Maximizing the Utility Value of Distributed Energy Resources

INTEGRAL ANALYTICS
COMPANY PROFILE

Utility Customers

40+

Customer Load Shapes

27 million

- Market leader in Grid & Supply Analytics for Planning, Operations, Demand-Side Management, Storage and DER Valuation, Integration and Optimization
- Products deliver **granular, actionable intelligence** to utility distribution management, energy, resources and financial value
- Patented architecture and methodology, based on least cost principles
- Scalable platform for emerging system regulations in California, New York, Massachusetts, and others

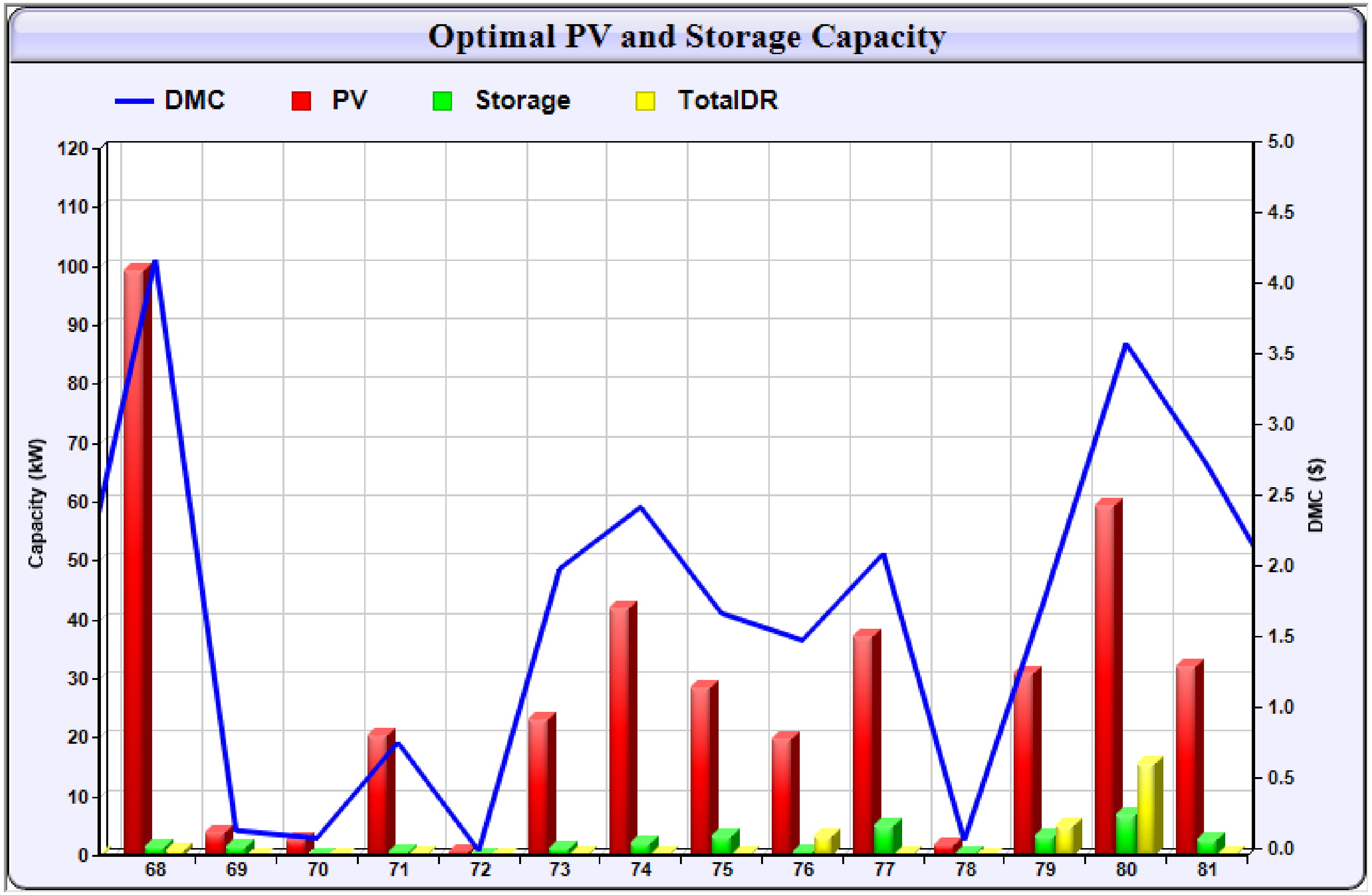
Customers Include:

DUKE ENERGY, KCP&L, SOUTHERN CALIFORNIA EDISON, NES, PG&E, DTE Energy, FORTIS BC, Seattle City Light, AVISTA, AEP, Xcel Energy

Smart Grid Data Analytics Global Market: $4.3 billion in 2020*

*Navigant Consulting

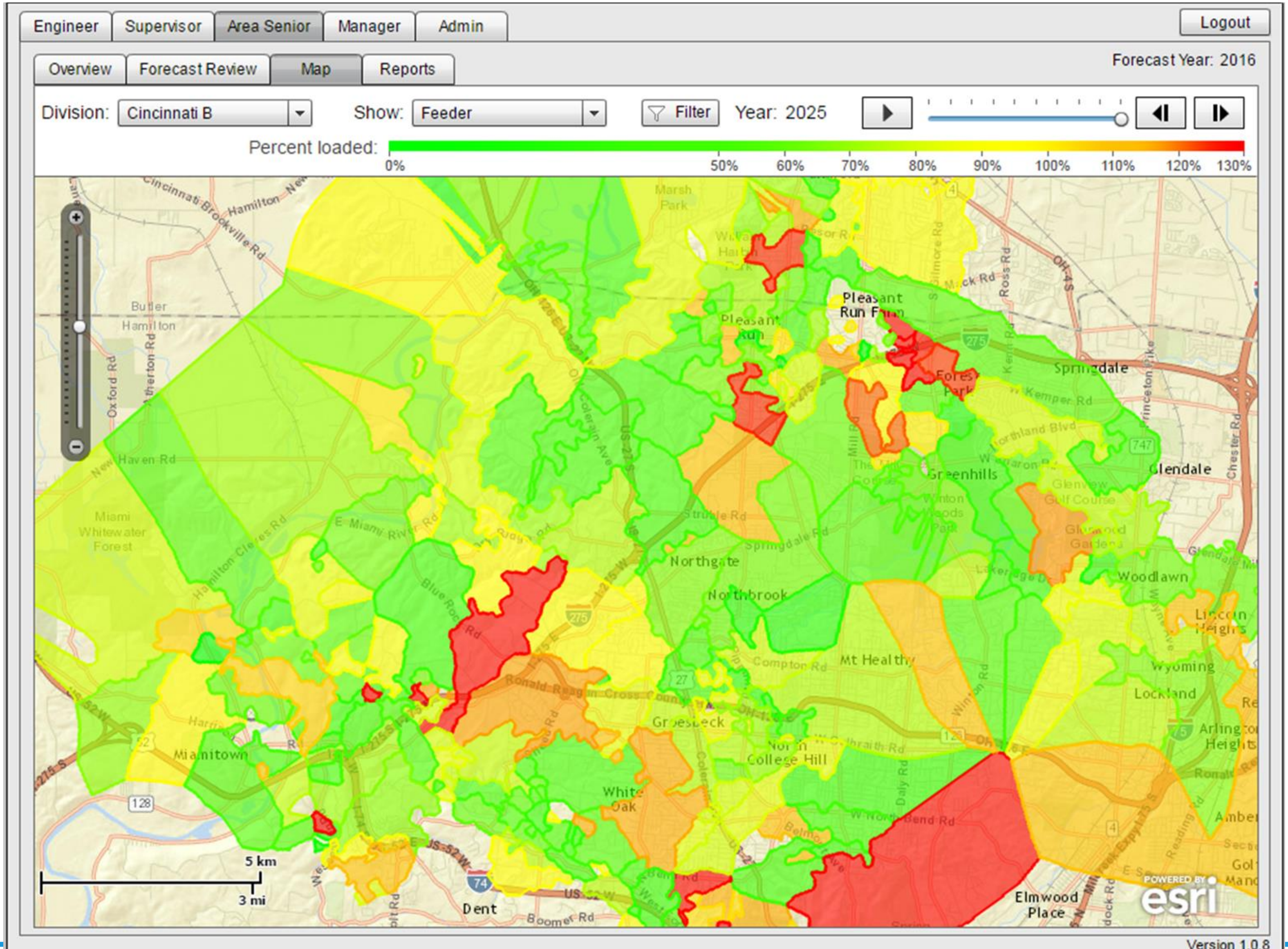
DER LOCATION MATTERS



COST TO SERVE AT GRID EDGE

	Grid Side	Supply Side
Variable Costs	Voltage KVAR Power Factor Line Losses Limiting Factors	Ancillary Services Plant Following Wind/ Cloud Firming Current hour LMP
+		
Fixed Costs / Capacity	Asset Protection Circuit Capacity Deferral Bank Capacity Deferral Future Congestion (Trans)	Capacity Premium 10 Year LMP Forecasts Future Covariance

WHERE WILL GRID BE CONSTRAINED?

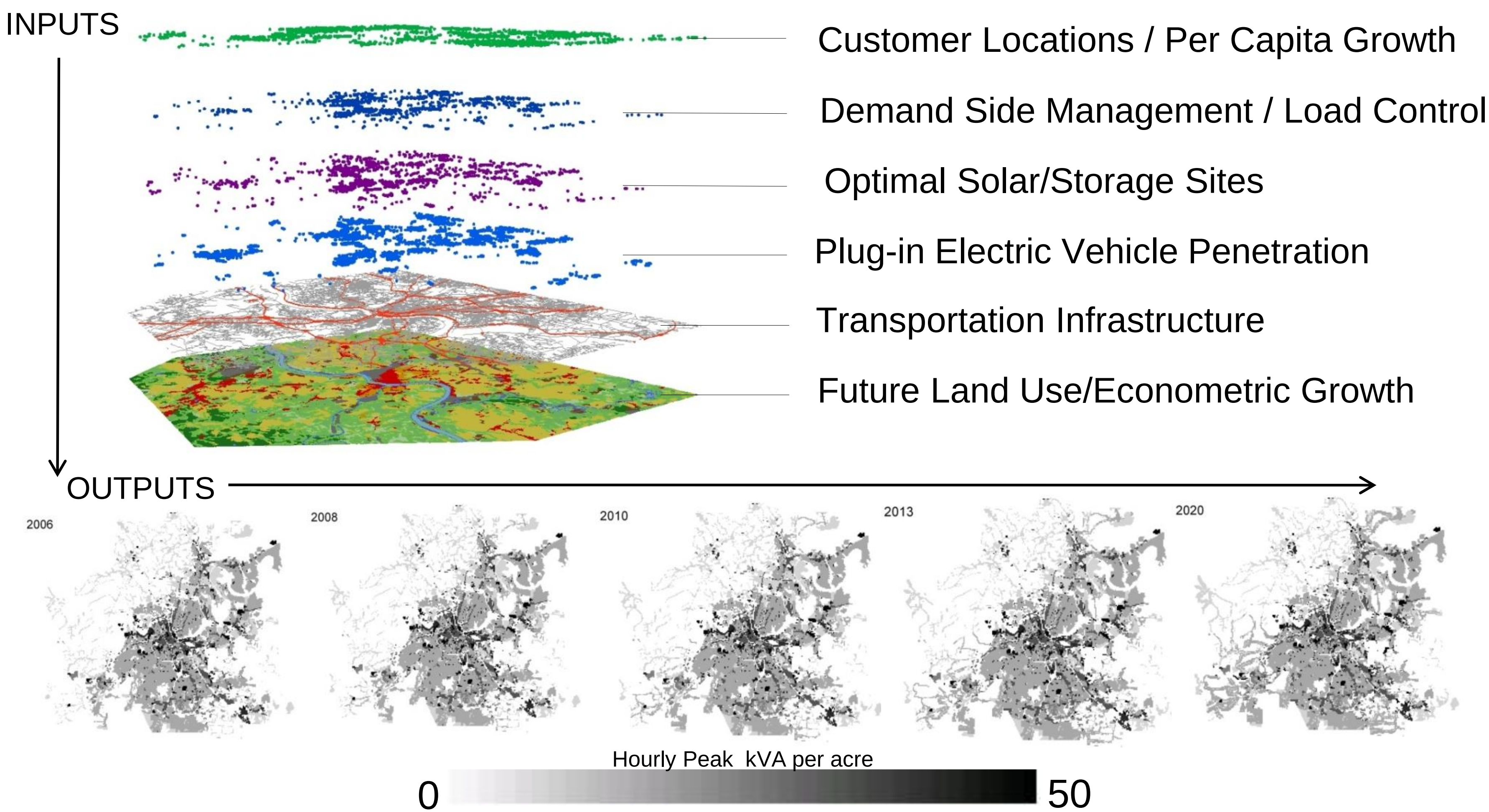


LONG-TERM FORECAST

Triangulate with 3 long-term forecasts approaches

1. Spatial Forecast
   - 30 years of satellite data into GIS
   - historical growth,
   - regression modeling on known patterns of past growth,
   - multiplier effects across industries.
2. Corporate Forecast allocated by MWh
   - Using customer billing data or equivalent
   - Econometric forecast for up to 100 variables, 20 weather variables,
   - Adjusted via circuit load factor, post hoc.
3. Circuit Peak Load Forecast
   - Based on historic peaks
   - Regression analysis using potentially 100 economic variables and 20 weather variables
   - Modelled over 30 weather years

SPATIAL LOAD FORECASTS



Engineer | Area Senior | Admin | Logout

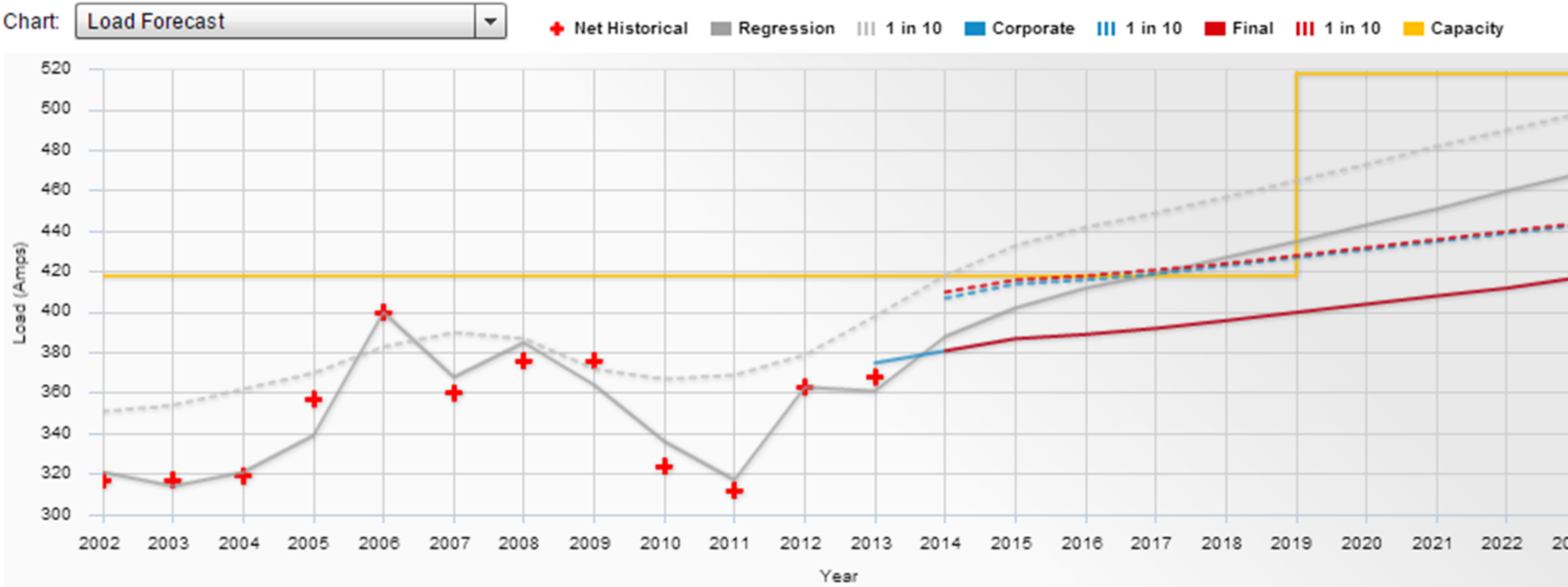
Edit Forecast: Franklin / Canyon Substation A / 8671112 ×

Forecast for: 8671112

Before Projects | After Projects

Model | Results

Chart: Load Forecast



	2014	2015	2016
Projected load (Amps)	410	416	418
Surplus / Deficiency (Amps)	8	2	0
Percent loaded	98%	100%	100%

Regression
Adjusted R Square: 0.88 (High)

Corporate
Spatial Growth: 0.79 (High)
Adjusted R Square: 0.9 (High)

Regression coefficients:

Variable	Coefficient
3-Day Weighted-Avg High Temperature	0.202533
Income: Total Personal, (Mil. $)	0.000229
Employment: Service Sector/Full or Part Ti	0.022601

Blend

Final forecast: 100% Corporate, 0% Regression
Recommended: 49% Corporate, 51% Regression

OK | Cancel

Engineer | Area Senior | Admin | Logout

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Before Projects | After Projects

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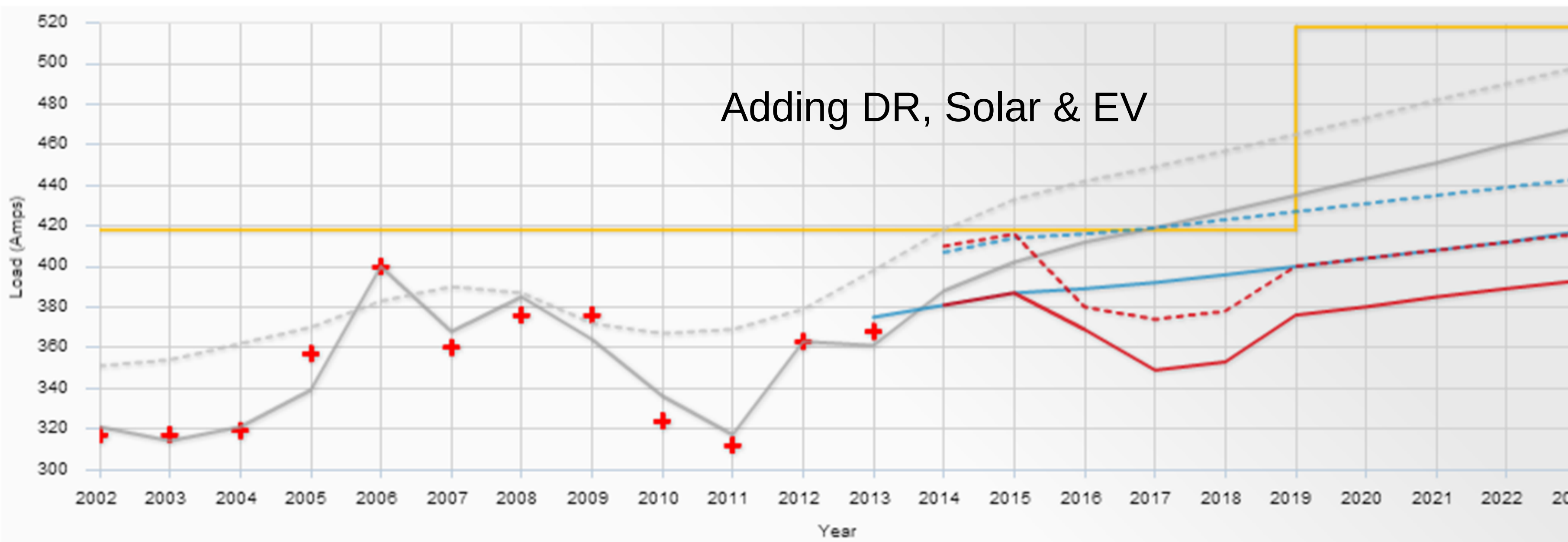
Chart: Load Forecast

Net Historical | Regression | 1 in 10 | Corporate | 1 in 10 | Final | 1 in 10 | Capacity



	2014	2015	2016
Projected load (Amps)	410	416	380
Surplus / Deficiency (Amps)	8	2	38
Percent loaded	98%	100%	91%

Regression
Adjusted R Square: 0.88 (High)

Corporate
Spatial Growth: 0.79 (High)
Adjusted R Square: 0.9 (High)

Regression coefficients:

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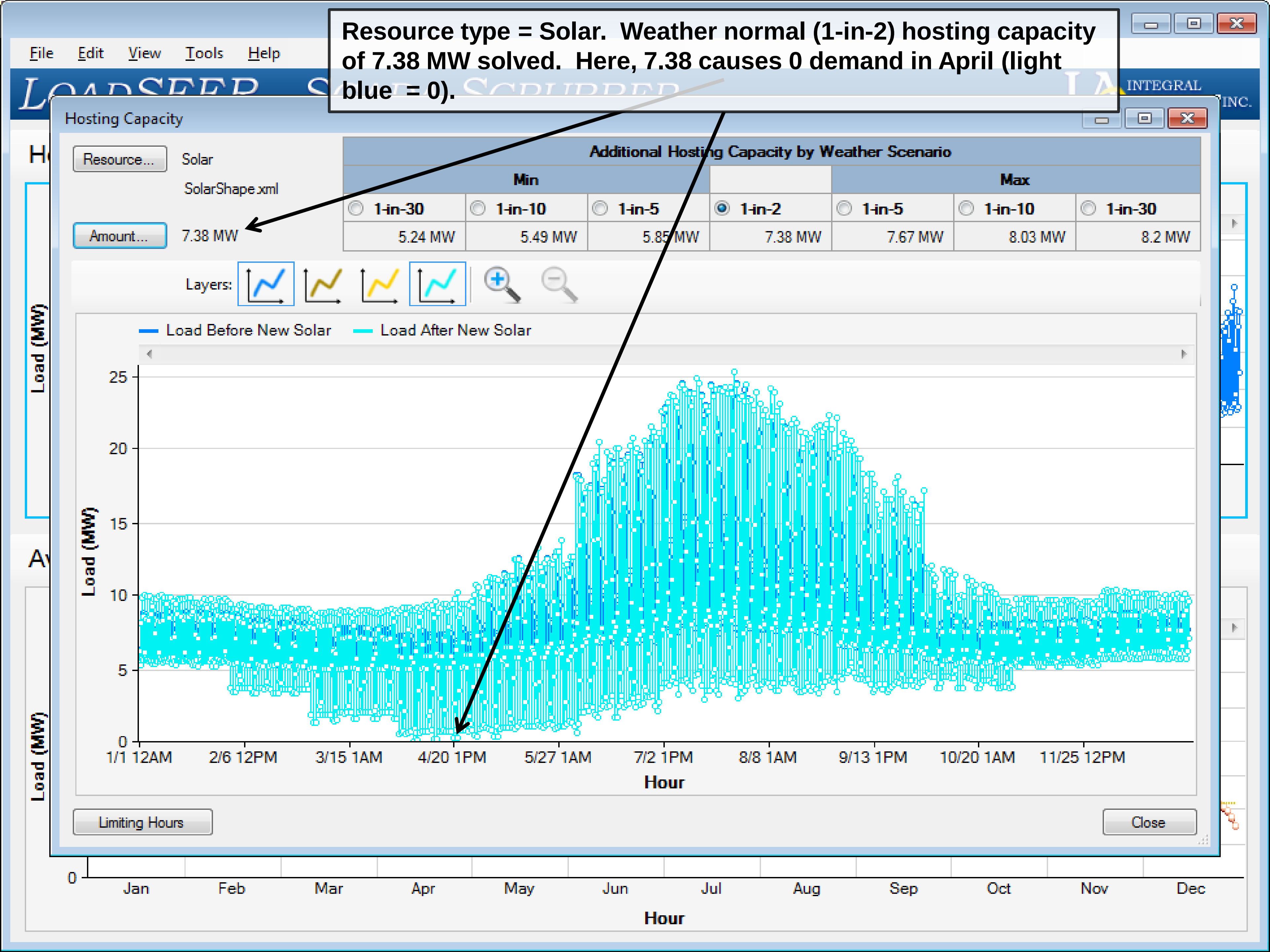
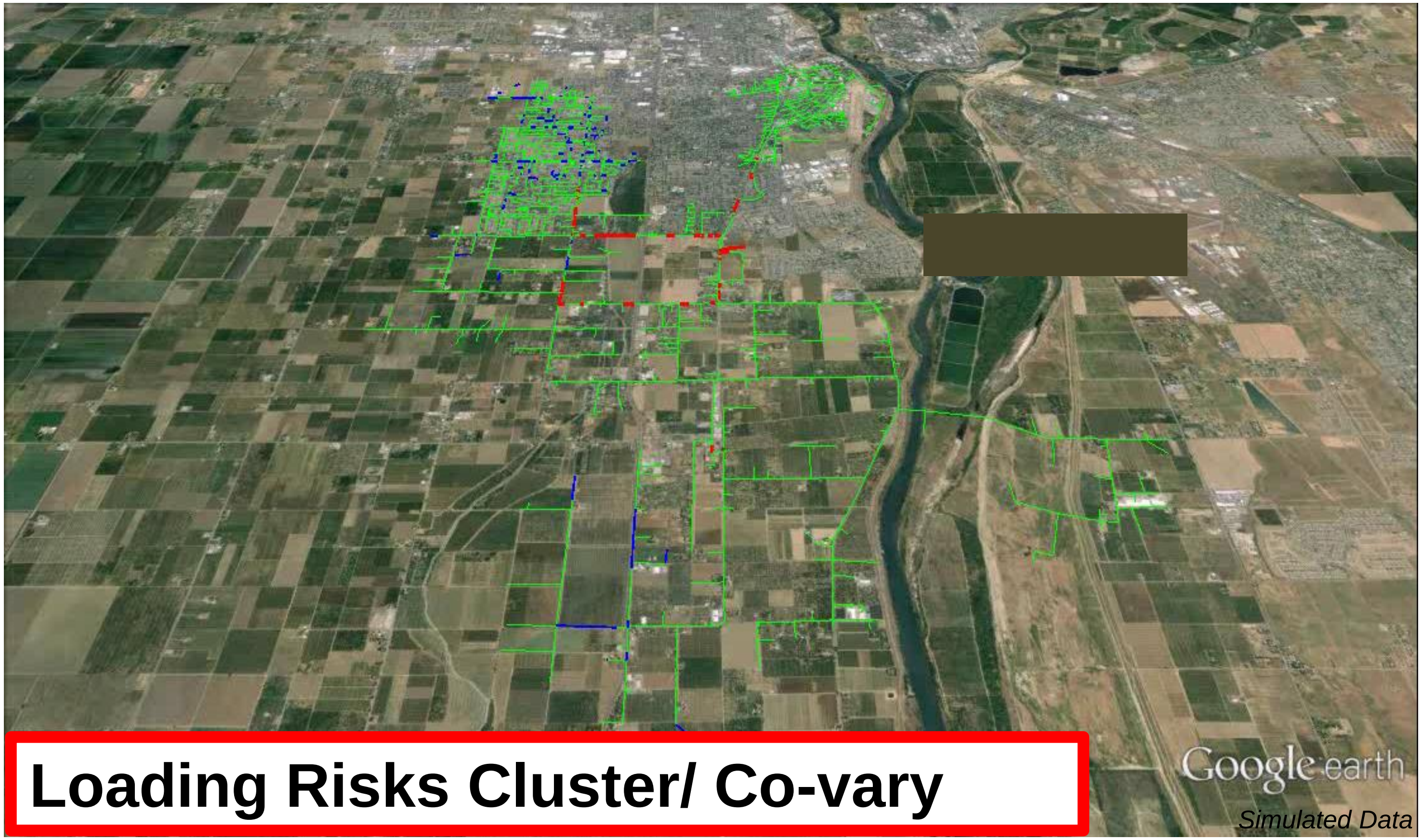
OK | Cancel

Resource type = Solar. Weather normal (1-in-2) hosting capacity of 7.38 MW solved. Here, 7.38 causes 0 demand in April (light blue = 0).



LIMITING FACTORS: GRID CONSTRAINTS POWERFLOW LEADS DER OPTIMIZATION



@ Service Transformer

Blue < 116V

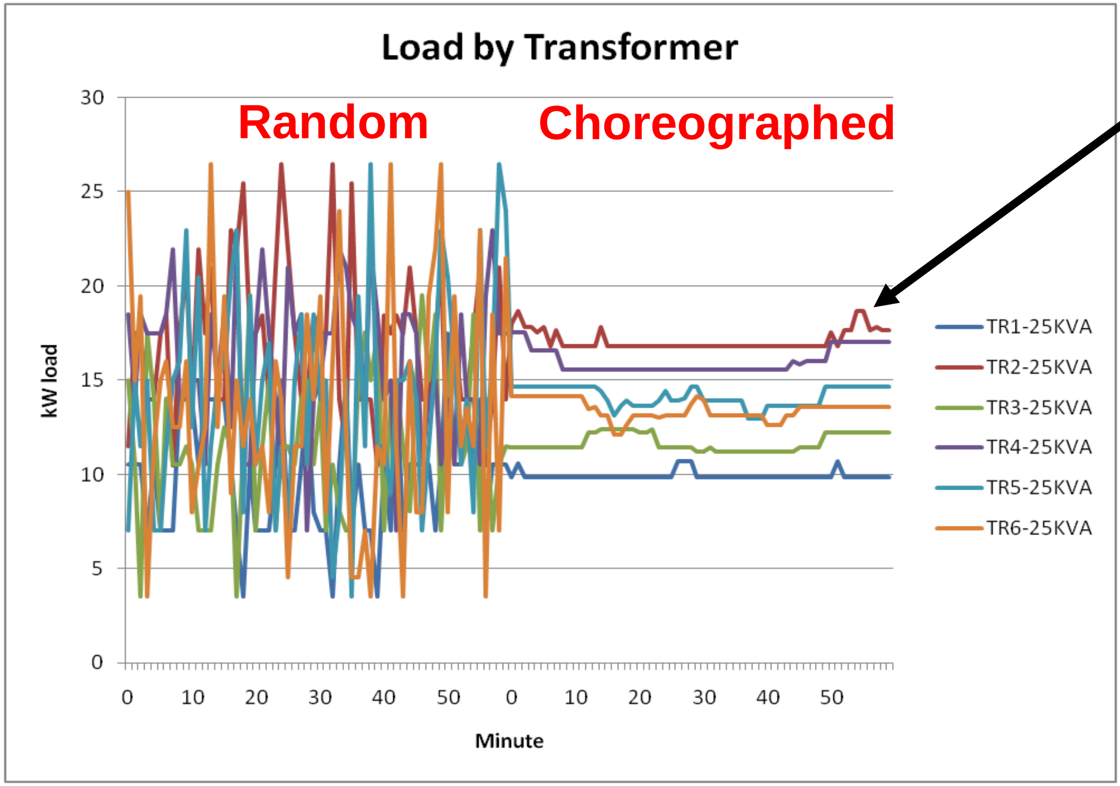
Red = Overloaded

INTEGRAL ANALYTICS

CHOREOGRAPHY OF DERS

Voltage Improves, Asset Protected

IA only needs 25%-40% customer participation to levelize load, which saves utility money and does not force customers to participate.



Bumps intentional to limit the extent that AC units are started/stopped, and to optimize on customer marginal costs, not just on load alone.

Loads are flat enough to observe improved voltages and protects the service transformer

Six transformers, 30 homes, displaying normal volatility in load prior to IA vs. after optimizations are operational.

DISTRIBUTED MARGINAL COSTS (DMC)

AMI Data | Smart Inverters | Zigbee | Dynamic Dispatch | Arbitraging DERs

Sensors | CYME Data/ Model | Satellite Data

	Grid Side	Supply Side
Variable Costs	Voltage KVAR Power Factor Line Losses Limiting Factors	Ancillary Services Plant Following Wind/ Cloud Firming Current hour LMP
+ Fixed Costs / Capacity	Asset Protection Circuit Capacity Deferral Bank Capacity Deferral Future Congestion (Trans)	Capacity Premium 10 Year LMP Forecasts Future Covariance

Time: *Minutes* → *Hours* → *Months* → *Years*

DMC is the actual Cost to Serve, and can be used in non ISO markets as well.

LOCATIONS CLOSELY CORRELATE TO DISTRIBUTED MARGINAL COST

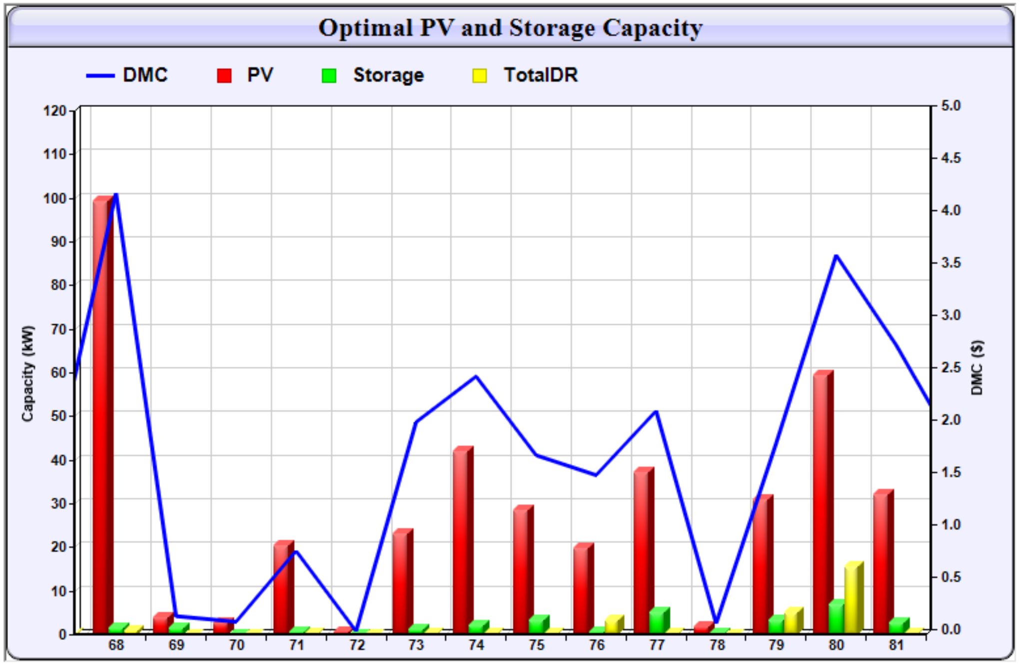
DAILY DMC ($$ COSTS AVOIDED) DRIVE LOCATION/MAGNITUDE

DER Optimization

DER OPTIMIZATION

INTEGRAL ANALYTICS, INC.

Model Setup | Optimal DER given DMC | Financial Results | Hourly Views | Map



Shift Left

Shift Right

Results

Sector	Benefit	Cost	Net	Test Result
Utility	$54,766.04	$12,319.46	$42,446.58	4.45
Part.	$14,125.41	$61,689.50	$-47,564.09	0.23
TRC	$68,891.45	$74,008.95	$-5,117.50	0.93

kW and kWh Summary

Percent kW Saved (avg over hours)	33.94 %
Percent kWh Saved (sum over hours)	33.62 %

Pointer

Zoom In

Zoom Out

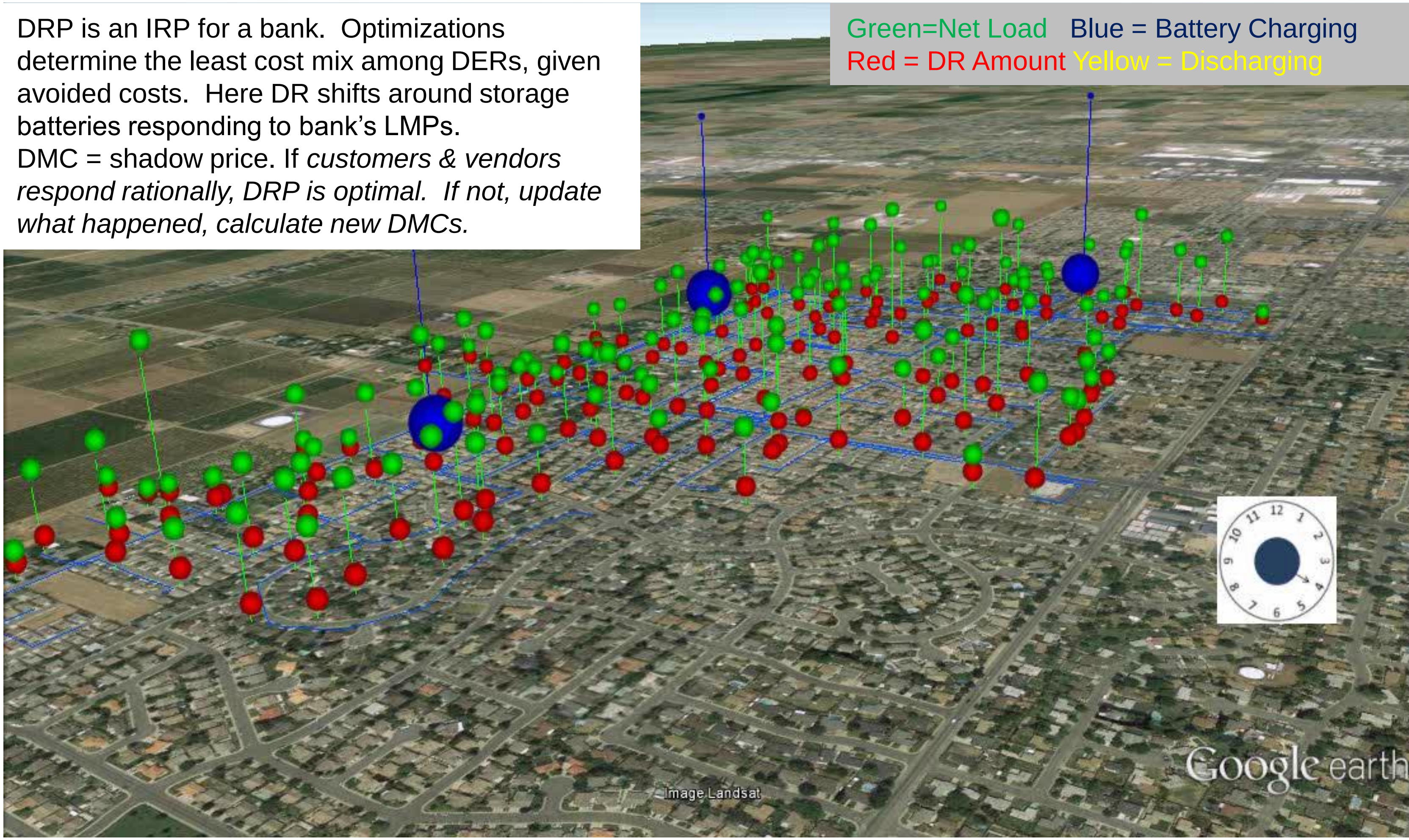
Zoom Level

Ready

INTEGRAL ANALYTICS

CHOREOGRAPHY OF DERS BASED ON DMC

DRP is an IRP for a bank. Optimizations determine the least cost mix among DERs, given avoided costs. Here DR shifts around storage batteries responding to bank's LMPs.
DMC = shadow price. If *customers & vendors respond rationally, DRP is optimal. If not, update what happened, calculate new DMCs.*



Optimal DR Dispatch (2 Hr) with Storage Charging

LESSONS LEARNED IN CA

- Reliability remains top priority
- “Wild West” edge solar development strains reliability and least-cost performance
- Hosting maps are needed to streamline PV/DER interconnection
  - Requires 10-year nodal forecasts
  - Proportionally spreading load change doesn’t work
- Each circuit has different operational needs, so policies/methods differ, as do costs (DRP approach)
- 10-year circuit-level forecasts and DER hosting technical limits are foundational (must be dynamically updated)
  - Prerequsite to distributed market signals, marginal value and capacity clearing incentives

IMPACT OF NODAL VALUATION: ONE CIRCUIT IN CA

Benefits: Granular	**$1,696,000**
Benefits: Traditional	**$298,000**
% Difference	**470%**

- Determine capacity deferral value by location
- Quantify power flow benefits and risks of DER
- Capture variable supply side benefits like supply following
- Forecast circuit peak loads
- Avoid over-averaging avoided T&D
- Calculate the customer specific capacity cost to serve
- Capture avoided costs between the substation and the customer location

Least Cost Service Depends on Optimal DER Siting

DER REQUIRE GRANULAR ANALYSIS

1. Determine capacity deferral value by location
2. Quantify power flow benefits/risks of DER
3. Capture variable supply side benefits like supply following
4. Forecast circuit peak loads
5. Avoid over-averaging avoided T&D
6. Calculate the customer specific capacity cost to serve
7. Capture avoided costs between the substation and the customer location

Need Granular analysis to capture full utility benefits of DER at the edge of the grid.

CONTACT INFORMATION

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