Grid Software

John Dirkman, P.E.
Vice President, Product Management
jdirkman@resource-innovations.com

resource innovations

Global Provider of Software and Services

resource innovations

Innovative Technology-Enabled Services, Software, and Consulting.

History:

- RI founded in 2016, Nexant in 2000
- Nexant joined forces with Resource Innovations in 2021
- TechniArt joined forces with Resource Innovations in 2022
- 700+ Employees
- 14 Offices Throughout North America

Nexant

TECHNIART

Our Clients:
Utilities & ISOs

100+
Electric and Gas Utility Clients Across North America

Wide Breadth of Program Services
From Grid Operations to the Customer

80+
Energy Engineers

$3B
Annual FTR Value Managed by iHedge Software

20+ YEARS
Expertise in Program Design, Delivery, and Grid Management

Resource Innovations and OTORIO Utility Software and Services

Innovative Technology-enabled Software, Services, and Consulting

Energy Software Platforms

- Grid360 - T&D Analytics and Optimization
- DARP - Day-Ahead Reactive Planning
- Grid360 External Network Modeling - Network Model Reduction
- SPIDER - Long-term DER and EV Forecasting
- iHedge - Financial Transmission Rights Analytics
- iEnergy - Workflow Management and Customer Engagement Platform
- EV Charging Data Aggregation Platform - Consolidate, validate, and analyze CPS data

Grid Security powered by OTORIO

- Asset Visibility
- Risk Assessment and Management
- Proactive Exposure Discovery
- Audit & Compliance
- SOC and Response Integration
- Penetration Testing and Incident Response
- Secure Remote Access

Grid Modernization

- GT&D Operations and Expansion Planning
- Grid Reliability and Compliance
- Grid Modernization Analysis, Strategy and Support

Customer Strategy

- Portfolio and Program Planning
- Behavioral Science and Research
- Demand Response Strategy
- System Economics/Locational Resource Planning
- DER Integration

Customer Initiatives

- Program Design
- Program Marketing and Customer Engagement
- Program Implementation and Delivery
- Market Ecosystem Management
- Regulatory Compliance and Reporting

Diversified Customer Base

Energy Program Management

PacifiCorp, ComEd, Pacific Gas and Electric Company, PECO, CenterPoint Energy, santee cooper, MidAmerican Energy, SRP, Dominion, QuestarGas, DTE Energy, JEA

Consulting

Duke Energy, Southern California Edison, SoCalGas, ieso, U.S. Department of Energy, Pacific Gas and Electric Company, Xcel Energy, Georgia Power, conEdison, SMUD, Puget Sound Energy

Grid Analytics

GE, Hitachi Energy, ABB, Fingrid, Toshiba, Celec EP Transelectric, Southern California Edison, UK Power Networks, arpa·e

Transmission Operators

nationalgrid, ercot, ISO New York Independent System Operator, pjm, SPP, ISO new england, WAPP EEEOA, CAPP, EirGrid Group, California ISO, MISO

Software & SI Partners

smarter grid solutions, Infosys, wipro, Cognizant, Guidehouse, accenture

Energy Software Solutions

Grid360 Engines: T&D grid planning, operations and analytics - white-labeled EMS/ADMS/DERMS engines for state estimation, optimal power flow, fault analysis, and forecasting deployed in 130+ control centers internationally

Grid360 Distribution Analytics: Advanced visualization, analytics, and planning applications, enabling DR, DER, EV, and smart meter analysis and optimization

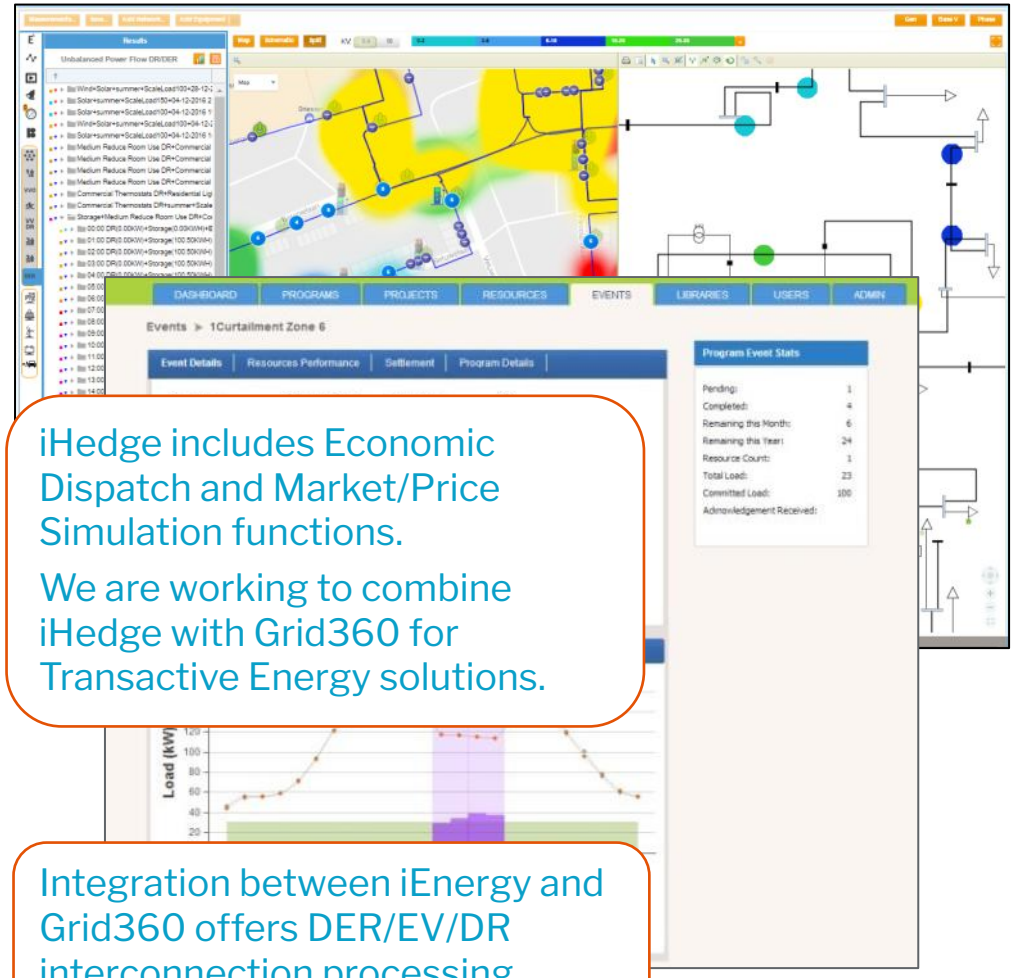
Day-Ahead Reactive Planning (DARP): Forecast and optimally dispatch reactive power to support voltage security, especially in the presence of variable renewables. DARP optimizes dispatchable controls based on voltage, power, and time-coupled control constraints, offering operational and study modes.

Grid360 TA External Network Modeling (Modelex): Simplifies and consolidates transmission network models to improve analytical performance

SPIDER: Advanced tools for long-term (years/decades) DER and EV forecasting

iHedge: Energy Market Financial Transmission Rights simulation, analysis, and engagement; the de-facto solution at ISOs in North America and New Zealand as well as for power traders

iEnergy: Workflow management and customer engagement suite used



iHedge includes Economic Dispatch and Market/Price Simulation functions.

We are working to combine iHedge with Grid360 for Transactive Energy solutions.

Integration between iEnergy and Grid360 offers DER/EV/DR interconnection processing.

Grid360 Implementations (partial list)

Direct Implementation at Utilities

- **North America:** Arizona Public Service, BC Hydro, California ISO, Duke Energy, Imperial Irrigation District, New York Independent System Operator, Pacific Gas & Electric, Public Service of New Mexico, Salt River Project, Santee Cooper, Saskatchewan Power, South Carolina Electric & Gas, Tennessee Valley Authority, Western Area Power Administration
- **Europe:** EirGrid, UK Power Networks

Through Hitachi Energy/ABB, GE, Toshiba, and Smarter Grid Solutions EMS, ADMS, and DERMS solutions

- **North America:** Consolidated Edison of New York, Grand River Dam Authority, Lower Colorado River Authority, National Grid (US), Orange & Rockland, Philadelphia Electric Company, Potomac Electric Power Company, Public Service Enterprise Group, San Diego Gas & Electric, Silicon Valley Power, Southern California Edison, Southwest Transmission Cooperative, Vectren, Xcel Energy
- **Europe:** Elering, FinGrid, LitGrid, National Grid (UK), Scottish Power, Svenska Kraftnat, UK
- **Asia:** Chubu Electric, Korea Electric Power Corporation, Kyushu Electric Power Company
- **Africa:** Société Nationale d'Électricité Congo, Volta River Authority Ghana
- **Australia:** Western Power

Superior
Scalability
Reliability
Performance
Functionality

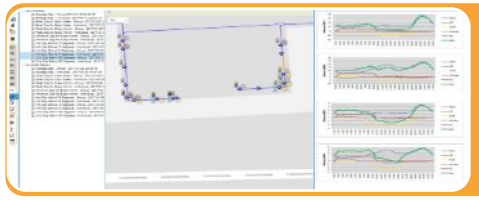
Grid360 Analytics Platform

State estimation, optimal power flow, contingency analysis, fault analysis

- Determine the current operating state of networks using AMI/SCADA/sensor data, discover and eliminate data/topology/latency errors, and recommend sensor placement
- Calculate and display system loading and voltage warnings and violations, including contingency analysis, calculate sensitivities and fault levels, run optimizations, generate alerts, recommending switching, and dispatch resources

Analysis of DR, DG, DER, PED, EV, microgrids, improved customer engagement

- Evaluate the current and near-term energy and economic state of distribution grids including demand response (DR), distributed generation (DG - solar and wind, including smart inverters), distributed energy resources (DER - energy storage), power electronic devices, electric vehicle (EV) supply equipment, microgrids, volt/VAR optimization (VVO), and Grid Interconnection programs, improving customer service



Load profiling, short-term, and long-term load and DER forecasting

- Create load profiles, develop short-term (days ahead) and long-term (months to years ahead) energy and economic forecasts including DR, DG, DER, PED, EV, and microgrids
- Generate alerts and dispatch resources based on forecast conditions

Management of independent grids and microgrids, reliability coordination/market operations

- Manage independently-owned commercial and industrial grids and microgrids
- Coordinated capacity calculation and security analysis, outage planning coordination, short- and medium-term adequacy forecasts

Advanced security, data quality, and reliability analytics

- Track critical and vulnerable assets, communication channels, protocols and encryption, patches and mitigations, ownership, and access and safety
- Analyze and improve transformer to meter assignment, phase assignment, sizing of devices and conductors, asset health forecasting, energy theft, outage causes and prediction, and other data quality and operational factors based on AMI/SCADA/sensor data and network models

Grid360 Optimization Objective Functions (partial list)

Active power optimization

- MW economic dispatch
- MW loss minimization
- Maximum MW transfer
- Minimum control shift
- Minimum number of controls shifted

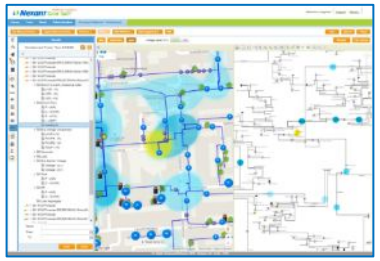
Reactive power optimization

- MVAR economic dispatch
- MVAR loss minimization
- VAR installation
- Minimum control shift
- Minimum number of controls shifted

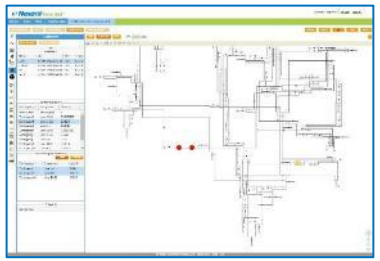
Provides advanced time-coupled look-ahead analysis and optimization

UK Power Networks Active Network Management System

Forecast Load and Generation

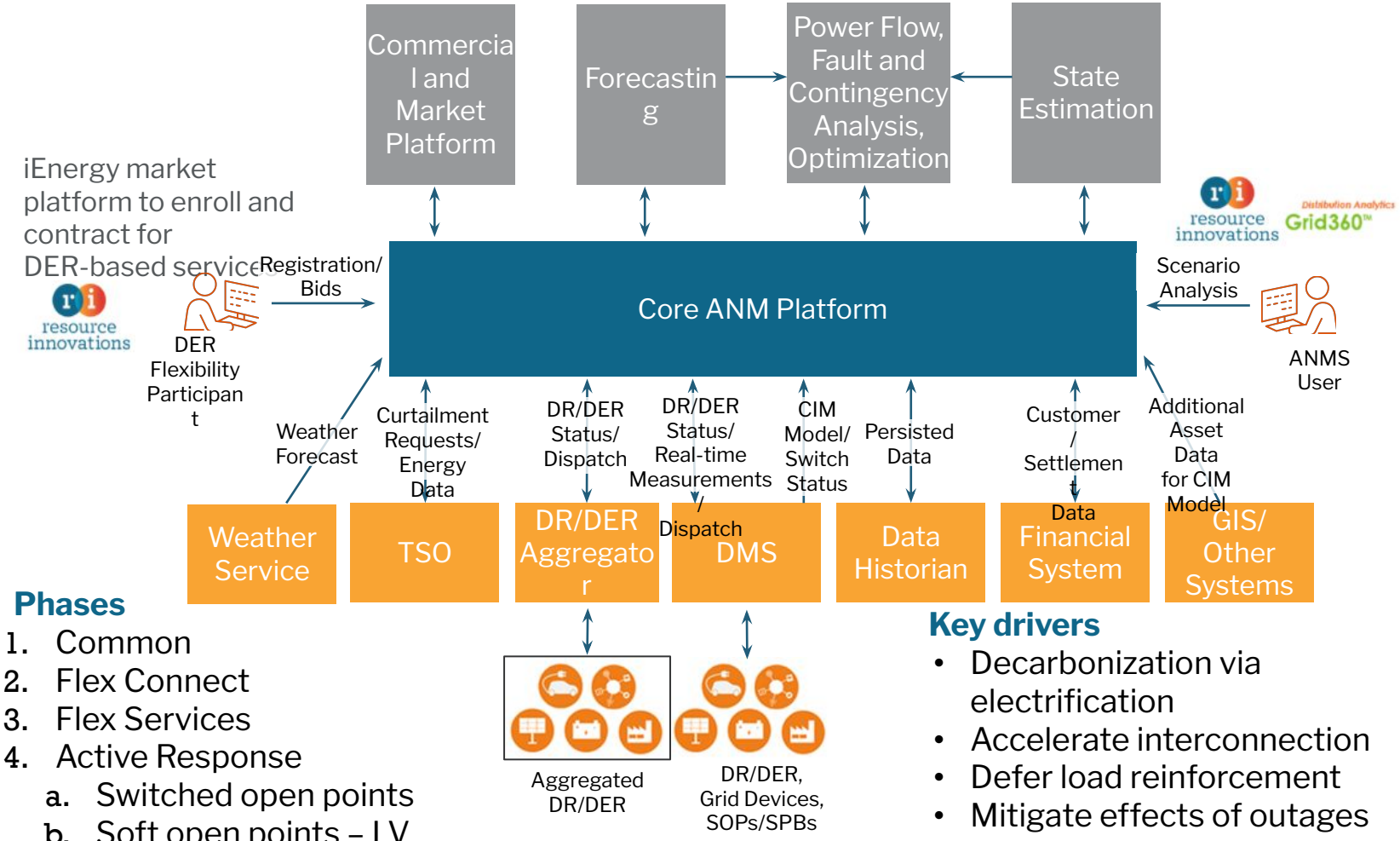


Loading and Voltage Heat Maps



Contingency Analysis

DR/DER Dispatch



Phases

1. Common
2. Flex Connect
3. Flex Services
4. Active Response
   a. Switched open points
   b. Soft open points – LV
   c. Soft power bridges – MV/HV

Key drivers

- Decarbonization via electrification
- Accelerate interconnection
- Defer load reinforcement
- Mitigate effects of outages
- Reduce manual switching
- Provide a platform for the future

UK Power Networks Power Electronic Devices

2T Soft Open Point

3T Soft Open Point

Soft Power Bridge (SPB) during installation

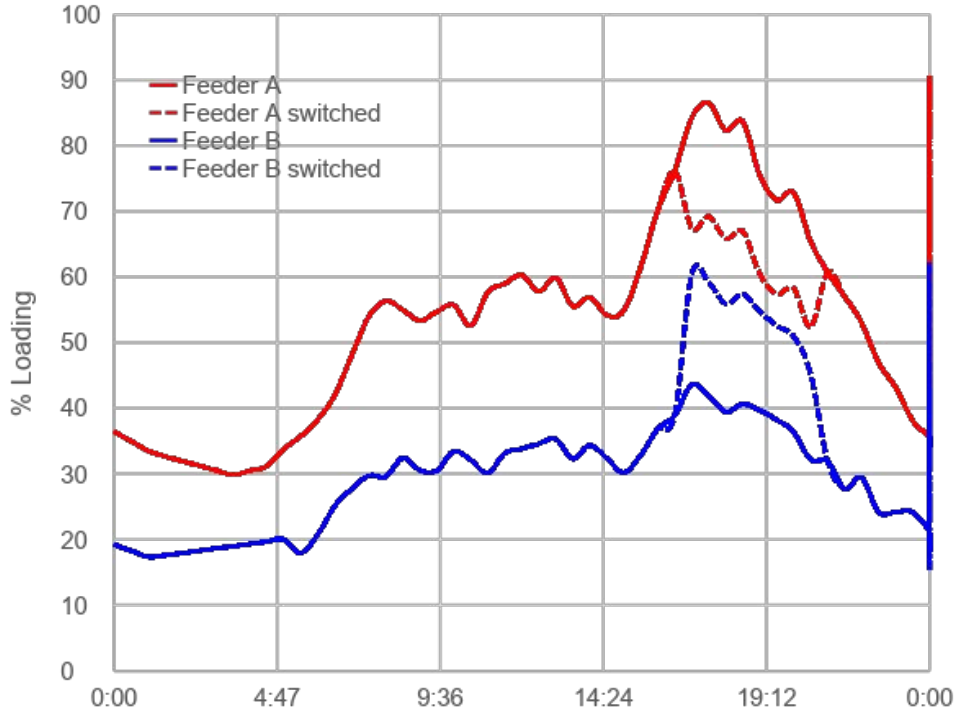
4-way Link Box Switch

Alvin Circuit Breakers

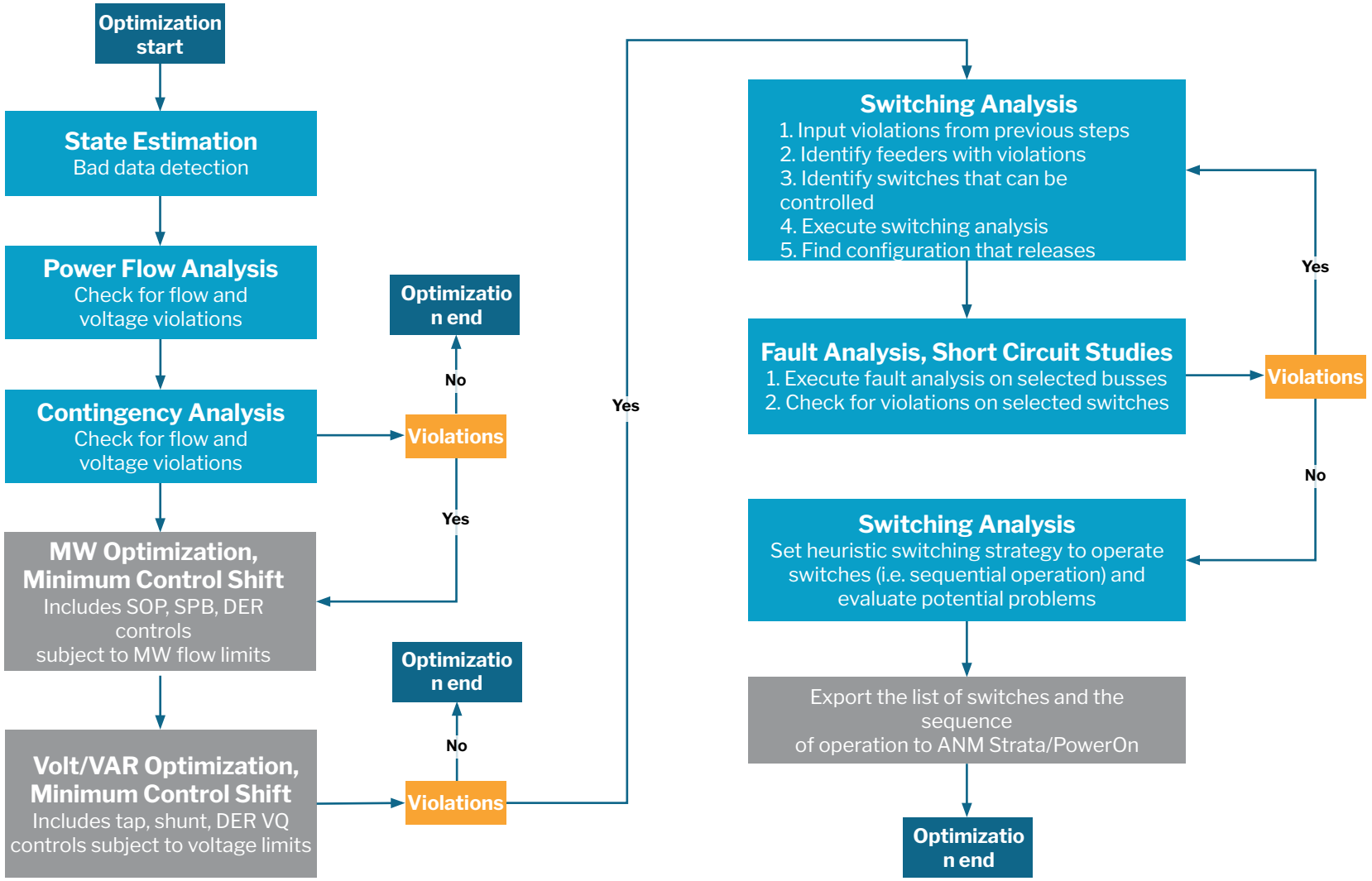
UK Power Networks Power Electronic Devices

Direct Benefits

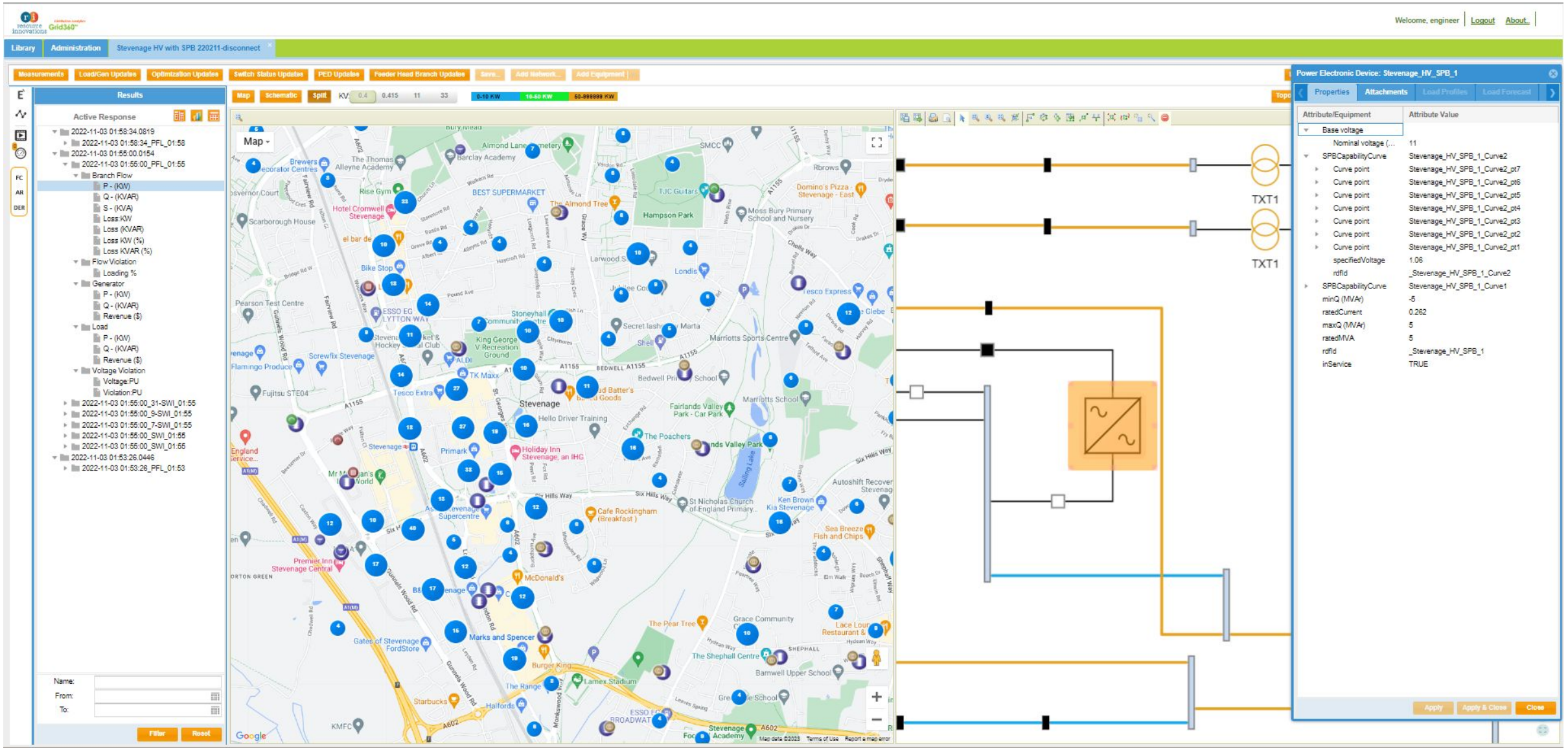
- Maximise network utilisation
- Dynamically shift loads to reduce peaks
- Manage sudden increases in loads due to EV charging
- Over £700m in direct financial benefits by 2050 across GB
- Over 6,000MVA capacity released by 2050 across GB
- ~40,000 tons CO2e saved directly by 2050 across GB
- Faster and more cost-effective connection offers due to deferred or mitigated network reinforcements



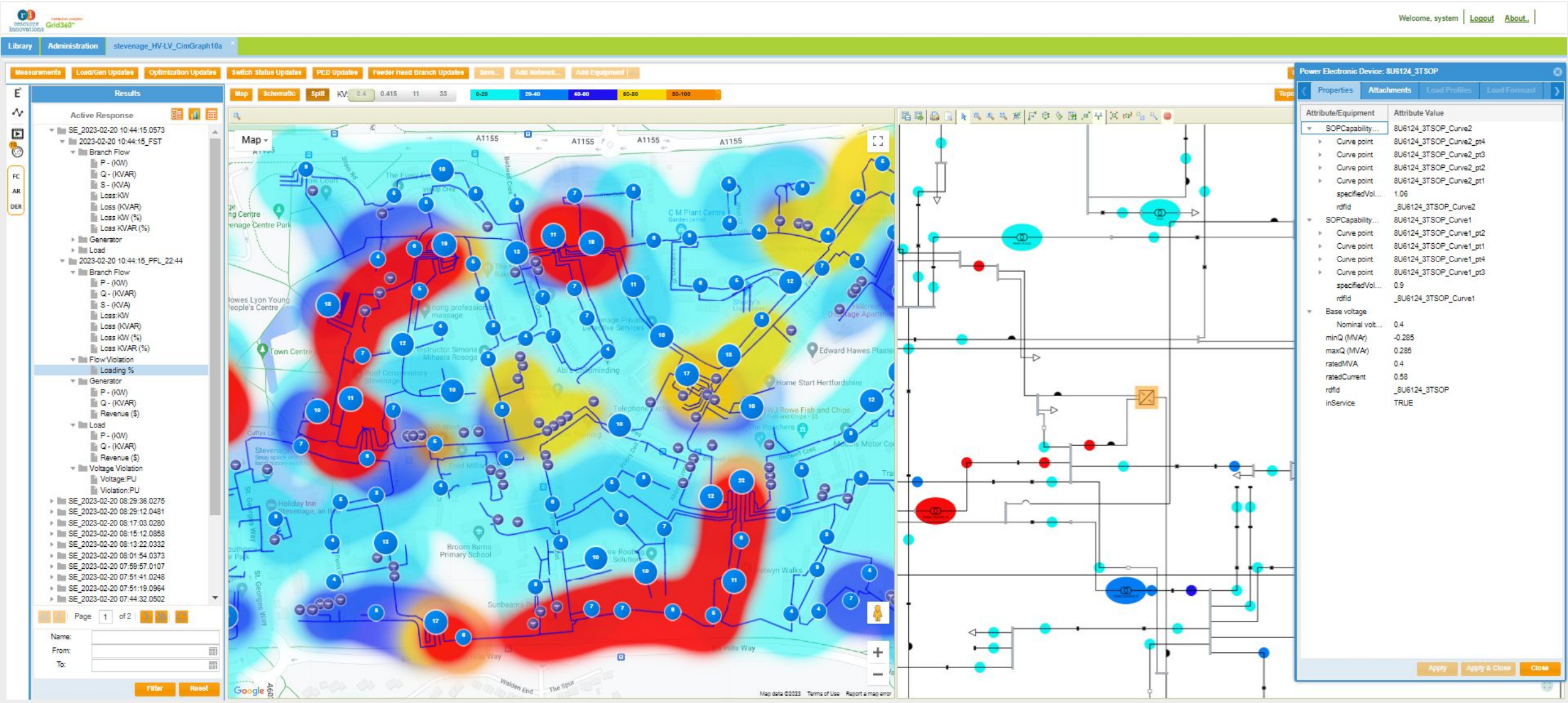
UK Power Networks ANMS Optimization Process Flow Diagram



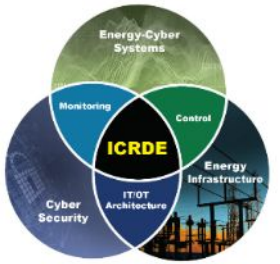
Grid360 Power Electronic Device Analytics



Grid360 Power Electronic Device Analytics



DOE ARPA-E and BIRD ICRDE Grant Projects



Sensor-enabled Modeling of Future Distribution Systems with Distributed Energy Resources

Partners include Arizona State University, Arizona Public Service, Resource Innovations

- Development of accurate, sensor-driven mathematical models of APS distribution feeders, loads, and dispatchable resource assets
- Development of monitoring and control algorithms for optimal scheduling of DERs
- Technology to Market strategy via Industry Advisory Board

Stochastic Optimal Power Flow for Real-time Management of Distributed Renewable Generation and Demand Response

Partners include Arizona State University, Resource Innovations, Sandia National Labs, PJM, MISO, NREL

- Prototype software for stochastic Security Constrained Economic Dispatch (SCED)/ Stochastic Look-Ahead Commitment (SLAC), scalable for large systems with high percentage of renewable generation (stochastic resources)
- Forecast algorithms for bulk and distributed wind and solar generation
- Classification and aggregate modelling of DR

Comprehensive Cybersecurity Technology for Critical Power Infrastructure AI-based Centralized Defense and Edge Resilience

Many partners, utilities include Arava Power, Duquesne Light Company, Arizona Public Service, Delek US

- Support research, development, testing, and commercialization of software to harden utility EMS, DMS, and SCADA against cyberattacks

Sensor-enabled Modeling of Future Distribution Systems with Distributed Energy Resources $2.8M DOE ARPA-E Grant

resource innovations

Team

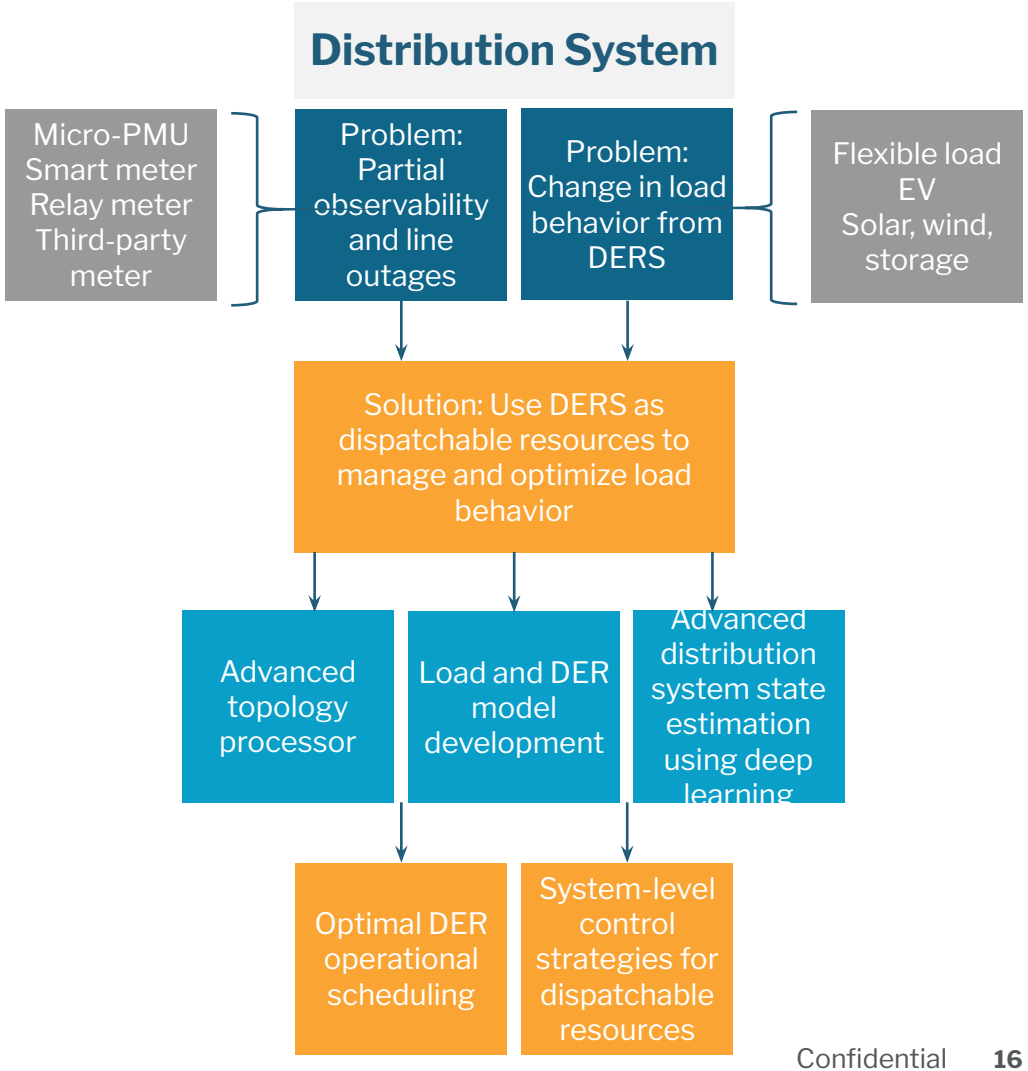
- Arizona State University
- Arizona Public Service
- Resource Innovations

Project

- Development of accurate, sensor-driven mathematical models of APS distribution feeders, loads, and dispatchable resource assets
- Development of monitoring and control algorithms
- Optimal scheduling of DERs
- System-level DER control improving PV dispatchability
- Demonstration on actual APS feeder with 1000 PV units, 75 with robust smart inverter control
- Technology to Market strategy via Industry Advisory Board

Technology Impact

- Sustainable distribution grids enhancing energy independence
- Data-driven inference on modeling, monitoring, and control, for improved energy efficiency
- Advanced deep learning tools ensuring USA energy technology leadership



Sensor-enabled Modeling of Future Distribution Systems with Distributed Energy Resources $2.8M DOE ARPA-E Grant

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Task 1: Advanced Topology Processor

- Application to provide improved topology error processing using state estimation (real and imaginary voltage of each bus, active and reactive power of each load, current flow of each line, and switch status of each line) for unbalanced distribution networks.
- Application to provide an integrated multi-stage spectrum clustering algorithm to accurately model secondary distribution network topology. Important for voltage drop calculation, outage prediction/management, and transformer loading calculation, as well as serving as foundational data for

Task 2: Developing and validating accurate data-driven load, dispatchable resource, and distribution system models

- Application to use AMI data to further validate meter to transformer connection so that secondary distribution network topology can be modelled more accurately and in detail.
- Application to utilize optimal power flow to properly allocate reactive power to the load buses based on measurement data at the feeder head.
- Application to use county parcel data to validate and improve the geographic location of meters.

Task 3: Formulating an Advanced Distribution System State Estimator

- Application to optimally place micro-PMUs in distribution feeders and estimate the distribution system state using deep neural network (DNN) processing, including available measurement data.

Sensor-enabled Modeling of Future Distribution Systems with Distributed Energy Resources
$2.8M DOE ARPA-E Grant

resource innovations

Task 4: Optimal energy management/scheduling of dispatchable resources

- Application to optimally schedule DERs including PV units with smart inverters with the objective of minimizing the total operational cost of curtailment while keeping the system voltage within acceptable range

Task 5: Design and validate system-level control strategies for PV/DER power converters

- Application to develop robust smart PV inverter modeling with volt-var control.
- Application to determine the best locations to place the minimum number of PV smart inverters to improve voltage along distribution feeders in over voltage and under voltage scenarios.

Task 6: Demonstration of proposed technologies on feeders with numerous PV with robust smart inverter control

- Application to implement a real-time simulation study on an OPAL-RT ePHASORSIM system with a fully detailed secondary feeder, the operation of battery storage, and a large number of PV inverters with volt-var control, to verify the performance of developed DER control and optimization functions.

Task 7. Develop Technology to Market strategy validated by an Industry Advisory Board

Stochastic Optimal Power Flow for Real-time Management of Distributed Renewable Generation and Demand Response - DOE ARPA-E

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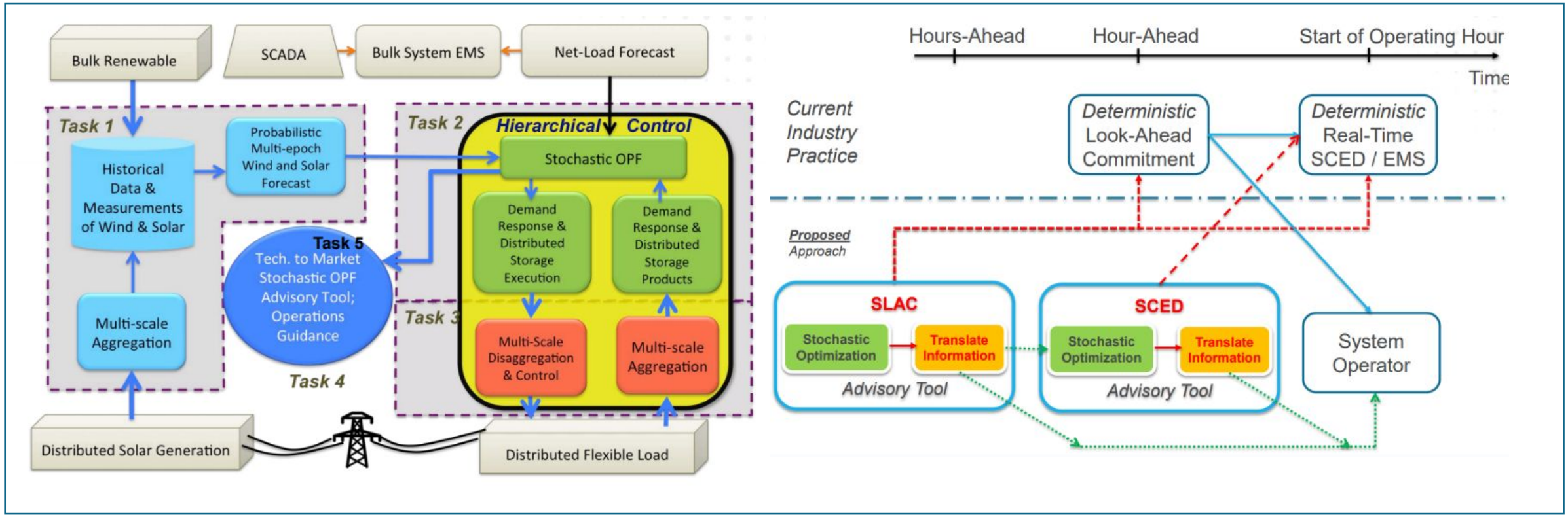
Team	Challenge	Deliverable	Outcome

• Arizona State University
• Resource Innovations
• Sandia National Labs
• PJM
• MISO
• NREL
	• Uncertainty and variability due to a high volume of DER and DR assets
	• High penetration of wind and solar renewables and DR increases cost and decreases operational reliability of power grid
		• Prototype software for stochastic Security Constrained Economic Dispatch (SCED)/ Stochastic Look-Ahead Commitment (SLAC)
		  ◦ Enhances performance using parallel processing
		  ◦ Scalable to large system with high percentage of renewable (stochastic resources) penetration
		• Forecast algorithms for bulk and distributed wind and solar generation; in progress
		• Classification and aggregate modeling of DR; in progress
			• Prototype is an effective advisory tool that may be used to reduce operating cost by providing operational guidance for uncertainty management (i.e., increase reliability)
			• SLAC is a standalone parallel advisory tool and does not replace a market tool
			• SLAC provides real-time policy functions (inputs) to implement within an existing market model
			• In order to realize potential benefits, enhance modeling, control, and management of DER, DR, and storage at the bulk level

Stochastic Optimal Power Flow for Real-time Management of Distributed Renewable Generation and Demand Response - DOE ARPA-E



Comprehensive Cybersecurity Technology for Critical Power Infrastructure AI-based Centralized Defense and Edge Resilience - BIRD ICRDE

CLIENT:

Israel Energy Center and Israel-U.S. Binational Industrial Research and Development (BIRD)

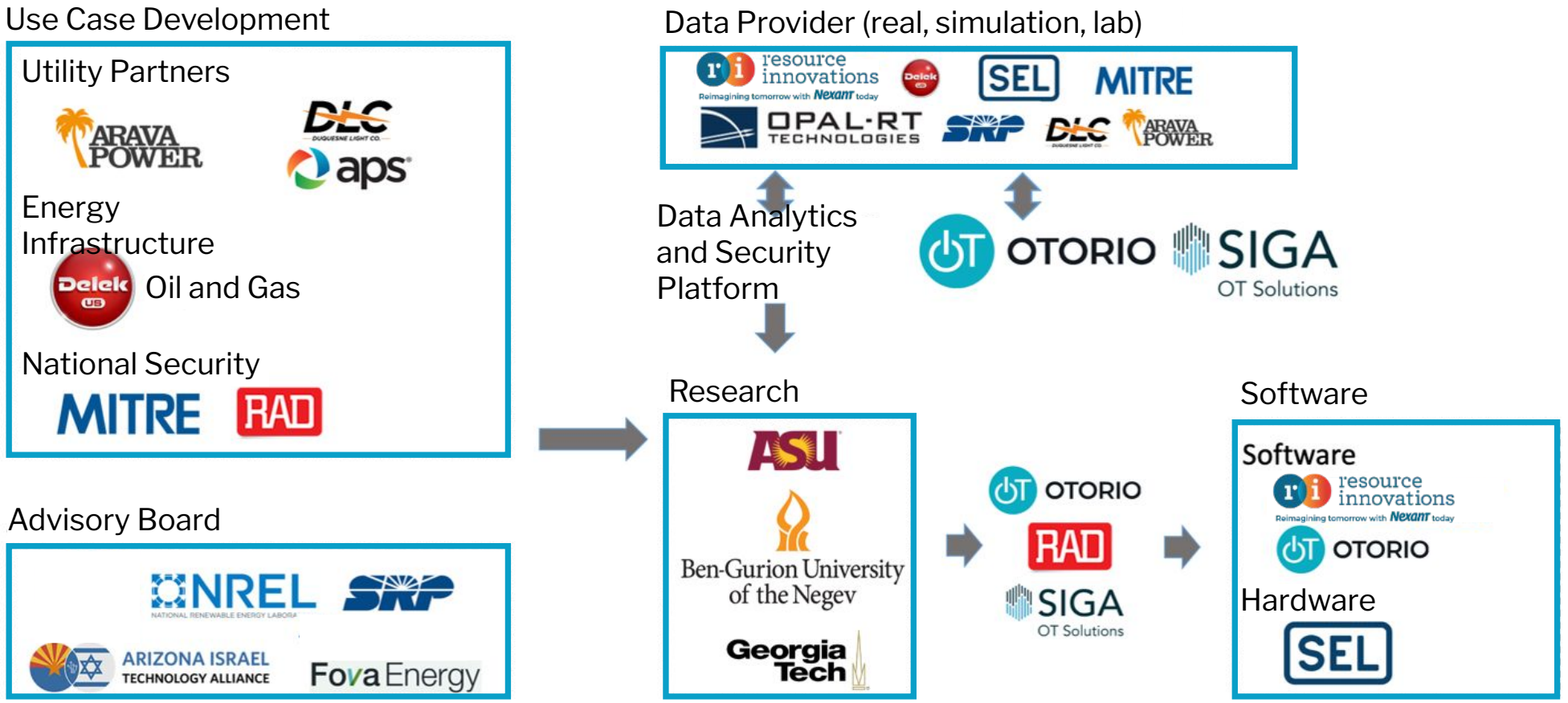
Israel-US Initiative on Cybersecurity Research and Development for Energy (ICRDE)

ROLE:

Support research, development, testing, and commercialization of software to harden utility EMS, DMS, and SCADA against cyberattacks

TOTAL PROJECT BUDGET:

$10M, with $622K for Resource Innovations, three-year project duration



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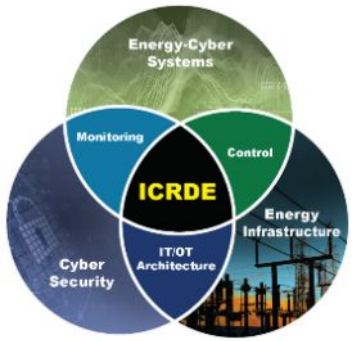


Theme 1: Cyber-Physical System (CPS) Data Preparation

- **Project 1**: Physical Processes as Cybersecurity Assets
  - **T1: Realization of advanced energy management applications**
  - **T2**: Digital representation of physical processes and operational process modelling
    - **T3**: Data collection and aggregation
- **Project 2**: Knowledge Base Establishment and Representation Learning of Threats
  - **T4**: Multi-level threat intelligence knowledge base (MITRE)
    - **T5**: Adversarial mimicking (Theoretic)
    - **T6**: Threat hunting (Actively learning)

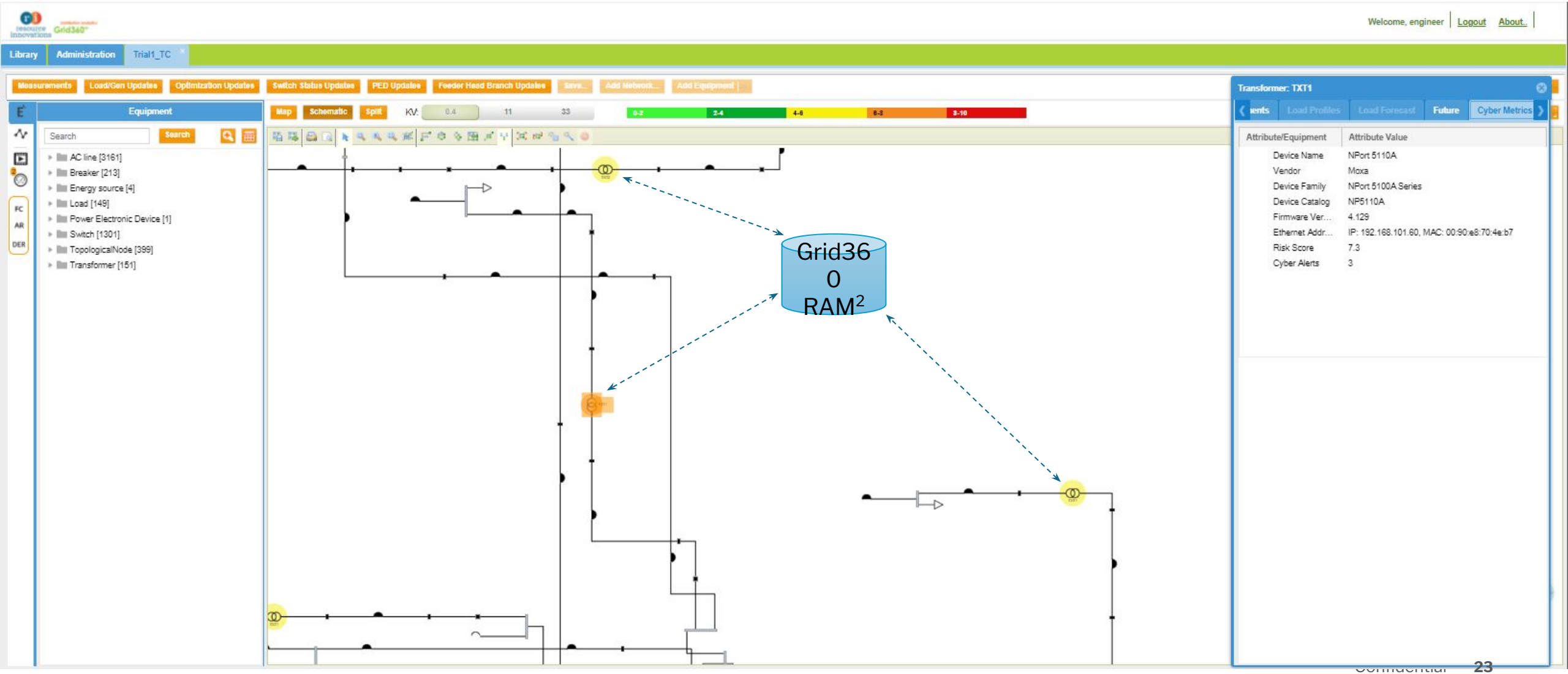
Theme 2: Data Analytics for Monitoring

- **Project 3**: Cyber Attacks Detection of IT/OT Architecture
  - **T7**: Malware threats mitigation (Smart enemy? Reduce probing and plan)
  - **T8**: Detect event mimicking attacks
    - **T10**: Multilayer anomaly detection (Uncertainty)
    - **T9**: False Data Injection (Physical Embedding)
  - **T11**: AI-based intrusion detection (Engage operator)
  - **T12**: Explainable cyber-AI analytics (Metric + Temporal)

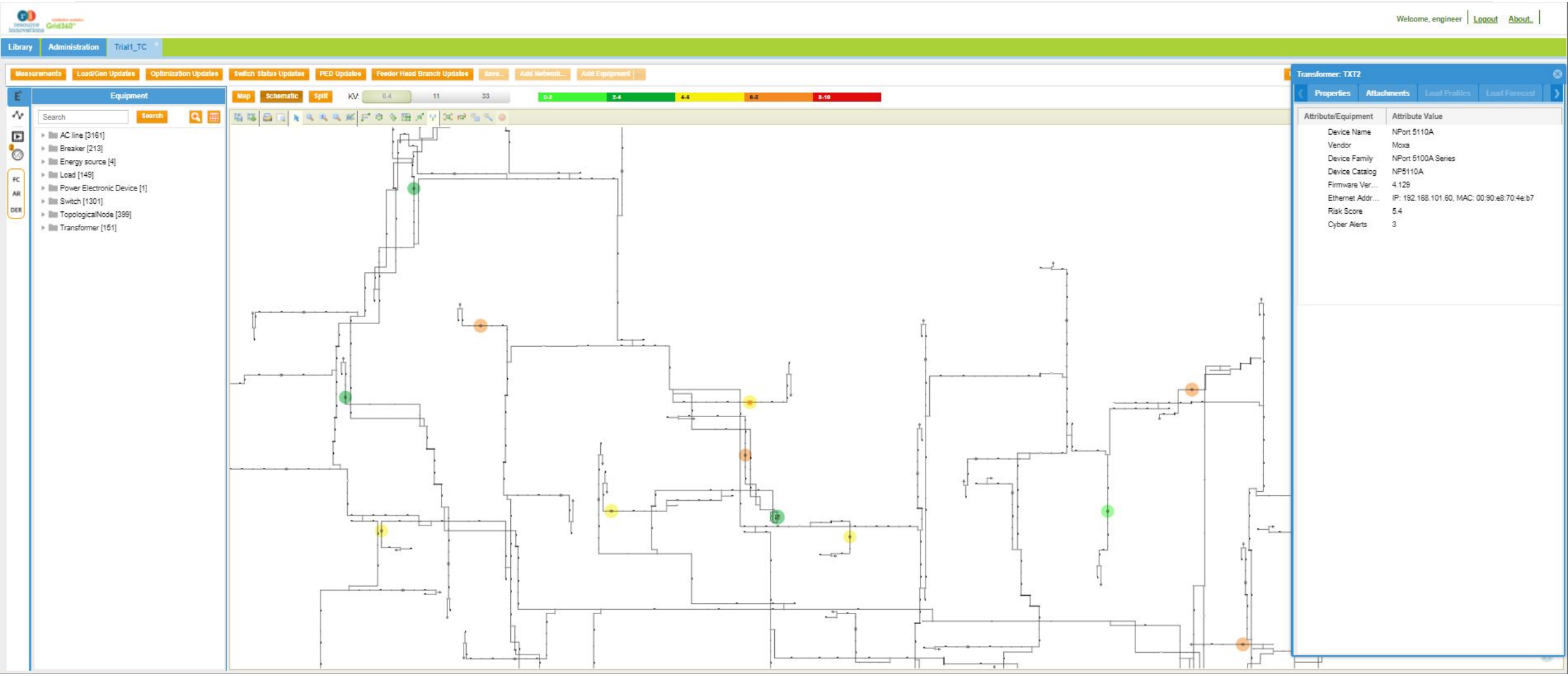
Theme 3: Control and Validation

- **Project 4**: Cyber Resilience and Robustness for Control Actions
  - **T13**: Firmware verification (Edge)
  - **T14**: Attack tolerance (Insensitive to the attack)
  - **T15**: Self healing and auto-remediation (Optimization)
    - **T16**: RL control for CPS (Advise Sys Operator)
- **Project 5**: Future-Proof Architectures
  - **T17**: ICS security by design
  - **T18**: Hardware in the loop

Threat Assessment Risk Score



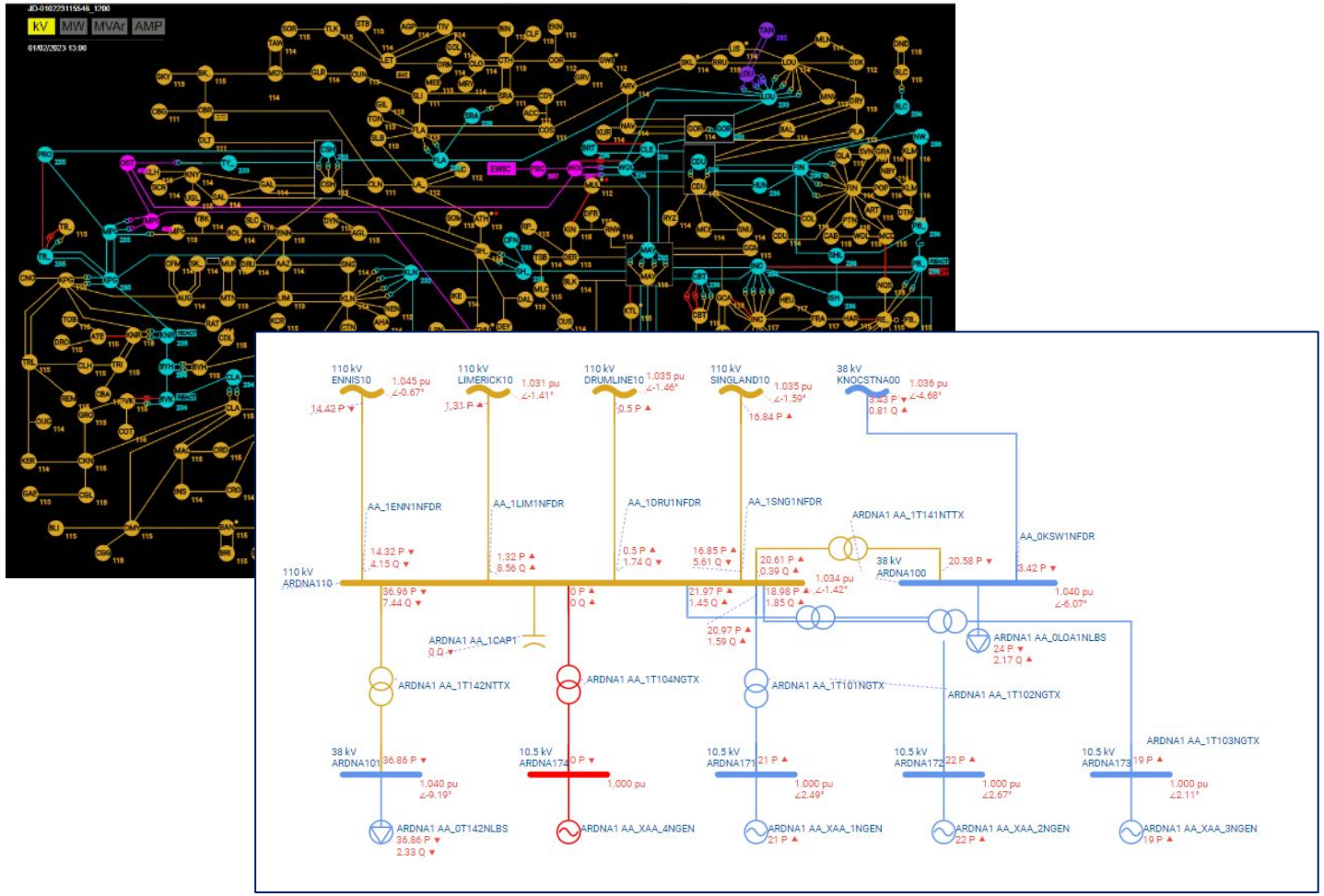
Threat Assessment Heat Map



Day Ahead Reactive Planning Tool (DARP) (EirGrid's Voltage Trajectory Tool)

DARP/VTT analyses various datasets to optimize dispatch instructions to maintain voltage over a 48-hour period via operational and study modes. DARP/VTT optimizes reactive power controls via minimum control shift considering time-coupled constraints to maintain voltage given variable renewable generation.

- Load forecast
- Generation and interconnection schedule
- Real-time network model from EMS
- Planned outages and equipment availability
- Contingency list
- List of reactive power resources providing voltage regulation, including Static Var Compensators (SVC), Static Synchronous Compensators (STATCOM), generators
- List of transformers with automatic and manual On-Load Tap Changers (OLTC)
- List of switchable capacitors and reactors
- Required voltage profile (or range) in specific areas of the grid



THANK YOU!

John Dirkman, P.E.
Vice President, Product Management
jdirkman@resource-innovations.com

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