

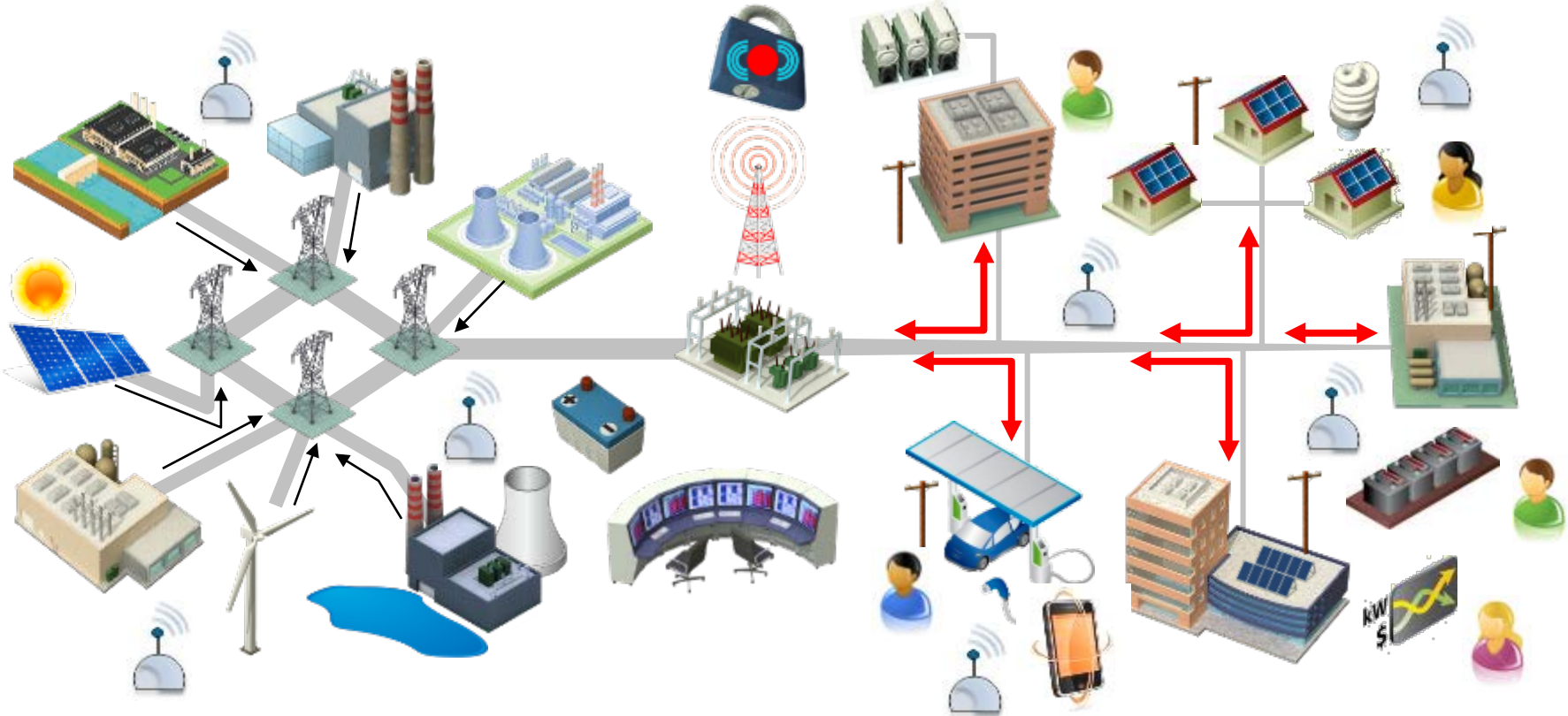
Leveraging Open-Source Tools to Advance Industry Capabilities: OpenDSS

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Advanced Energy Conference
March 28, 2018
New York City, NY



Landscapes – The Future Integrated Grid



Power System that is Highly Flexible, Resilient and Connected and Optimizes Energy Resources

Integrating New Technologies and Advanced Resources

- *Grid-edge control*
- *Automation*
- *PV*
- *Storage*
- *Advanced metering*
- *Demand response*
- *Customer choice*
- *Adv Communications*



***Distribution
Operations and
Planning***

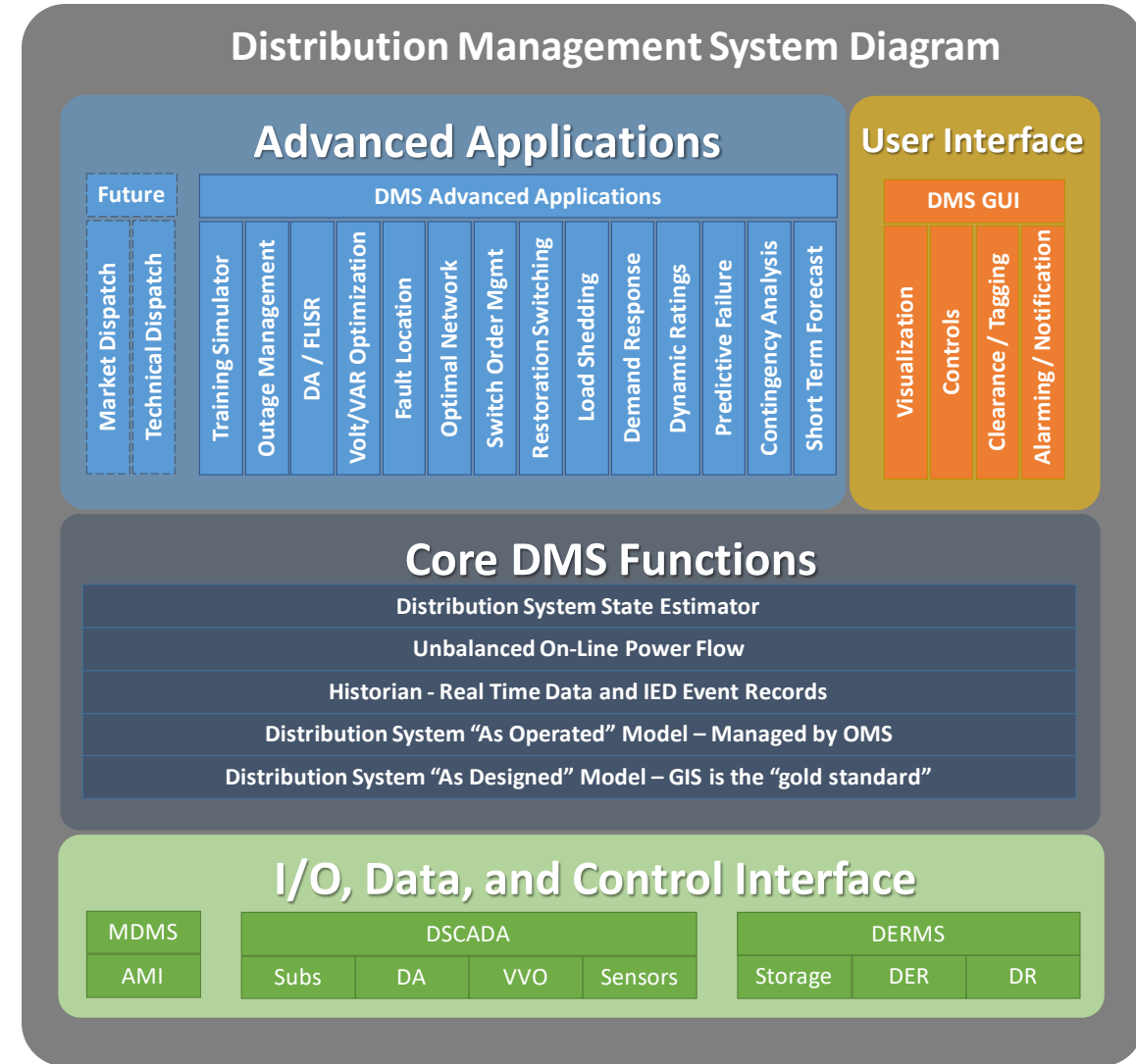
Advanced Distribution Operations

Advanced Applications

- Volt/var optimization
- Fault location, isolation, and restoration (FLISR)
- Unbalanced power flow with distributed controls
- Optimal network management
- Contingency analysis
- Operator training
- Predictive failure

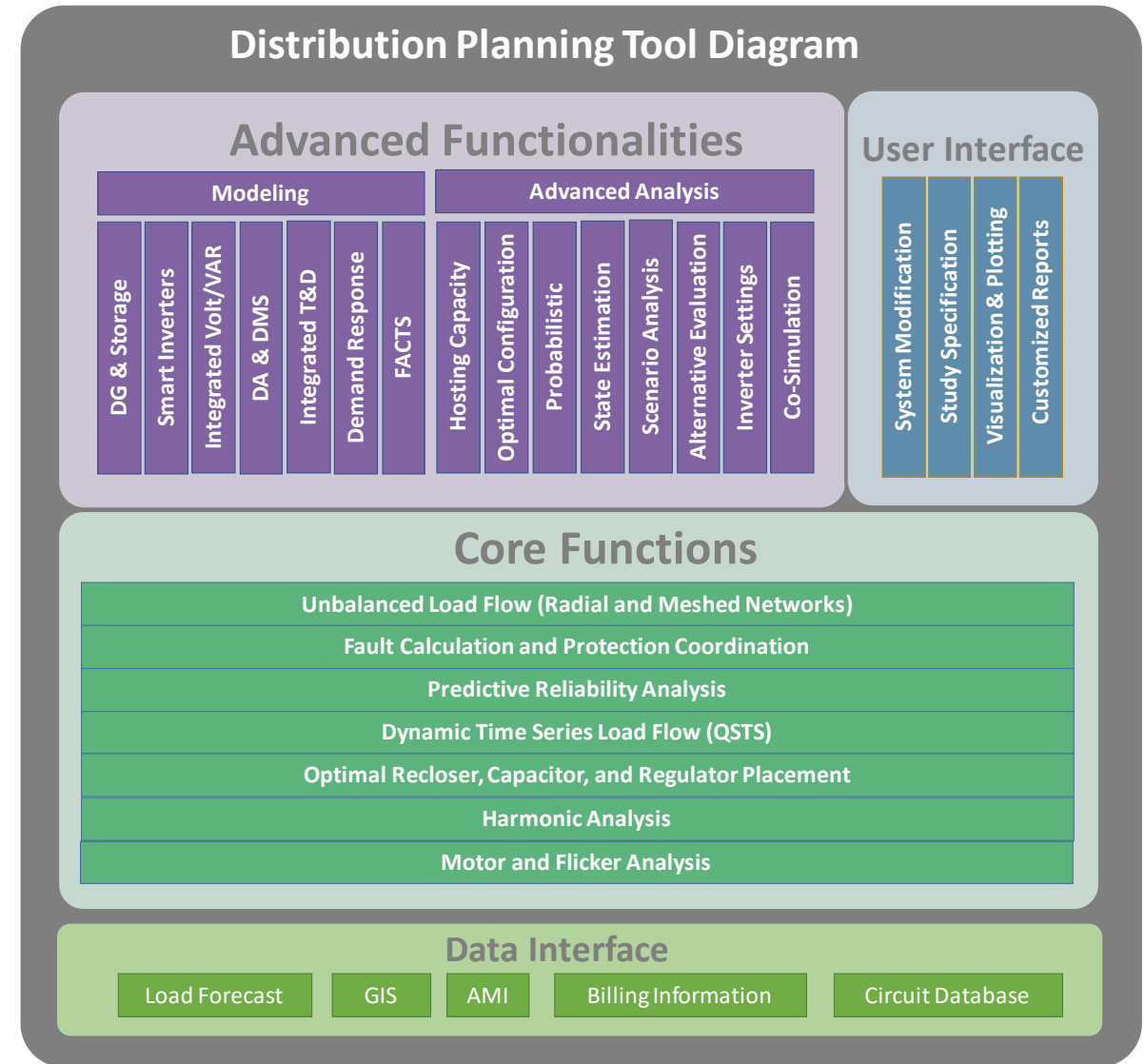
Enabling

- Effective integration of distributed resources, automation and control, and improved situational awareness
- Enhanced system operation and automation technologies, processes, and work rules that incorporate new technologies and resource alternatives to improve safety, efficiency, and reliability
- Integration and coordination of DSP and ISO processes and priorities

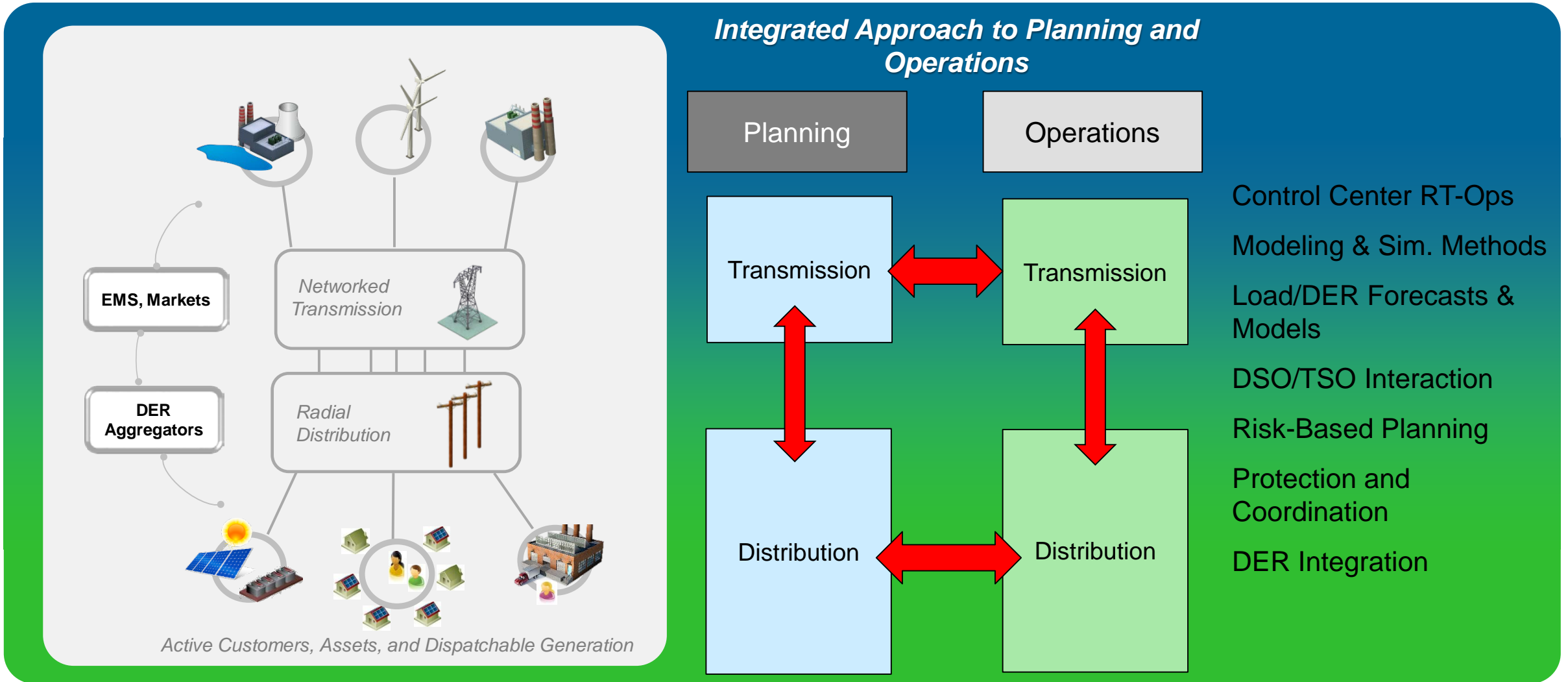


Advanced Distribution Planning

- Advanced Capabilities
 - Probabilistic planning
 - Load and DER forecasting
 - DER/customer choice modeling
 - Hosting capacity assessment
 - DER Interconnection screening
 - Non-wires solution assessments
 - DA/DMS simulation
 - Automated scenario/mitigation analysis
- Enabling
 - Effective integration of distributed resources, new automation and control, and facilitation of new domain interactions
 - Informed system design and investment decisions that consider new technologies and resource alternatives
 - Safe, reliable, and efficient system designs given rapidly changing system conditions and uncertainty
 - Efficient and timely planning assessments and decisions



Integrated Transmission and Distribution Operations and Planning



Advanced Distribution System Analysis Platform

Open-Source Distribution System Simulator (OpenDSS)

New Technologies

- Grid-edge control
- Automation
- PV
- Storage
- Advanced metering
- Demand response
- Customer choice
- Adv Communications

Distribution Operations and Planning

Operations

Distribution Management System Diagram

Future		DMS Advanced Applications										User Interface								
Market Dispatch	Technical Dispatch	Training Simulator	Outage Management	DA / FDR	Web/AR Optimization	Feet Location	Optimal Network	Switch Order Mgmt	Restoration Scheduling	Load Shedding	Demand Response	Dynamic Ratings	Predictive Failure	Contingency Analysis	Short Term Forecast	Visualization	DMS GUI	Controls	Clearance / Tagging	Alarming / Notification

Core DMS Functions

Distribution System State Estimator

Unbalanced On-Line Power Flow

Historical: Real Time Data and IED Event Records

Distribution System "As Operated" Model - Managed by OMS

Distribution System "As Designed" Model - GIS is the "gold standard"

I/O, Data, and Control Interface

MDMS	DSCADA					DERMS	
AMI	Subs	DA	VVO	Sensors	Storage	DER	DR

Planning

Distribution Planning Tool Diagram

Advanced Functionalities										User Interface				
Modeling					Advanced Analysis					System Modification	Study Specification	Visualization & Reporting	Customized Reports	
DC Storage	Smart Inverters	Integrated VVO/AR	DA & DMS	Integrated TDD	Demand Response	RCTCS	Hosting Capacity	Optimal Configuration	Probabilistic					State Estimation

Core Functions

- Unbalanced Load Flow (Radial and Meshed Networks)
- Fault Calculation and Protection Coordination
- Predictive Reliability Analysis
- Dynamic Time Series Load Flow (DSTS)
- Optimal Recloser, Capacitor, and Regulator Placement
- Harmonic Analysis
- Motor and Flicker Analysis

Data Interface

- Load Forecast
- GIS
- AMI
- Billing Information
- Circuit Database

Integrated Transmission and Distribution Analysis

Integrated Approach to Planning and Operations

Control Center RT-Ops
Modeling & Sim. Methods
Load/DER Forecasts & Models
DSO/TSO Interaction
Risk-Based Planning
Protection and Coordination
DER Integration



OpenDSS – Brief Overview

- Open source of EPRI's Distribution System Simulator
 - Originally developed in 1997 for DG interconnection and planning
 - Open-sourced in 2008
- Designed from the beginning to capture
 - Time-specific impacts and
 - Location-specific impacts
- Unique application capabilities
 - Operations and planning
 - Integration into other simulation toolsets/environments
 - Co-simulation (power and communications)

Core Solution Capability

Full, unbalanced 3P power flow
Quasi-Static time-series analysis (QSTS)
Linear and non-linear analysis
Arbitrary n-phase circuit analysis
Harmonics analysis
Stray voltage/current analysis
Fault analysis

DER Models

Smart inverters (Phase I, II, and III functions)
Storage models with controllers
PV system models
Wind system models
Demand response
Microgrid modeling
DER Short-circuit models

Advanced Control Systems

Coordinated and integrated volt/var control
DERMS control
Full regulation control for LTC's, line regs, cap banks

High-Performance Computing Capabilities

Parallel processing
Multithreading circuit processing
Multi-core management

Misc

Both radial feeders and meshed networks
Transmission systems
Real-Time Simulation