Maximizing the Value of Distributed Energy Resources

April 21, 2015

Bill Kallock, Vice President Business Development

INTEGRAL ANALYTICS
COMPANY PROFILE

Software Users:

200+

Software Tools:

18

- 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
- Software users span utilities, integrators, consultants & regulators
- Bench depth of PhDs and programmers with deep energy expertise
- Patented architecture and methodology, based on least cost principles
- Scalable platform integrates requirements of emerging system regulations in California, New York, Massachusetts, and others

Customers Include:

Duke Energy, KCP&L, Southern California Edison, NES, PG&E, DTE Energy, FortisBC, Seattle City Light, Avista, AEP, Xcel Energy

Smart Grid Data Analytics Global Market: $760 million in 2012 to $4.3 billion in 2020*

*Navigant Consulting Q4 2013

LOCATION BASED (DISTRIBUTION) MARGINAL COSTS

Optimal integration of DERs into the distribution system requires more Granularity

Locational value (2 types)	1) Customer costs granularity. Cost to serve. 2) Geo-spatial granularity. Growth & DERs. Utilities need to use the AMI data, to achieve it.
Optimization	To yield portfolios of least cost resources, by circuit Based on local granular load forecasts, costs of DERs
Coordination	Use the granular values to move markets. Use of "prices to devices". DMC vendor bounties. Arbitraging power factor. Hourly/ 5 min DMPs.

ENGINEERING MEETS ECONOMICS (DMC)

Grid Side

Supply Side

Capacity Premium

10 Year LMP Forecasts

Future Covariance

ENGINEERING MEETS ECONOMICS (DMC)

Sensors | CYME Data/ Model | Satellite Data

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

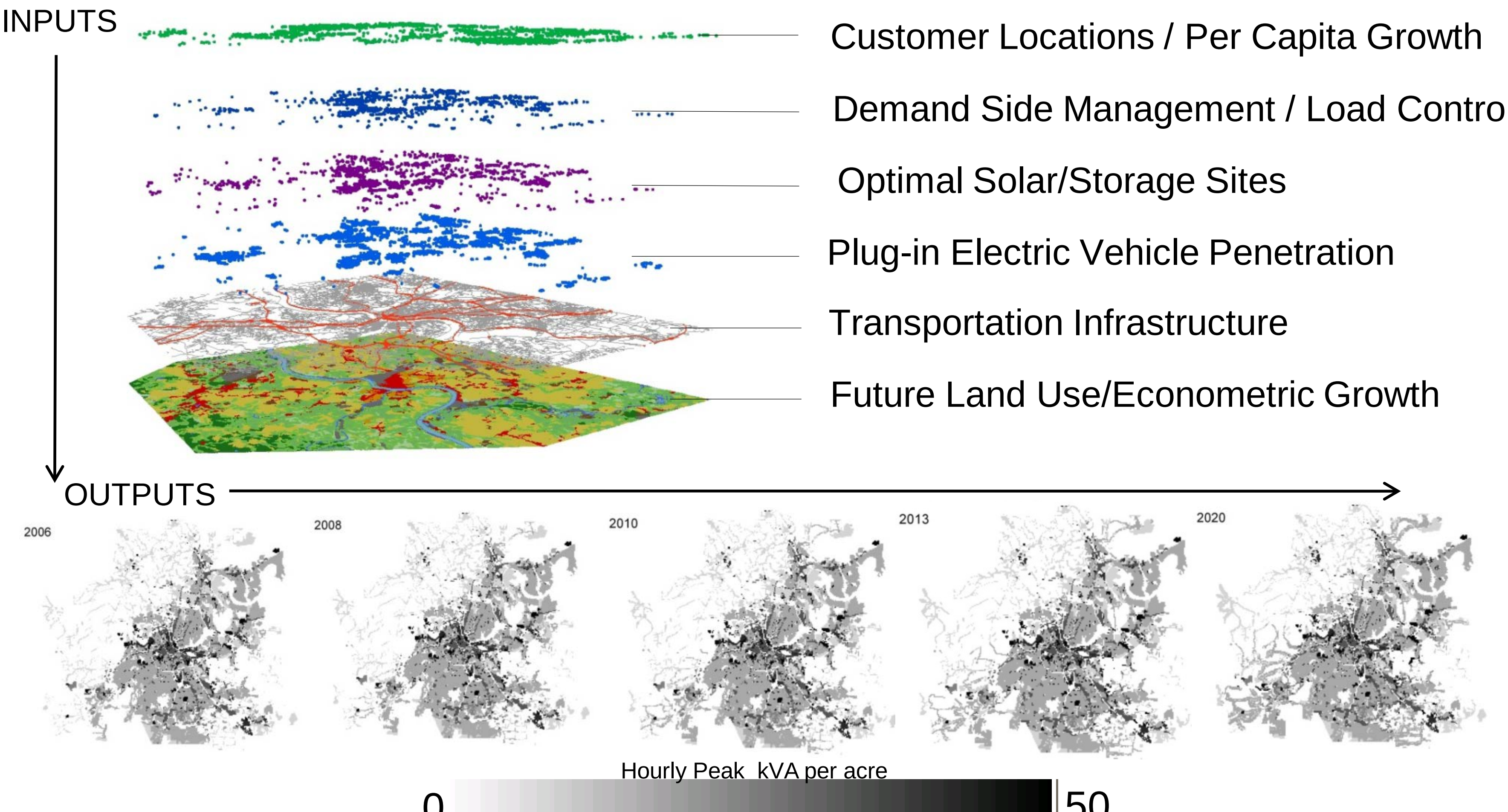
	Grid Side	Supply Side
Variable Costs	Voltage KVAR Power Factor Line Losses Limiting Factors	Ancillary Services Plant Following Wind/ Cloud Firming Current hour LMP
+ Fixed Costs / Capacity	Asset Protection Circuit Capacity Deferral Bank Capacity Deferral Future Congestion (Trans)	Capacity Premium 10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

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

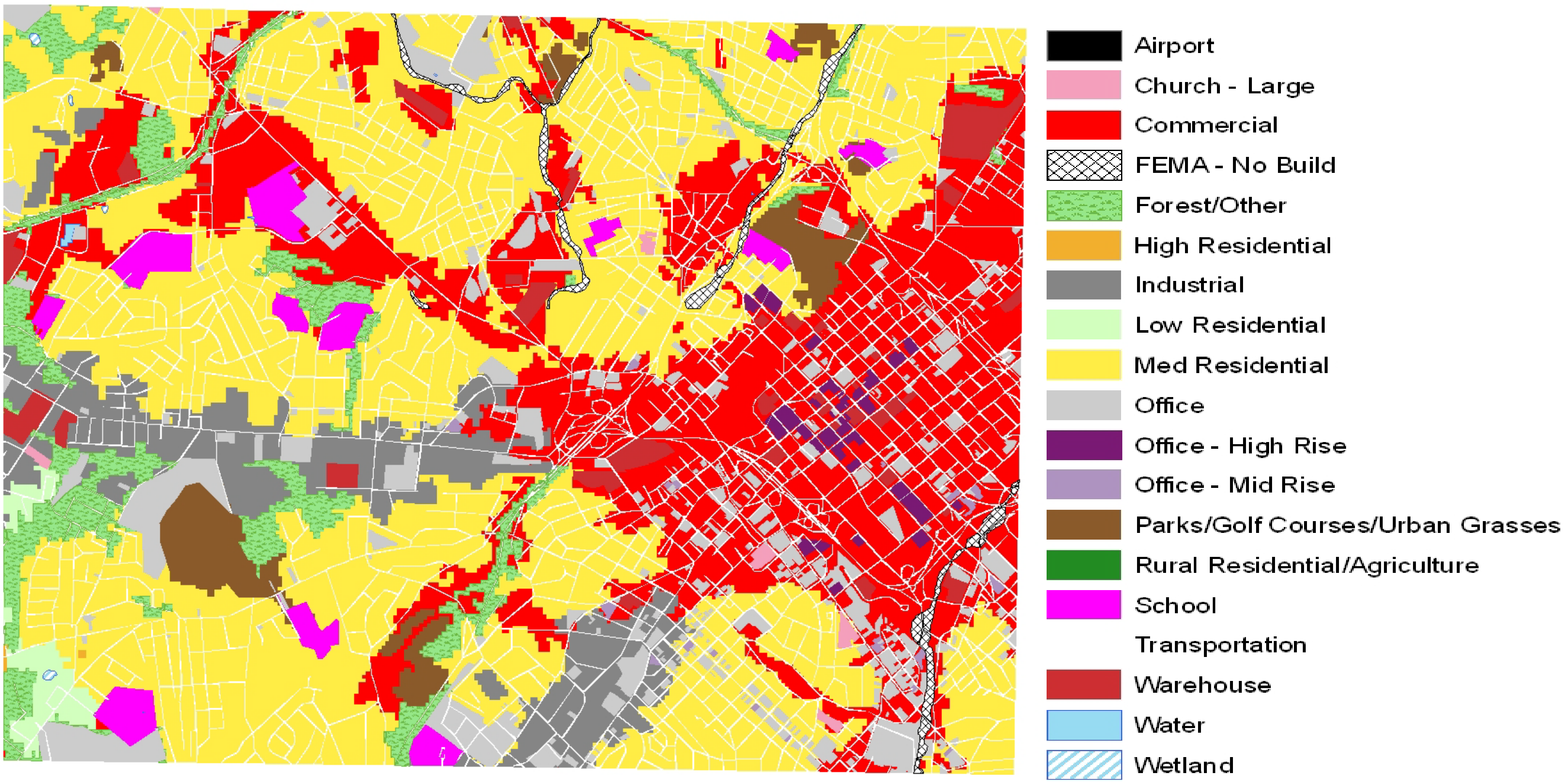
DMC = DMP, which would be market traded price for nodal kW and kWh.
DMC is the actual Cost to Serve, and can be used in non ISO markets as well.

IA Integral Analytics

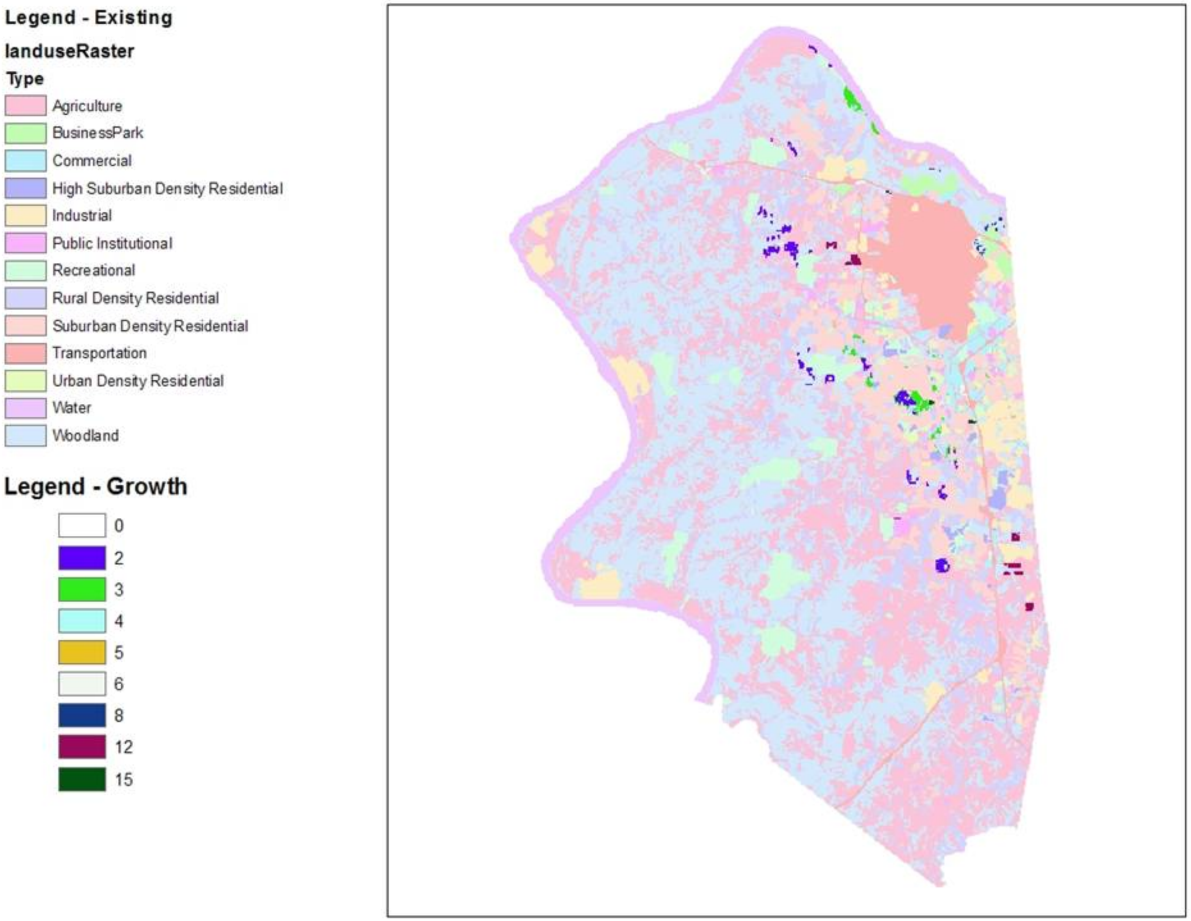
SPATIAL LOAD FORECASTS



FORECAST: LAND USE EXAMPLE



LAND USE FORECAST (2011)



Land Growth Classes

2 = Residential - Rural

3 = Residential - Suburban

4 = Residential - Multi/Dense

5 = Residential - High Rise

6 = Retail Commercial (Including Parking Lots)

8 = Business Parks

12 = Light and Medium Industrial

15 = Institutional (Schools, Churches)

LAND USE FORECAST (2028)

Legend - Existing

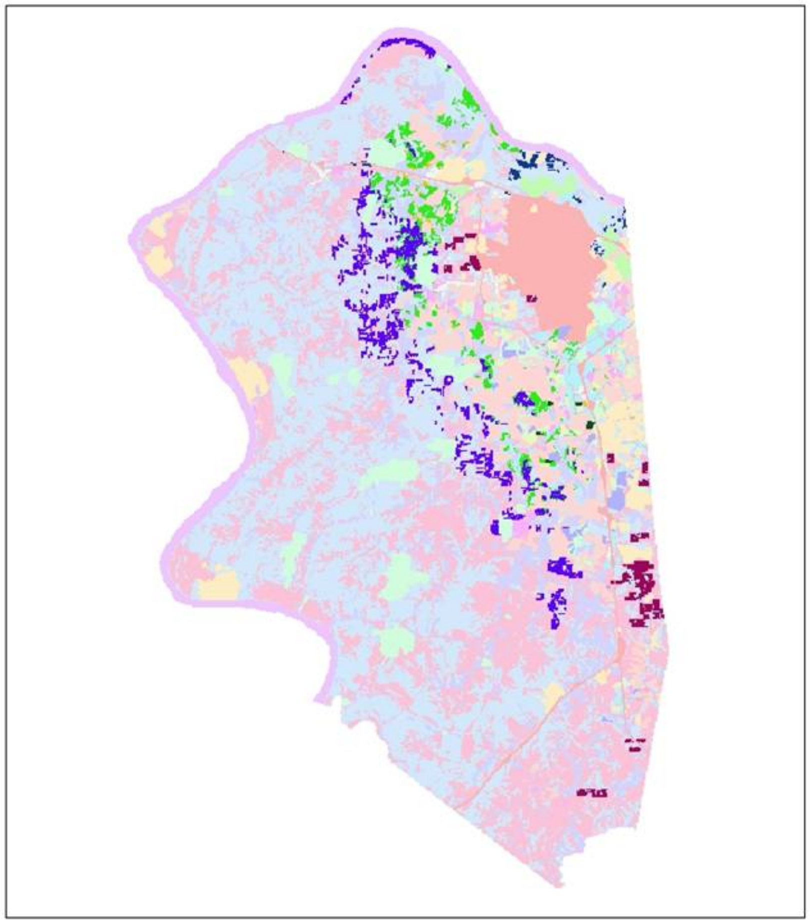
landuseRaster

Type

- Agriculture
- BusinessPark
- Commercial
- High Suburban Density Residential
- Industrial
- Public Institutional
- Recreational
- Rural Density Residential
- Suburban Density Residential
- Transportation
- Urban Density Residential
- Water
- Woodland

Legend - Growth

- 0
- 2
- 3
- 4
- 5
- 6
- 8
- 12
- 15



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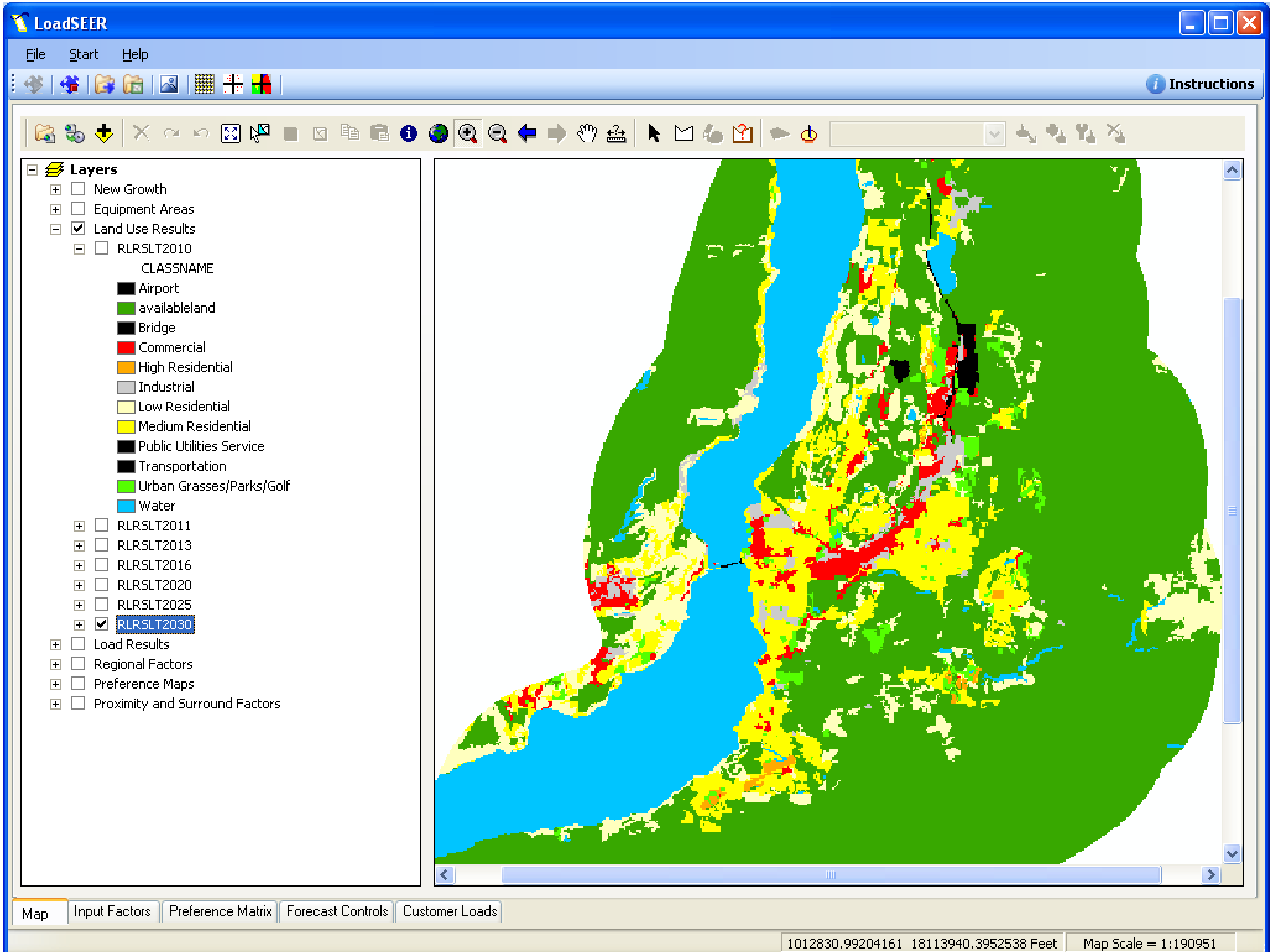
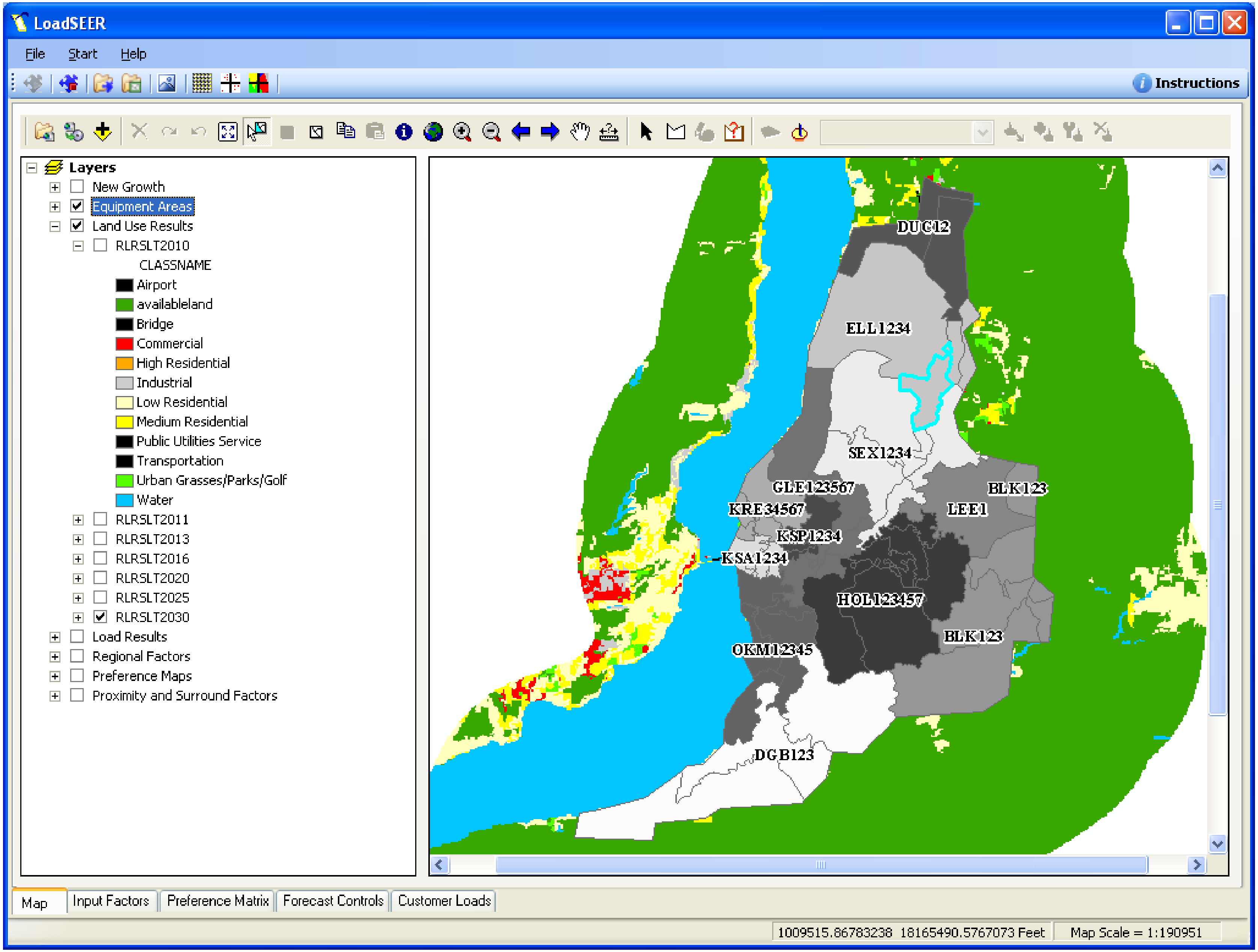
LoadSEER


LoadSEER
File
Start
Help
Instructions
Layers
New Growth
Equipment Areas
Land Use Results
RLRSLT2010
CLASSNAME
Airport
availableland
Bridge
Commercial
High Residential
Industrial
Low Residential
Medium Residential
Public Utilities Service
Transportation
Urban Grasses/Parks/Golf
Water
RLRSLT2011
RLRSLT2013
RLRSLT2016
RLRSLT2020
RLRSLT2025
RLRSLT2030
Load Results
Regional Factors
Preference Maps
Proximity and Surround Factors
Map
Input Factors
Preference Matrix
Forecast Controls
Customer Loads
1012830.99204161 18113940.3952538 Feet
Map Scale = 1:190951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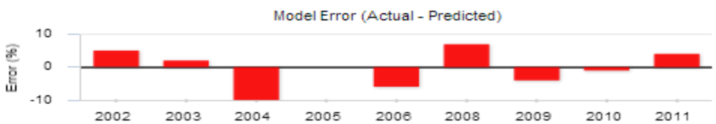
Load Results
Regional Factors
Preference Maps
Proximity and Surround Factors
DUC12
ELL1234
SEX1234
GLE123567
BLK123
KRE34567
LEE1
KSP1234
KSA1234
HOL123457
BLK123
OKM12345
DGB123
Map
Input Factors
Preference Matrix
Forecast Controls
Customer Loads
1009515.86783238 18165490.5767073 Feet
Map Scale = 1:190951

LoadSEER FORECAST INTEGRATION TOOL

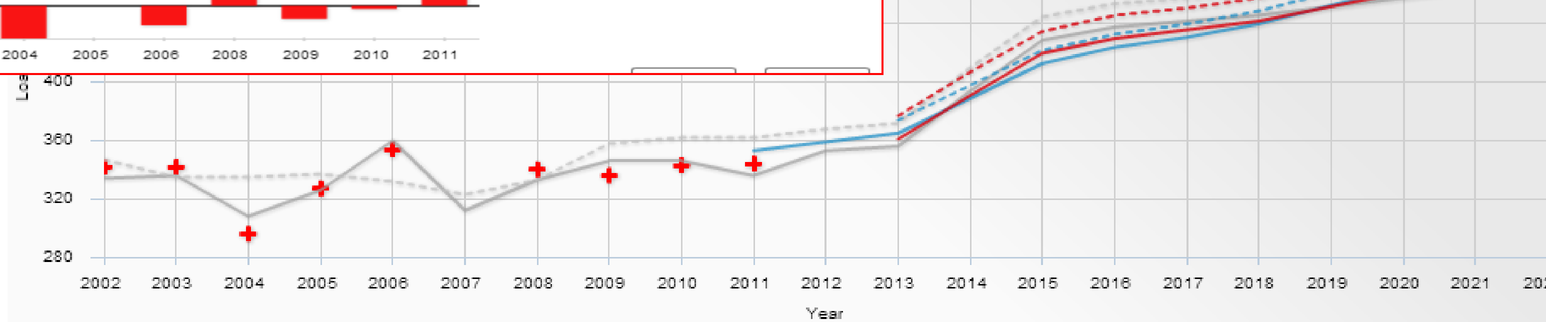
Number of Variables	Variables	Adjusted R Square	Model Error (%)	Regression Forecast
0	n/a	0.00	5.24	
1	3-Day Weighted-Avg Low Temperature	0.26	5.07	
2	3-Day Weighted-Avg Low Temperature Labor Force, (Ths.)	0.42	4.96	
3	3-Day Weighted-Avg Low Temperature Employment: Landscape/Farm/Agriculture, (Ths.) Employment: Natural Resources and Mining, (Ths.)	0.63	5.09	

Limit Variables...



Logout

Before Projects | After Projects



	2013	2014	2015
Projected load (Amps)	377	407	435
Surplus / Deficiency (Amps)	177	147	119
Percent loaded	68%	74%	79%

Regression
Adjusted R Square: 0.63 (Medium)

Corporate
Spatial Growth: 0.72 (High)
Adjusted R Square: 0.97 (High)

Regression coefficients:

Variable	Coefficient
3-Day Weighted-Avg Low Temperature	0.092158
Employment: Natural Resources and Mini	5.066735
Employment: Landscape/Farm/Agriculture	0.061133

Blend

Final forecast: 57% Corporate, 43% Regression
Recommended: 57% Corporate, 43% Regression

OK Cancel

Version 1.0.0

INTEGRAL ANALYTICS

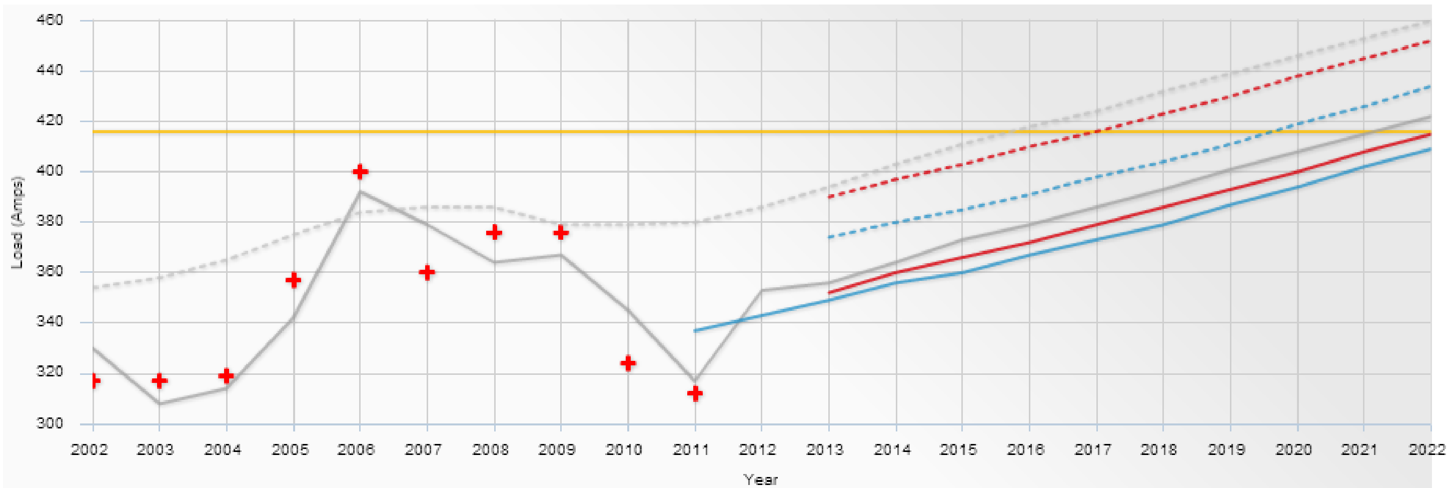
LoadSEER FORECAST INTEGRATION TOOL

Engineer | Supervisor | Area Senior | Manager | Admin | Logout

Before Projects | After Projects

Model | Results

Chart: Load Forecast



	2013	2014	2015
Projected load (Amps)	390	397	403
Surplus / Deficiency (Amps)	26	19	13
Percent loaded	94%	96%	97%

Regression
Adjusted R Square: 0.77 (High)

Corporate
Spatial Growth: 0.9 (High)
Adjusted R Square: 0.98 (High)

Regression coefficients:

Variable	Coefficient
3-Day Weighted-Avg High Temperature	0.221287
Gross Product: Total, (Mil. Chained 2005 $	0.000145

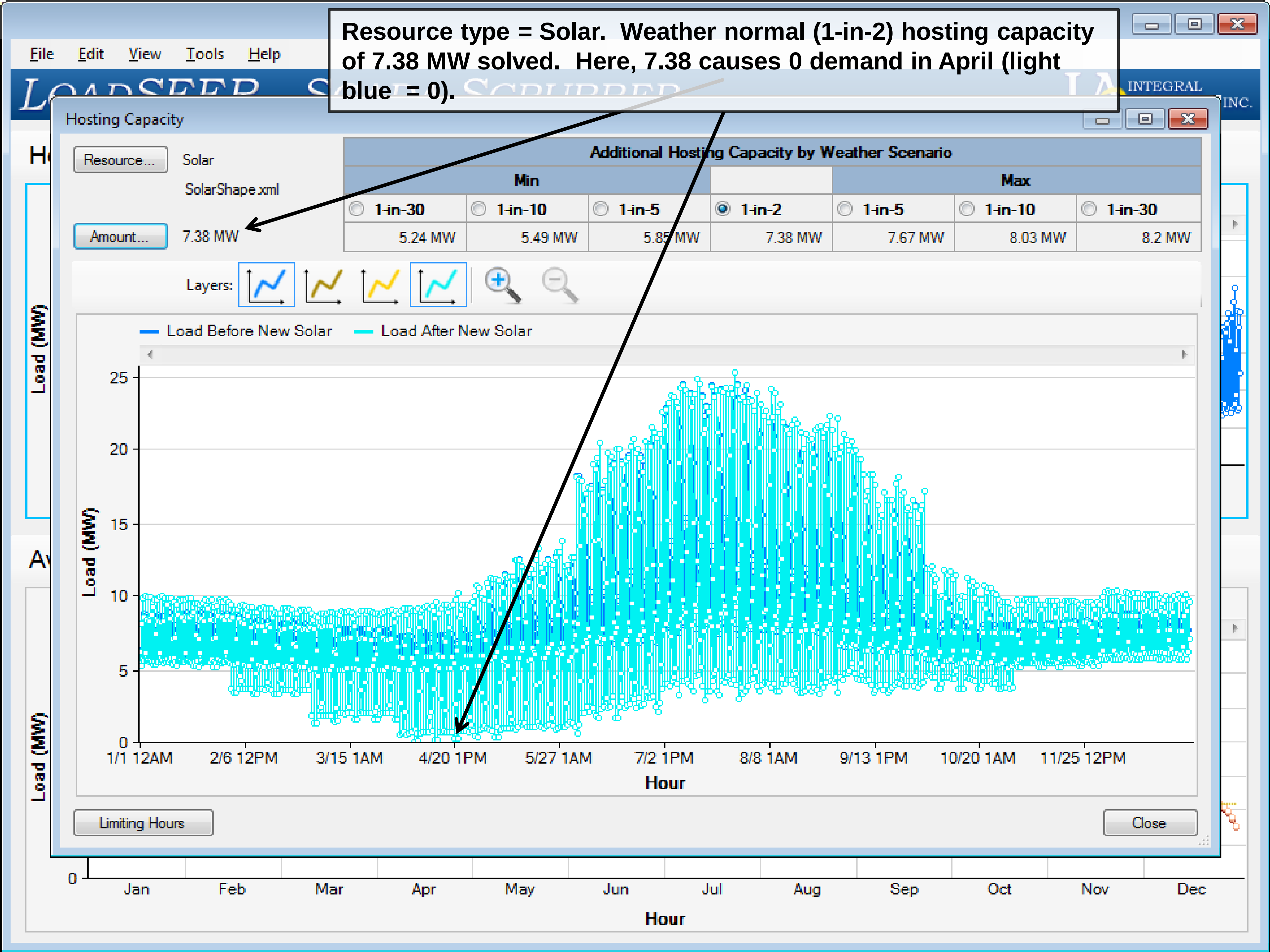
Blend
Final forecast: 55% Corporate, 45% Regression
Recommended: 55% Corporate, 45% Regression

OK | Cancel

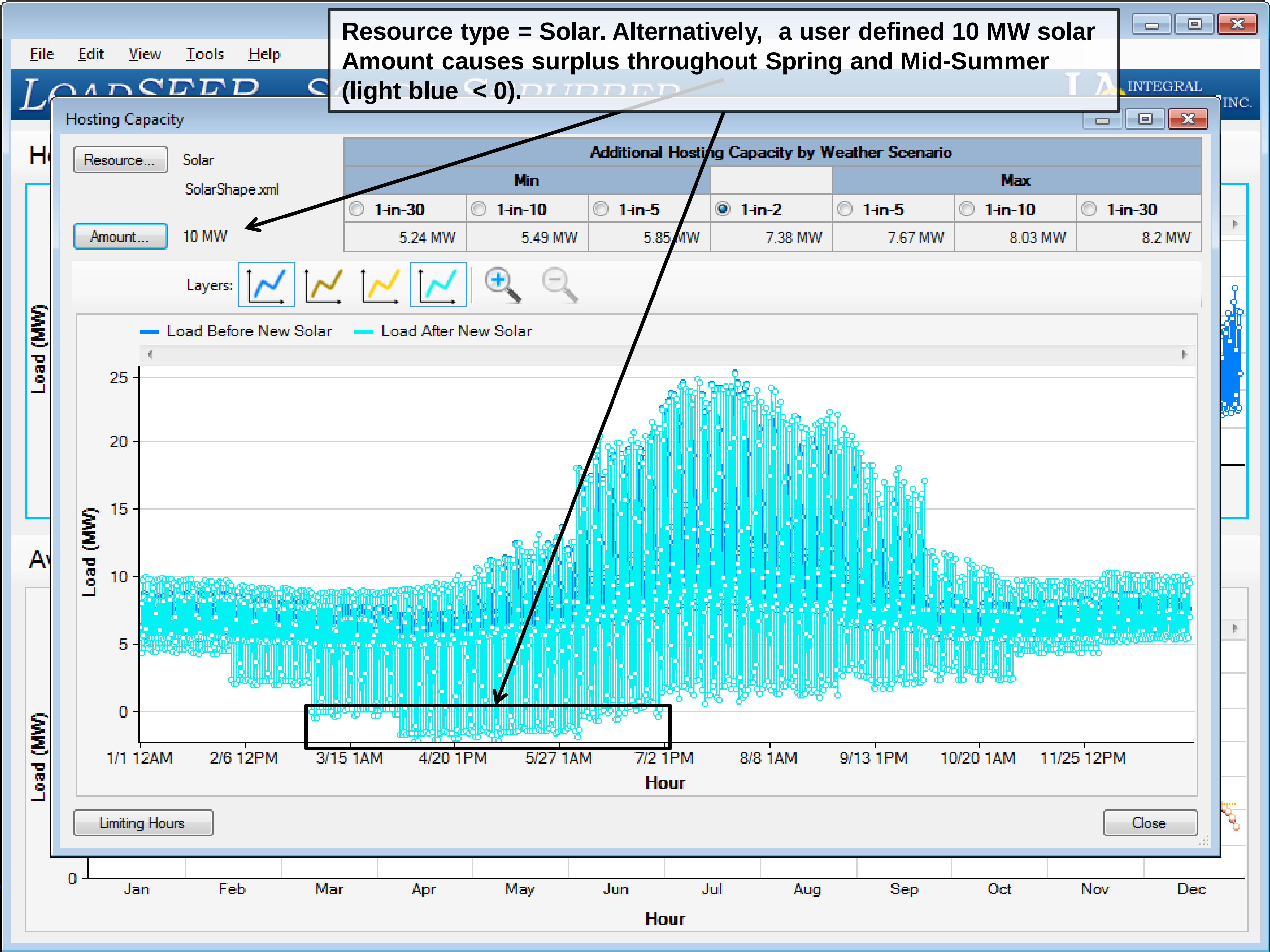
Version 1.0.0

Integral Analytics

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).



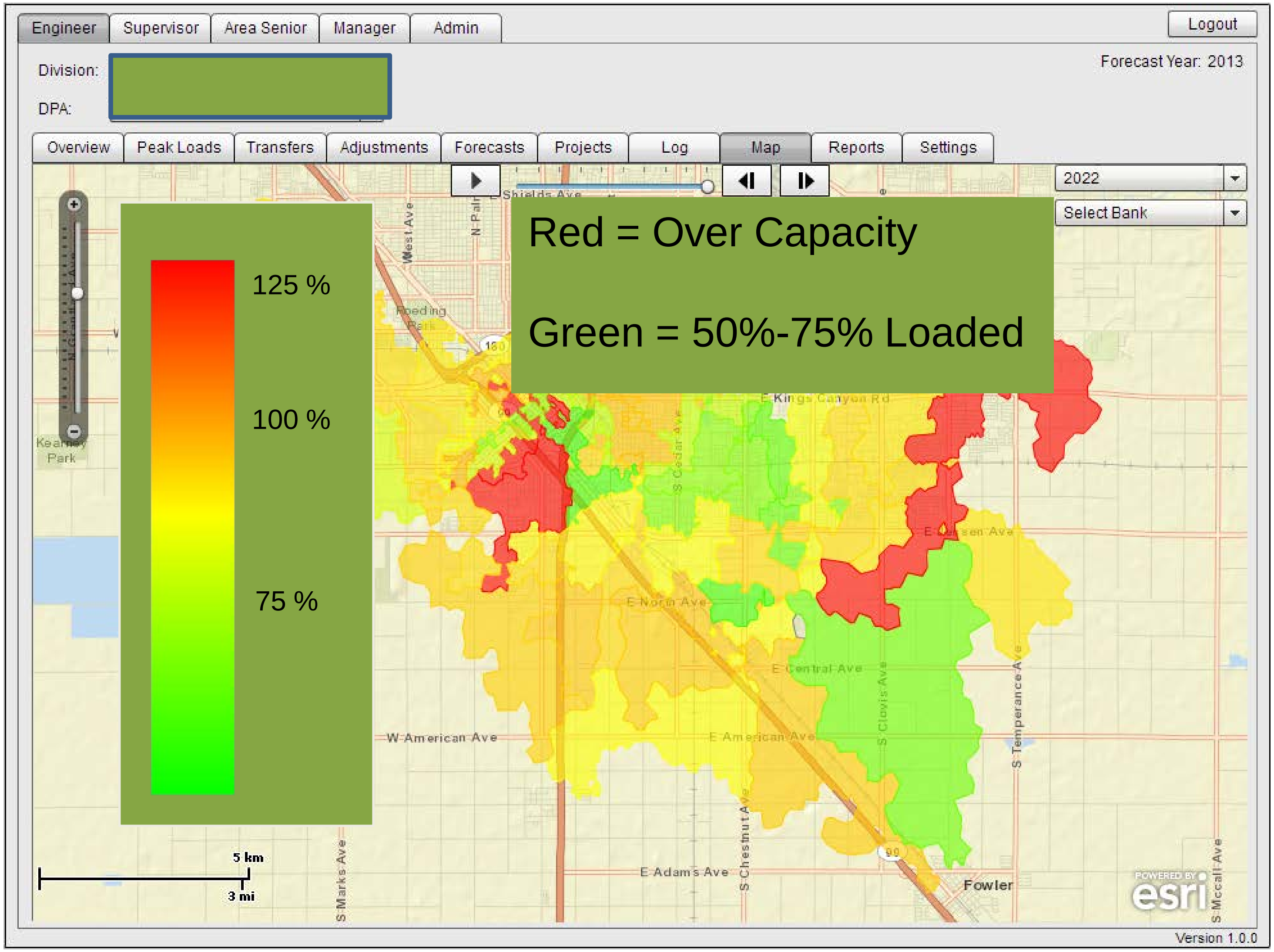
Resource type = Solar. Alternatively, a user defined 10 MW solar Amount causes surplus throughout Spring and Mid-Summer (light blue < 0).



LoadSEER FORECAST INTEGRATION TOOL

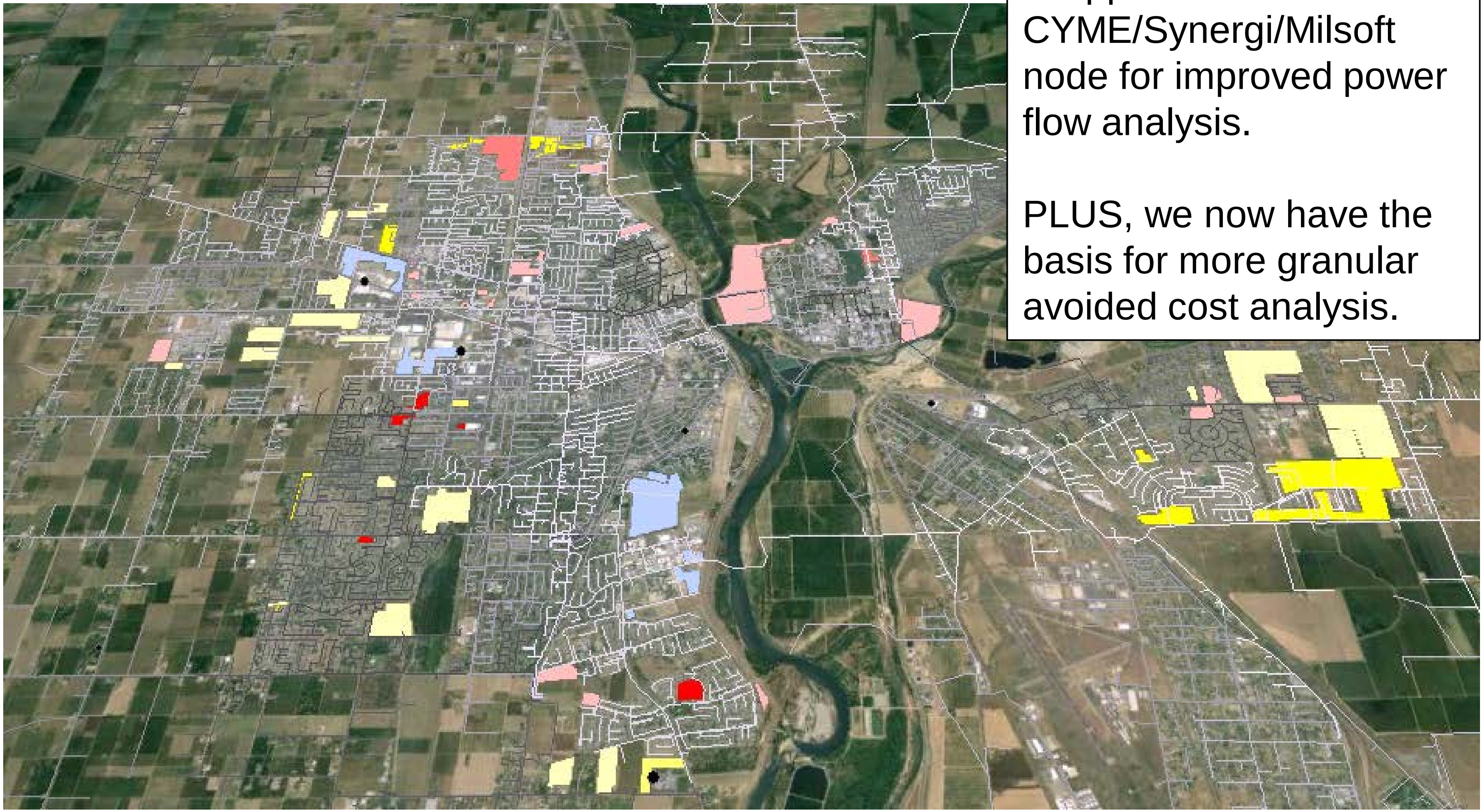
Red = Target EE/DR/PV

Green = Load Building is Least Cost, for EV Charging or New Economic Development



INTEGRAL ANALYTICS

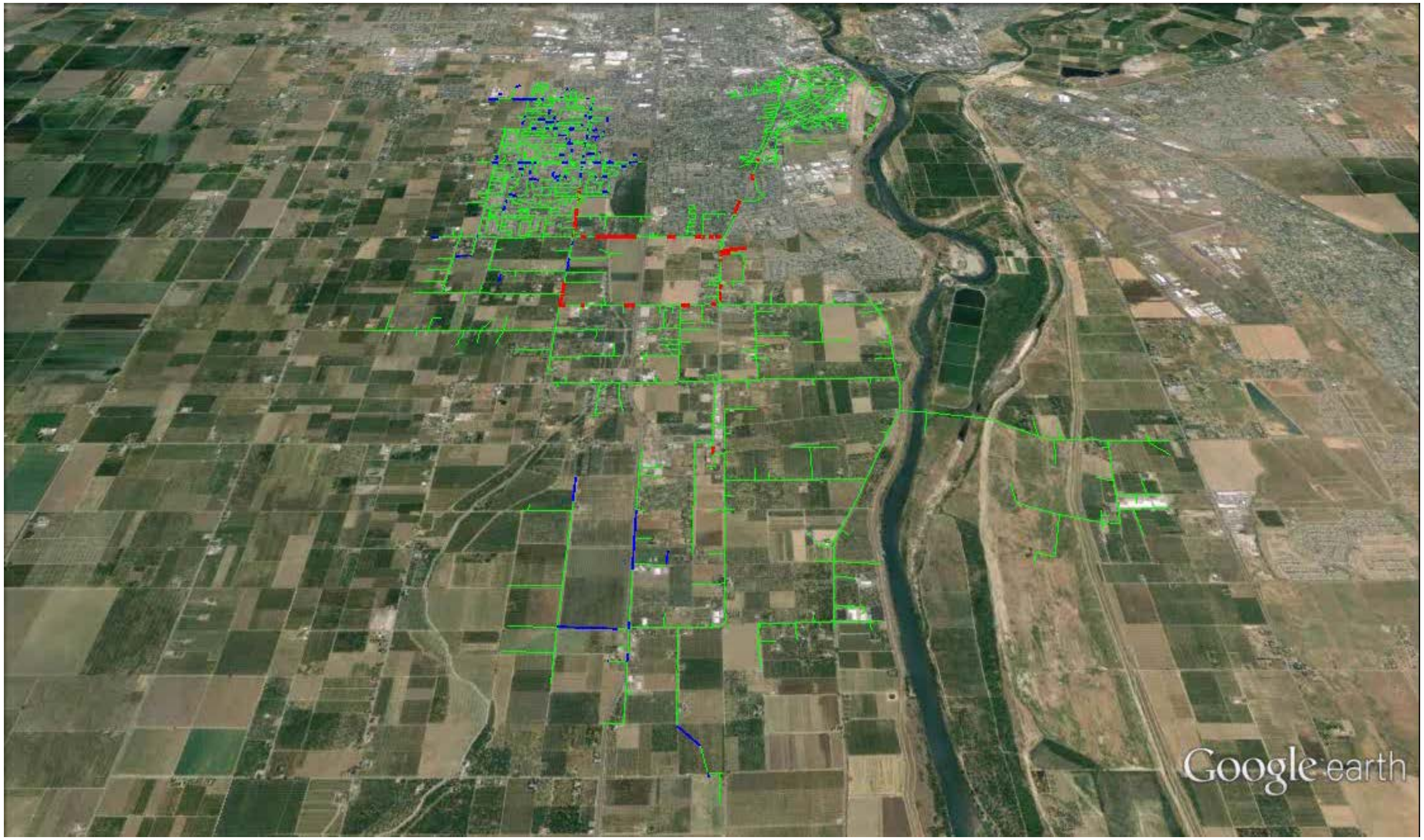
LOADSEER ACRE LEVEL



Local load increases get snapped to nearest CYME/Synergi/Milsoft node for improved power flow analysis.

PLUS, we now have the basis for more granular avoided cost analysis.

LIMITING FACTORS: POWERFLOW LEADS DER OPTIMIZATION



@ Service Transformer

Blue < 116V

Red = Overloaded

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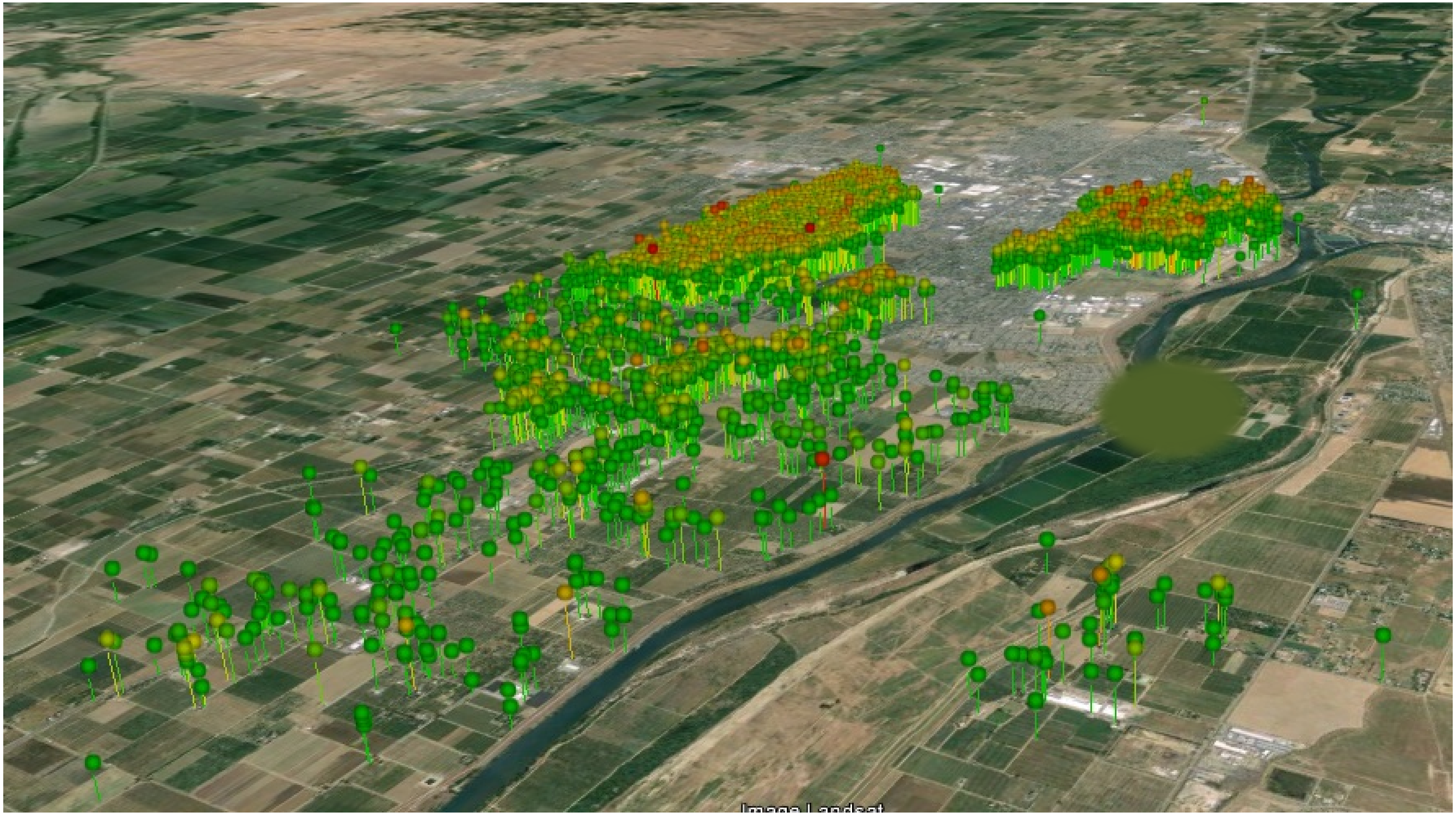
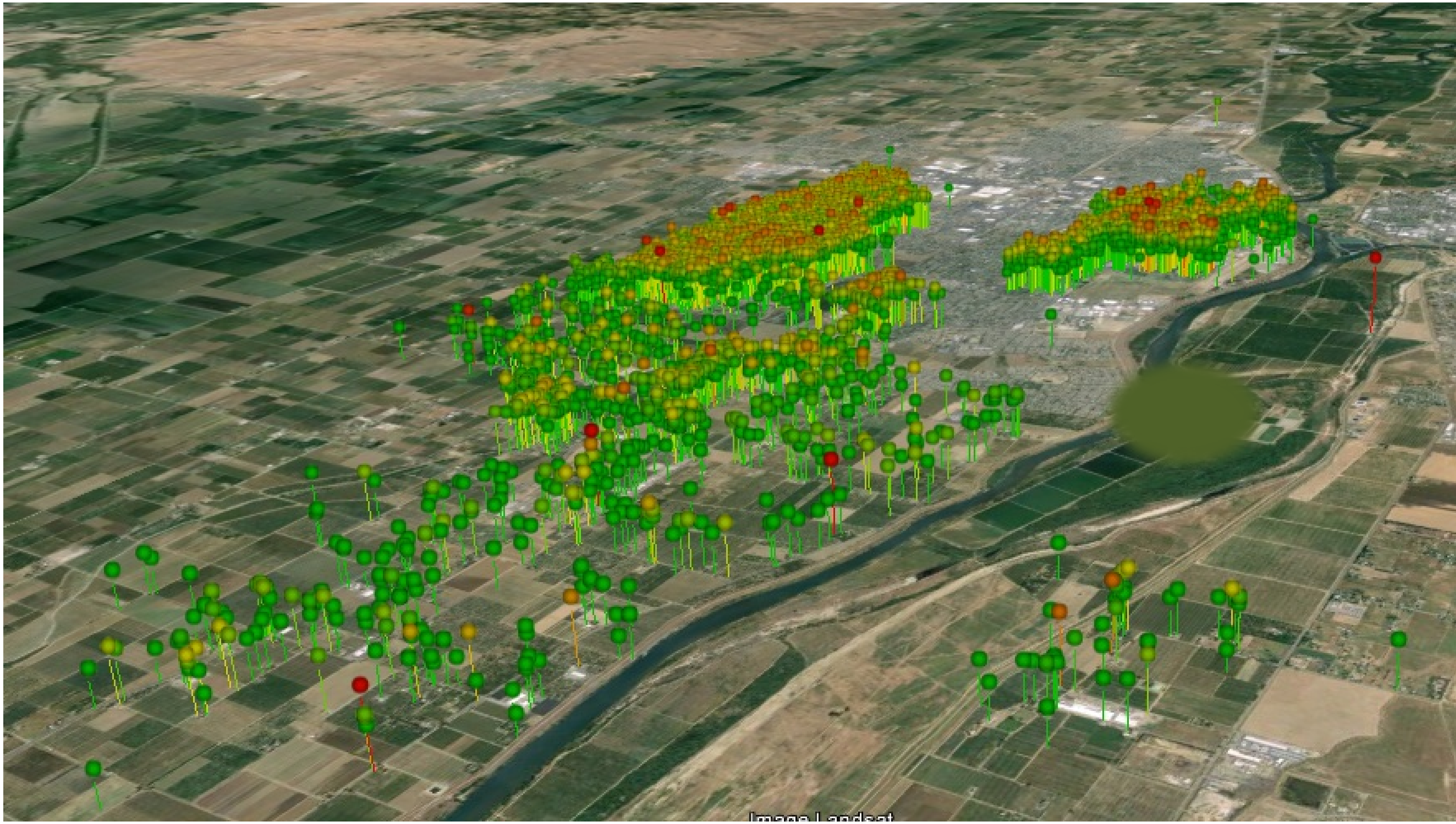
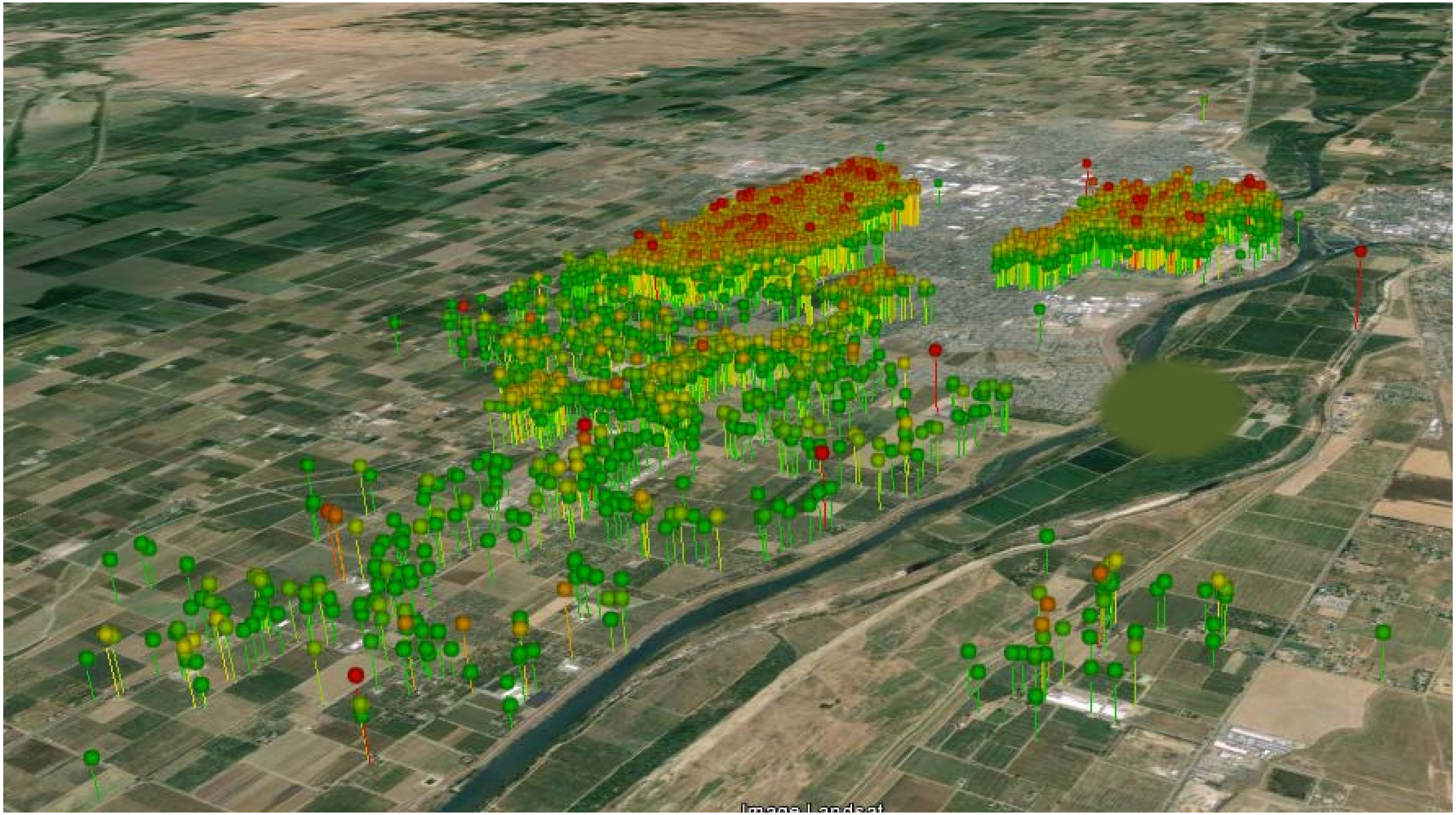
AVOIDED COSTS: SUPPLY (BANK LMP)



AVOIDED COSTS: SECONDARY LOSSES

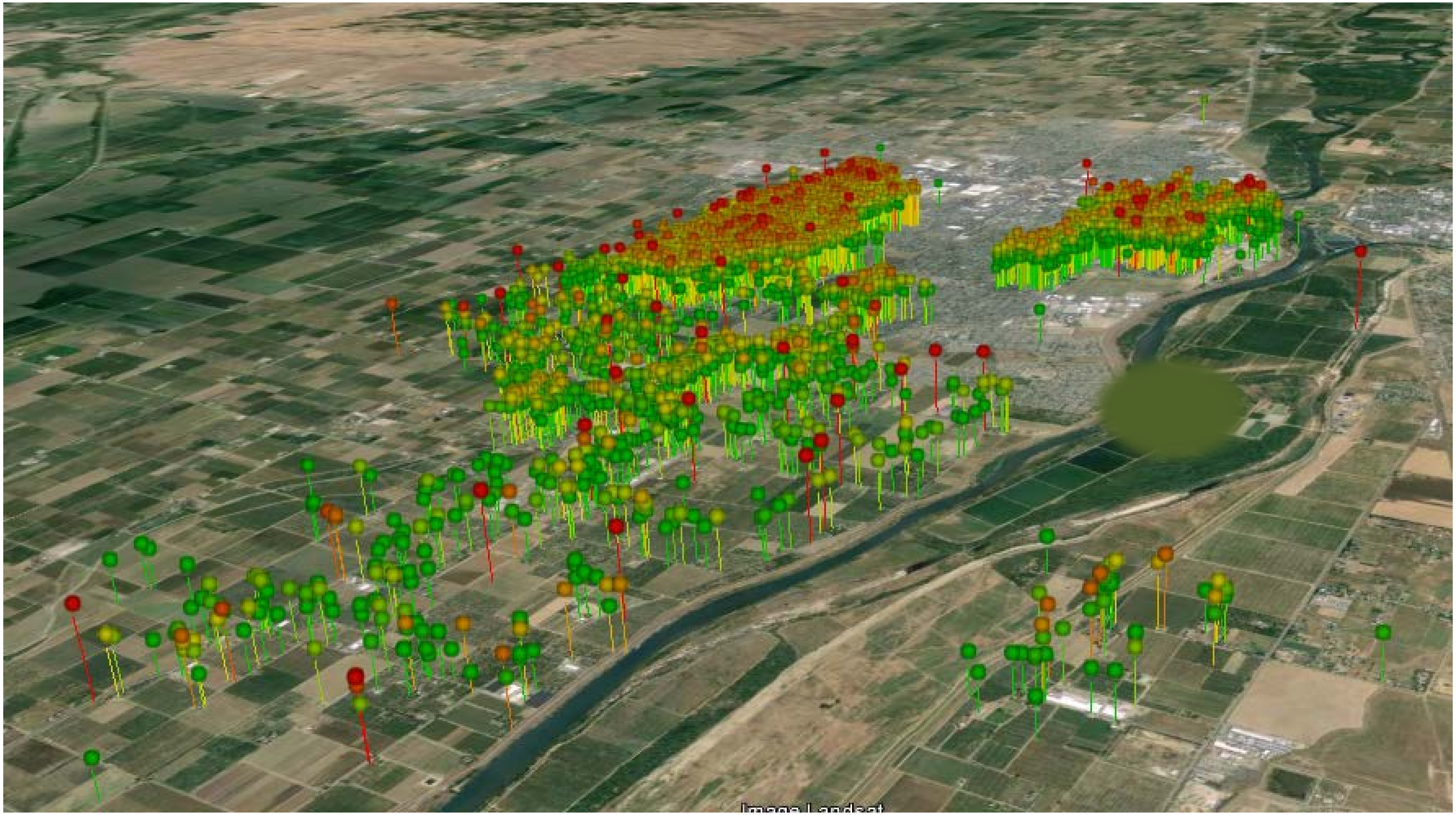


AVOIDED COSTS: PRIMARY LOSSES



INTEGRAL ANALYTICS

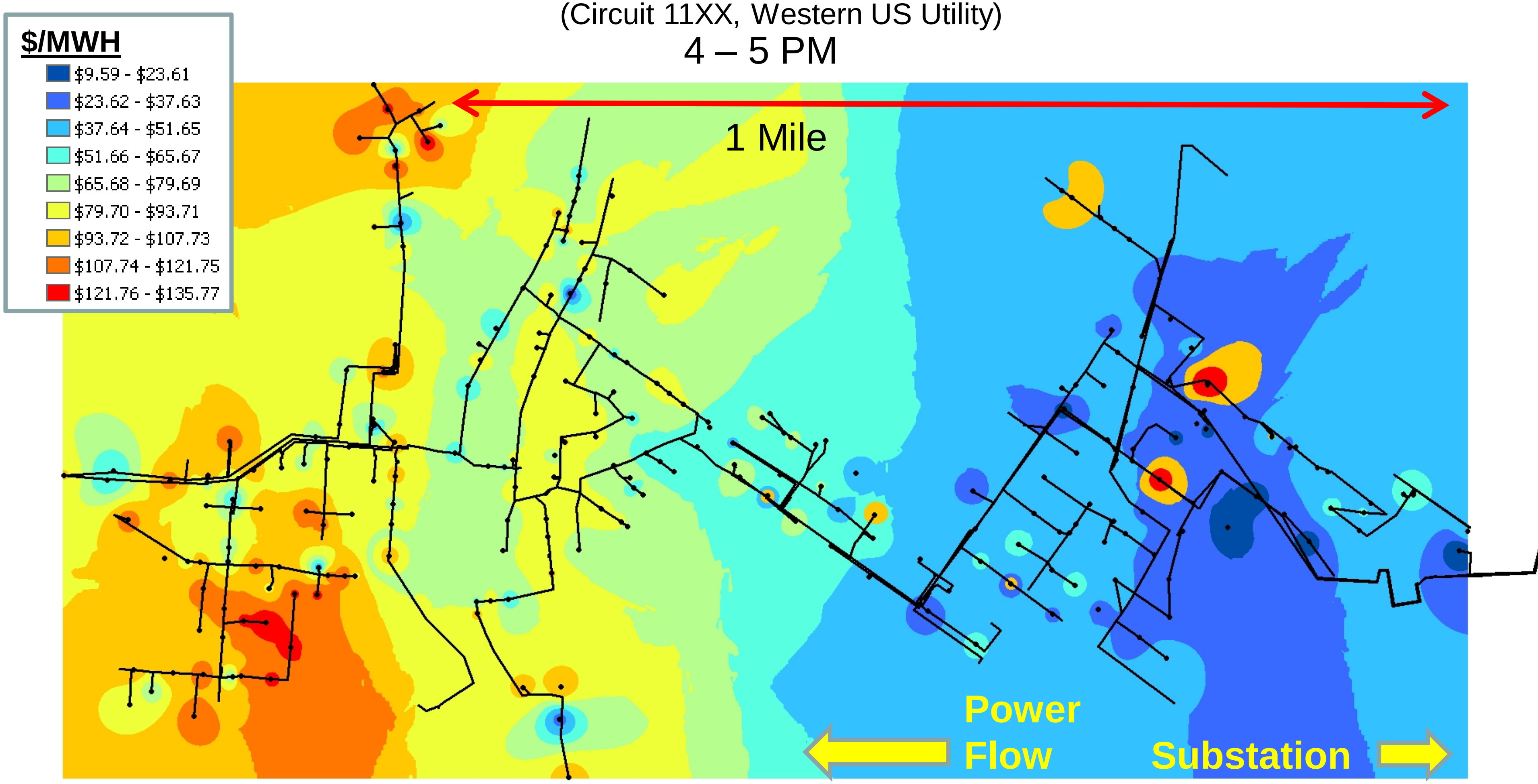
AVOIDED COSTS: TRANSFORMERS & CAPACITORS



DISTRIBUTED MARGINAL COSTS (DMC)

DMC Prices (4pm) BASE CASE

Transactive Price Signal from IDROP
(Circuit 11XX, Western US Utility)
4 – 5 PM



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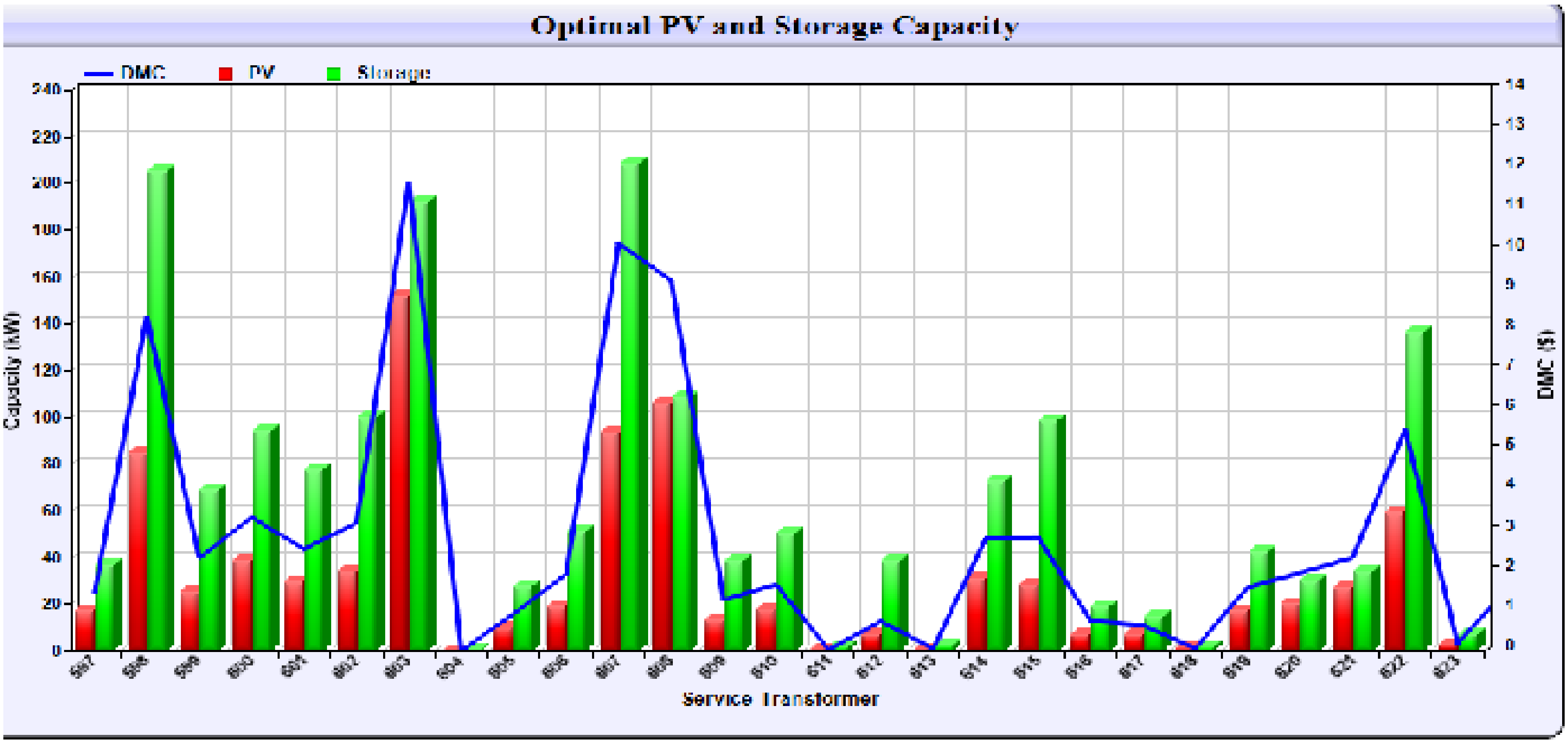
LOCATIONS CLOSELY CORRELATE TO DISTRIBUTED MARGINAL COST

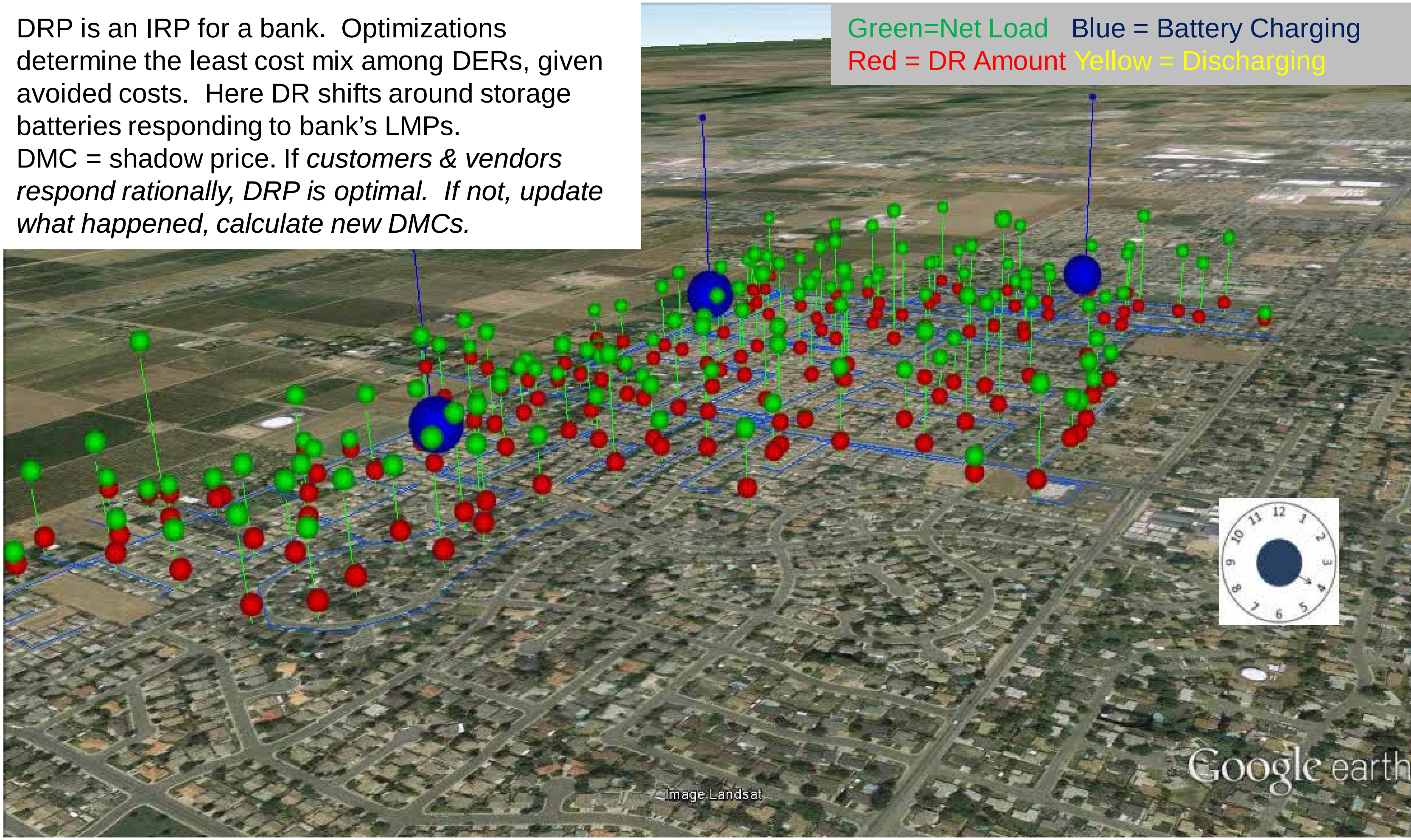
DAILY DMC ($$ COSTS AVOIDED) DRIVE LOCATION/MAGNITUDE



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

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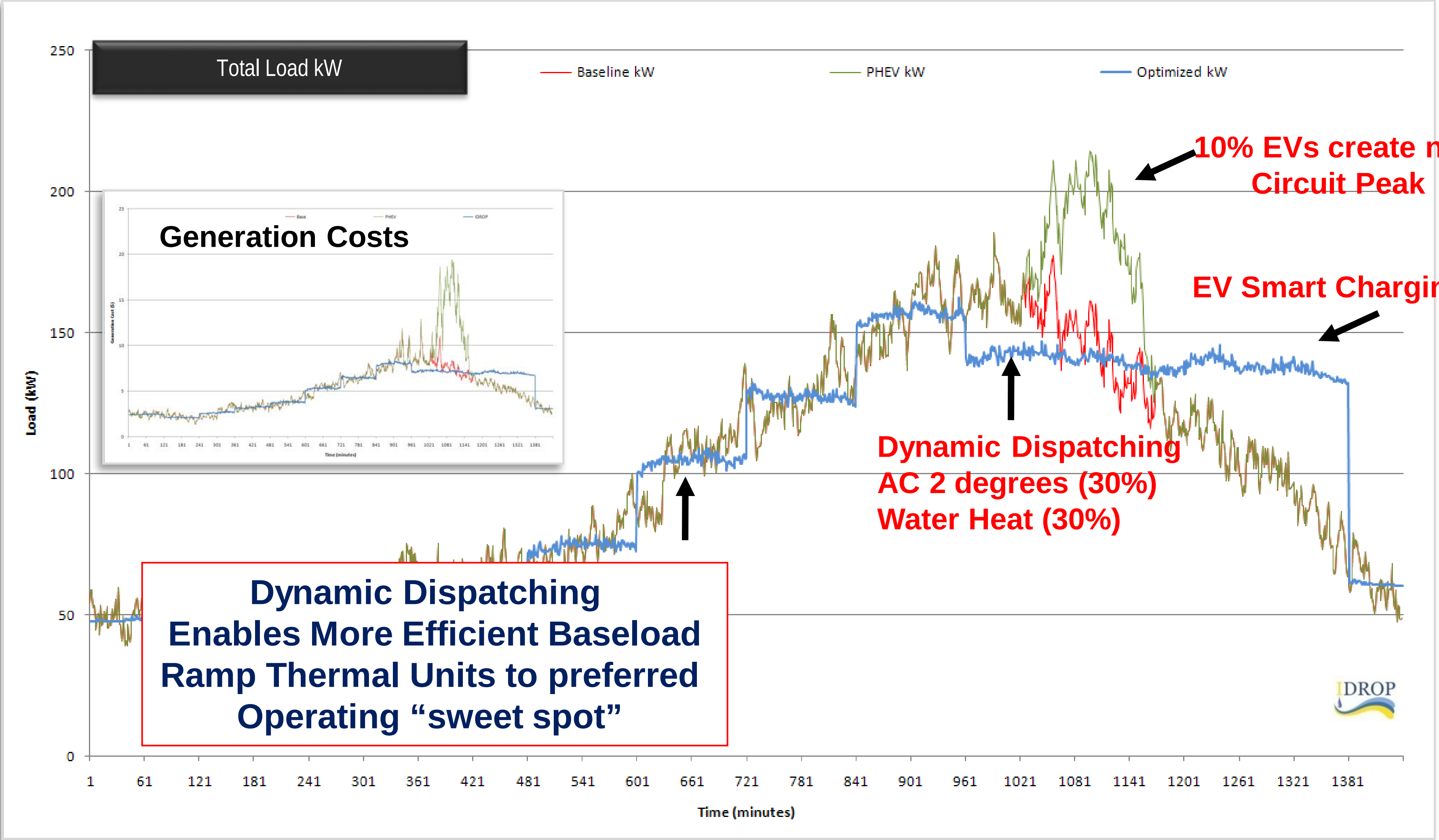
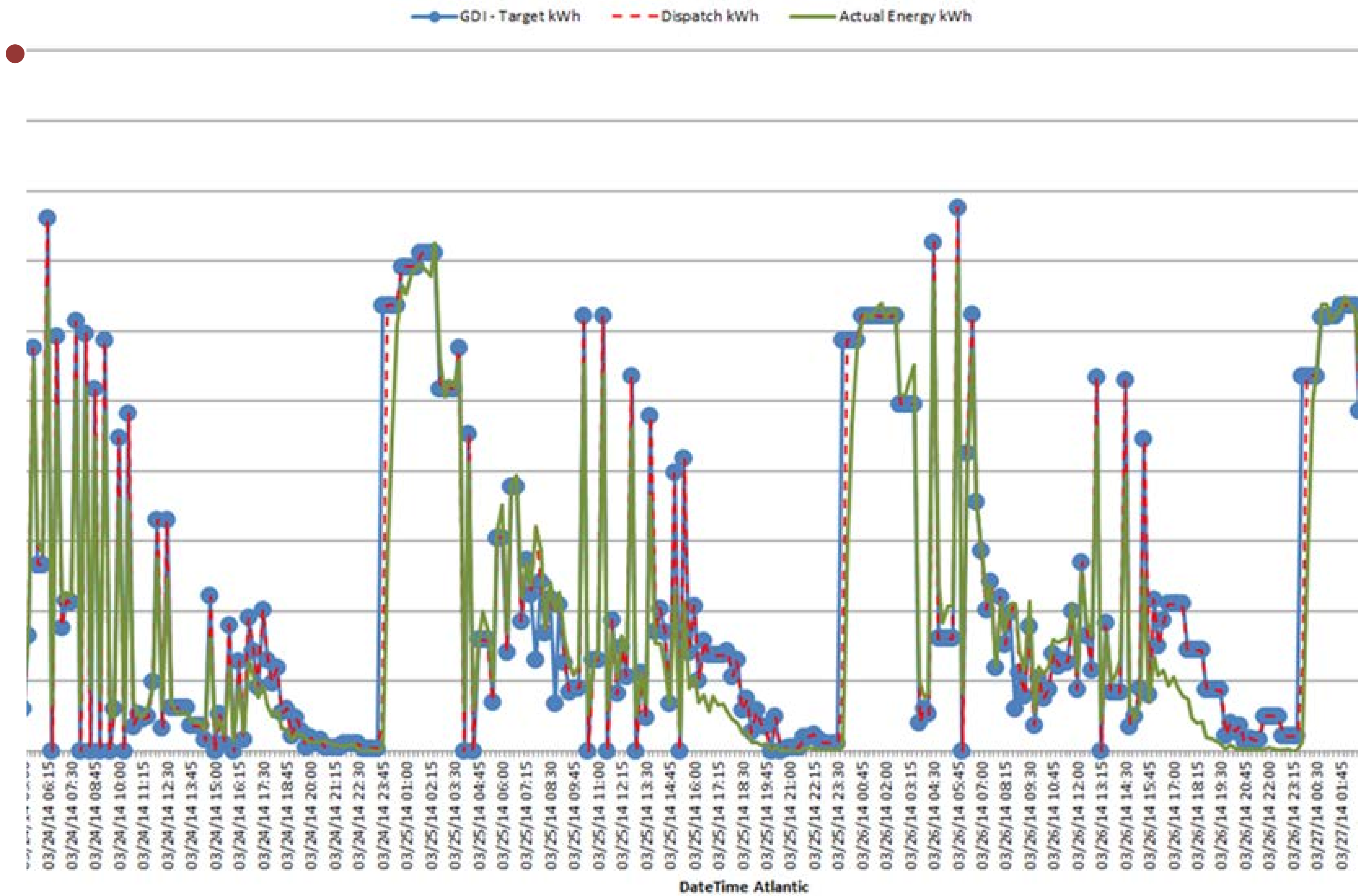
DMP LEVELS LOADS DYNAMICALLY

Instead of load following, we talk about plant following, wind following, cloud following.
Instead of demand response, IDROP enables "supply response".



INTEGRAL ANALYTICS

WIND STORAGE WITH ETS SPACE HEATERS

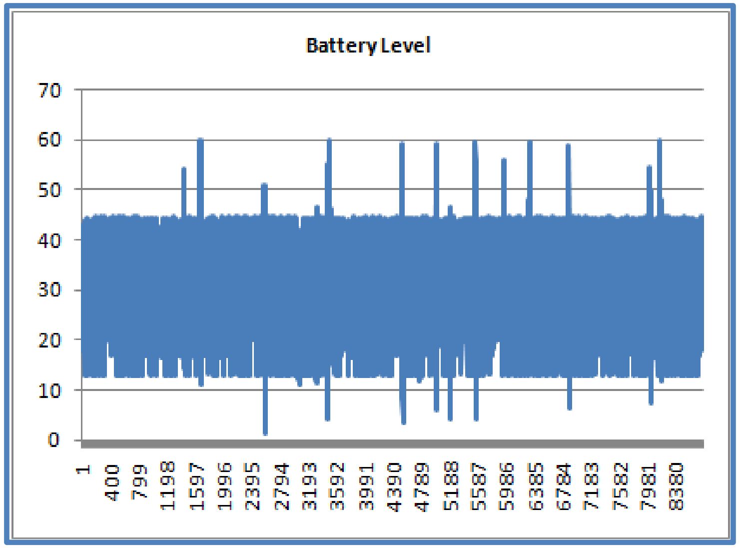


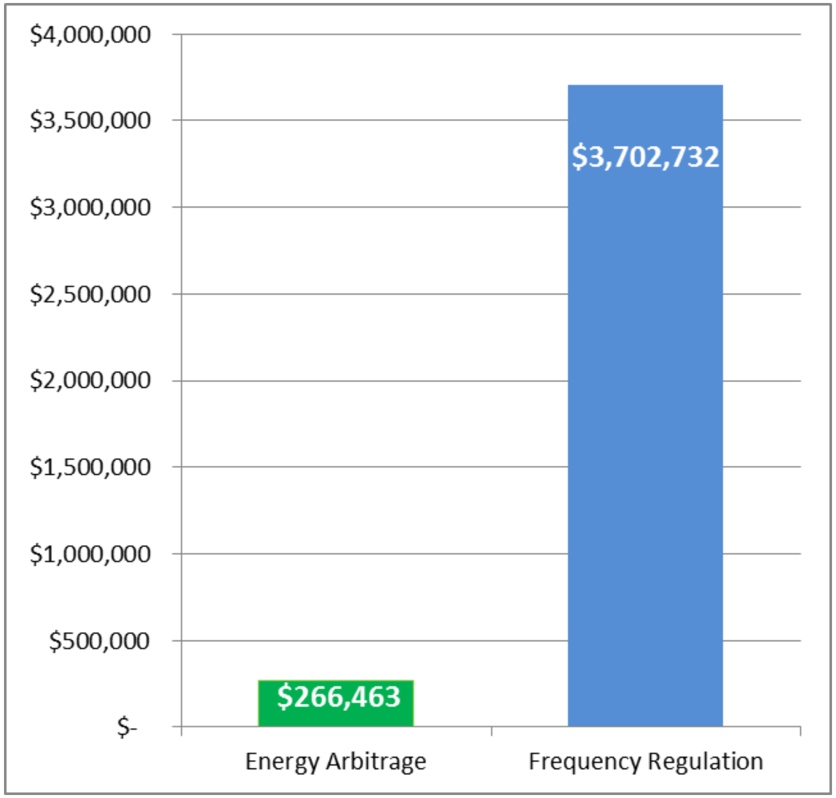
FREQUENCY REGULATION

Battery Data

Battery Size (MWh)	60
Battery Peak Power (MW)	20
Battery Cost	$ 12,000,000

	Revenue	Payback (yrs.)
Energy Arbitrage Only	$ 266,463	45.0
Energy Arbitrage & Frequency Regulation	**$3,702,732**	**3.2**



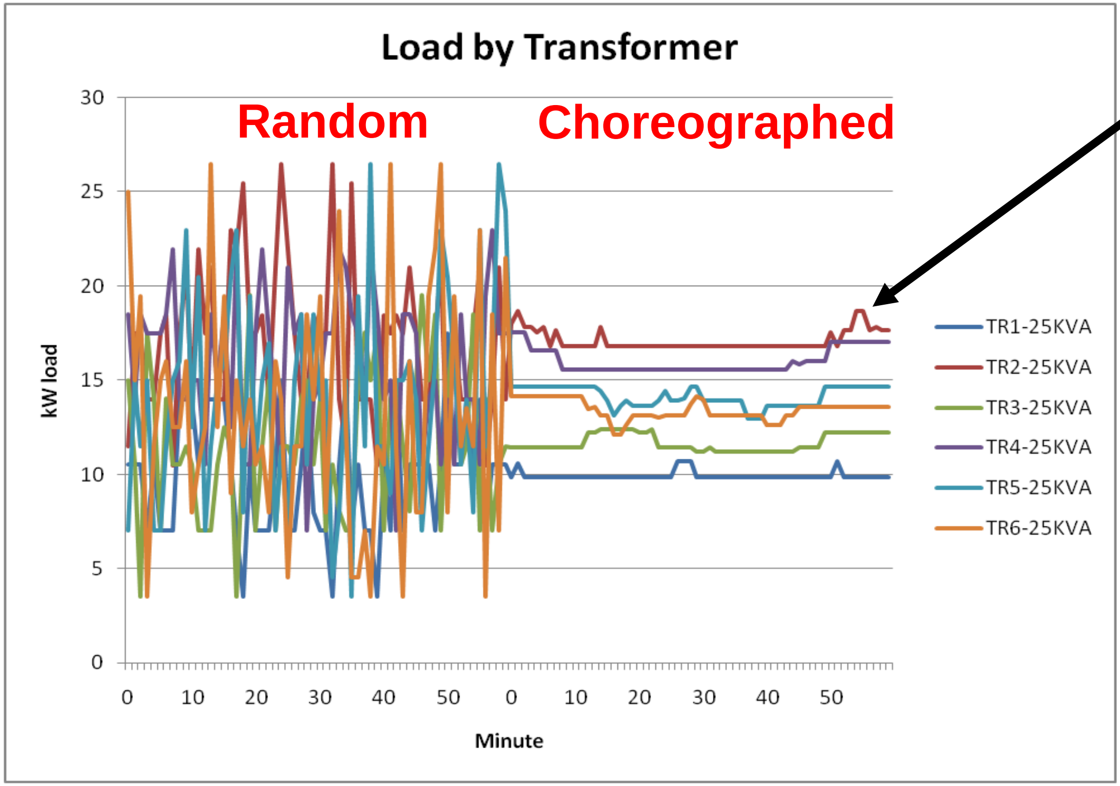


Sub-Hourly Dynamic Dispatching of Battery Saves the Battery Life Optimizes Energy Value

IA PROTECTS TRANSFORMERS

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

1. DMC = analogous to system lambda which combines Supply System + Grid Costs
2. Mathematically similar to the supply side LMP, but more holistic (as kVA, kVAh), since it has both kW and kVAR included, explicitly.
3. Grounded in a least cost planning framework, so consistent with IRP and avoids potential for gaming.
4. Defined by mathematical optimization methods analogous to the methods used for traditional IRPs, and
5. Yields a “global optimum”, which tells us that this is the best optimal mix of DER resources for this circuit, or bank of circuits.

DISTRIBUTED MARGINAL COSTS - PUC

1. Integrates with existing benefit cost analysis tools (DSMore). Cost effectiveness calculations are unchanged, but granularity increases
2. Captures full value from AMI data
3. Insures that all cost effective DERs are being pursued by location
4. Improves Distribution Planning to integrate DERs and mitigate risk
5. Assures stakeholders that the Distribution Resource Plan (DRP) for each circuit is **least** cost.

CONTACT INFORMATION

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Integral Analytics