NRECA’s DER Interconnection Work for Cooperatives

Open Modeling Framework and others

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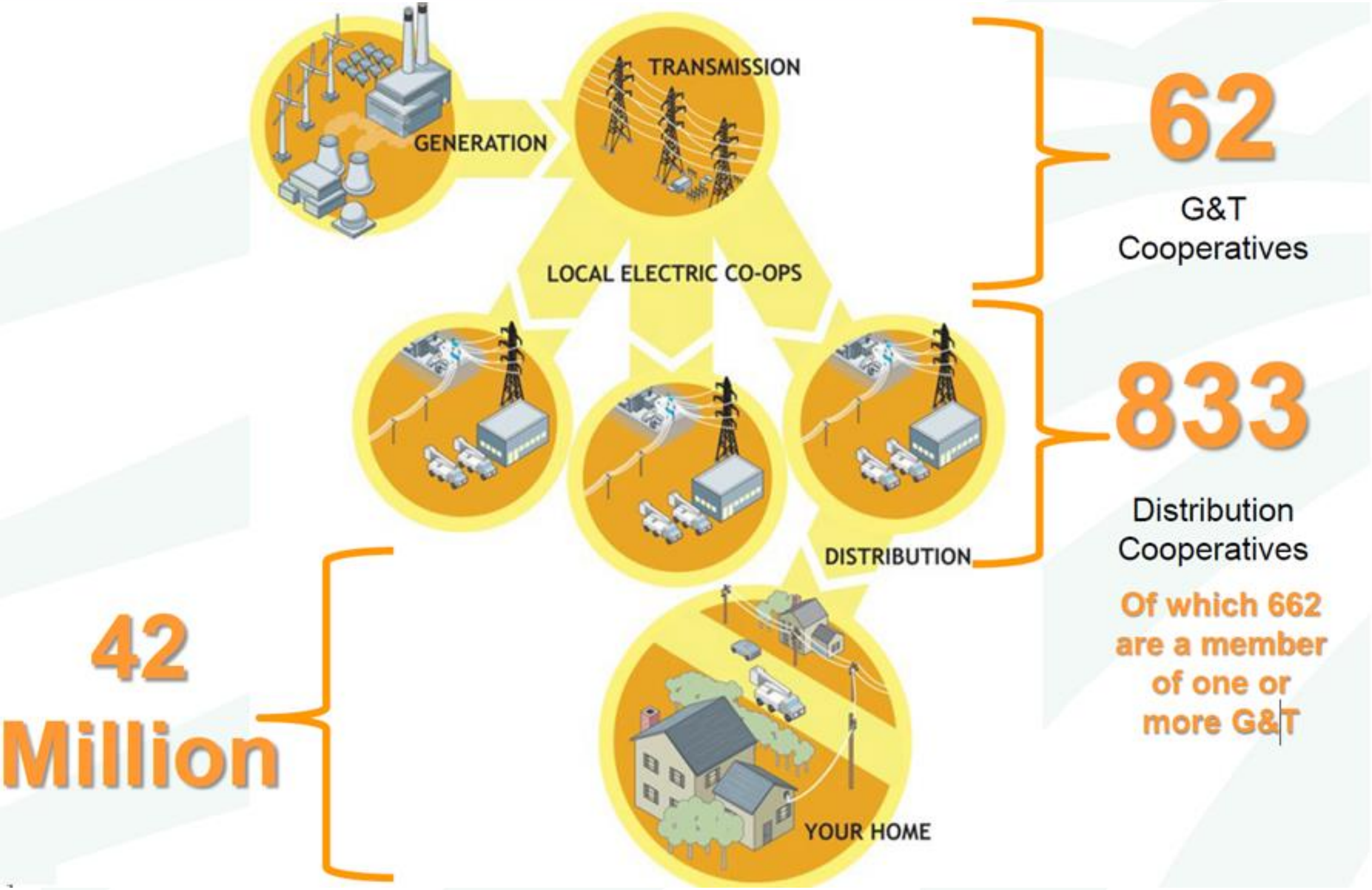
Outline

- Our team (NRECA and BTS)
- DER growth among the cooperatives (co-ops)
- NRECA offerings to co-ops in the DER space
- Open Modeling Framework (OMF)
- DER interconnection applications
  - Completed
    - DER Interconnection in omf.coop
    - Rapid Solar Interconnection automation model (R3IT)
  - Being finalized
    - Model-free Hosting Capacity Analysis (MOHCA)
    - Microgrid Planning Utilizing OMF (Microgrid-UP)
  - Smart Inverters field studies
  - DG Toolkit

National Rural Electric Cooperative Association (NRECA)



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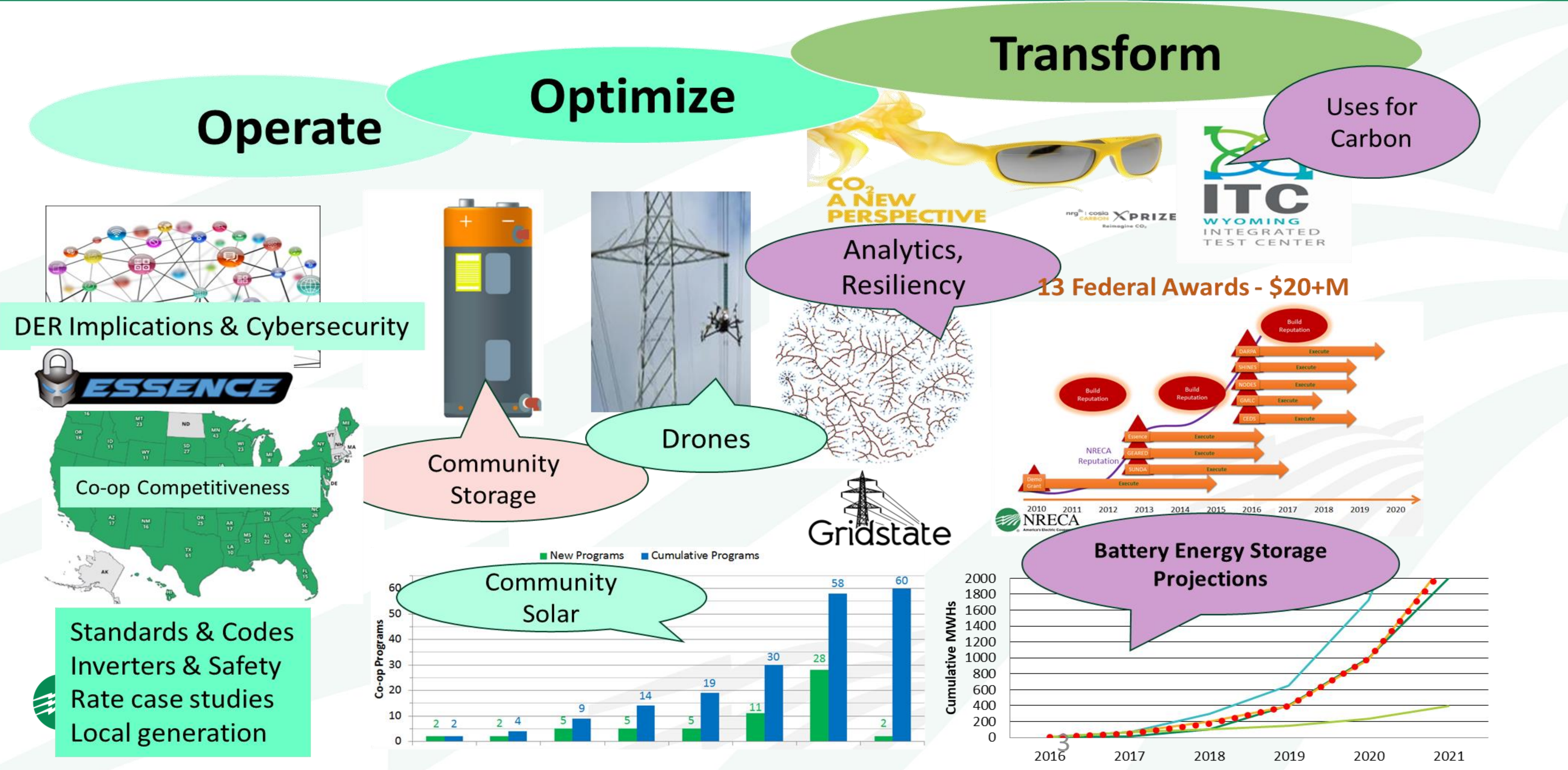
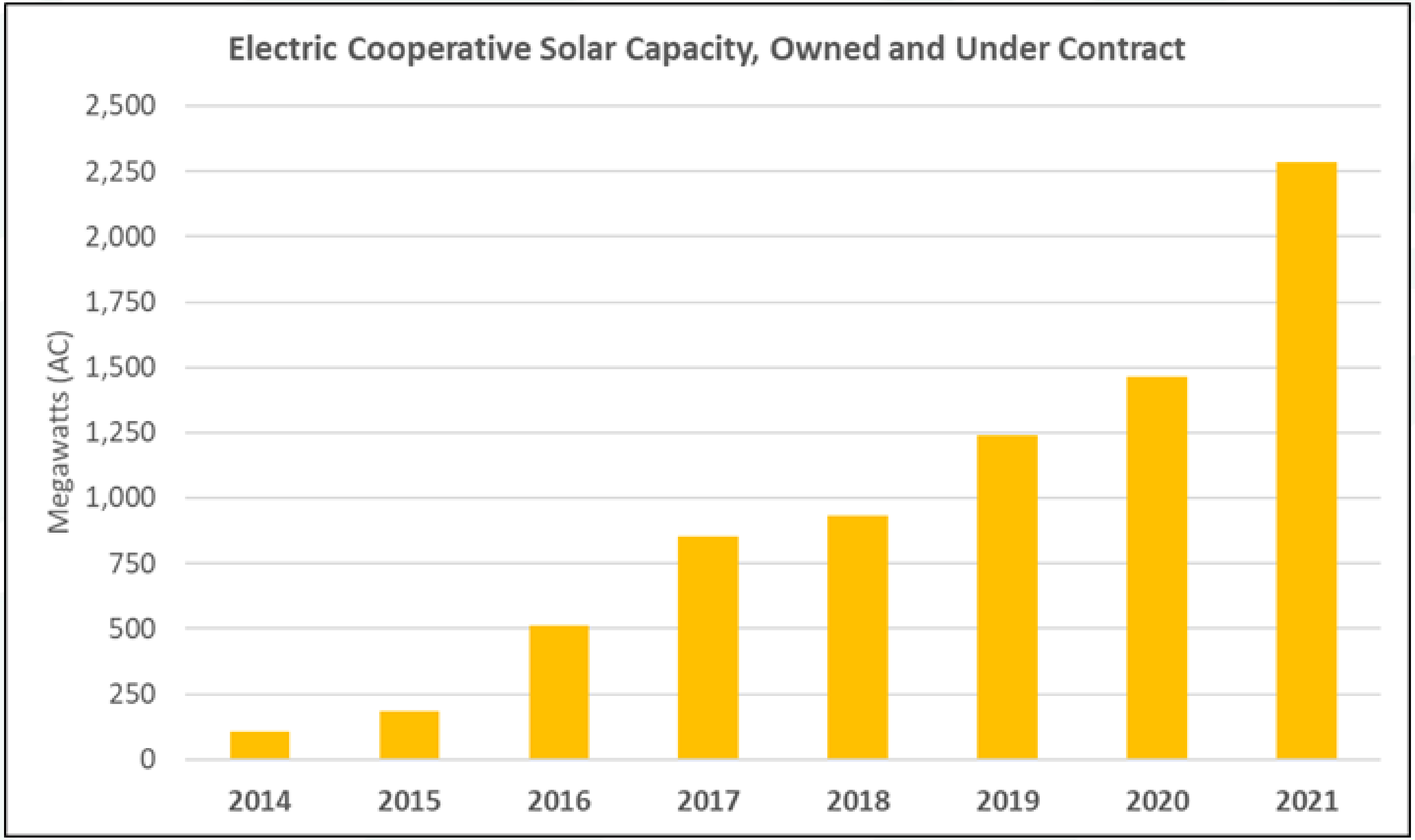
NRECA's BTS Applied Research & Development



Solar Growth in co-ops territories

- As end of 2021, co-ops solar capacity (owned & contracted) more than 2.2 GW



NRECA DER Interconnection Efforts

- NRECA offers tools and resources to help distribution and G&T co-ops nationwide with influx of DER interconnections
- These resources are in form of:
  - Educational materials to DER interconnection standard IEEE 1547
  - DG toolkit (set of documents to handle DG interconnection requests)
  - Software tools to help co-ops process DER interconnection faster and easier
    - DER Interconnection in omf.coop
    - R3IT
    - MOHCA
    - Microgrid UP
  - Smart Inverters alternative settings for voltage regulations here

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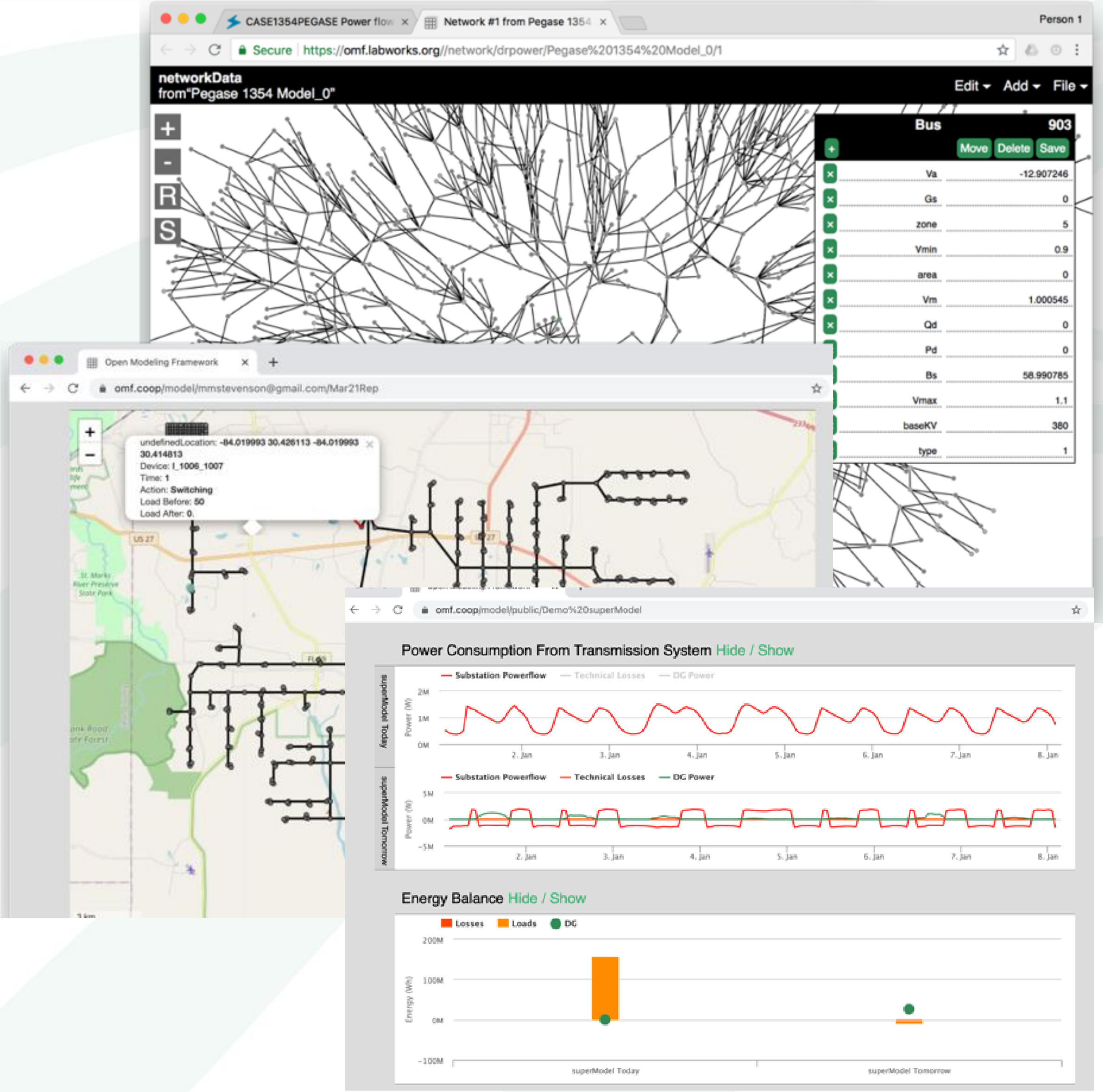
DER Interconnection Tools

- **Open Modeling Framework (OMF)**
  - Web-based modeling platform OMF.coop allows utility access to advanced algorithms and modeling tools via easy graphical interface
  - Visualization, data conversion, and model management tools in place
  - 100+ utilities active on the platform



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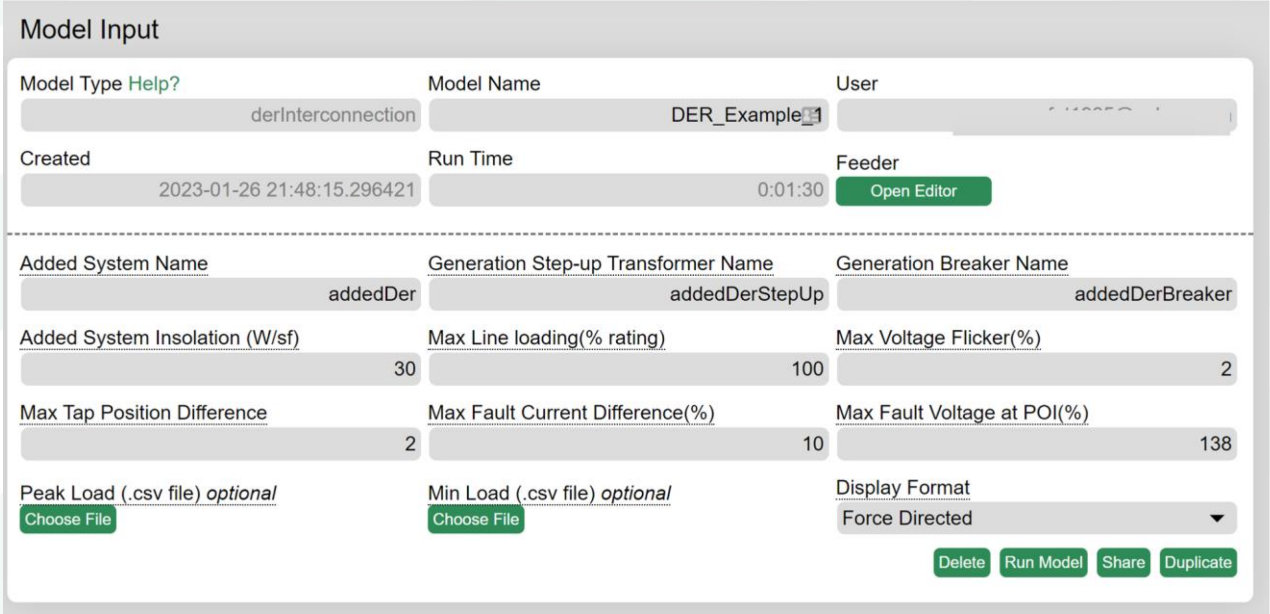
Open Modeling Framework
DER Interconnection Model

- **DER Interconnection Model in OMF**
  - carries out key modelling and analysis steps involved in DER impact study including
    - Load Flow computations
    - Short Circuit Analysis
    - Effective Grounding Screenings
  - analysis presented in a static point-of-view of a 24-hr simulation period (not time series analysis)
  - We will walk through an example together towards the end of this session

Model Inputs



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https://github.com/dpinney/omf/wiki/Models-~-derInterconnection

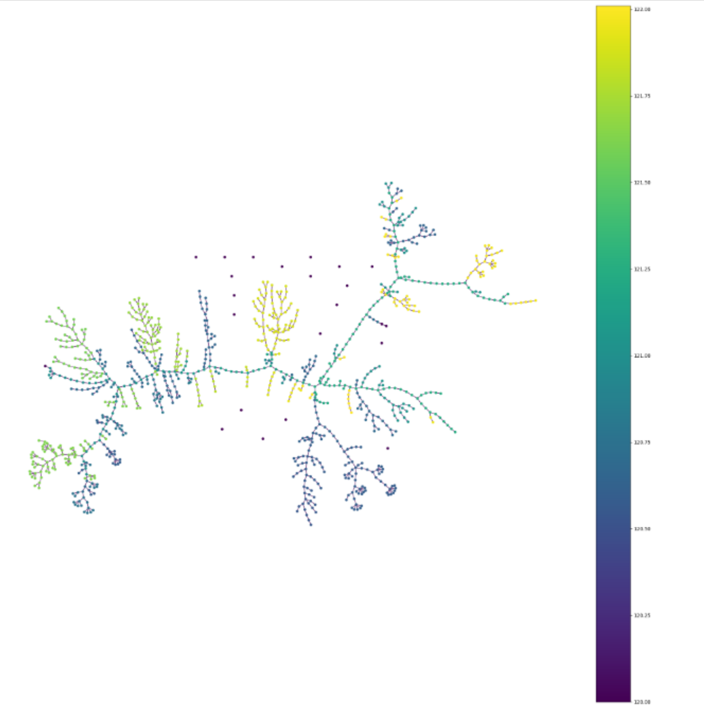
Open Modeling Framework
DER Interconnection Model

- **DER Interconnection Model in OMF**
  - **Some Outputs**

Load Flow Analysis

Distributed Energy Resource Status: On Off   Load Type: Peak Minimum

Voltage | Current | Line Loading | Flicker



Nodes with voltage value >126 outlined in red
Nodes with voltage value <114 outlined in orange

Maximum and Minimum Voltages

DER Status	Load Condition	Max Voltage		Min Voltage	
		V	Location	V	Location
On	Peak	7320.39	nodeT6246216924517038	120.55	node62462225428T62462224580
On	Min	7309.85	nodeT6246216924517038	120.75	node62474204371T62474204354
Off	Peak	7325.79	node18410F7423	120.37	node62462058558T62462057585
Off	Min	7314.53	nodeT6246216924517038	120.73	node62474204371T62474204354

Maximum Voltage Flicker when DER is turned off

Regulator Power Flow

Location	Power	DER Status
regulator171929	504.39	Peak Load, DER On
regulator171929	542.74	Peak Load, DER Off
regulator171929	325.78	Min Load, DER On
regulator171929	350.81	Min Load, DER Off

Reverse power flow violations displayed in red

Tap Changes

Load Condition	Location	Tap Position DER On	Tap Position DER Off	Difference
Peak	regulator171929 tapA	2	2	0
Peak	regulator171929 tapB	1	1	0
Peak	regulator171929 tapC	1	1	0
Min	regulator171929 tapA	2	2	0
Min	regulator171929 tapB	1	1	0
Min	regulator171929 tapC	1	1	0

Tap change differences greater or equal to the input max tap change difference are displayed in red

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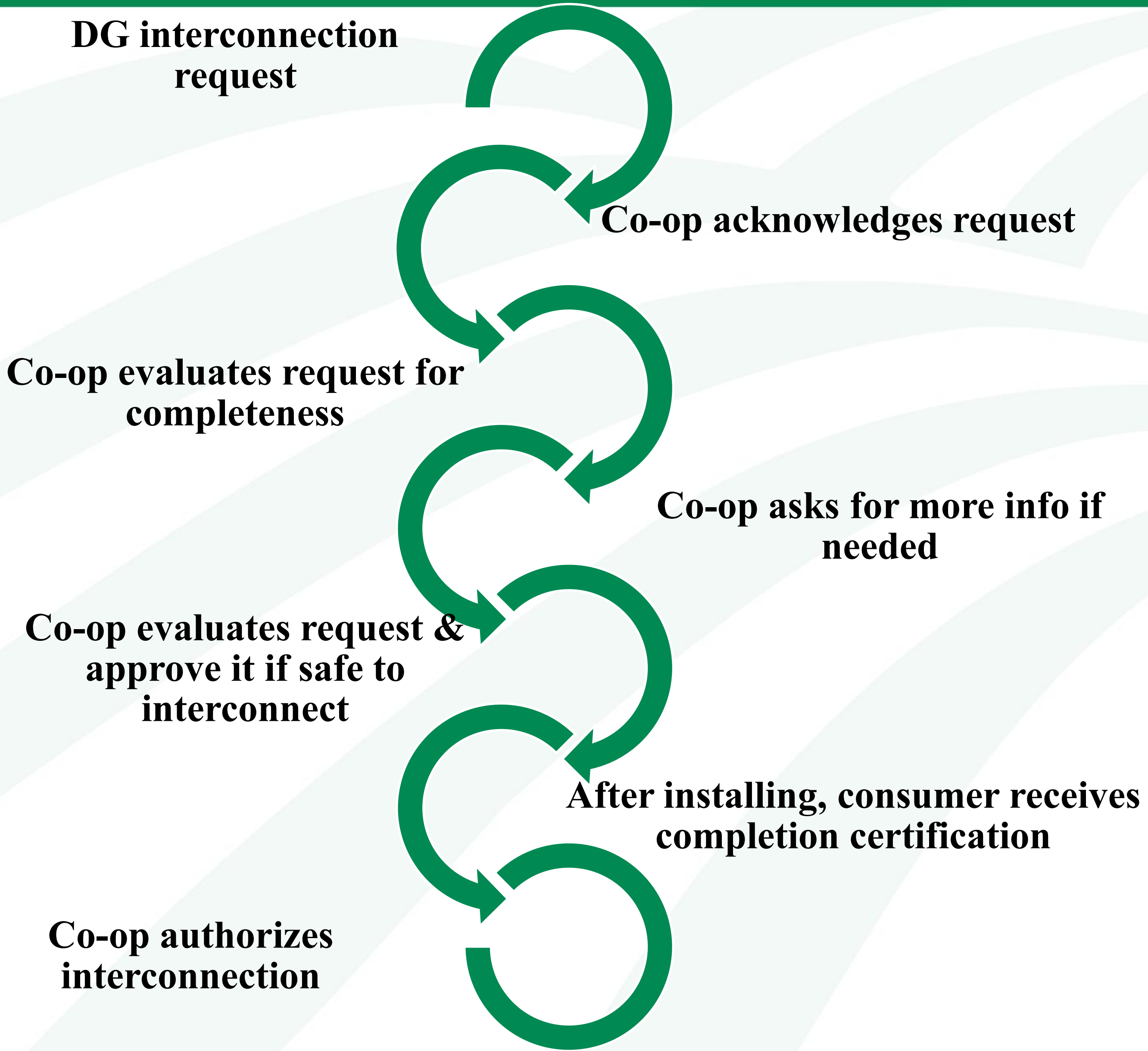
R3IT

- Traditional interconnection workflow steps for 10 kW system or less ➔

- NRECA developed a software application that automates the steps of the utility interconnection workflow (R3IT)
- This software available for installation as a free, open-source application



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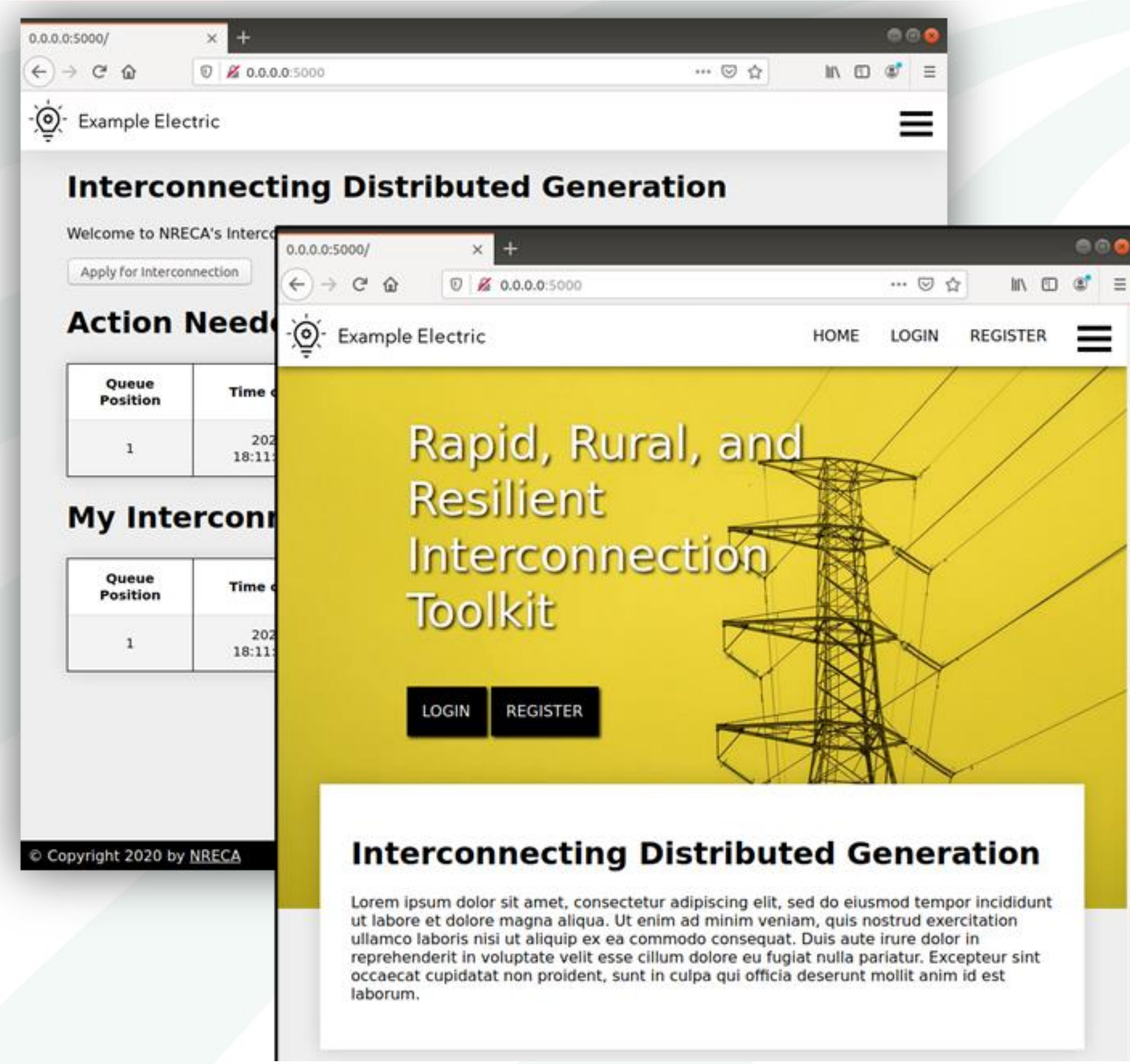
R3IT

- **Production Release Overview**
  - Features:
    - Online application and document submission
    - Payment and signature collection
    - Interconnection lifecycle management
    - Email notifications
    - Automated engineering screening
    - Configurable through single file
    - Can be Cloud hosted or deployed locally
  - Try it out!
    - https://demo.r3it.ghw.io
    - Register with your email to see the consumer workflow
    - Login with username "engineer@electric.coop" and password
- Want to install? See the open-source release:
  - https://github.com/dpinney/r3it



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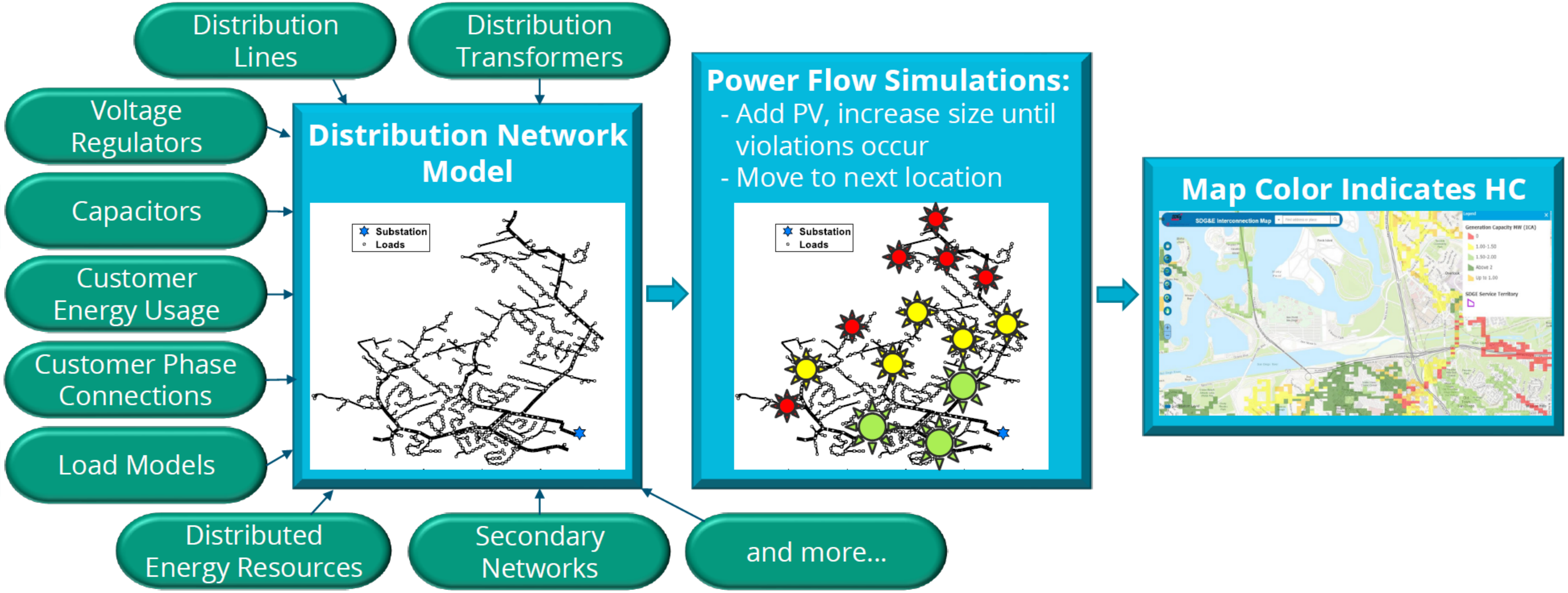
This work supported by the DOE's EERE under the Solar Energy Technologies Office

Tools Being Finalized
MOHCA (NRECA-Sandia-GTech)

- **Conventional model-based HCA**



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Source : Sandia

Tools Being Finalized
MOHCA (NRECA-Sandia-GTech)

- **Objectives**
  - Develop scalable algorithms for estimating the voltage and thermal-constrained HC at smart meter locations
  - Algorithms for identifying optimal inverter settings
  - Evaluating hosting capacity as a time-series, instead of considering a handful of worst-case scenarios that may underestimate HC
- **Motivation**
  - Co-ops already have the smart meter infrastructure and data, but maybe not models/tools/time
  - Help drive down the cost of solar, improving access to affordable clean energy
  - Providing energy justice by facilitating the siting of Community Solar projects that benefit low-income areas

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Tools Being Finalized
MOHCA (NRECA-Sandia-GTech)

Speed and Scalability of Generating HC Maps

Iterative

Pros:
- High accuracy, if grid models are accurate

Cons:
- Requires detailed, error-prone grid models
- Very long simulation times

Streamlined

Pros:
- Moderate simulation times

Cons:
- Requires detailed, error-prone grid models
- Less accurate than iterative

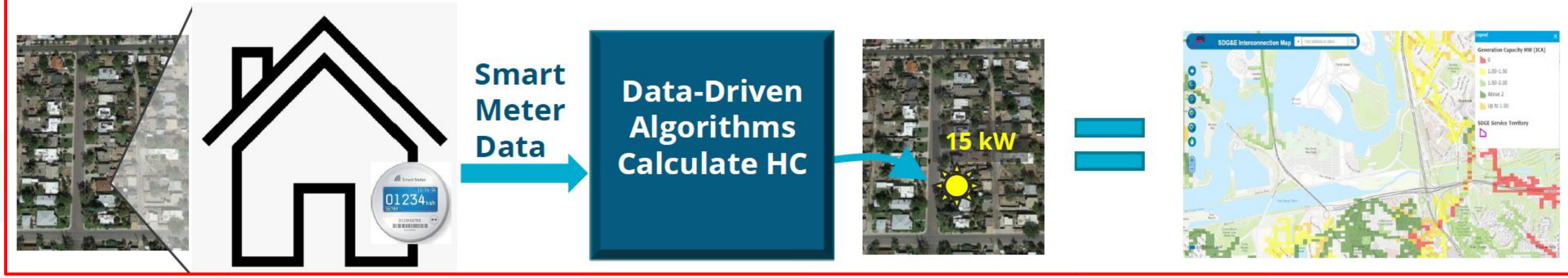
Data-Driven

Pros:
- *No* grid modeling required
- *No* simulations required
- New functionality

Cons:
- Requires smart meter data

Model-Based (Iterative, Streamlined)

Model-Free (Data-Driven)



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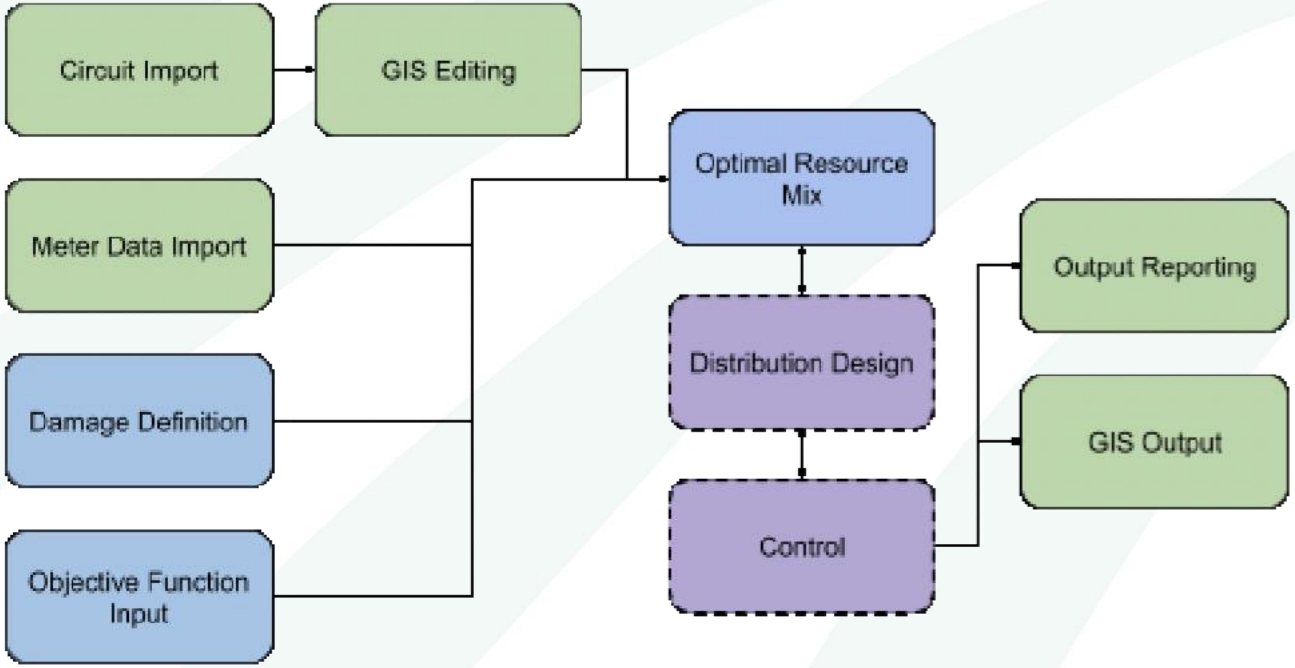
Tools Being Finalized
Microgrid UP

- **Core problem is installation resilience**
  - Critical installations require electric power to operate at full strength, as is reflected in for 14 days of islanded operation
  - Majority of electric power outages were due to disruptions to the bulk grid
- **Microgrids offer resilience but planning them is challenging:**
  - Deployment incurs large planning costs (20-40% of total costs)
  - Complex environment of legacy generators and infrastructure are not interconnected
  - Planning requires engineering planning, damage modeling, and characterization of critical loads
- **Current approach:**
  - No shared approach across the utility industry, especially for multi-building sites
  - No comprehensive planning tools (unlike for e.g. distribution design)

Tools Being Finalized Microgrid UP

- **Objectives**
  - Develop a common microgrid planning methodology including standardization of assumptions and data requirements
  - Implement an open-source tool that solves the key computational problems in large installation microgrid design (optimal distribution design and generation mix)
  - Field-validate the process and tool by creating microgrid roadmaps for 4 diverse military installations
- **System architecture**



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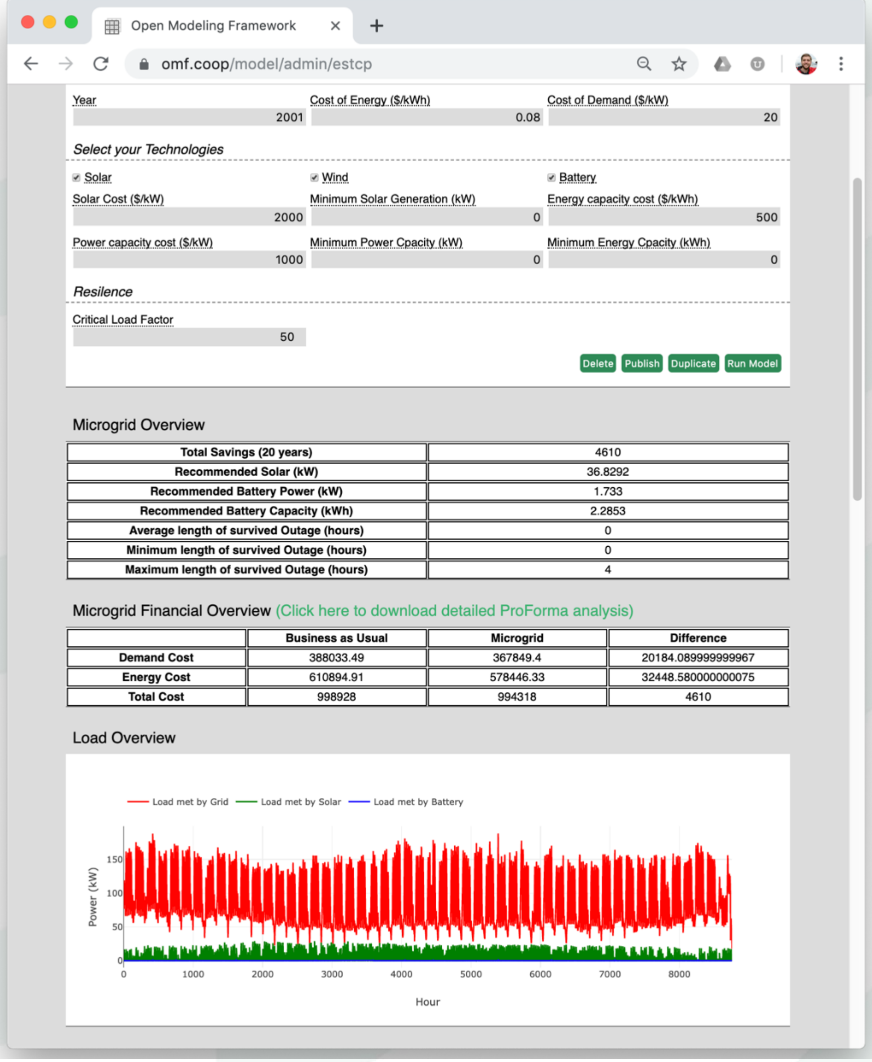
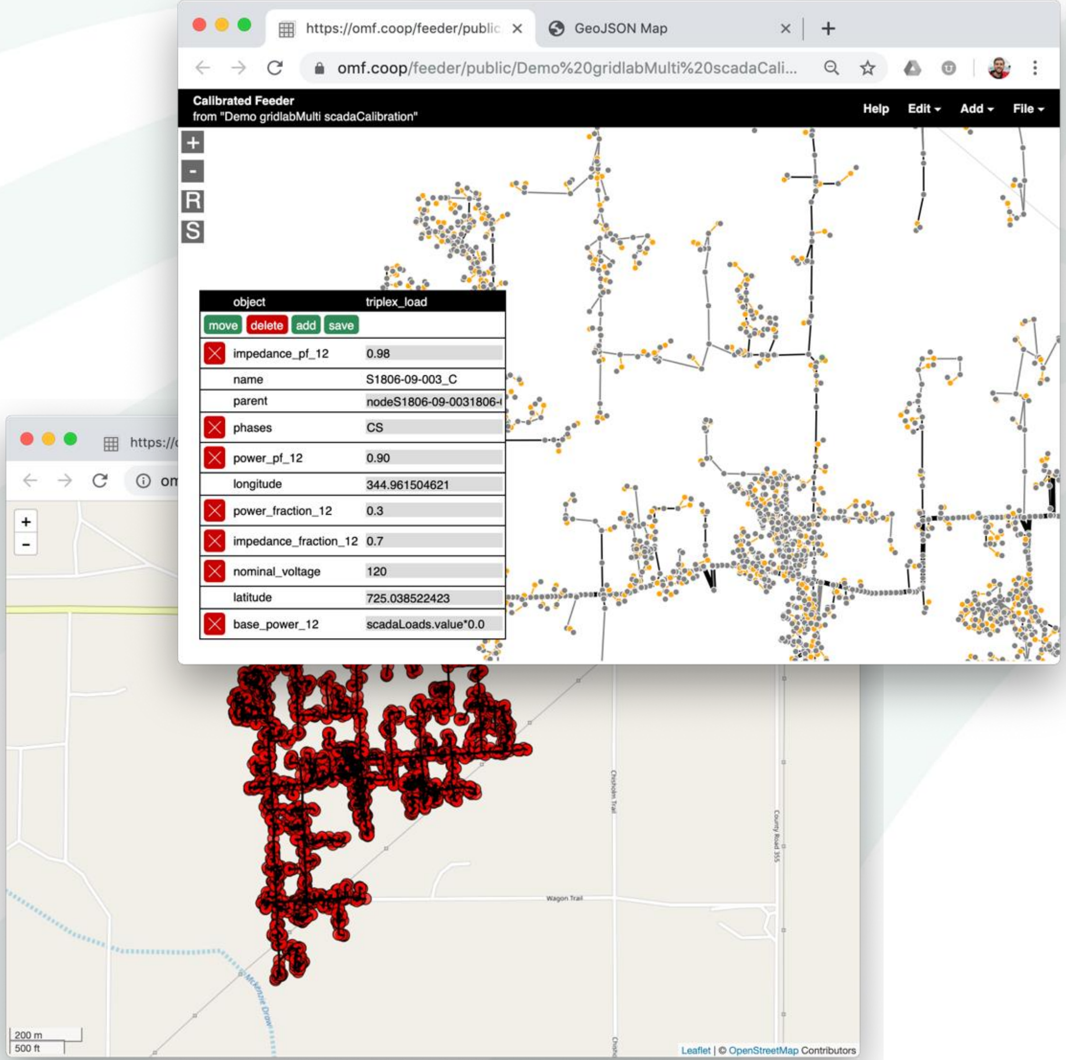
Tools Being Finalized
Microgrid UP

- **Generation mix**



- **Data Ingest**



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Smart Inverter Demo Project – Voltage Regulation

- **Simulation Studies**
  - Objective of simulation studies determine alternative settings for studied solar PV sites
  - Study the impact of changing the settings on inverters operations and distribution feeder
  - Used actual load and solar datasets from sites
  - We use circuit models and run QSTS using NRECA's **OMF & OpenDSS**
  - It considers the unique characteristics of rural distribution feeders

Step 1: Pre-test data collection

- Circuit model (e.g., WindMil, CYME)
- Hourly/sub-hourly solar generation
- Hourly/sub-hourly load data at substation, and at individual meters

Step 2: Simulation studies (alternative settings)

- Base Case (Unity PF/No voltage regulations)
- Case-I (Fixed non-unity PF)
- Case-II (Volt-Var) or (Volt-Watt) curves

Step 3: Test plan and field test

- Implementing different simulated VR settings
- Circuit response and collecting data of covariates impacting results

Step 4: Post-test data collection & analyses

- Substation data (Voltage, load, regulators operation)
- Point of Interconnection (POC) data (Voltage, power, etc.)
- AMI readings at different parts of the system

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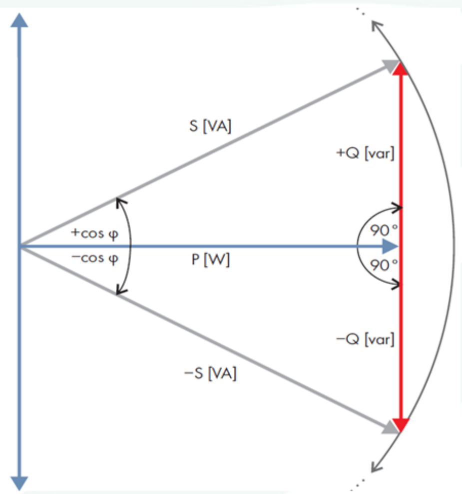
Smart Inverter Demo Project – Voltage Regulation

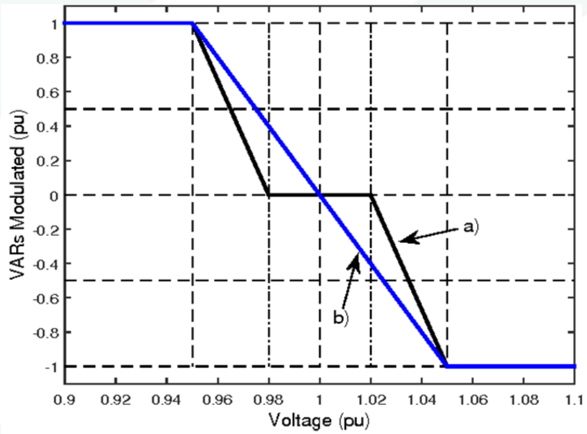
- **Simulation Studies**
  - **Base Case (Default Settings)**
    - Unity PF/Set and forget
    - No Voltage Regulation required (older versions IEEE 1547)
  - **Case-I**
    - Fixed PF Inductive/Capacitive
    - Considering CAT-I & CAT-II
  - **Case-II**
    - Volt-Var Curve (with and without dead-band)
    - Volt-Watt if available
    - Considering CAT-I & CAT-II

Case-I: Fixed PF



Considering fixed step fixed PF

Case-II: Volt-Var Curves



Considering different slopes, with and without dead-band curves

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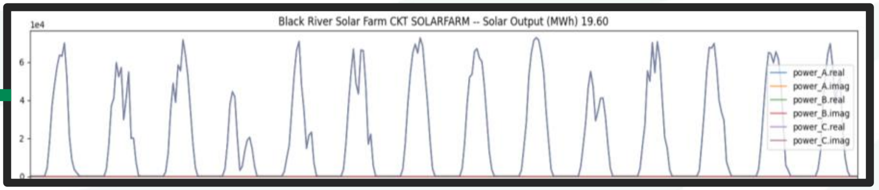
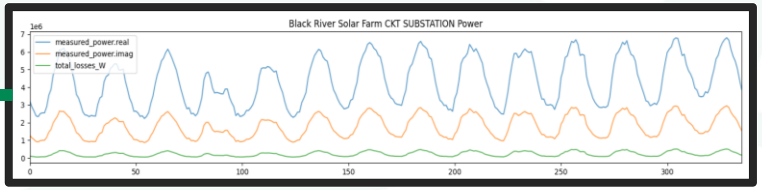
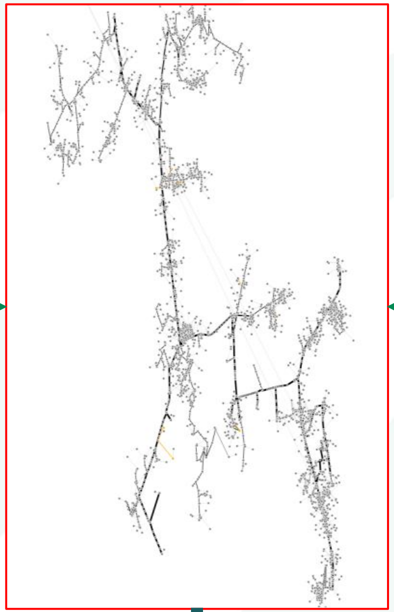
Smart Inverter Demo Project – Voltage Regulation

- **Simulation Studies Outputs**
  - Voltage profile along the feeder and how it relates to the distance from solar PV system and the substation
  - Impact on losses
  - Impact on voltage regulating devices operations
  - Power Factor at the substation

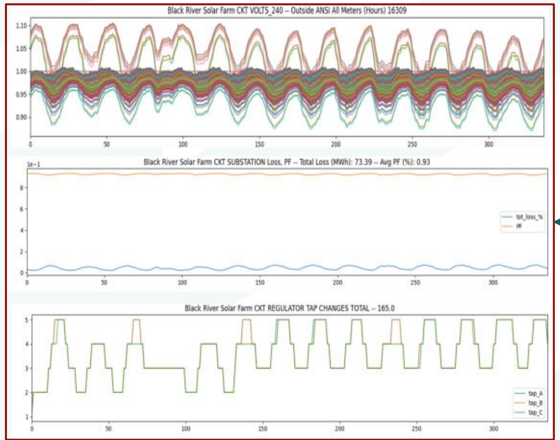




Historical data



QSTS power flow



Simulations outputs

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Distributed Generation Toolkit Update

- DG Toolkit consists of forms and procedures to help co-ops with DER interconnection
- For all sizes of DG: A model distribution cooperative agreement for interconnection and operation of distributed generation
- Small size applications:
  - Small size DG model interconnection application
  - Shortened small size DG application for residential members (only Solar and/or Storage)
- Medium size DG model interconnection application
- Large size DG model interconnection application
- Extra-Large applications:
  - Extra Large DER fast-tack document
  - Extra Large – Generator Interconnection (GI) Study Data Sheets for all types (PV, wind, synchronous)

Thank you

Questions ?

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