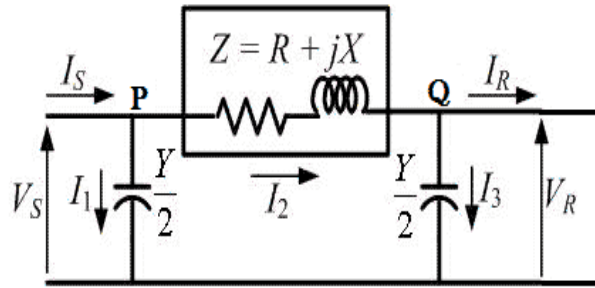# ADVANCED DISTRIBUTION PLANNING TOOLS

David MacRae, **Director**
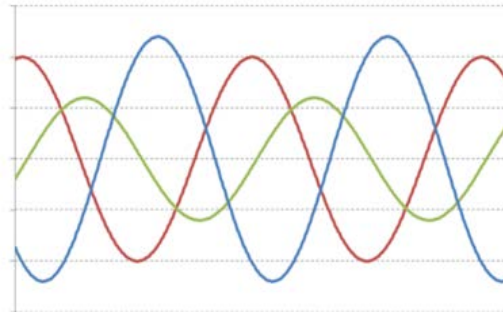
POWERFUL CORE – GRID'S DNA IS OUR DNA
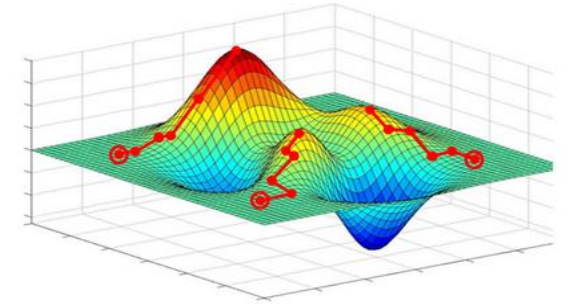
MODELING & TOPOLOGY PROCESSING

- 3-phase AC unbalanced for distribution grids at the "edge"
- Dynamic topology processor for "as-operated" network analysis
- Advanced decision making under complex two-way power flow
- CIM IEC 61970 native

STATE ESTIMATION, FORECASTING & POWER FLOW ENGINE

- Research breakthrough for 100% convergence of voltage state variables within 1% accuracy at 2.5σ and within <1min as design criteria, even under two-way unbalanced power flow
- Full situation awareness (e.g. P, Q, I, V) under many unknowns while leveraging available data (e.g. SCADA, AMI) for convergence
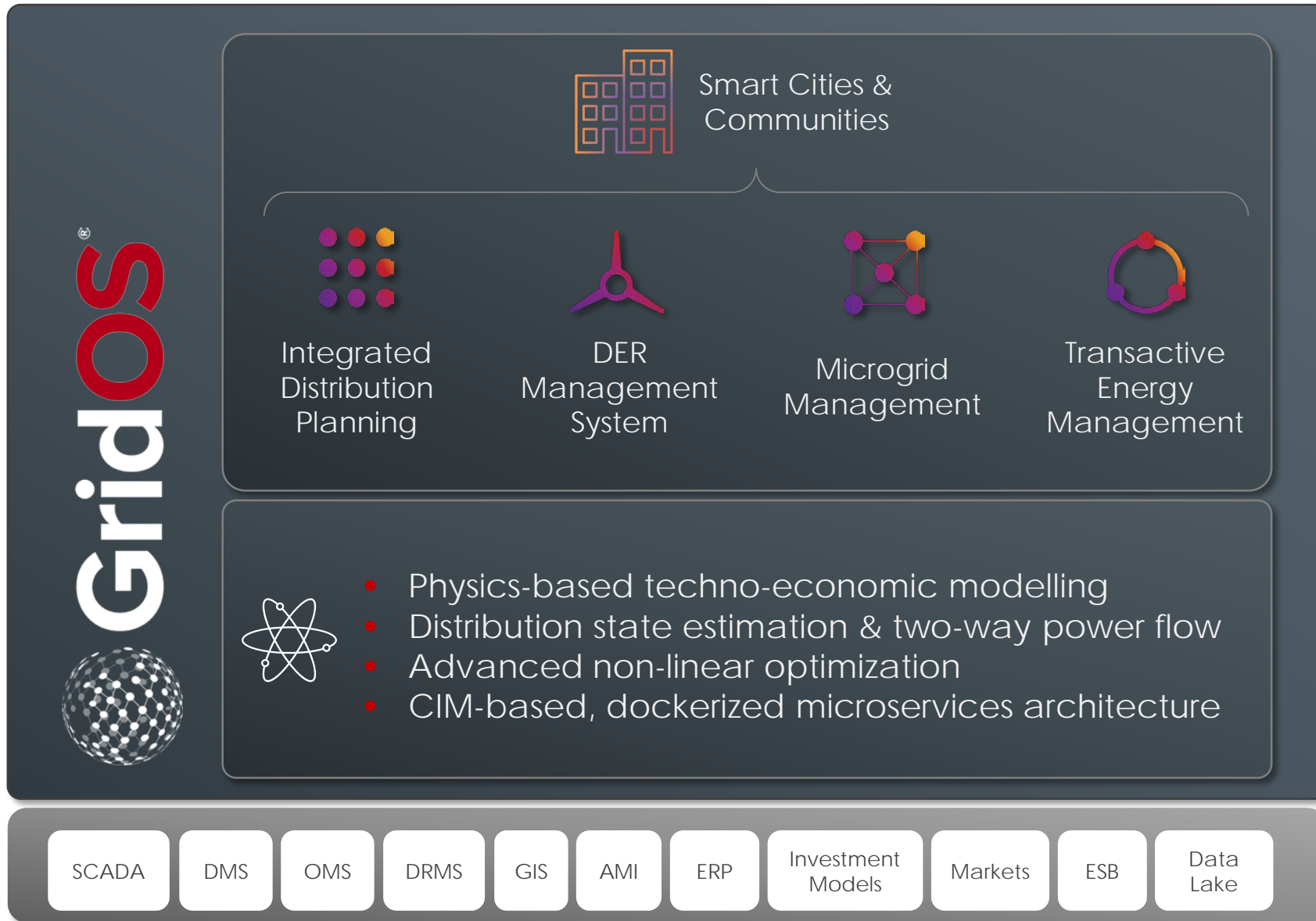
NON-LINEAR OPTIMIZATION ENGINE

- Non-linear optimizer computing exact Jacobian, Hessian and Lagrangian, to overcome non-convexities to reach global optimality
- Multi-objective, multi-agent enabling new utility and customer business models (e.g. transactive energy)

SOLUTION: INTEGRATED DISTRIBUTION PLANNING (IDP)

Application Suites

GridOS

Smart Cities & Communities

Integrated Distribution Planning

DER Management System

Microgrid Management

Transactive Energy Management

Applications that capture the value from the trends of yesterday, today and tomorrow on a common platform

Core Platform Analytics

- Physics-based techno-economic modelling
- Distribution state estimation & two-way power flow
- Advanced non-linear optimization
- CIM-based, dockerized microservices architecture

Industry leading grid physics + data science as foundation for big data platform

Data Integration

| SCADA | DMS | OMS | DRMS | GIS | AMI | ERP | Investment Models | Markets | ESB | Data Lake |

Integrating disparate data sources

GridOS IDP FEATURES
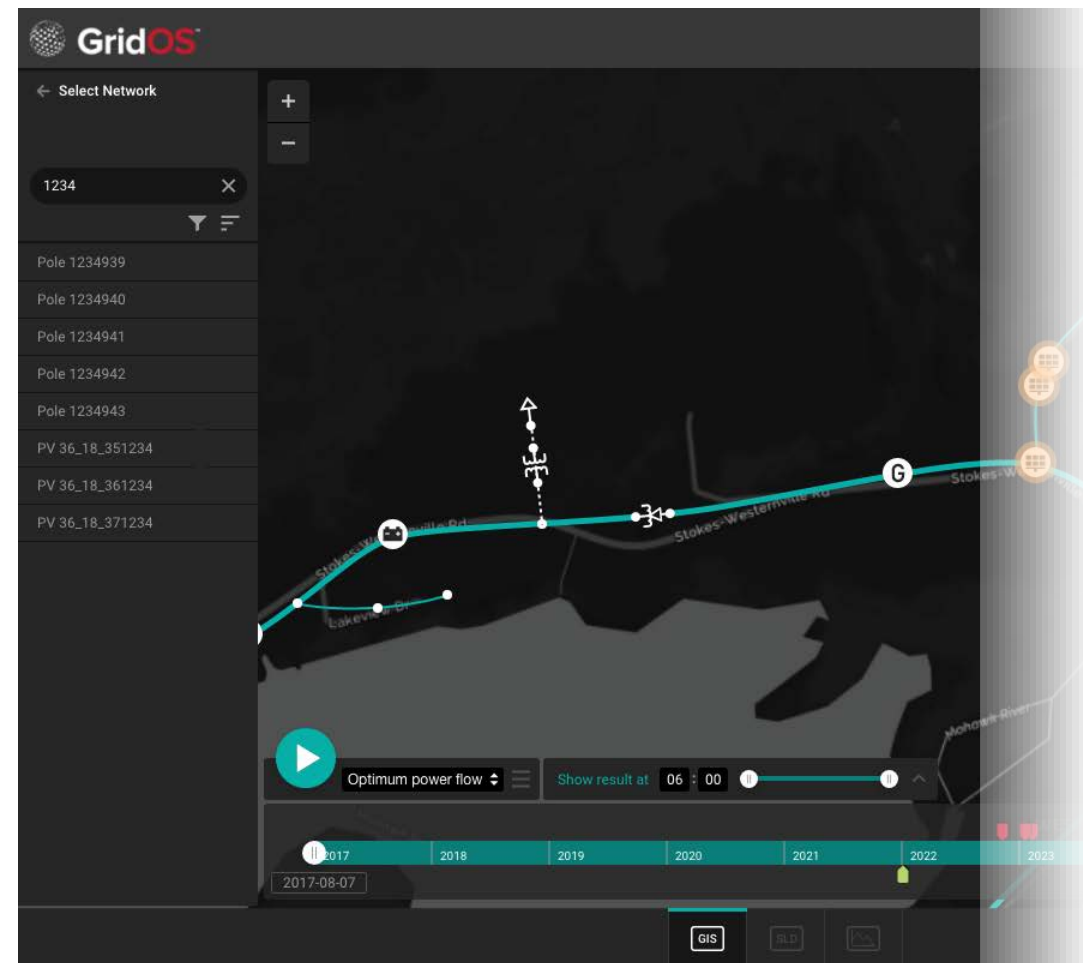
- Time series observation at various study intervals

- Ranked constraints at each node, feeder, and substation

- External parameter scenarios based on current, historical, and forecasted data

- Locational net benefit analysis (LNBA) and distribution locational marginal pricing (DLMP)

- Feasibility analysis for non-wire alternatives

- Investment scenarios for hosting capacity upgrades using traditional expansion strategies, distribution automation capabilities, and NWA opportunities

GridOS

Select Workspace

Search...

Global

DEP NW Region   •••

DEC South Region

Jimmy's Workspace

Region 5

Project ABC

Nick's Workspace

Region 8

Region 9

Please select network to show data

User information and settings

User specific workspace shows regions under management by planner

Ability to create new workspaces by importing new network models

+

Create New Workspace

Imports in IEC 61970 CIM XML or Jason files

Optimal Powerflow

1 Hour

John M...

2 Feeder 36_18_356732 , Feeder 36_18_3...

Network | Asset

Search...

☐ Substation 36_18_65355

☑ Substation 36_18_65356 ⊗

☑ Feeder 36_18_356732 ⊗

☑ Feeder 36_18_356733

State Forest

State

Buck Hill State Fore

Canada Creek State Forest

Delta Reservoir

Delta Lake State

Selected Asset

Option to change perspective between network and asset level view

Indication of Error with network model, either from faulty export of previous model management tool or through mistakenly entered data, GridOS performs a plausibility check and fixes obvious mistakes

User can select how many substations and which feeders to include in the analysis

Load/Generation data for a selected asset over observed time span

Geospatial representation of the network with all feeders

Import Data

Information ✕

Feeder
36_18_356732

Warnings and Errors	⚠ 00	⊗ 01
Number of Customers		
Nominal kVLL		kV
Voltage Used	A	B	C
		kVLN
		pu

Update Load/Gen

Load (kW)

200
160
120
80
40

Jan   Mar   May   July   Sep   Nov

1 year | 5 years | 10 years

Generation (kW)

200

Optimal Powerflow ⇕

1 Hour ⇕

2017-08-07 16:00

DEP NW Region

2 Feeder 36_18_356732 , Feeder 36_18_3...

Network | Asset

Search...

ACLineSegment(11)

ACLineSegmentPhase(8)

EnergyConsumer(9)

EnergyConsumerPhase(19)

EnergySource(1)

Line(1)

LoadBreakSwitch(1)

PhaseImpedanceData(26)

Photovoltaic(3)

    Asset A

    Photovoltaic PV342

    Photovoltaic PV3166

RatioTapChanger(3)

ShuntCompensator(2)

ShuntCompensatorPhase(4)

TapChangerControl(11)

TransformerTank(5)

TransformerTankEnd(10)
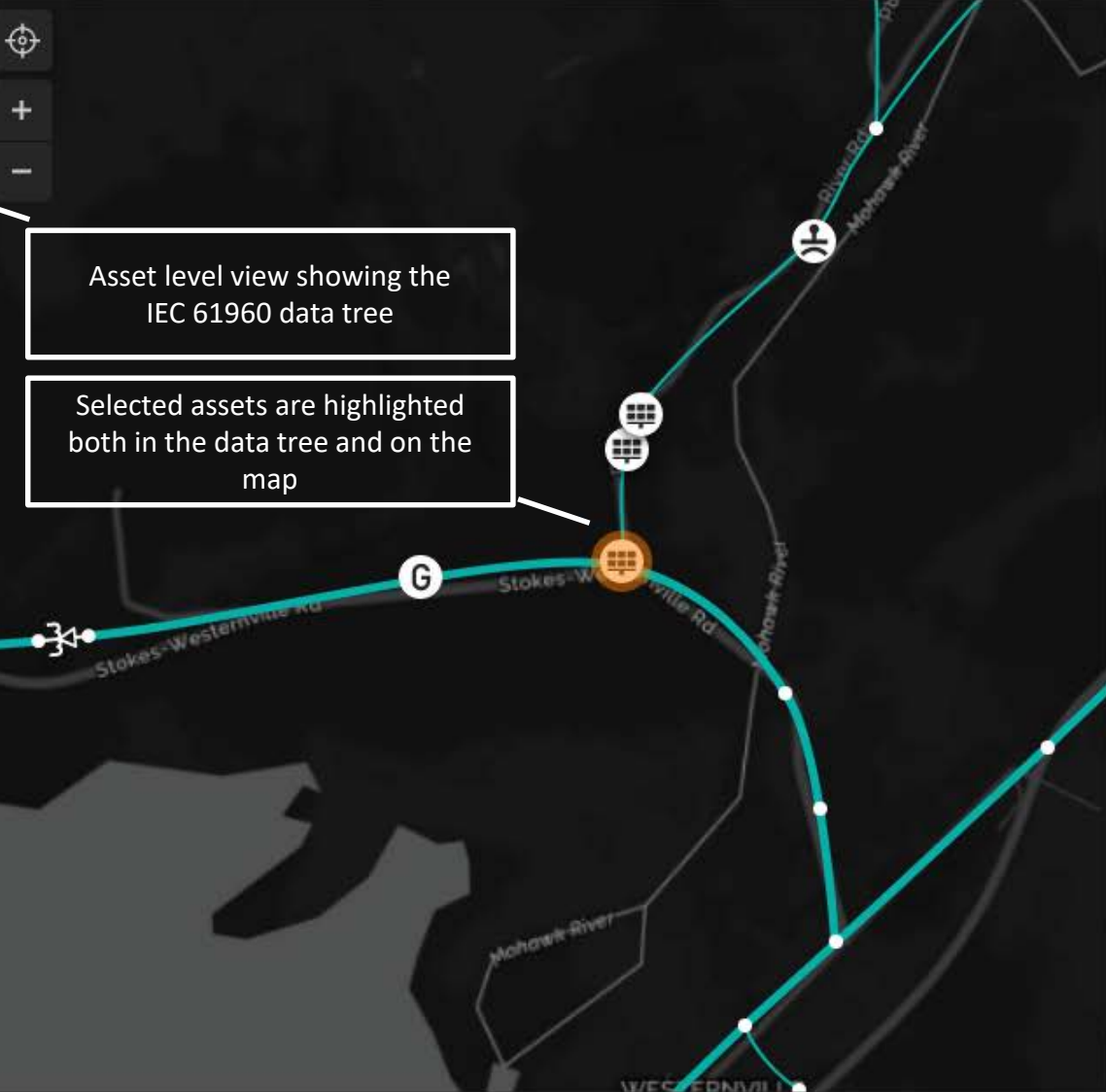
Asset level view showing the IEC 61960 data tree

Selected assets are highlighted both in the data tree and on the map

G

Stokes-Westernville Rd

Mohawk River

WESTERNVILLE

Information

📌 Pin on map ✕

⊞ Asset A   ↻ Apply Changes

Warnings and Errors		⚠ 00 ⊗ 01	
Phase			KVAR
Rated Power Factor			KV
☐ Rated S			MVAR
☐ Rated Voltage			@@@@
Machine Type		####.##	@@@

	Total	A	B	C	
☐ P				####.##	@@@
☐ Voltage		200.00	265.00	195.00	Volts
☐ xxxx					@@@@
☐ xx					@@

	X	A	B	C	
☐ X					@@@@
	A				
	B				
	C				

Asset failed the plausibility check, user now has the opportunity to change asset parameters in the CIM data set through the interface

▶ Optimal Powerflow ⇕ ☰
    1 Hour ⇕

2017-08-07 16:00

Feeder 36_18_356732 , Feeder 36_18_3...

Network   Asset

Search...

- ☐ Substation 36_18_65355
- ☑ Substation 36_18_65356
  - ☑ Feeder 36_18_356732
  - ☑ Feeder 36_18_356733

Selecting to run a power flow from current observed data or over a specific range of dates

| 1 Hour | 1 Year |
| 5 Years | 10 Years |

Costom Time Range

Start
Please select

End
Please select

Apply

1 Hour

Information ✕

Feeder
36_18_356732

Warnings and Errors	⚠ 00	✖ 00
Number of Customers		
Nominal kVLL		kV
Voltage Used	A	B	C
			kVLN
			pu

Update Load/Gen

Load (kW)

200
160
120
80
40

Jan   Mar   May   July   Sep   Nov

1 year   5 years   10 years

Generation (kW)

200

Currently observed date

2017-08-07 16:00

John M...

Network   Asset

Information

GridOS provides a wide array of import options for the power flow analysis

Import new network models that GridOS automatically connects to active workspace, if physical connection present through CIM data references

What would you like to import?

and Errors   ⚠ 00 ⊗ 00

Customers

LL   kV

A   B   C

Forecasted data for load and generation. Uncertainties within forecasts are handled through the probabilistic and stochastic engines

Model

Import new feeder, asset; update existing model

Forecast

Load or generation foresasted data

Import Model

Import Load/Gen

Forecasts are auto referenced to network models and, where needed load allocation or state estimation is performed to ensure edge load and generation visibility on the forecasts

Generation

700

Import Data

Optimal Powerflow

5 Years

Missing Load/Gen Data for Selected Time Range   Update

DEP NW Region

Feeder 36_18_356732 , Feeder 36_18_3...

Network   Asset

Search...

☐ Substation 36_18_65355

☑ Substation 36_18_65356

☑ Feeder 36_18_356732

☑ Feeder 36_18_356733

Import Data

Load   Generation

Canada Creek State Forest

Buck Hill State Forest

Delta Reservoir

Delta Lake State Park

South Hill Fore
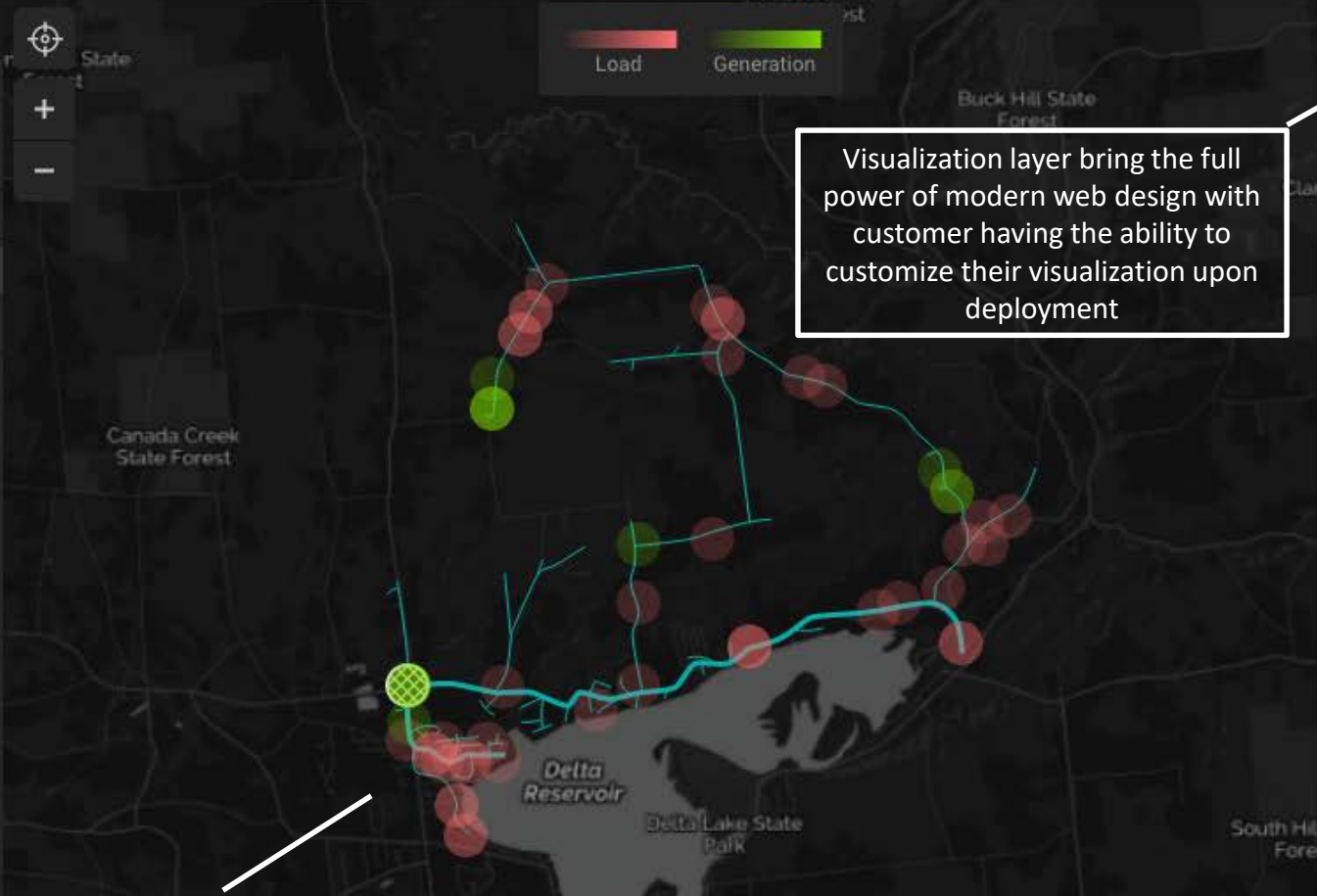
Visualization layer bring the full power of modern web design with customer having the ability to customize their visualization upon deployment

GIS shows the results for current viewed interval, changes with selection of time slot on planning horizon, also shows average, min, max values for time spans

Observed planning time frame with results for each interval with the ability for the planner to freely scroll forward and backward

Visual Layers   ✕

☐ DLMP ⌄

☑ Load & Generation ⌄

☐ Current Loading % ⌄

☐ Voltage ⌄

☐ DLMP Overlay ⌄

☐ Abnormality Overlay ⌄

☐ Three Phases ⌄

☐ Overhead & Underground ⌄

☐ Dark Theme   ☐ Light Theme

Optimal Powerflow ⇕

5 Years ⇕

2017   2018   2019   2020   2021

Network　　Asset

Search... 🔍

■ Substation 36_18_65355 ⌄

▬ Substation 36_18_65356 ⌃

■ Feeder 36_18_356732

☑ Feeder 36_18_356733

Problem areas are highlighted on the geospatial view as well, including number of occurrences

With critical grid conditions, the results will show, on a time scale abnormal events.

Import Data

Through the stochastic and probabilistic engines, a risk based evaluation of events with corresponding probabilities is recorded. User has the ability to set thresholds for probabilities to trigger alarms

List of events by type, time, and asset

Delta Reservoir

Abnormality ✕

Probability %

60
50
40
30
20
10
0

00:00　04:00　08:00　12:00　16:00　20:00　24:00

Type ▾	Asset ▾	Time ▾
Phase Inbalance	TM2904801	2017-10-20 14:00
Phase Inbalance	TM2904801	2017-10-20 15:00
Phase Inbalance	TM2904801	2017-10-20 16:00
Overload	ND302913	2017-10-20 15:00
Overload	PV3S2910	2017-10-20 05:00
Overload	PV3S2910	2017-10-20 12:00
Overload	PV3S2910	2017-10-20 13:00
Under Voltage	ACL294801	2017-10-20 02:00
Under Voltage	ACL294801	2017-10-20 03:00
Under Voltage	ACL294802	2017-10-20 02:00
Under Voltage	ACL294802	2017-10-20 03:00
Under Voltage	ACL294803	2017-10-20 02:00

Optimal Powerflow ⇕
2017-10-20 ⇕

3　3　　　　　　　　　　　　　　2

00:00　02:00　04:00　06:00　08:00　10:00　12:00　14:00　16:00　18:00　20:00　22:00

Network | Asset

Search... 🔍

☐ Substation 36_18_65355 ∨

■ Substation 36_18_65356 ∧

☐ Feeder 36_18_356732

☑ Feeder 36_18_356733

➕ Import Data

Choose Asset to Add ✕

For the scenario analysis and non-wires alternatives evaluation the user has the ability to add assets to the network model and analyze their impact on the planning horizon

Shunt-based Devices

🔋 BESS   🔲 PV   🌀 Wind   Ⓖ Power Source

⊥ Wind   ↓ Load

Link-based Devices

Transformer   Regulator   Fuse   Switch

Recloser

Delta Reservoir

▶ Optimal Powerflow ⇕
2017-10-20 ⇕

00:00 02:00 04:00 06:00 08:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00

DEP NW Region ⌄

Feeder 36_18_356733

⚠ ◆ ⓘ

Network	Asset

Search... 🔍 ⌕

■ Substation 36_18_65355 ⌄

▬ Substation 36_18_65356 ⌃

■ Feeder 36_18_356732

☑ Feeder 36_18_356733

⊕ + −

Planner is given access to the full CIM data semantics through he interface enabling a detailed model description of the newly added resource

Information 📌 Pin on map ✕

⊞ New Asset ↺ Apply Changes

Warnings and Errors	⚠ 00 ⊗ 00
Phase	.... KVAR
Rated Power Factor	.... KV
☐ Rated S	.... MVAR
☐ Rated Voltage	.... @@@@
Machine Type	####.## @@@

	Total	A	B	C
☐ P	....			####.## @@@
☐ Voltage	....			Volts
☐ xxxx	....			@@@@
☐ xx	....			@@

☐ X	A	B	C
A	....		@@@@
B	....		
C	....		

Delta Reservoir

Import Data

＜ ＋ ＞

▶ Optimal Powerflow ⇕ ≡
2017-10-20 ⇕

3 3 | | | | 2 |

00:00 02:00 04:00 06:00 08:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00

IDP, END TO END PLANNING SOLUTION

Integrated Distribution Planning
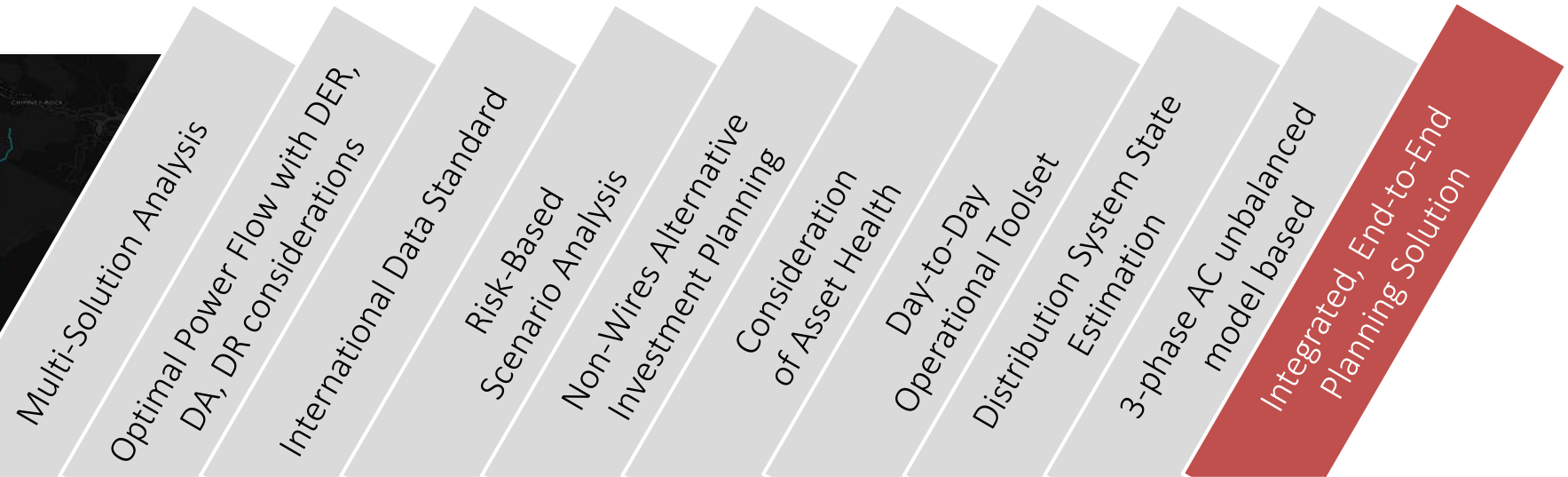
	Multi-Solution Analysis	Optimal Power Flow with DER, DA, DR considerations	International Data Standard	Risk-Based Scenario Analysis	Non-Wires Alternative Investment Planning	Consideration of Asset Health	Day-to-Day Operational Toolset	Distribution System State Estimation	3-phase AC unbalanced model based	Integrated, End-to-End Planning Solution
GridOS IDP	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Standalone Grid Analytics	-	-	~	✓	~	~	~	-	✓	-
System Planning Suites	-	~	-	~	-	~	✓	~	✓	-
Consulting Services	~	✓	✓	✓	✓	✓	-	~	✓	-
In-House Patchwork Solutions	~	✓	~	~	-	~	✓	~	✓	-
Big Data Analytics Tools	-	-	~	✓	-	~	✓	~	-	-

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