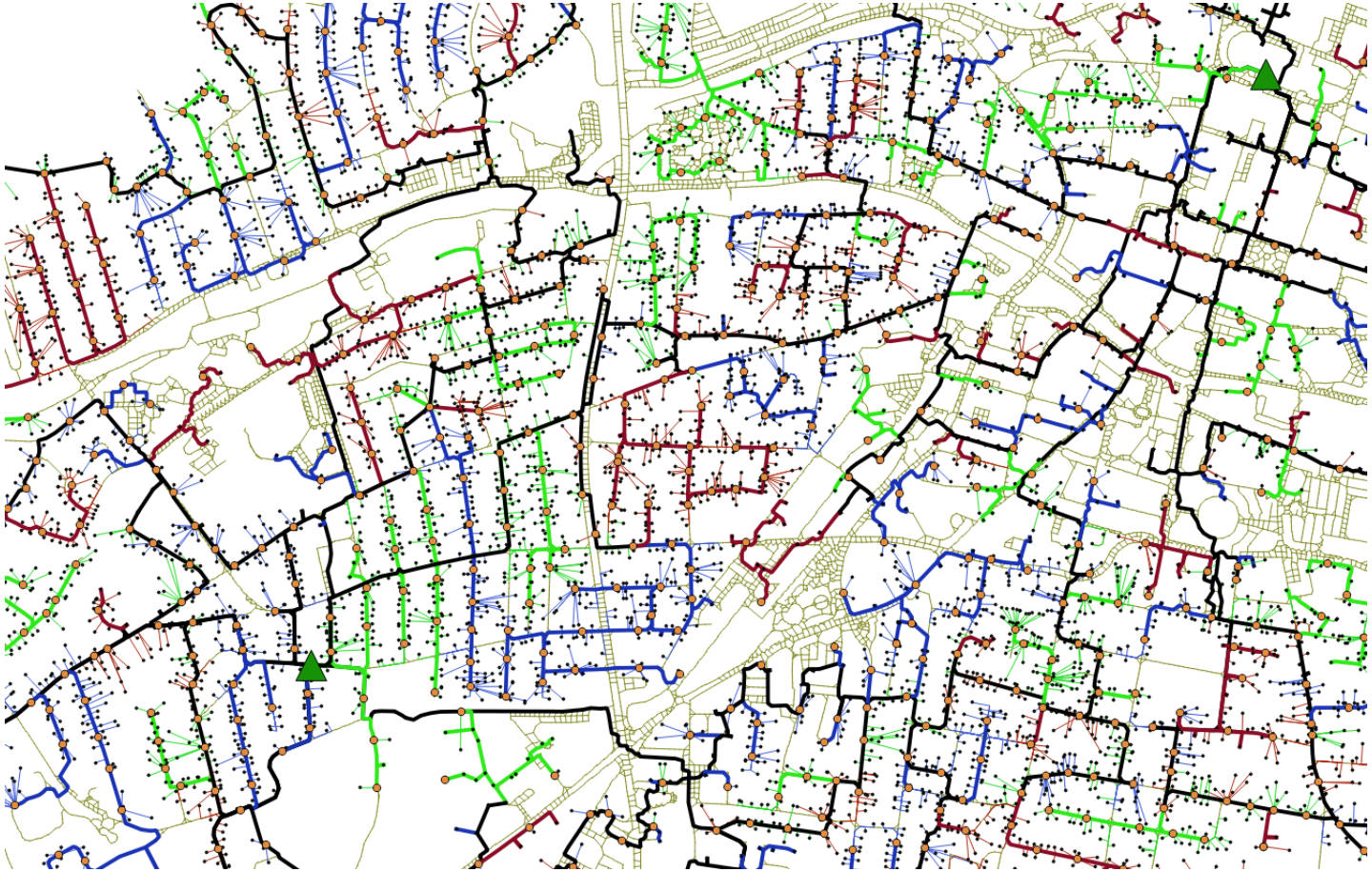
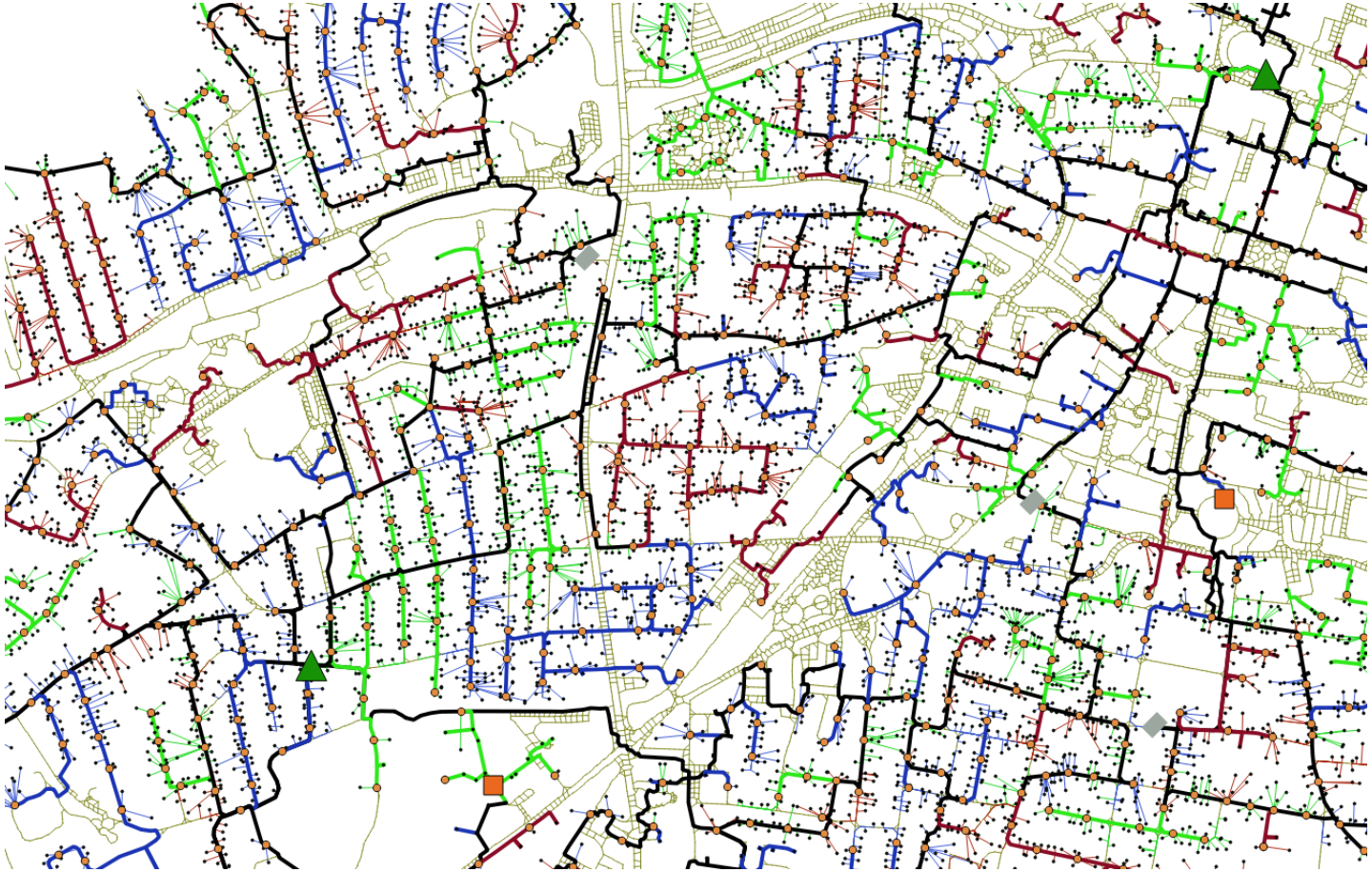
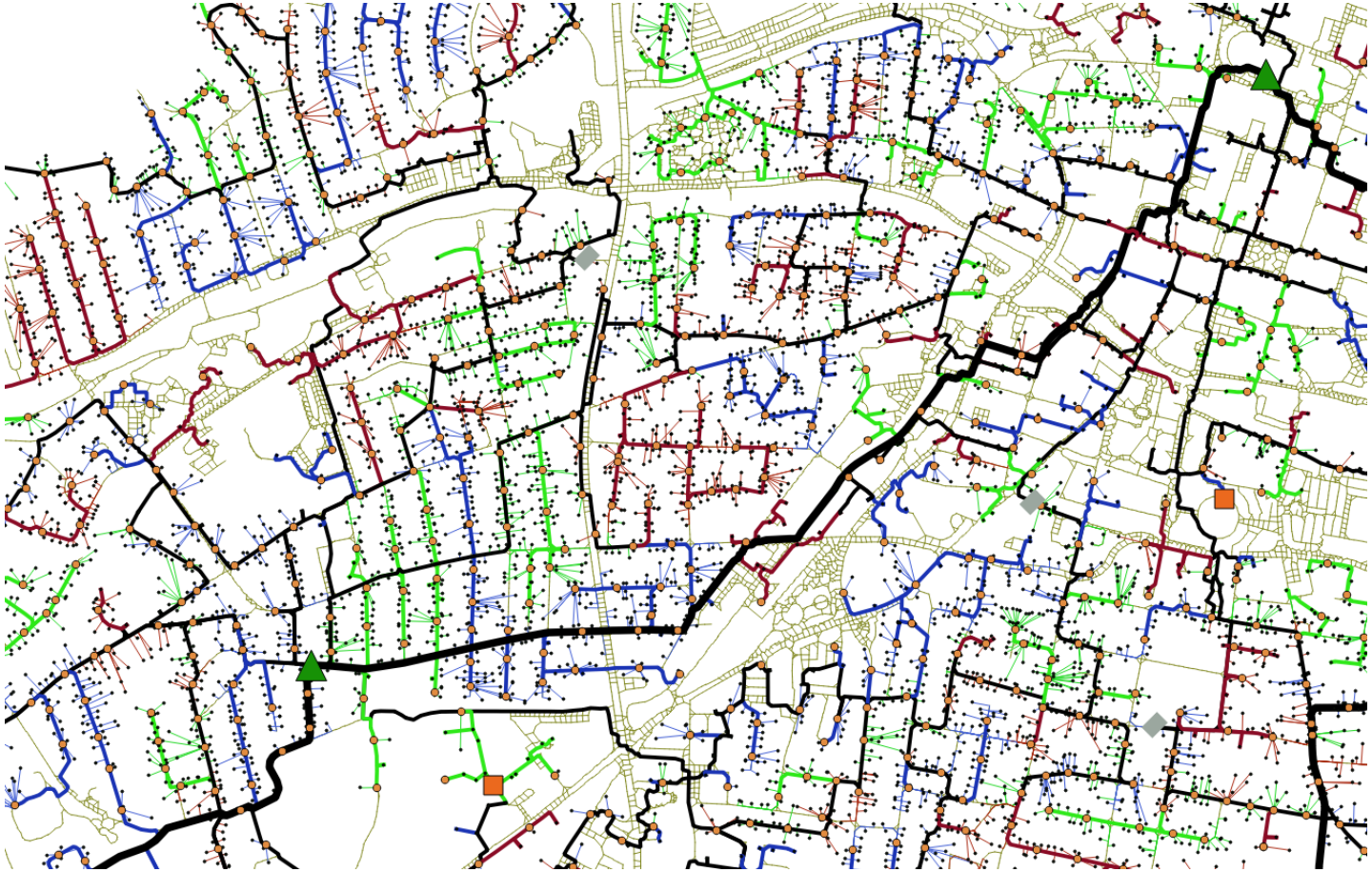
Phasing (Single Phase laterals & LV)



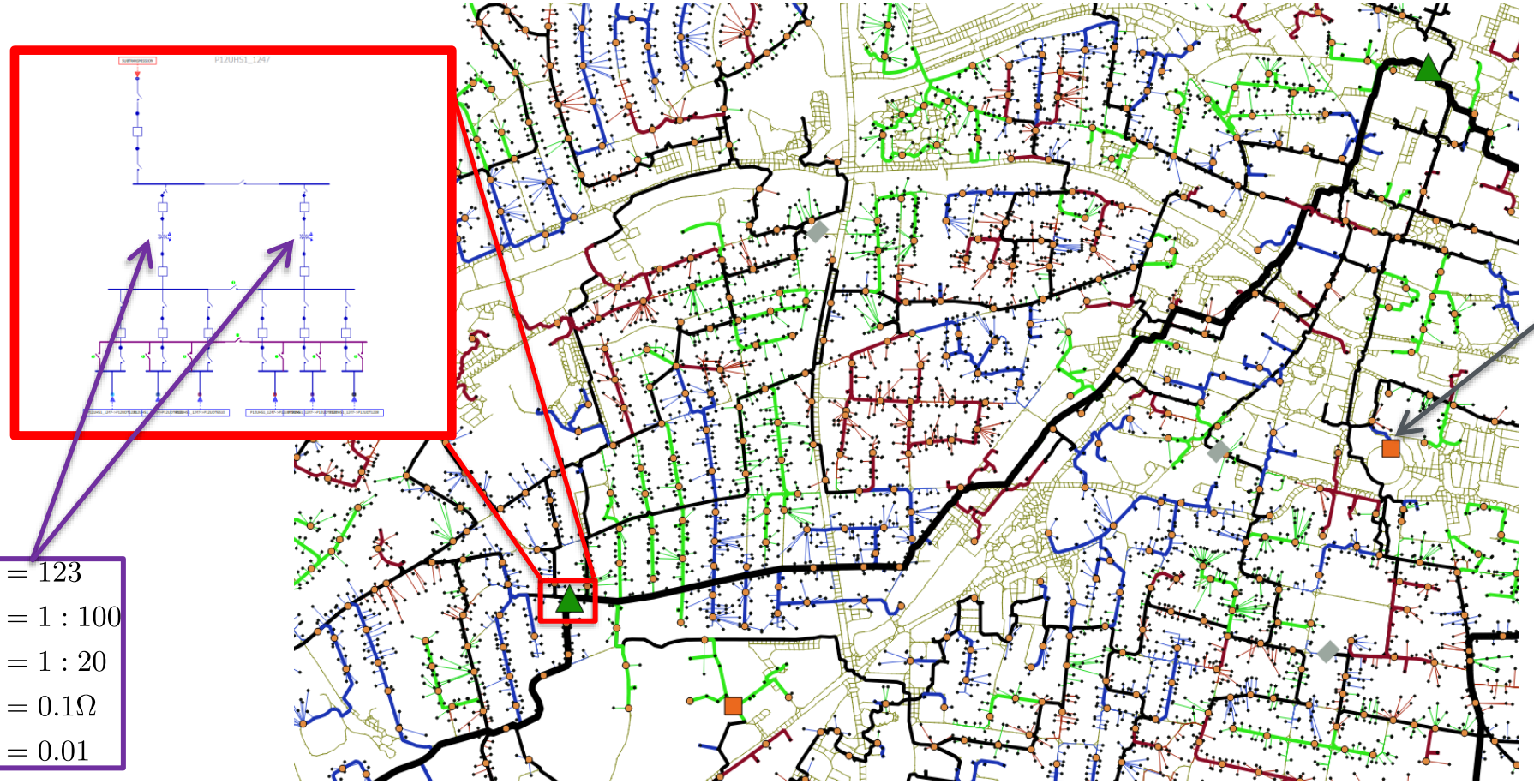
Capacitors, Voltage Regulators, Switches, etc.



(Sub) Transmission



Post-processing:
Substation Internals & Control Settings



$V_{reg} = 123$
$PT = 1:100$
$CT = 1:20$
$R_{ldc} = 0.1\Omega$
$X_{ldc} = 0.01$

$Mode: VAR$
$On = 100kVAR$
$Hysteresis = 2\%$

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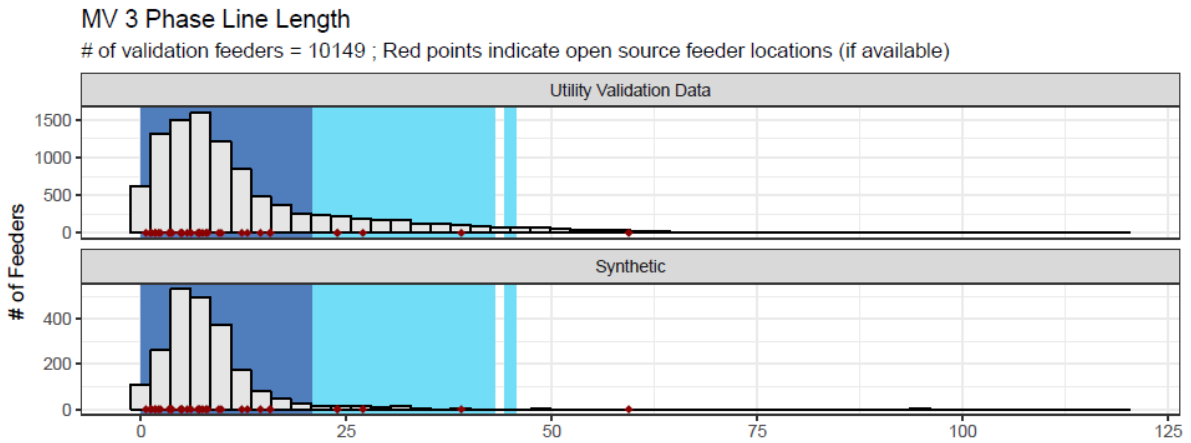
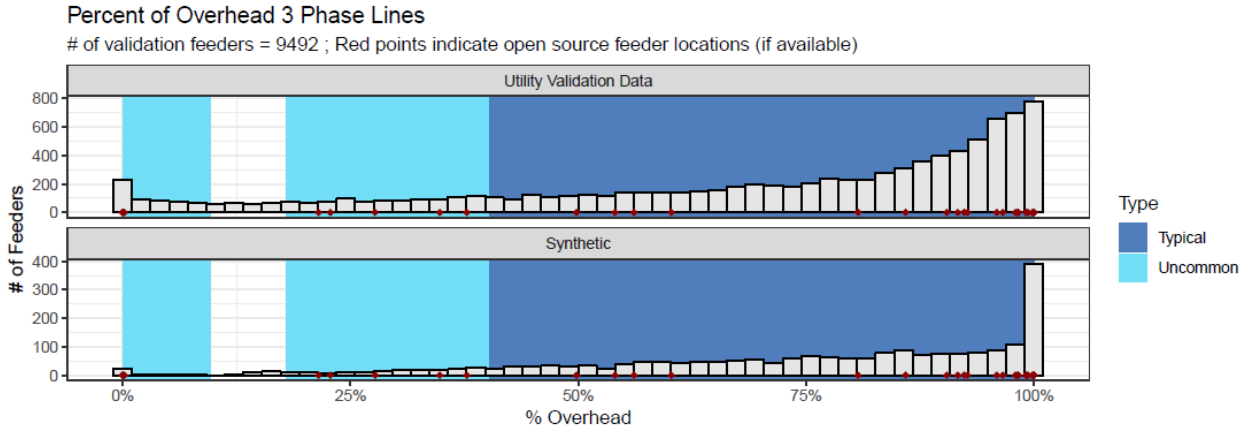
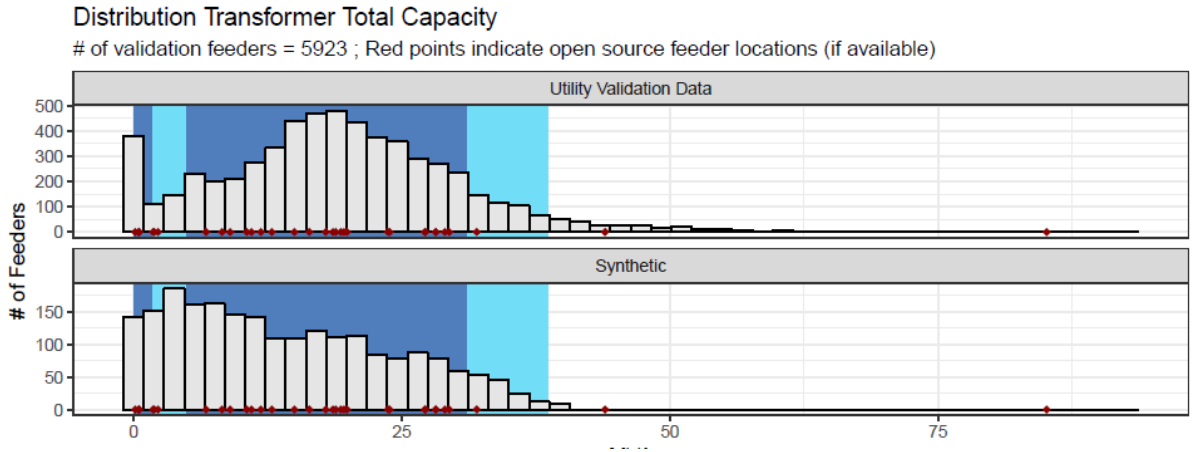
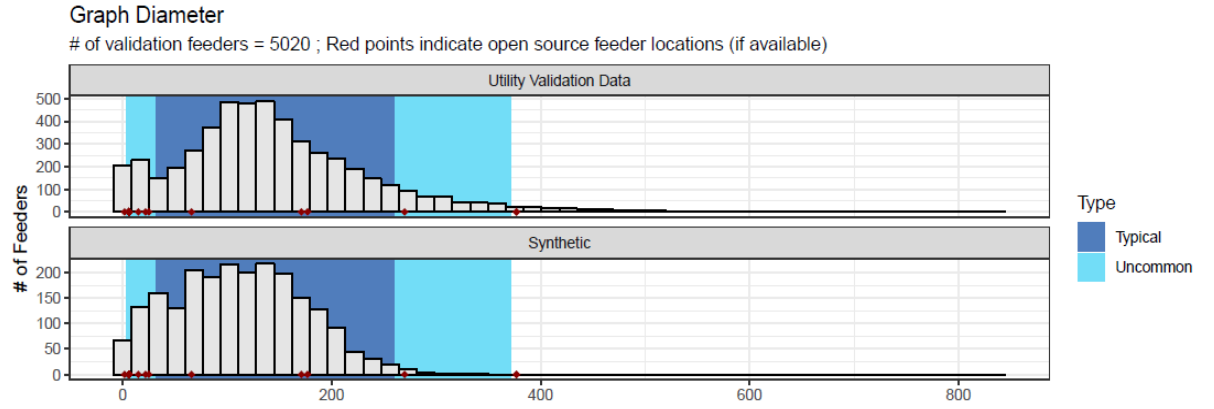
Distribution Validation: SFO Synthetic vs Utility Data









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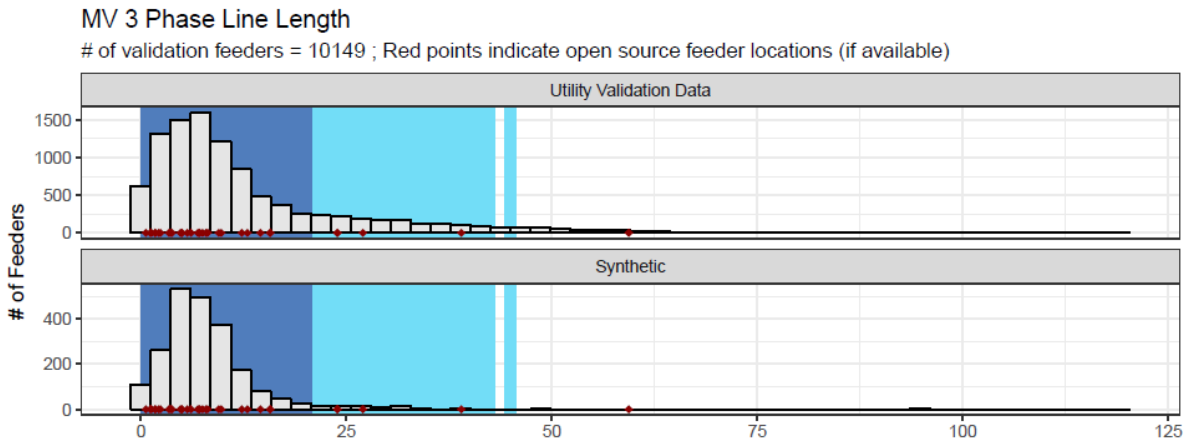
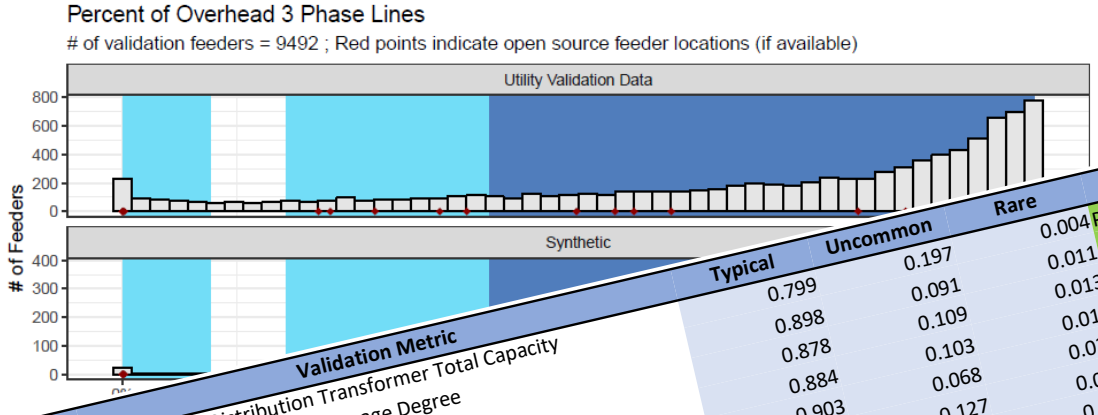
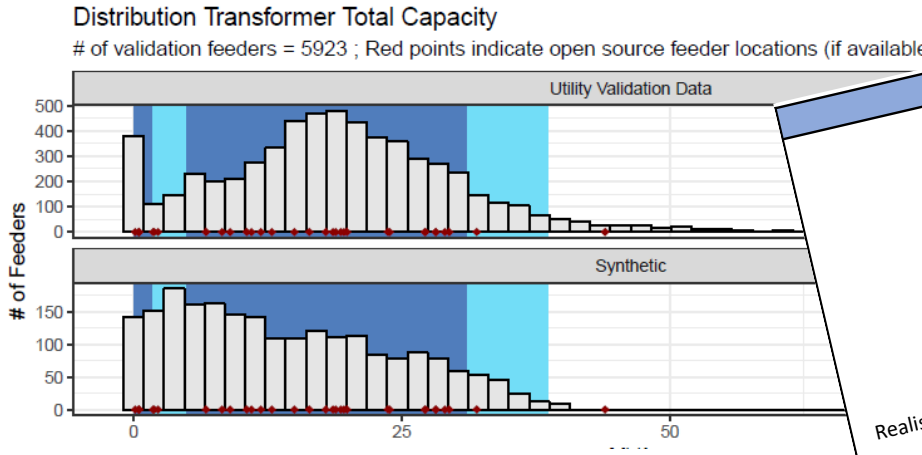




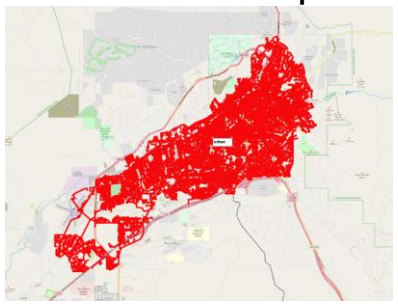


Classification	Validation Metric	Typical	Uncommon	Rare	Grade
Load specification	Distribution Transformer Total Capacity	0.799	0.197	0.004	Pass
Physical layout/topology	Average Degree	0.898	0.091	0.011	Pass
	Char Path Length	0.878	0.109	0.013	Pass
	Graph Diameter	0.884	0.103	0.013	Pass
Realistic electrical design and equipment parameters	LV 1 Phase Line Length	0.903	0.068	0.029	Pass
	LV 3 Phase Line Length	0.845	0.127	0.028	Pass
	Ratio of MV 1 & 2 Phase Line Length to Number of Customers	0.989	0.011	0.000	Pass
	Ratio of MV 3 Phase Line Length to Number of Customers	0.871	0.118	0.011	Pass
	MV 1 & 2 Phase Line Length	0.695	0.276	0.029	Pass
	MV 3 Phase Line Length	0.965	0.034	0.001	Pass
	LV Overhead 1 Phase Line Length	0.627	0.354	0.019	Pass
	LV Overhead 3 Phase Line Length	1.000	0.000	0.000	Pass
	MV Overhead 1 & 2 Phase Line Length	0.901	0.099	0.000	Pass
	MV Overhead 3 Phase Line Length	0.953	0.045	0.001	Pass
	Percent of Overhead 1 & 2 Phase Lines	0.815	0.176	0.009	Pass
	Percent of Overhead 3 Phase Lines	0.895	0.090	0.015	Pass
Realistic physical size	Number of Customers	0.766	0.199	0.035	Pass
	Number of Breakers	1.000	0.000	0.000	Pass
	Number of Fuses	0.790	0.210	0.000	Pass
	Number of Reclosers	0.922	0.067	0.011	Pass
	Number of Regulators	1.000	0.000	0.000	Pass
Reconfiguration options	Number of Sectionalizers	1.000	0.000	0.000	Pass
	Number of Switches	0.747	0.196	0.057	Par
	Number of Capacitor Banks	1.000	0.000	0.000	Pa

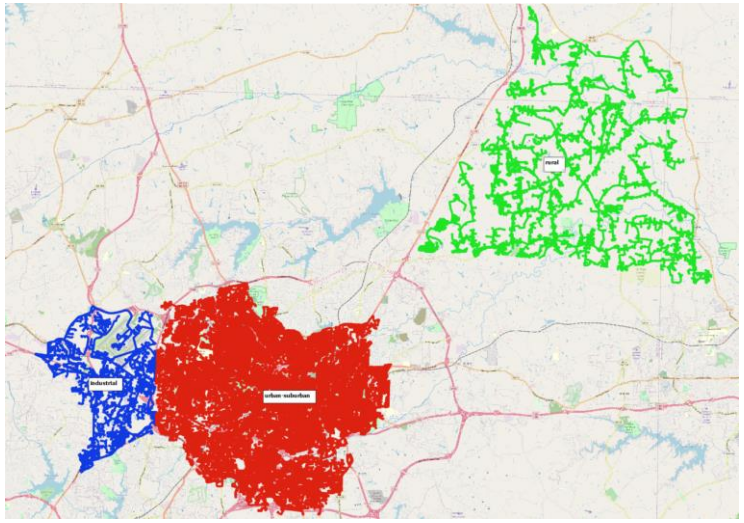
Dataset Contents

Four Datasets: San Francisco, Austin, Greensboro, Santa Fe (Not to Scale)

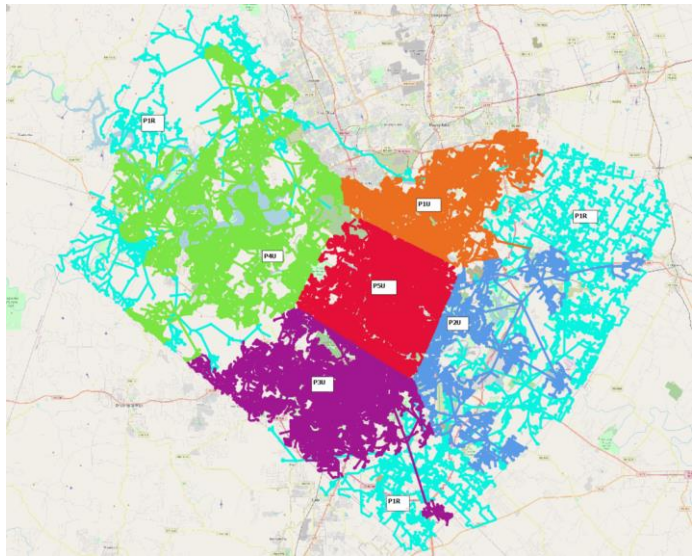
Santa Fe, NM (SAF)
84k consumers – peak only



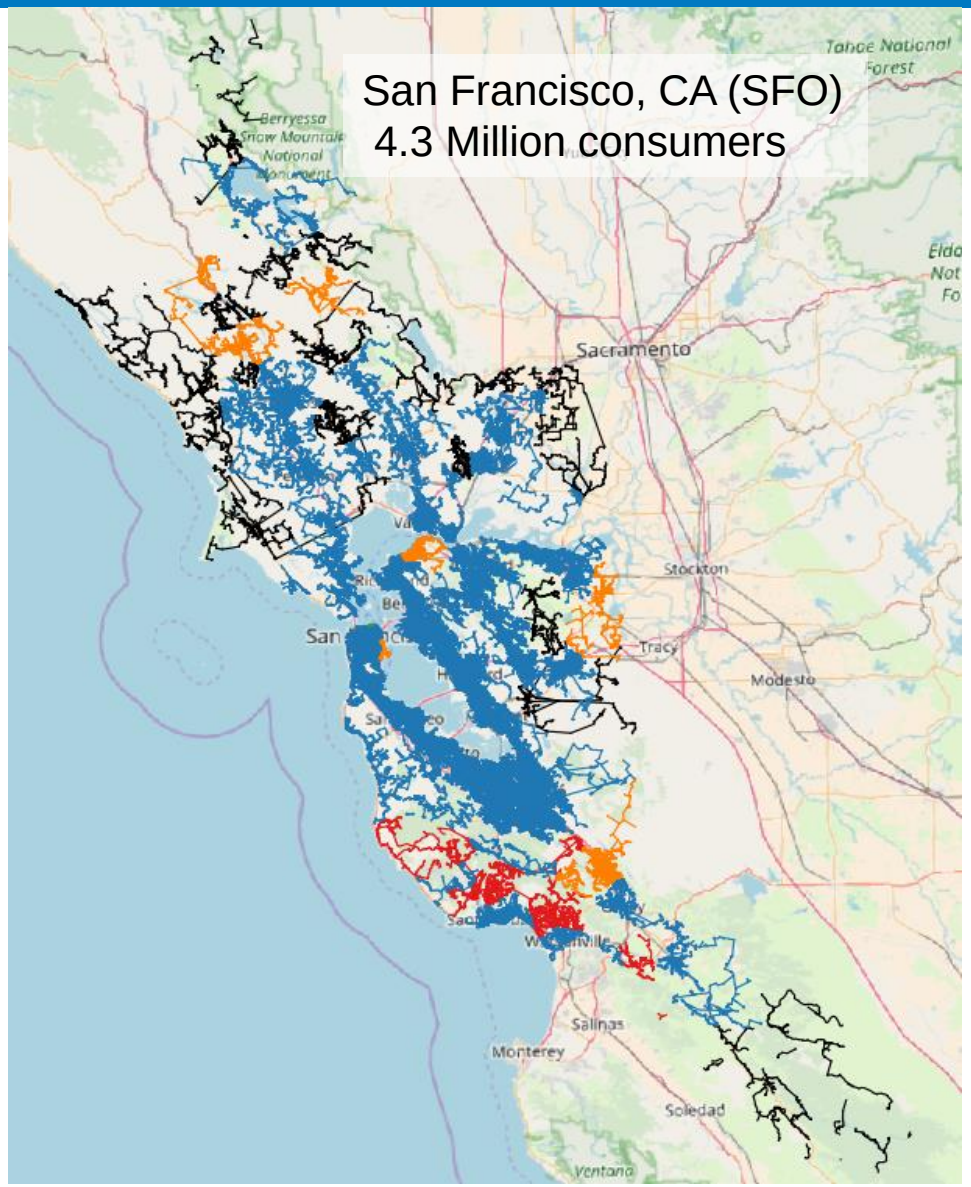
Greensboro, NC (GSO)
134k consumers



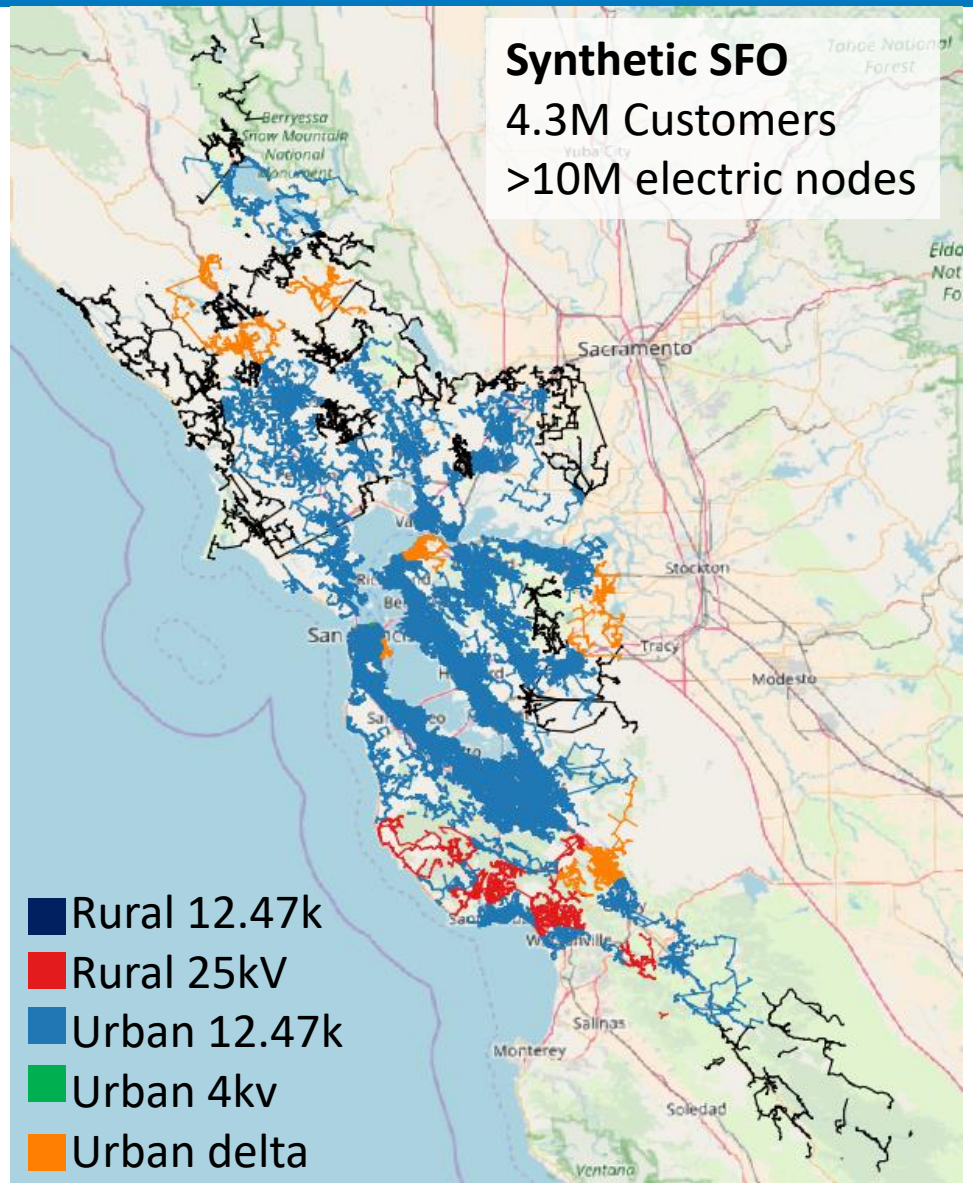
Austin, TX (AUS)
307k consumers



San Francisco, CA (SFO)
4.3 Million consumers



Large test system: Bay Area, CA (SFO, v1.0)



Additional Diversity:

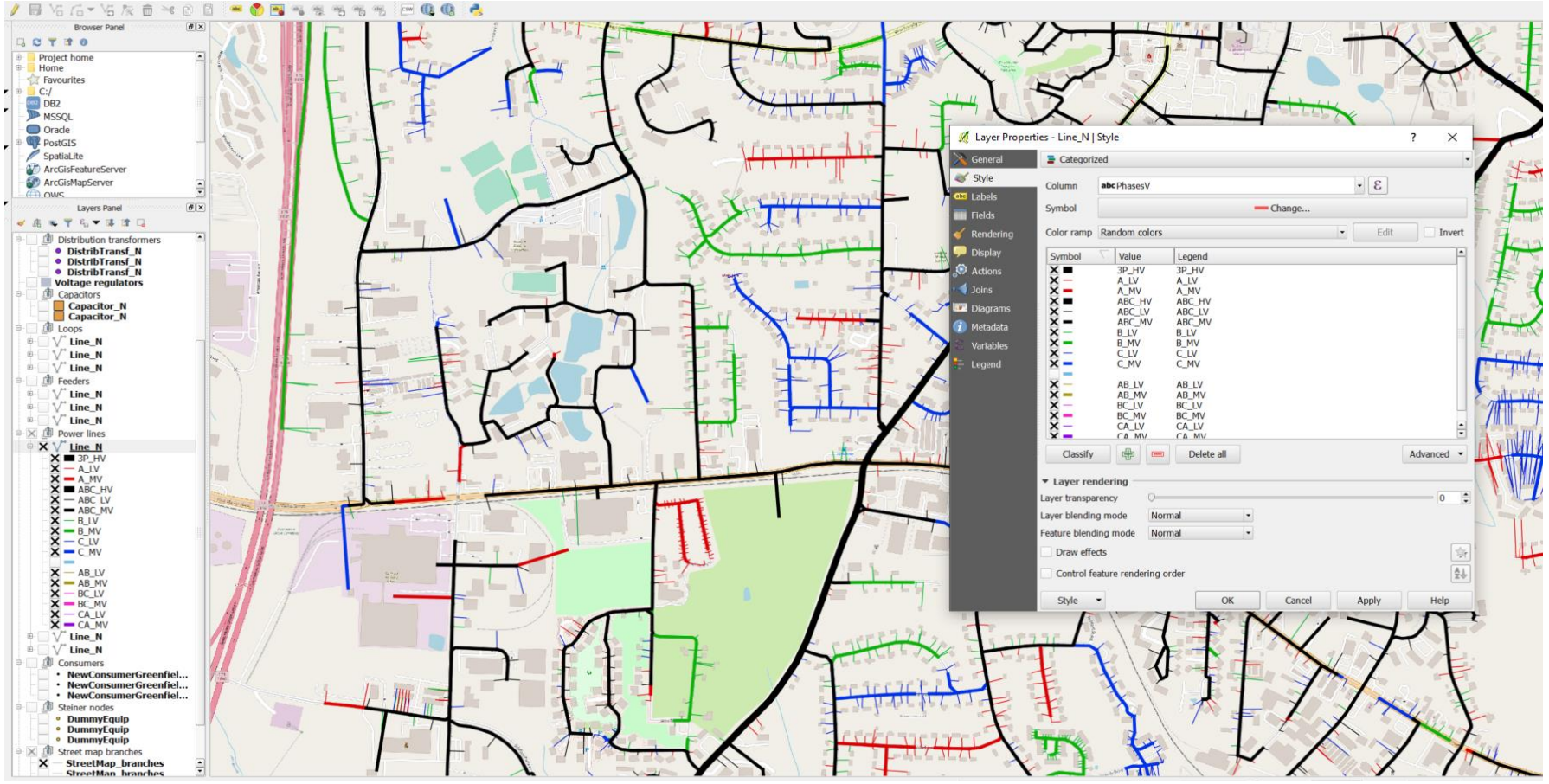
- Voltage class: 12.47kV, 4kV, 25kV
- Voltage Management: Regulator, Capacitors
- Arrangement: Wye, Delta
- Area type: Urban-suburban, rural
- Networked secondary

Rich Scenarios:

- 1yr x 15min ZIP loads for all customers
- Defined DER adoption
  - Low, Med, High PV, etc.

GIS Data: Shapefiles

- Shapefiles provided of network data
- Created before post-processing
- No equipment parameters
- Useful for visualization



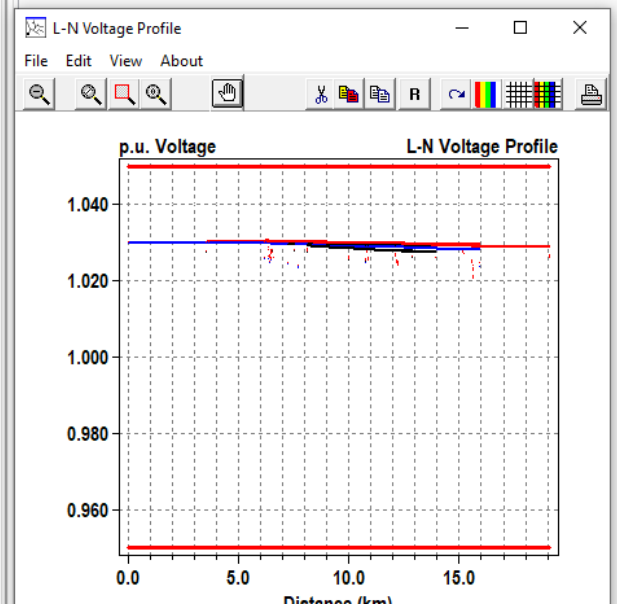
GIS Data: Geojson

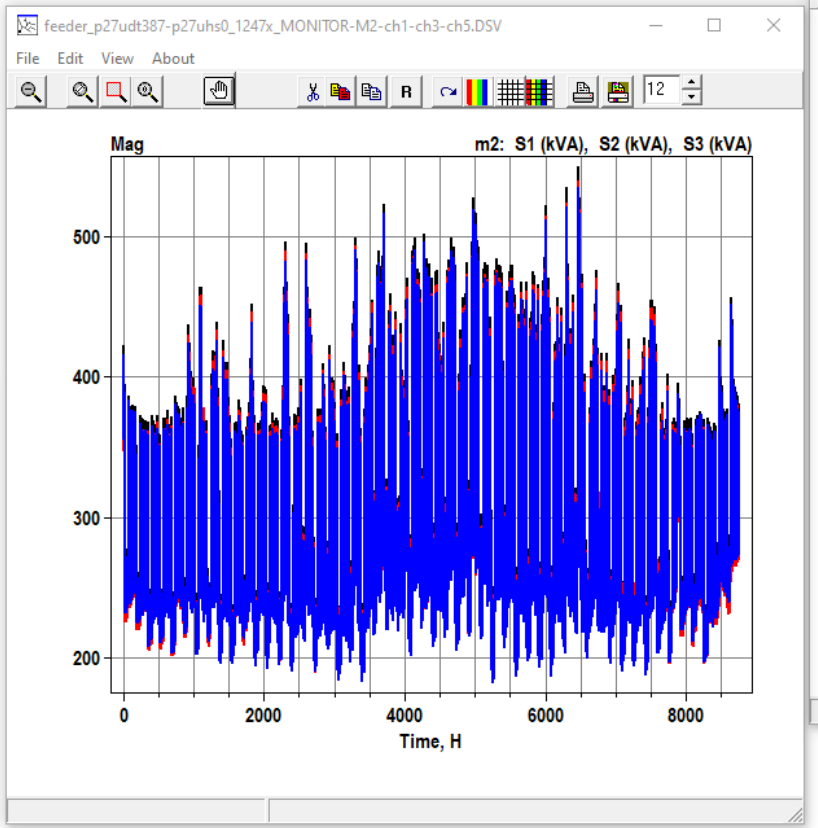
- Geojson files provided for each feeder
- Key network and power system information included as properties
- Useful for data extraction and visualization

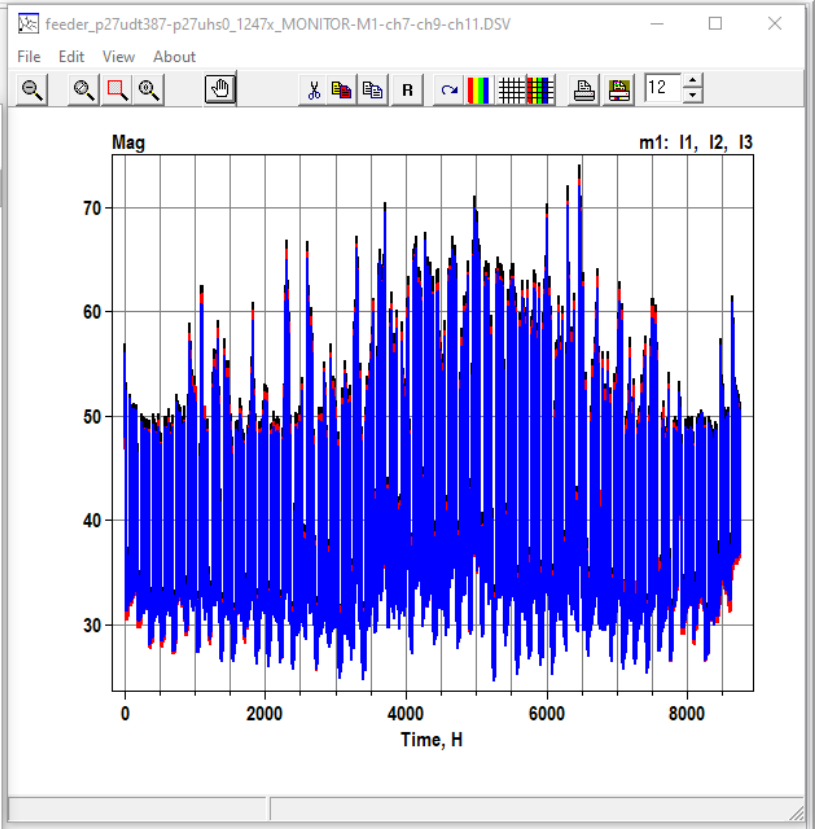
OpenDSS

```
Results for Actor ID # 1
CPU selected : 0
Status = SOLVED
Solution Mode = Yearly
Number = 35040
Load Mult = 1.000
Devices = 222
Buses = 143
Nodes = 307
Control Mode =STATIC
Total Iterations = 2
Control Iterations = 1
Max Sol Iter = 2

 - Circuit Summary -

Year = 0
Hour = 8760
Max pu. voltage = 1.0305
Min pu. voltage = 1.0194
Total Active Power:  0.813246
MW
Total Reactive Power: -0.145006
Mvar
Total Active Losses:  0.0103385
MW, (1.271 %)
Total Reactive Losses: -
0.00653448 Mvar
Frequency = 60 Hz
Mode = Yearly
Control Mode = STATIC
Load Model = PowerFlow
-----------------------
```

```
Clear

New Circuit.feeder_p27udt387-p27uhs0_1247x bus1=p27udt387-p27uhs0_1247x pu=1.03 basekV=12.47 R1=1e-05 X1=1e-05 R0=1e-05 X0=1e-05

Redirect LineCodes.dss
Redirect Lines.dss
Redirect Transformers.dss
Redirect LoadShapes.dss
Redirect Loads.dss
Redirect Capacitors.dss
new monitor.m1 element=Line.l[r:p27udt387-p27uhs0_1247]_s1 mode=0
new monitor.m2 element=Line.l[r:p27udt387-p27uhs0_1247]_s1 mode=1
new energymeter.m3 Line.l[r:p27udt387-p27uhs0_1247]_s1

Set Voltagebases=[0.12, 0.208, 0.48, 7.2, 12.47]

Calcvoltagebases

Buscoords Buscoords.dss
set maxcontroliter=50

Solve mode=yearly stepsize=15m number=35040
Export monitors m1
Plot monitor object= m1 channels=(7 9 11 )
Export monitors m2
Plot monitor object= m2 channels=(1 3 5 )
Plot Profile Phases=All
```







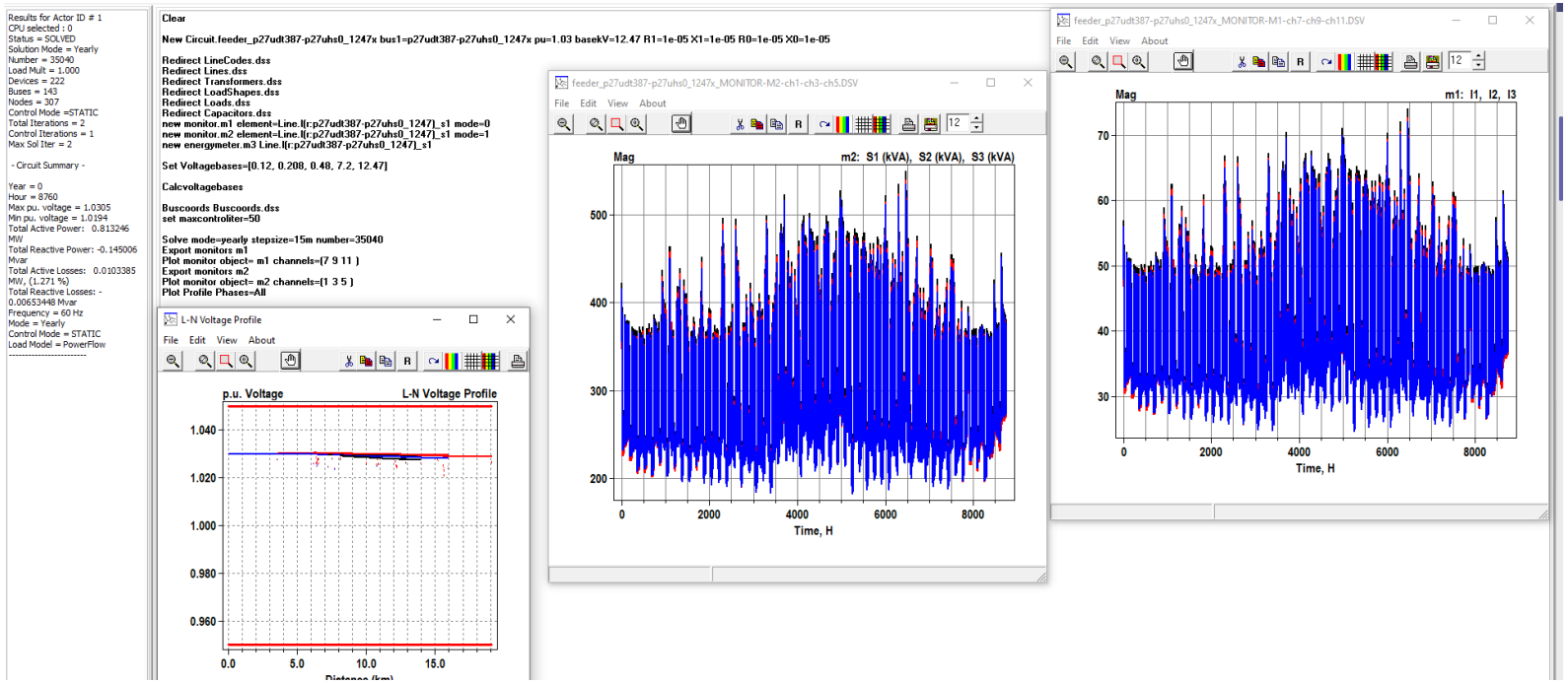
OpenDSS

Models Provided in OpenDSS format

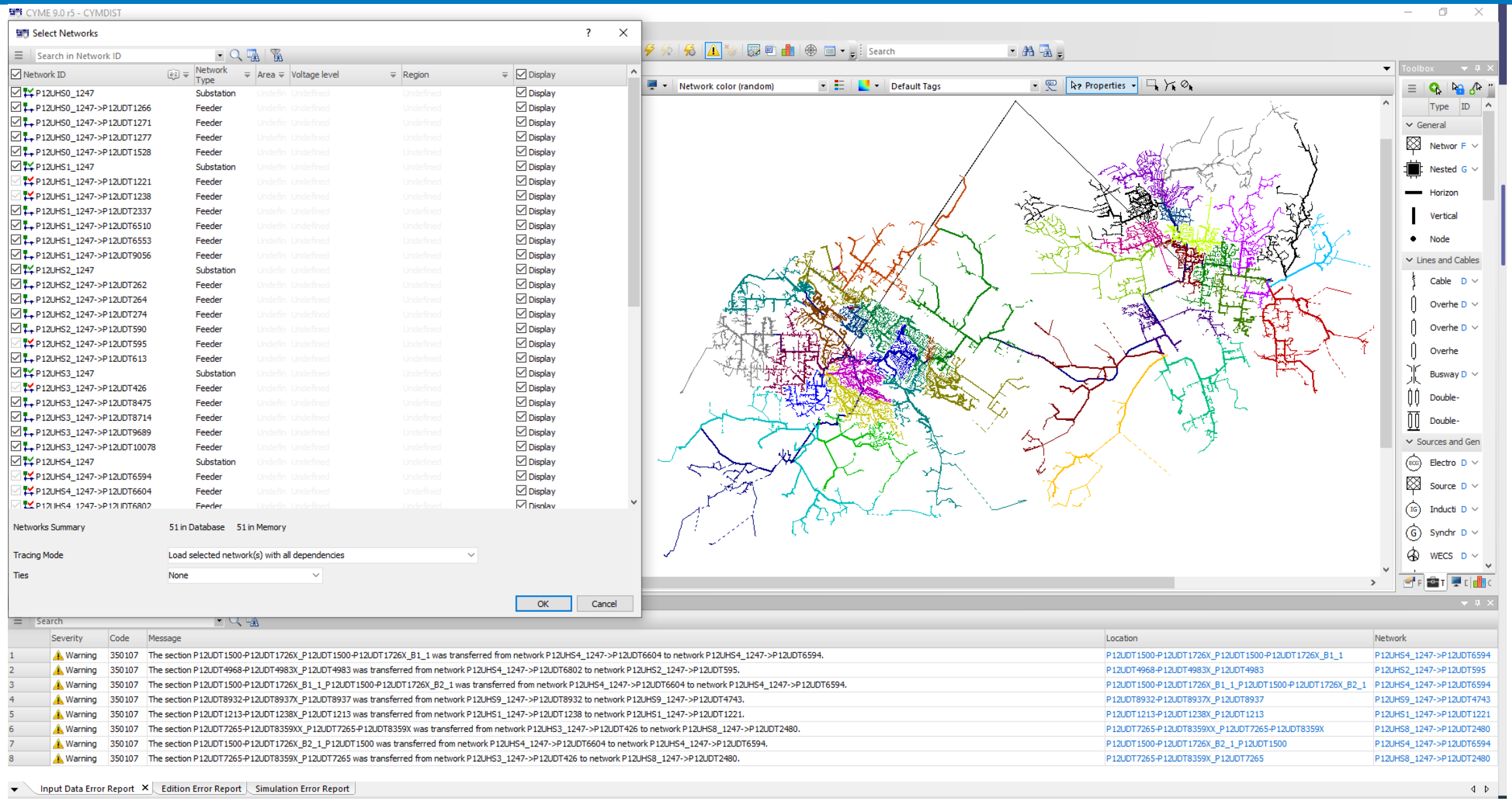
OpenDSS files organized by region, substation and feeder

Timeseries profiles provided and linked by Loadshapes

Can be run with OpenDSSDirect using python or julia



CYME

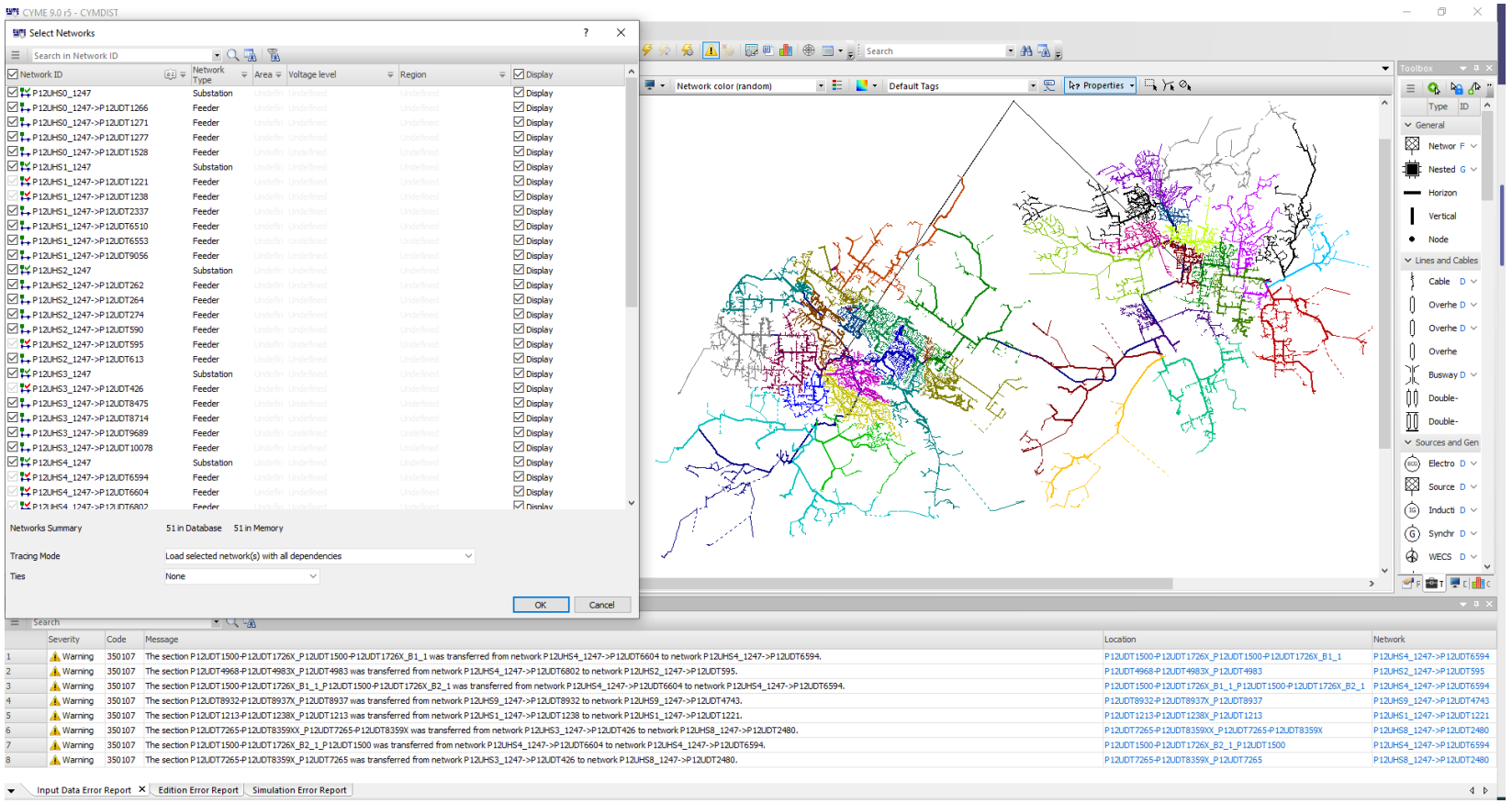

CYME 9.0 r5 - CYMDIST
Select Networks
Search in Network ID
Network ID
Network Type
Area
Voltage level
Region
Display
P12UHS0_1247
P12UHS0_1247->P12UDT1266
P12UHS0_1247->P12UDT1271
P12UHS0_1247->P12UDT1277
P12UHS0_1247->P12UDT1528
P12UHS1_1247
P12UHS1_1247->P12UDT1221
P12UHS1_1247->P12UDT1238
P12UHS1_1247->P12UDT2337
P12UHS1_1247->P12UDT6510
P12UHS1_1247->P12UDT6553
P12UHS1_1247->P12UDT9056
P12UHS2_1247
P12UHS2_1247->P12UDT262
P12UHS2_1247->P12UDT264
P12UHS2_1247->P12UDT274
P12UHS2_1247->P12UDT590
P12UHS2_1247->P12UDT595
P12UHS2_1247->P12UDT613
P12UHS3_1247
P12UHS3_1247->P12UDT426
P12UHS3_1247->P12UDT8475
P12UHS3_1247->P12UDT8714
P12UHS3_1247->P12UDT9689
P12UHS3_1247->P12UDT10078
P12UHS4_1247
P12UHS4_1247->P12UDT6594
P12UHS4_1247->P12UDT6604
Substation
Feeder
Networks Summary
51 in Database
51 in Memory
Tracing Mode
Load selected network(s) with all dependencies
Ties
None
OK
Cancel
Search
Network color (random)
Default Tags
Properties
Toolbox
General
Lines and Cables
Sources and Gen
Horizon
Vertical
Node
Search
Severity
Code
Message
Location
Network
1 Warning 350107 The section P12UDT1500-P12UDT1726X_P12UDT1500-P12UDT1726X_B1_1 was transferred from network P12UHS4_1247->P12UDT6604 to network P12UHS4_1247->P12UDT6594.
2 Warning 350107 The section P12UDT4968-P12UDT4983X_P12UDT4983 was transferred from network P12UHS4_1247->P12UDT6802 to network P12UHS2_1247->P12UDT595.
3 Warning 350107 The section P12UDT1500-P12UDT1726X_B1_1_P12UDT1500-P12UDT1726X_B2_1 was transferred from network P12UHS4_1247->P12UDT6604 to network P12UHS4_1247->P12UDT6594.
4 Warning 350107 The section P12UDT8932-P12UDT8937X_P12UDT8937 was transferred from network P12UHS9_1247->P12UDT8932 to network P12UHS9_1247->P12UDT4743.
5 Warning 350107 The section P12UDT1213-P12UDT1238X_P12UDT1213 was transferred from network P12UHS1_1247->P12UDT1238 to network P12UHS1_1247->P12UDT1221.
6 Warning 350107 The section P12UDT7265-P12UDT8359XX_P12UDT7265-P12UDT8359X was transferred from network P12UHS3_1247->P12UDT426 to network P12UHS8_1247->P12UDT2480.
7 Warning 350107 The section P12UDT1500-P12UDT1726X_B2_1_P12UDT1500 was transferred from network P12UHS4_1247->P12UDT6604 to network P12UHS4_1247->P12UDT6594.
8 Warning 350107 The section P12UDT7265-P12UDT8359X_P12UDT7265 was transferred from network P12UHS3_1247->P12UDT426 to network P12UHS8_1247->P12UDT2480.
Input Data Error Report
Edition Error Report
Simulation Error Report

CYME

Models Provided in CYME format

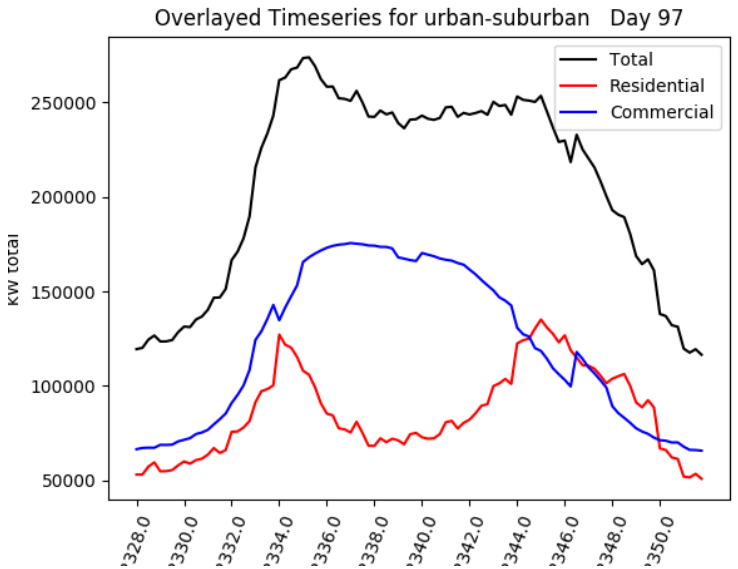
CYME files organized by region

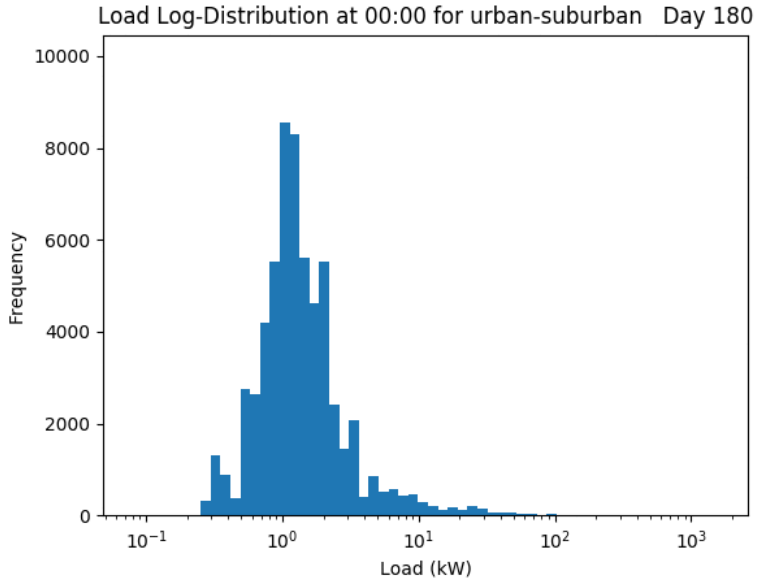
Timeseries load and solar profiles provided

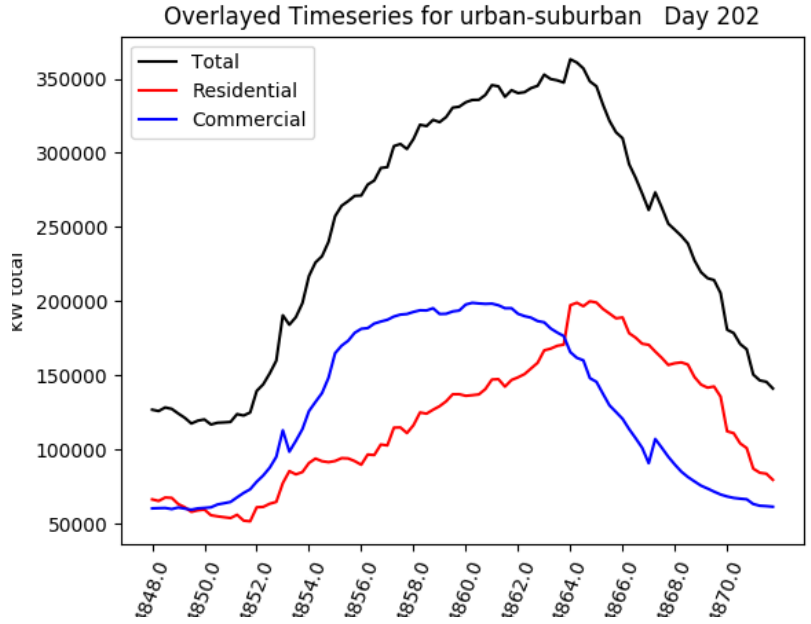


Timeseries Load Profiles

- Profiles added with latest Restock and Comstock data at 15 minute resolution
- Profiles connected for each customer contain real and reactive power based on end-use power factors.
- Weather dependent loads which vary throughout the year
- Data provided for 2016, 2017 and 2018
- A “peak planning” scenario with a single timepoint also provided







End-Use Details

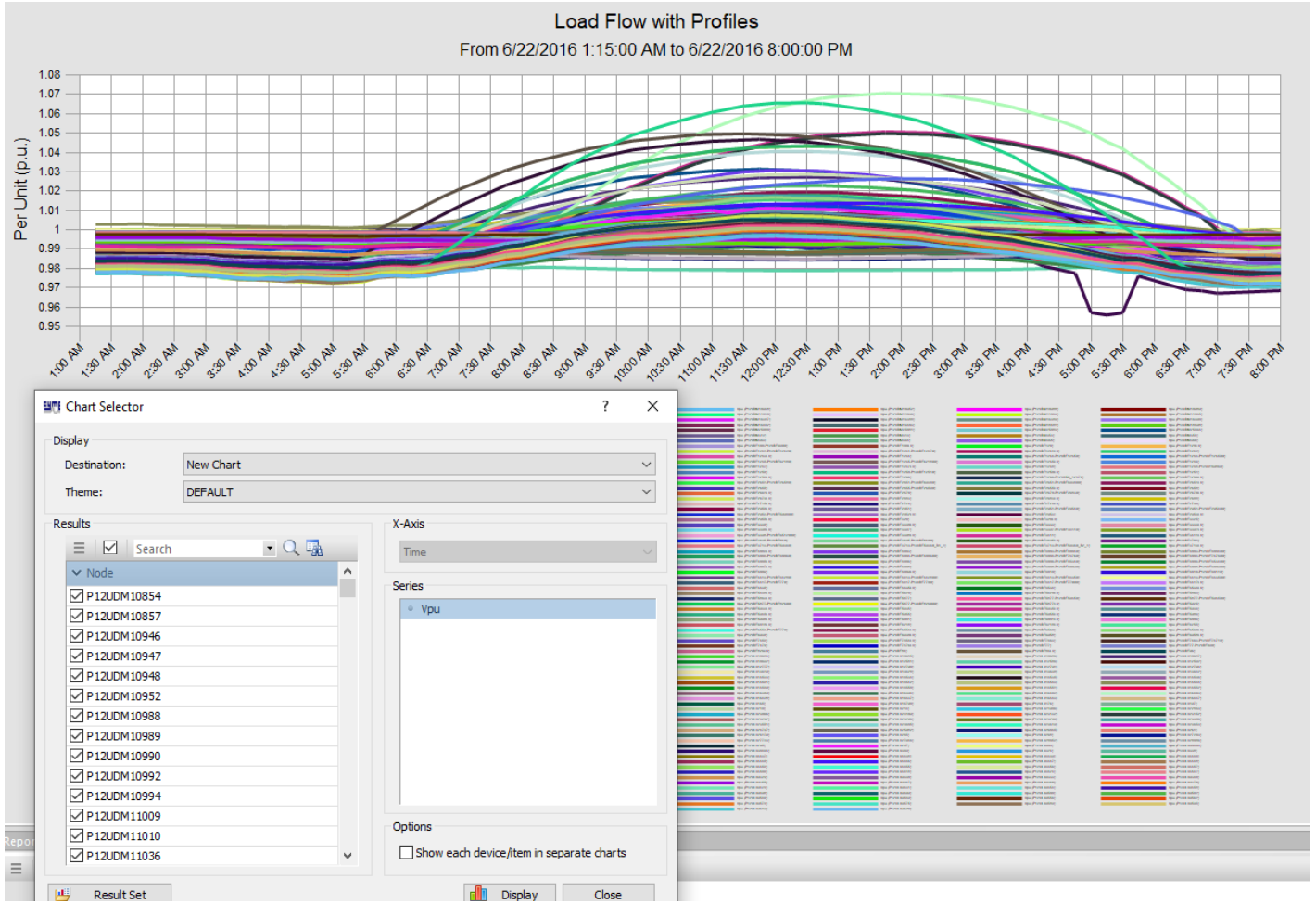
- Time series load provided in parquet files
- Same profile often assigned to multiple buildings based on peak planning load
- Load is broken down into real and reactive end-uses:

  - Time
  - total_site_electricity_kw
  - building
  - pf
  - total_site_electricity_kvar
  - heating_kw
  - heating_kvar
  - cooling_kw
  - cooling_kvar
  - lighting_kw
  - lighting_kvar
  - fans_kw
  - fans_kvar
  - pumps_kw
  - pumps_kvar

•water_systems_kw
•water_systems_kvar
•refrigeration_kw
•refrigeration_kvar
•motors_kw
•motors_kvar
•plug_loads_kw
•plug_loads_kvar
•clothes_dryer_kw
•clothes_dryer_kvar
•clothes_washer_kw
•clothes_washer_kvar
•stove_kw
•stove_kvar
•dishwasher_kw
•dishwasher_kvar

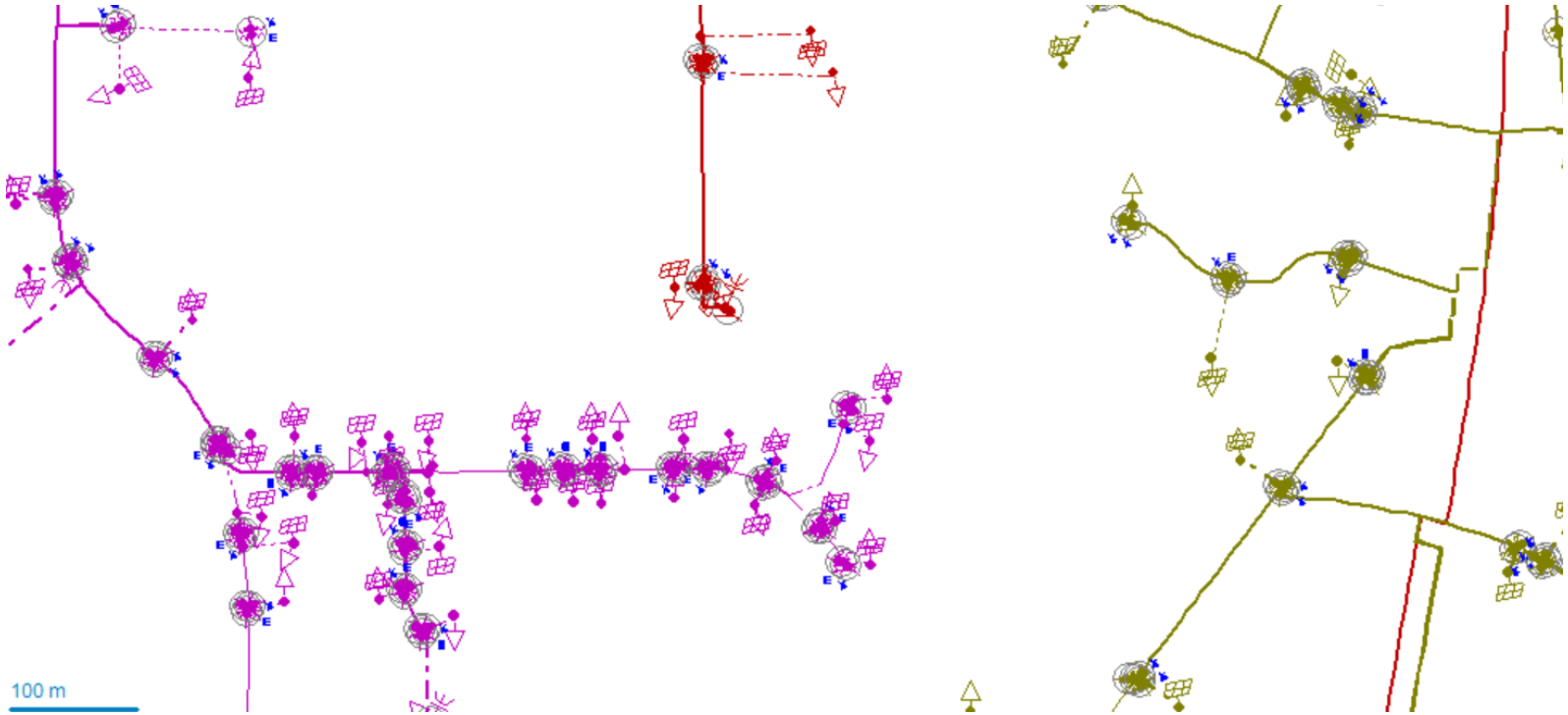
Timeseries Solar Profiles

- Solar irradiance data is provided at 4x4 km grid square resolution using data from NSRDB (National Solar Radiation Database)
- Plane of array irradiance with combinations of:
  - panel tilt
  - Azimuth
- GHI, DNI and DHI, wind speed, temperature and power output are provided
- Standardized panel power output computed
- Volt-Var and Volt-Watt curves used for some deployments using IEEE1547



Standardized Scenarios for DER, etc.

- Integrated into CYME/OpenDSS/Geojson:
  - Low/medium/high/extreme PV penetration for distributed and utility solar
  - Low/high battery penetration for distributed and utility batteries
- Additionally extra static placements provided in json files:
  - Fault locations
  - EV uptake
  - Demand response
  - AMI
  - Upgrade locations
  - Controllable switches



Dataset Metrics

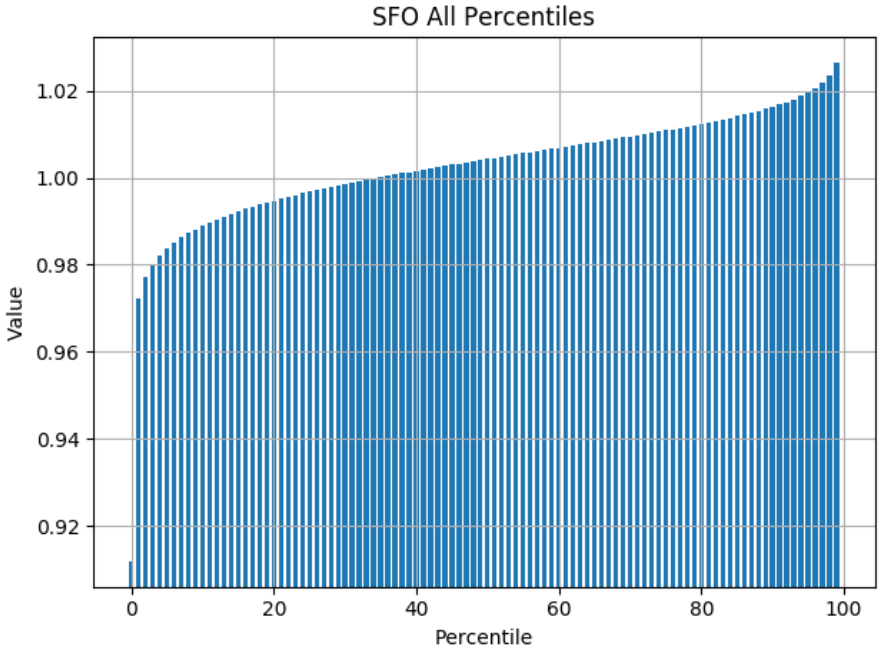
How to choose which feeders to do studies on?

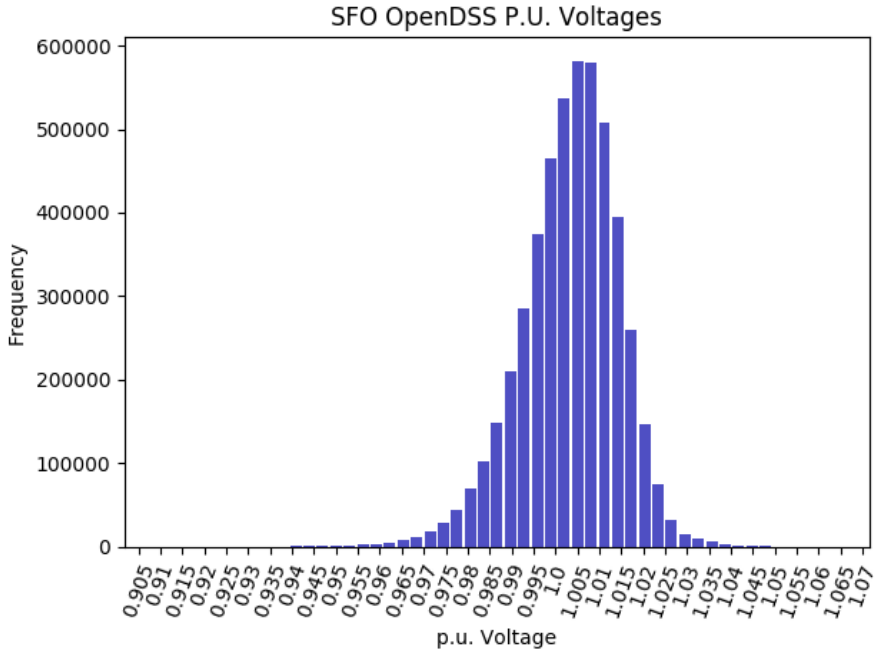
The following metrics are provided for each feeder:

- Feeder Name
- Feeder Head Node
- Substation Name
- Medium Voltage Length (miles)
- Three Phase Medium Voltage Length (miles)
- Three Phase Overhead Medium Voltage Length (miles)
- Two Phase Medium Voltage Length (miles)
- Two Phase Overhead Medium Voltage Length (miles)
- Single Phase Medium Voltage Length (miles)
- Single Phase Overhead Medium Voltage Length (miles)
- Overhead Percentage of Medium Voltage Line Miles
- Ratio of Medium Voltage Lines to Number of Customers
- Maximum Node Distance From Substation (miles)
- Nominal Voltage of Source (kV)
- Low Voltage Length (miles)
- Three Phase Low Voltage Length (miles)
- Three Phase Overhead Low Voltage Length (miles)
- Two Phase Low Voltage Length (miles)
- Two Phase Overhead Low Voltage Length (miles)
- Single Phase Low Voltage Length (miles)
- Single Phase Overhead Low Voltage Length (miles)
- Maximum Line Length From Transformer to Load (miles)
- Overhead Percentage of Low Voltage Line Miles
- Ratio of Low Voltage Lines to Number of Customers
- Number of Voltage Regulators
- Number of Capacitors
- Average Regulator Distance From Substation (miles)
- Average Capacitor Distance From Substation (miles)
- Number of Fuses
- Number of Reclosers
- Average Recloser Distance From Substation (miles)
- Number of Breakers
- Number of Switches
- Number of Lines Connected to Adjacent Feeder
- Number of Closed Loops
- Number of Transformers
- Total Transformer Capacity (MVA)
- Number of Single Phase Transformers
- Number of Three Phase Transformers
- Ratio of Single Phase Transformers to Three Phase Transformers
- Total Planning Load (MW)
- Total Phase A Planning Load (MW)
- Total Phase B Planning Load (MW)
- Total Phase C Planning Load (MW)
- Total Reactive Planning Load (MVar)
- Percentage of Low Voltage Planning Load on Phase A
- Percentage of Low Voltage Planning Load on Phase B
- Percentage of Low Voltage Planning Load on Phase C
- Number of Single Phase Low Voltage Loads
- Number of Three Phase Low Voltage Loads
- Number of Medium Voltage Loads
- Total Medium Voltage Planning Load (MW)
- Average Number of Loads per Transformer
- Average Planning Load Power Factor
- Average Planning Load Imbalance by Phase
- Total Number of Customers
- Number of Customers per Square Mile of Feeder Convex Hull
- Total Planning Load (MW) per Square Mile of Feeder Convex Hull
- Total Reactive Planning Load (MVar) per Square Mile of Feeder Convex Hull
- Total Transformer Capacity (MVA) per Square Mile of Feeder Convex Hull
- Average Node Degree
- Average Shortest Path Length
- Diameter (Maximum Eccentricity)
- Number of PVs
- Total PV Capacity (MW)
- Number of PVs with Volt- Var Control
- Total Capacity of PVs with Volt- Var Control (MW)
- Number of PVs with Volt- Watt and Volt- Var Control
- Total Capacity of PVs with Volt- Watt Volt- Var Control (MW)
- Number of Batteries
- Total Capacity of Batteries (MW)
- Average Year of Building Construction
- Average Land Value (USD per Square Foot)
- Percentage of Rural Customers
- Percentage of Urban Customers
- Percentage of Residential Customers
- Percentage of Commercial Customers
- Percentage of Industrial Customers
- County
- Line Configuration

Powerflow Results

- OpenDSS simulations run for the peak loading time of each year for each feeder, substation and region of each scenario.
- Voltages, line overloads, transformer loads and other simulation data provided
- For peak loading time of 2016 base scenario in SFO region:
  - Voltage Ranges between 0.9117 and 1.0616 p.u.
  - 99.9939% of nodes below 1.05 p.u.
  - 99.923% of nodes above 0.95 p.u.





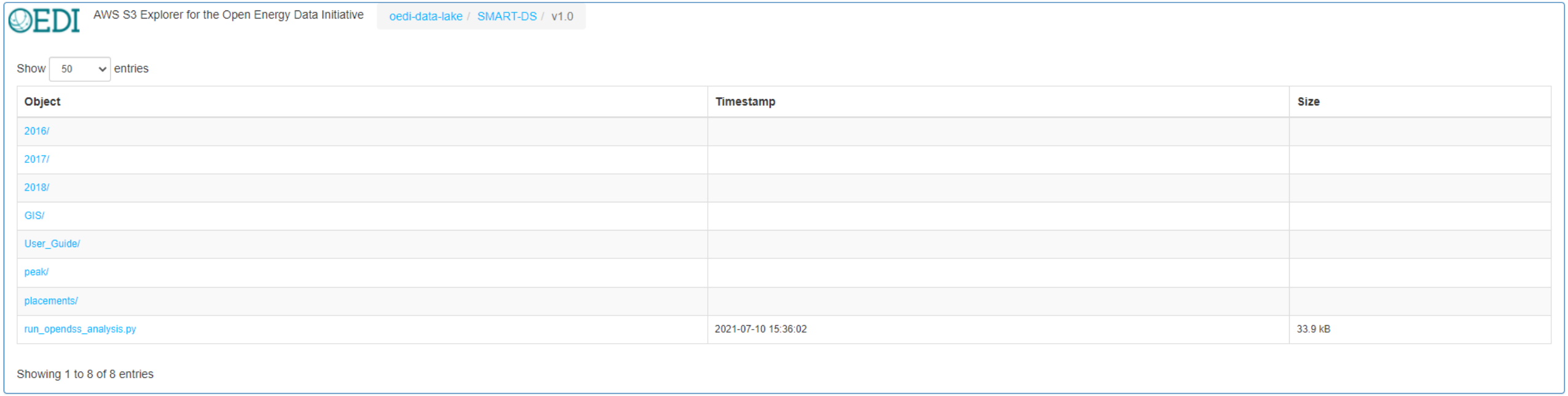
Accessing the Data

OEDI User Interface

- Open Energy Data Initiative (OEDI) Provides a resource for accessing very large datasets
- Hosted on AWS
- S3 buckets can be accessed through a web user interface:

https://data.openei.org/s3_viewer?bucket=oedi-data-lake&prefix=SMART-DS%2Fv1.0%2F

- Users can view the data and download specific files



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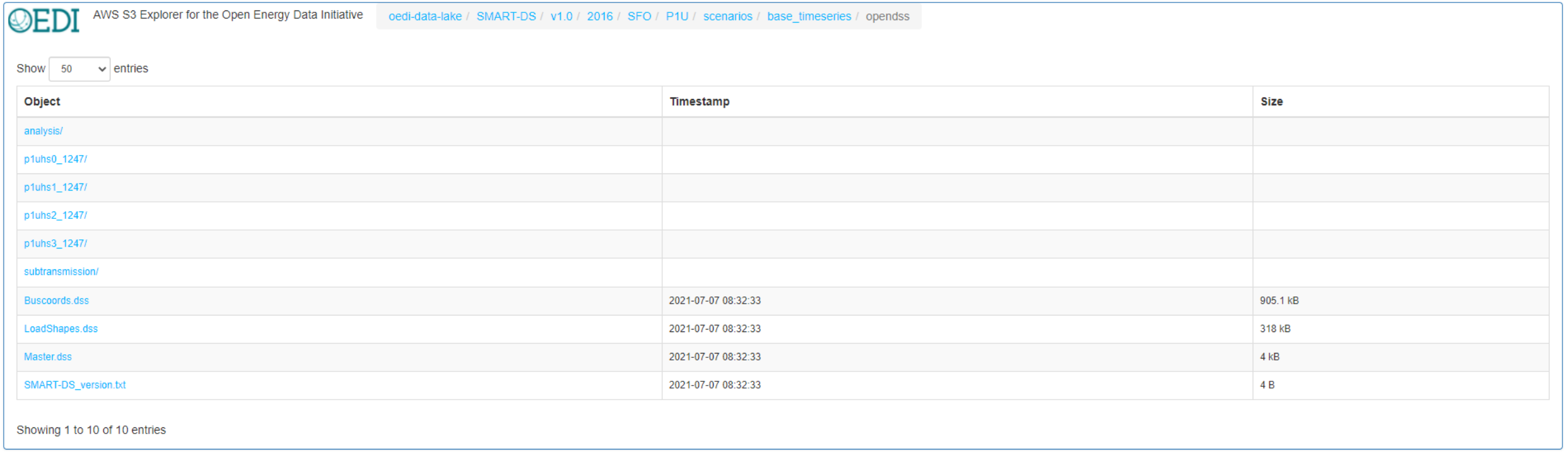


OEDI – AWS

Navigating the UI can be difficult for large data grabs

The AWS command-line interface can be used to navigate the dataset:

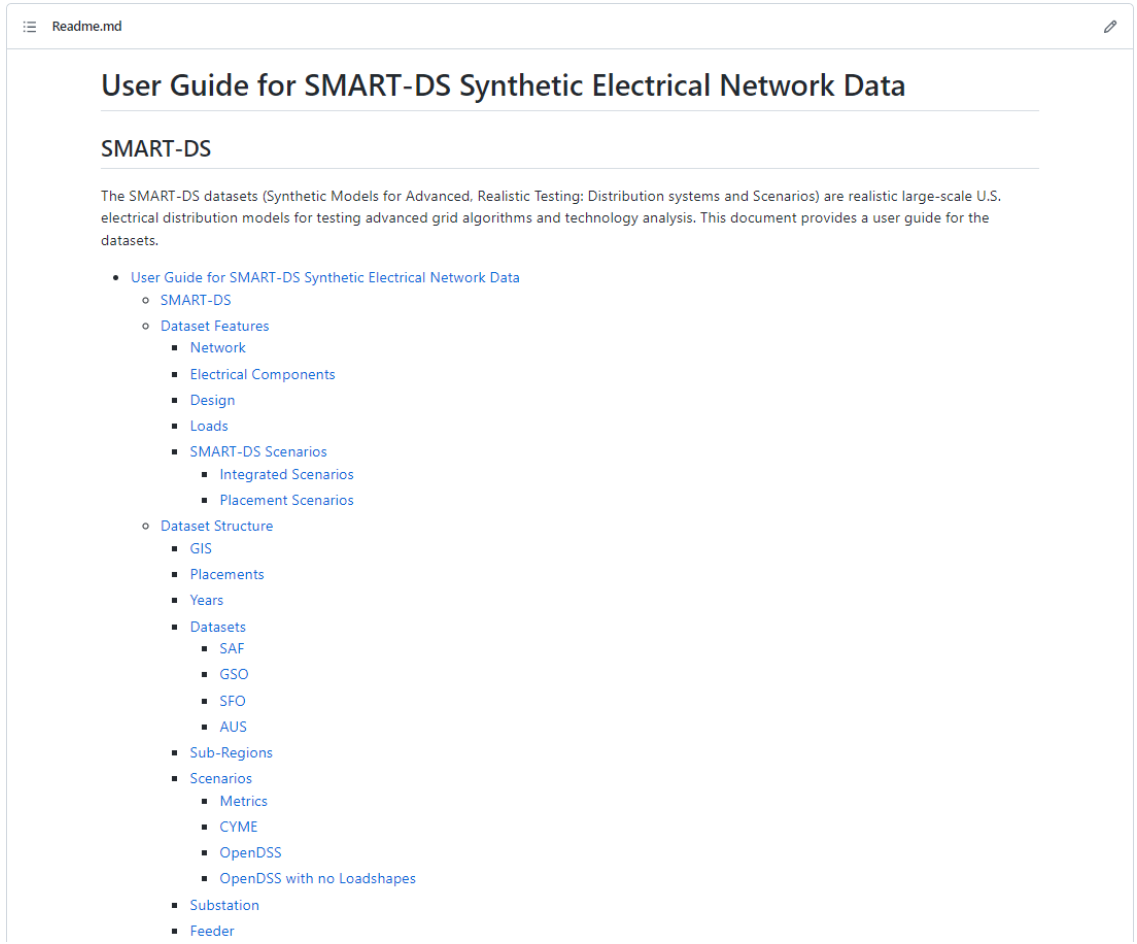
```
$ aws s3 ls "s3://oedi-data-lake/SMART-DS/v1.0/2016/SFO/P1U/scenarios/base_timeseries/opendss/" --no-sign-request
                           PRE analysis/
                           PRE p1uhs0_1247/
                           PRE p1uhs1_1247/
                           PRE p1uhs2_1247/
                           PRE p1uhs3_1247/
                           PRE subtransmission/
2021-07-07 09:32:33     926794 Buscoords.dss
2021-07-07 09:32:33     325659 LoadShapes.dss
2021-07-07 09:32:33       4057 Master.dss
2021-07-07 09:32:33          4 SMART-DS_version.txt
```

The following command recursively downloads all files from the opendss folder of the base_timeseries scenario of P1U in SFO for 2016:

```
$ aws s3 cp "s3://oedi-data-lake/SMART-DS/v1.0/2016/SFO/P1U/scenarios/base_timeseries/opendss/" opendss --recursive --no-sign-request
```

OEDI – User Guide

Detailed user guide of dataset available on Github:
https://github.com/openEDI/documentation/tree/main/SMART-DS



Readme.md

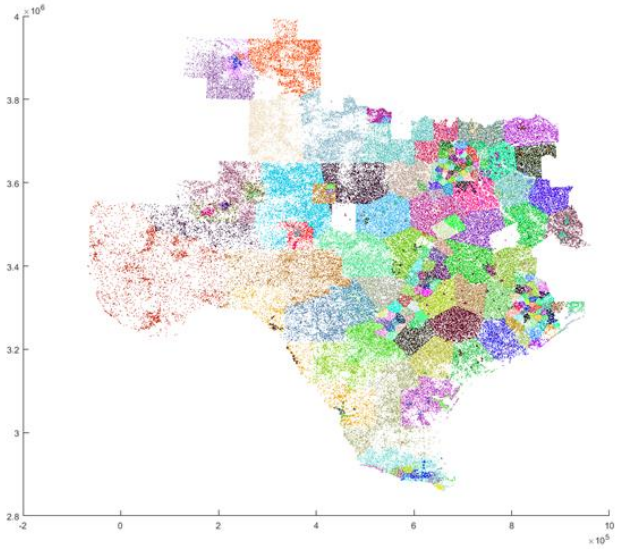
User Guide for SMART-DS Synthetic Electrical Network Data

SMART-DS

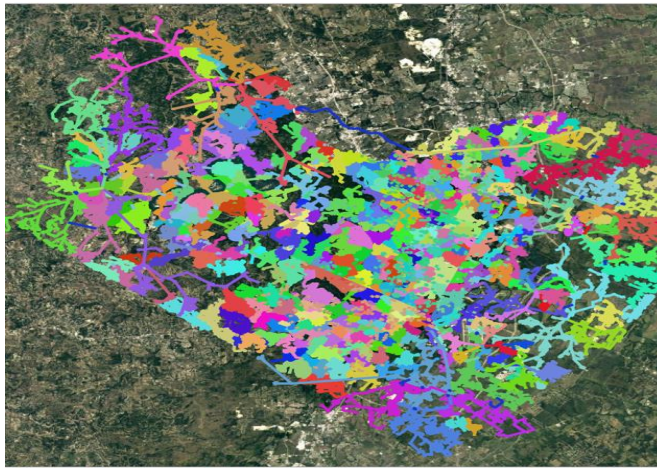
The SMART-DS datasets (Synthetic Models for Advanced, Realistic Testing: Distribution systems and Scenarios) are realistic large-scale U.S. electrical distribution models for testing advanced grid algorithms and technology analysis. This document provides a user guide for the datasets.

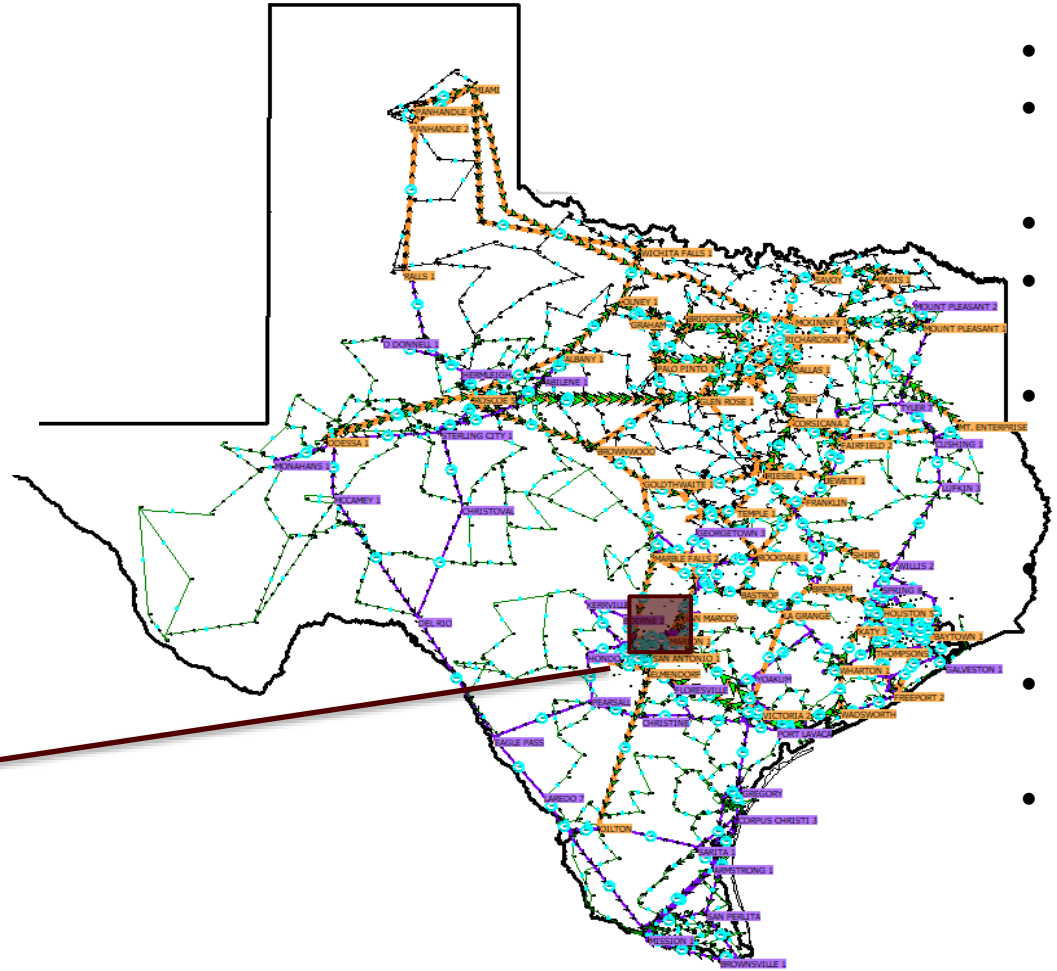
Expanded Datasets

Combined Transmission-Distribution System: Texas



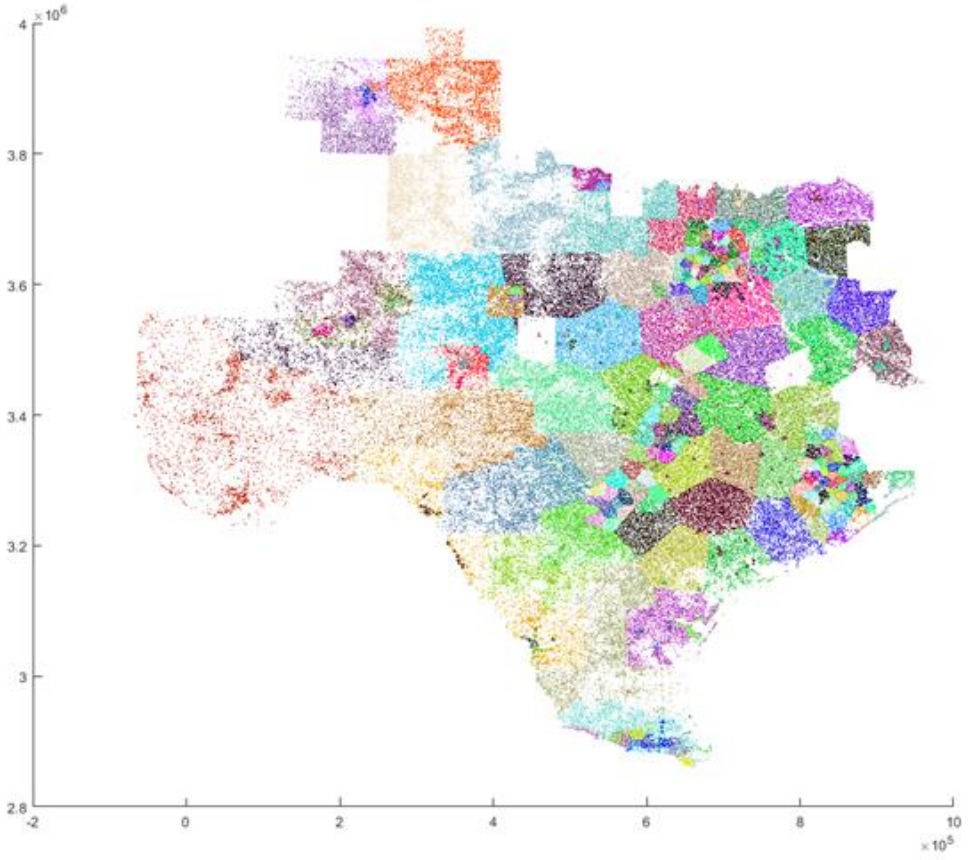
Austin area distribution system

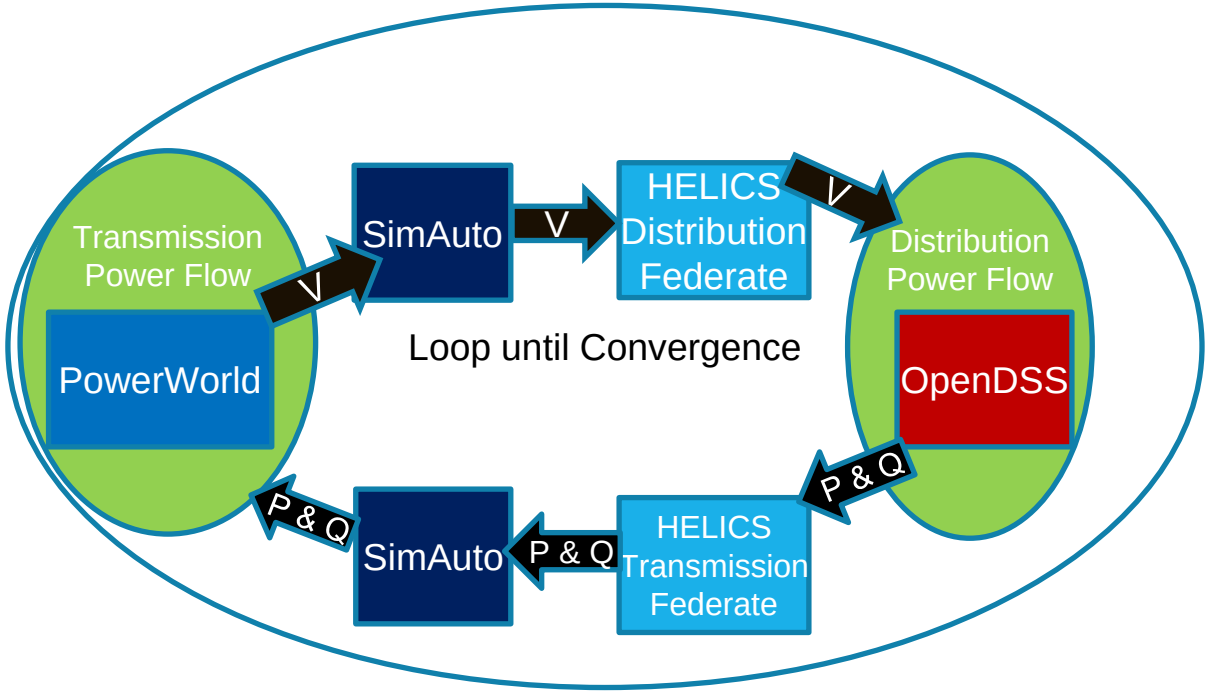


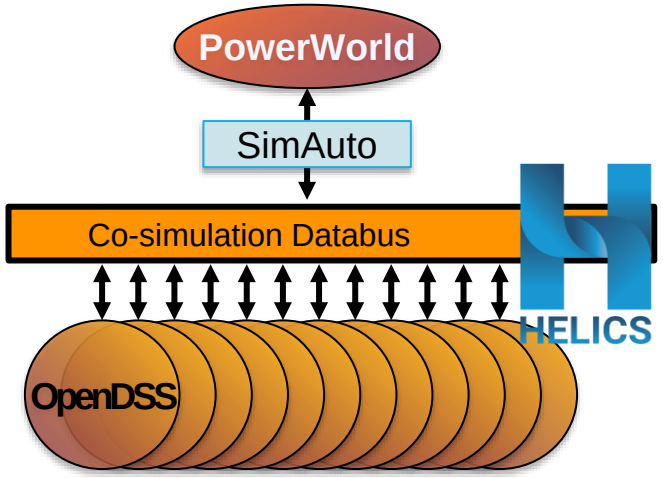


- Transmission -> PowerWorld
- Distribution -> Opendss
- Substation interface between Transmission and Distribution
- Load at 15 minute resolution
- Load aggregated to Transmission
- Co-ordination of Transmission and Distribution managed by HELICS
- Pass information on loads up from distribution
- Pass substation voltage down from transmission
- Capture cascading behavior between timesteps

Co-simulation for Synthetic Texas Grid





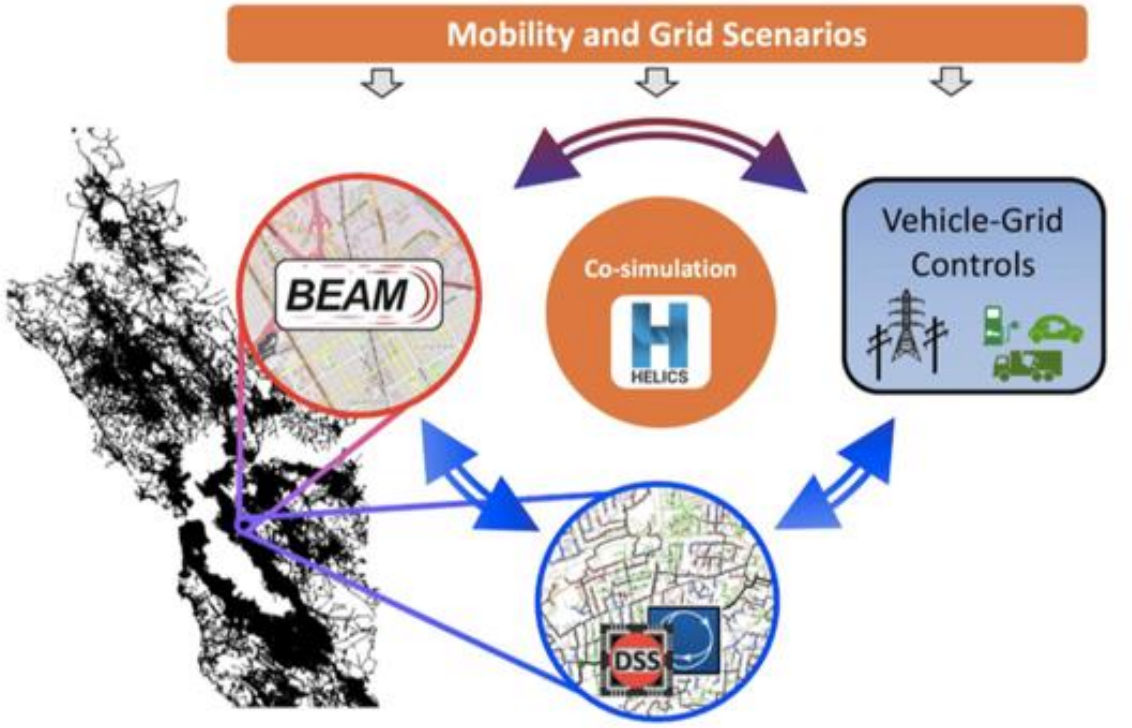


SMART-DS + EV Modelling

GEMINI-XFC will use **first-of-a-kind integrated high-fidelity grid and transport modeling to identify effective pathways for widespread electrification**, design and evaluate integrated vehicle-grid control schemes, and optimize electric vehicle integration at a **full regional scale with individual customer resolution.**

Control variables will include:

- **Charging station design** and planning (where and what kind of charging stations);
- **EV route scheduling** considering grid ”status”;
- **Dispatch of behind-the-meter energy storage** and legacy voltage control actuators (on-load tap changes, voltage regulators, capacitors).

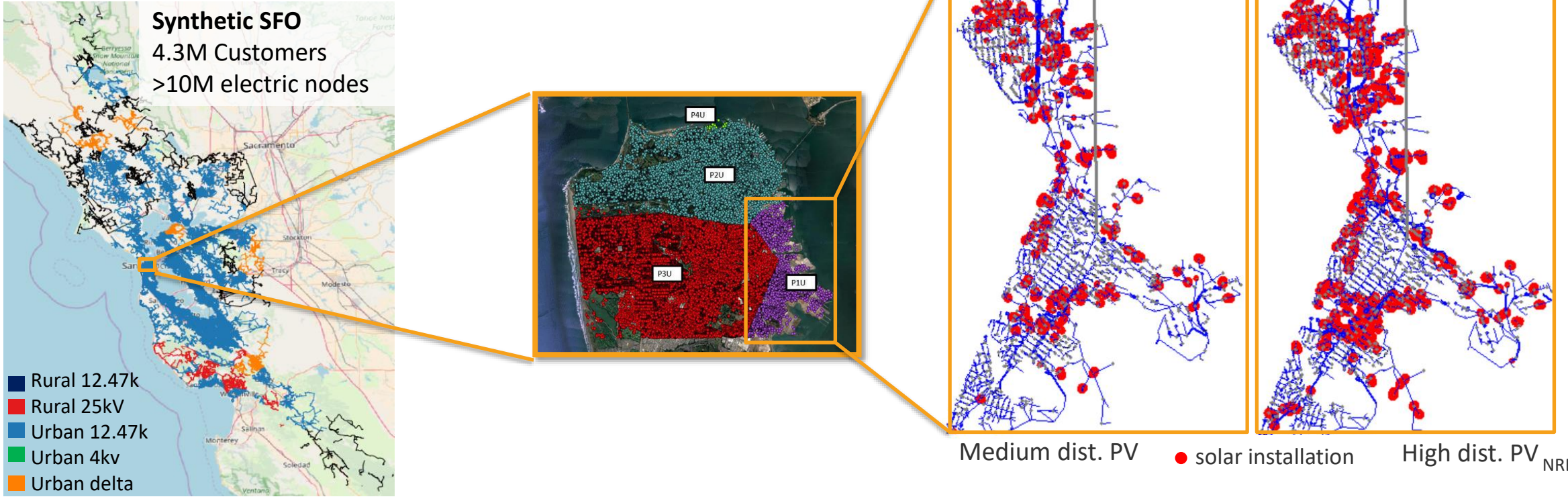


Focus on **extreme fast charging, XFC** (single plug at 250 kW or multiple plugs for a total of 1+MW)

Slides from Nadia Panossian and Bryan Palmintier @NREL

SMART-DS + EV Modelling: Solar Scenarios

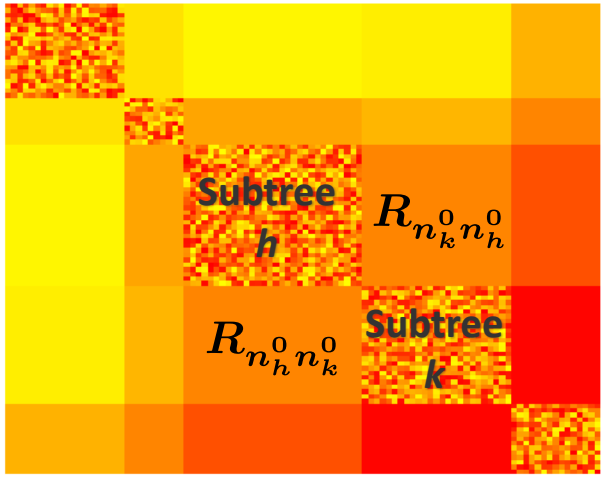
- Can smart charging reduce line congestion and increase power quality (e.g. voltage drops from increased distributed charging)?
- Can smart charging reduce voltage and variability issues from high penetrations of distributed solar?
- Can distributed solar and storage reduce congestion and voltage drop challenges from EV fast charging?



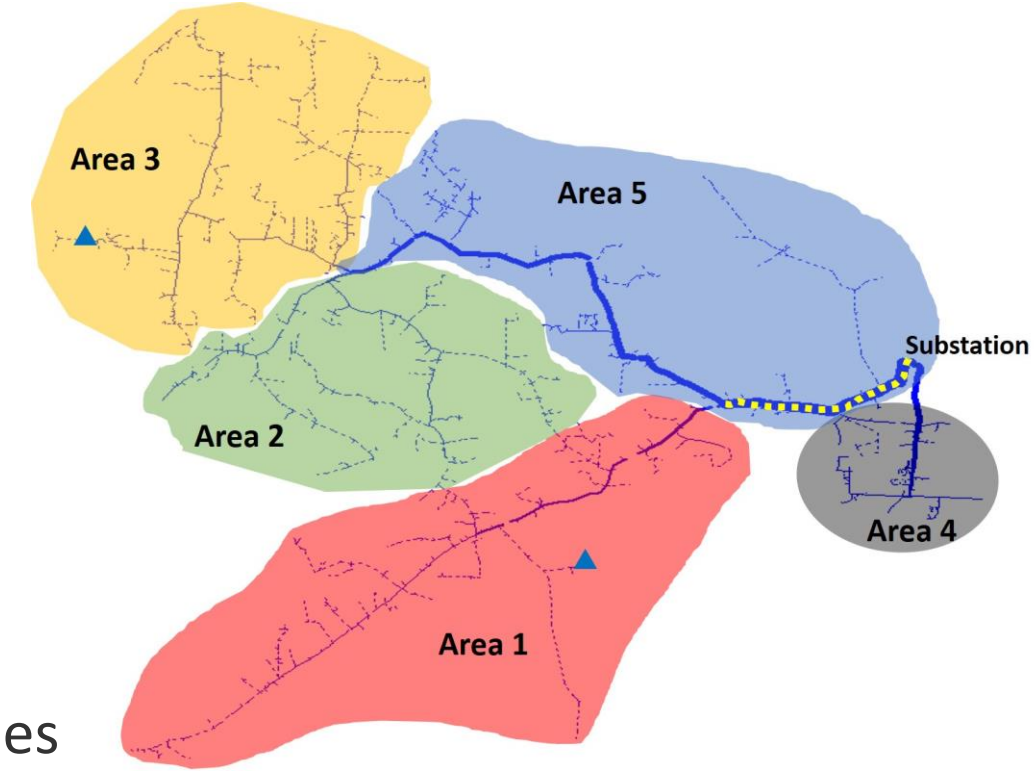
Optimization and Controls advances

- Developed hierarchical controls/optimization strategies
- Separate into areas to improve computation time (approach real-time operation)

Why: more easily distributed

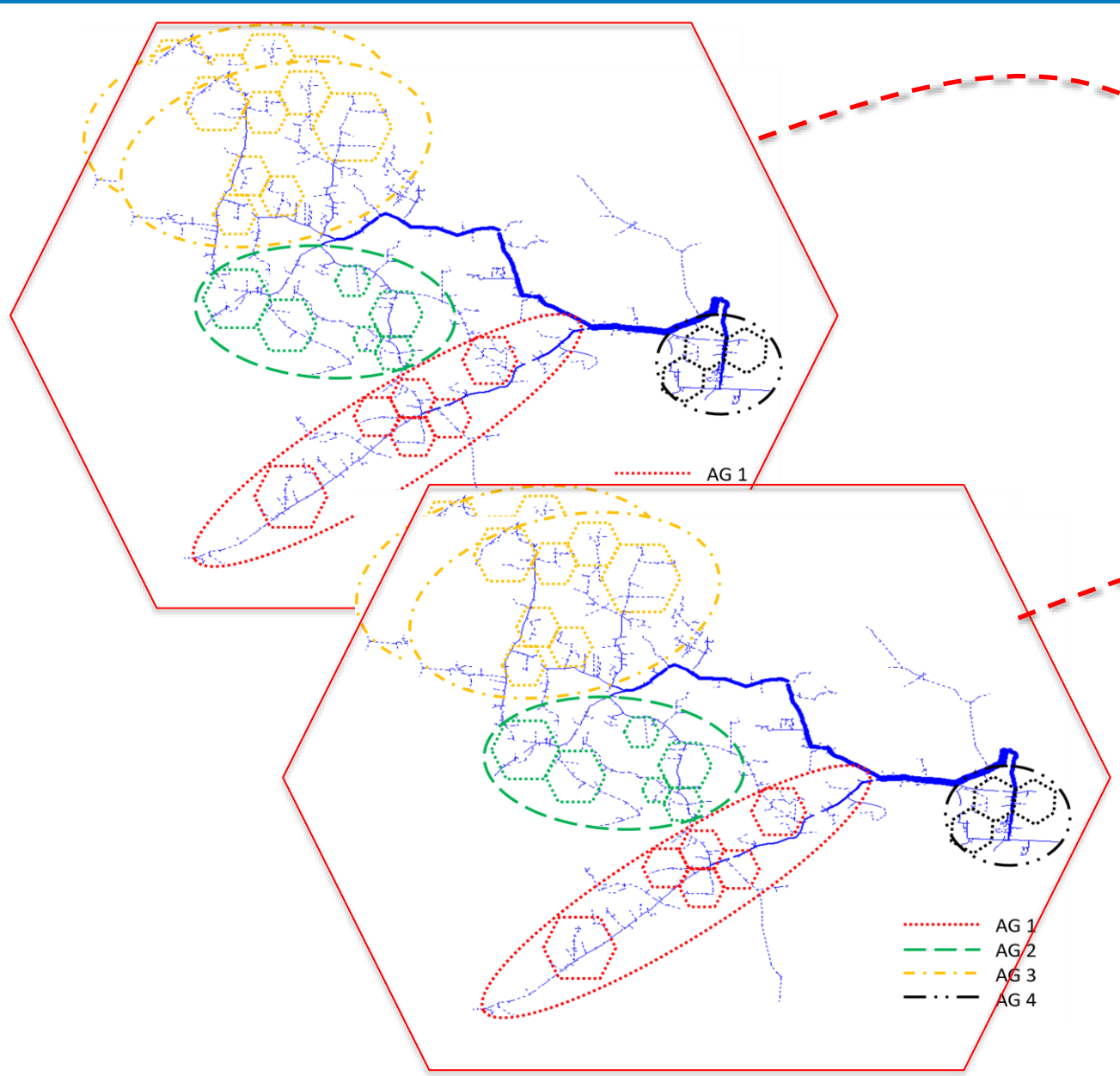


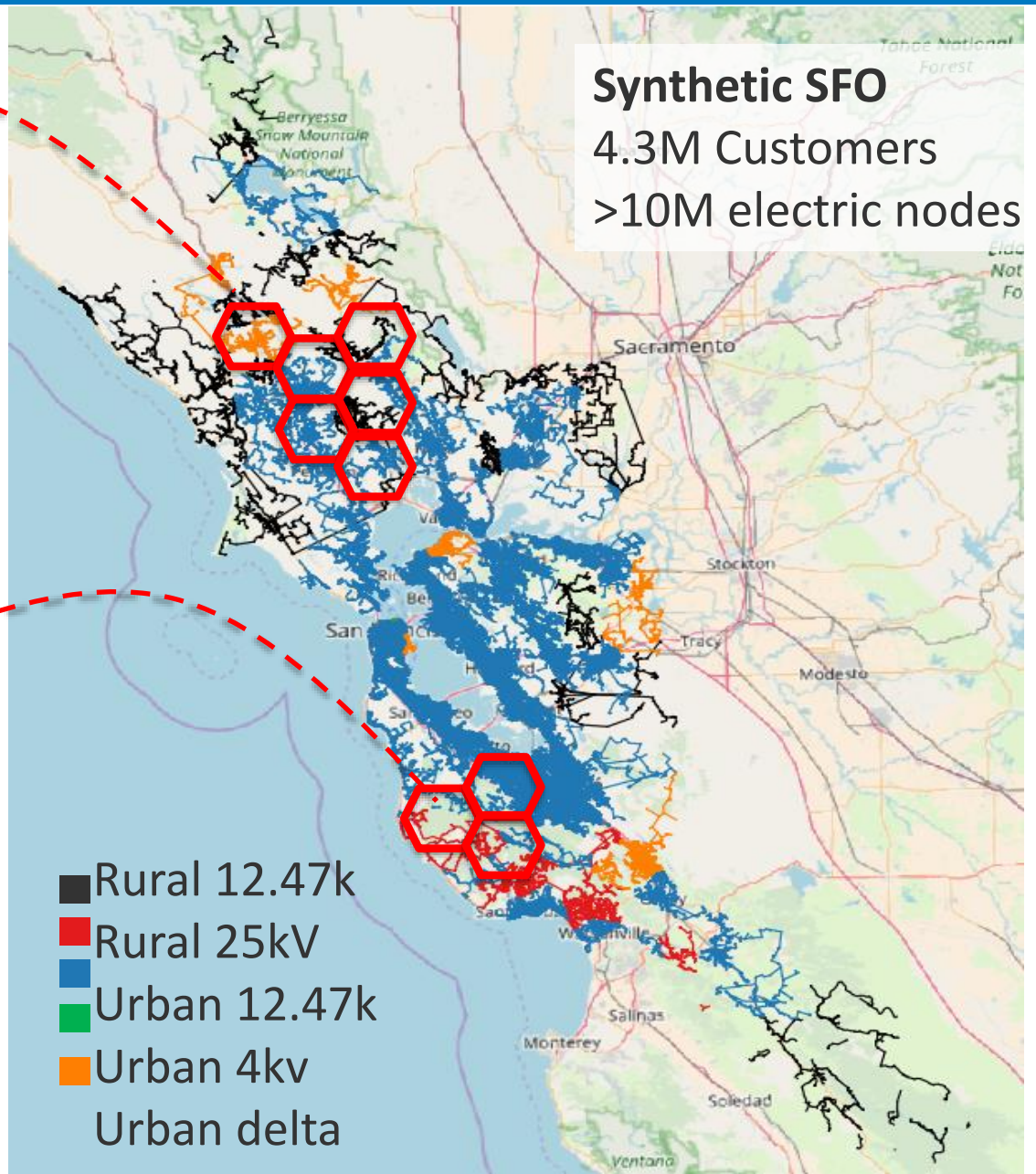
Assume nodes are only impacted by neighboring nodes



Slides from Ben Kroposki @NREL

Demonstrate Autonomous Energy Systems on Realistic Grids





Conclusions

Current Publications

- N. Panossian, T. Elgindy, B. Palmintier and D. Wallison, "Synthetic, Realistic Transmission and Distribution Co-Simulation for Voltage Control Benchmarking," *2021 IEEE Texas Power and Energy Conference (TPEC)*, 2021, pp. 1-5, doi: 10.1109/TPEC51183.2021.9384935.
- H. Li *et al*., "Building Highly Detailed Synthetic Electric Grid Data Sets for Combined Transmission and Distribution Systems," in *IEEE Open Access Journal of Power and Energy*, vol. 7, pp. 478-488, 2020, doi: 10.1109/OAJPE.2020.3029278.
- H. Li *et al*., "Building Highly Detailed Synthetic Electric Grid Data Sets for Combined Transmission and Distribution Systems," in *IEEE Open Access Journal of Power and Energy*, vol. 7, pp. 478-488, 2020, doi: 10.1109/OAJPE.2020.3029278.
- C. Mateo *et al*., "Building Large-Scale U.S. Synthetic Electric Distribution System Models," in *IEEE Transactions on Smart Grid*, vol. 11, no. 6, pp. 5301-5313, Nov. 2020, doi: 10.1109/TSG.2020.3001495.
- V. Krishnan *et al*., "Validation of Synthetic U.S. Electric Power Distribution System Data Sets," in *IEEE Transactions on Smart Grid*, vol. 11, no. 5, pp. 4477-4489, Sept. 2020, doi: 10.1109/TSG.2020.2981077.
- Bryan Palmintier, Tarek Elgindy, Carlos Mateo, Fernando Postigo, Tomás Gómez, Fernando de Cuadra, Pablo Duenas Martinez, Experiences developing large-scale synthetic U.S.-style distribution test systems, Electric Power Systems Research, Volume 190, 2021, 106665, ISSN 0378-7796, https://doi.org/10.1016/j.epsr.2020.106665.

Team + Data + Questions

- Data Available online now!
- Feel free to cite us!
- Project Team:
  - National Renewable Energy Laboratory (NREL)
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    - Bryan Palmintier (PI), Tarek Elgindy (Co-PI), Nadia Panossian, Dheepak Krishnamurthy, Michael Rossol, Henry Horsey, Eric Wilson, Phil White
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    - Co-lead, Transmission
    - Tom Overbye (PI), Diana Wallison, Jessica Wert, Hanyue Li
  - MIT
    - Distribution, Parcel Data
    - Pablo Dueñas
  - Comillas-IIT
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