

Control Room Visualization and Situational Awareness

IEEE PES Transmission and Distribution
Conference and Exposition

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Chicago, Illinois



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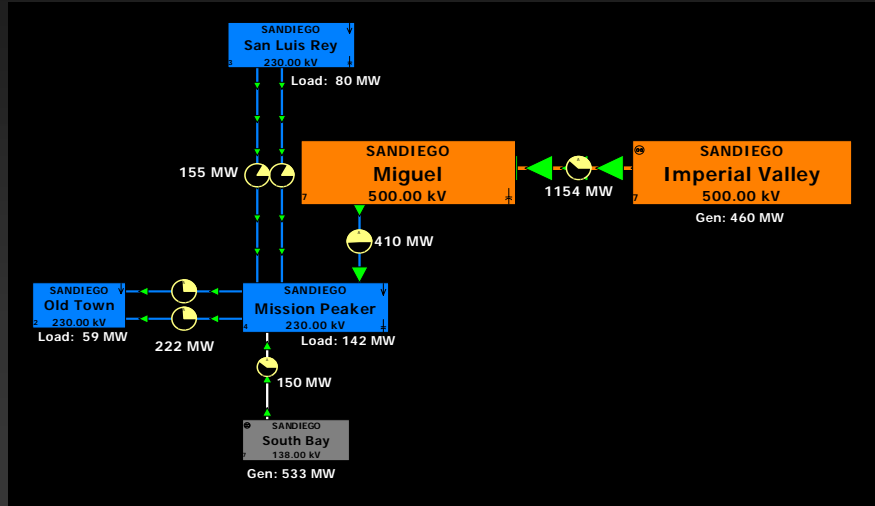


Example Visualizations

- One-line diagrams
 - Wide-area geographic views
 - Local and sub-topology views
 - Bus View and Substation View
- Animated flows
- Dynamically-sized pie charts for line and interface loading
- Color contouring for any numeric quantity such as voltage, LMP, line loading, etc.
- Dynamic formatting and emphasis
- GIS Support



Map Board-Style Substation Diagram

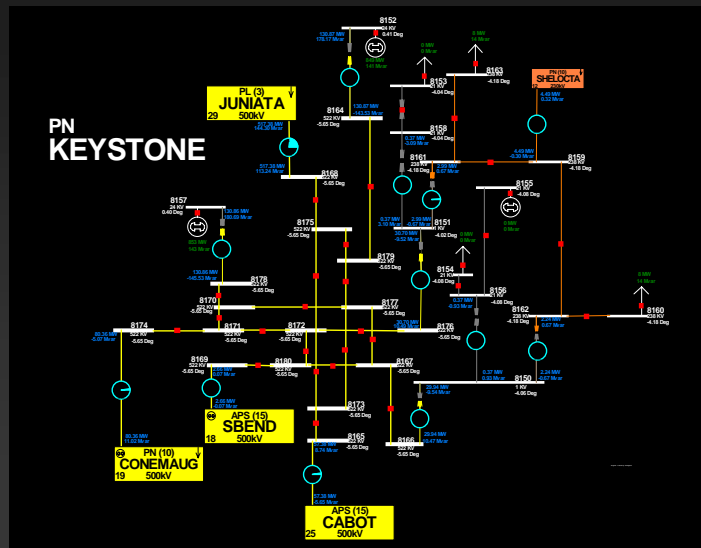


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Substation Topology

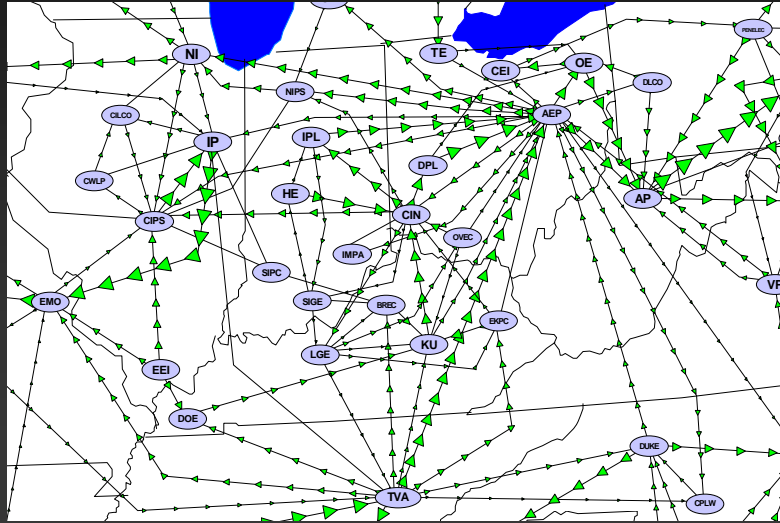


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Areas and Tie-Line Interfaces



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Tabular Displays

- “Spreadsheet-like” tables which show numeric and text information

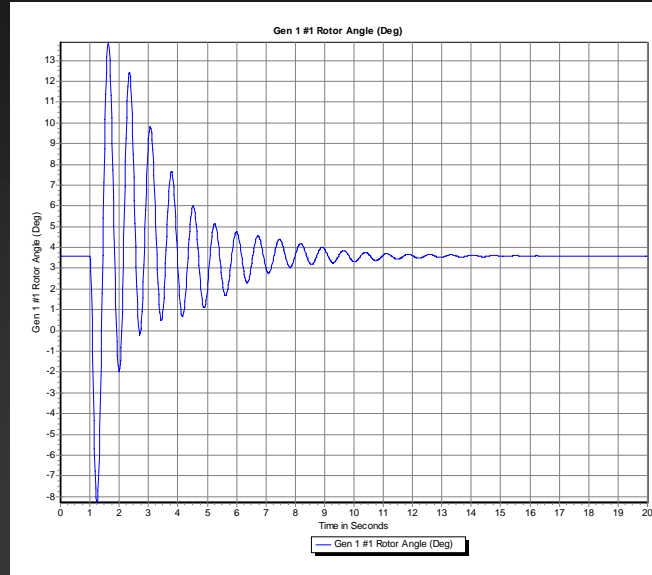
Number	Name	ID	Status	Gen MW	Gen P/W	Net Vult	AGC	AVC	Flw MW	Flw P/W	Flw P/W	Flw P/W	Cost Model	Part. Factor
1	270 BQGHUW2	1	Closed	150.00	50.56	1.03	YES	YES	0.00	160.00	112.00	54.00	Cost	1.99
2	244 WHETBY1	1	Closed	15.00	-4.71	1.03	YES	YES	0.00	15.00	-5.00	7.00	Cost	0.17
3	245 WHETBY2	2	Closed	15.00	-4.71	1.03	YES	YES	0.00	15.00	-5.00	7.00	Cost	0.17
4	247 BQGHUW1	2	Closed	150.00	50.56	1.03	YES	YES	0.00	160.00	112.00	54.00	Cost	1.99
5	251 BQGHUW3	2	Closed	150.00	30.96	1.03	YES	YES	0.00	160.00	112.00	54.00	Cost	1.99
6	253 BQGHUW4	2	Closed	90.00	10.96	1.03	YES	YES	0.00	120.00	90.00	40.00	Cost	1.40
7	332 FELLER1	1	Closed	70.00	17.05	1.04	YES	YES	18.50	88.00	-36.00	48.00	Cost	0.88
8	333 FELLER2	2	Closed	120.00	26.95	1.04	YES	YES	37.00	136.00	-40.00	73.00	Cost	1.34
9	334 FELLER3	3	Closed	190.00	46.74	1.04	YES	YES	65.00	240.00	-94.00	115.00	Cost	2.40
10	335 FELLER4	4	Closed	104.00	23.37	1.04	YES	YES	0.00	130.00	112.00	54.00	Cost	1.99
11	336 FELLER5	5	Closed	104.00	23.37	1.04	YES	YES	0.00	130.00	112.00	54.00	Cost	1.99
12	344 FROSHOP	1	Closed	12.00	1.81	1.01	YES	YES	0.00	12.00	-5.00	6.00	Cost	0.11
13	345 FROSHOP2	2	Closed	12.00	1.81	1.01	YES	YES	0.00	12.00	-5.00	6.00	Cost	0.11
14	346 TENASKA	1	Closed	172.00	41.49	1.02	YES	YES	20.00	200.00	84.00	100.00	Cost	2.00
15	347 TENASKA2	2	Closed	86.00	20.62	1.02	YES	YES	20.00	114.00	-70.00	68.00	Cost	1.16
16	503 WTEKAS1	1	Closed	15.00	5.00	1.01	YES	YES	5.00	18.00	-2.90	5.00	Cost	0.22
17	504 WTEKAS2	2	Closed	15.00	5.00	1.01	YES	YES	5.00	18.00	-2.90	5.00	Cost	0.22
18	505 WTEKAS3	3	Closed	35.00	7.82	1.01	YES	YES	15.00	40.00	-16.00	15.00	Cost	0.44
19	719 WTEC 12G	1	Closed	20.00	7.07	1.01	YES	YES	12.00	20.00	-8.00	15.00	Cost	0.25
20	719 WTEC 12G	2	Closed	20.00	7.07	1.01	YES	YES	12.00	20.00	-8.00	15.00	Cost	0.25
21	720 WTEC 34G	3	Closed	20.00	7.07	1.01	YES	YES	12.00	20.00	-8.00	15.00	Cost	0.25
22	720 WTEC 34G	4	Closed	20.00	7.07	1.01	YES	YES	12.00	20.00	-8.00	15.00	Cost	0.25
23	798 TAMINGR1	1	Closed	20.00	15.00	1.00	YES	YES	5.00	24.00	-5.00	15.00	Cost	0.60
24	817 WESTHANS	1	Open	0.00	0.00	1.01	YES	YES	15.00	40.00	0.00	17.00	Cost	0.44
25	818 WESTHANS2	1	Open	0.00	0.00	1.01	YES	YES	0.00	17.00	0.00	8.00	Cost	0.16
26	819 WESTHANS3	1	Open	0.00	0.00	1.01	YES	YES	0.00	17.00	0.00	8.00	Cost	0.16
27	820 WESTHANS4	1	Open	0.00	0.00	1.01	YES	YES	3.00	8.00	-2.00	4.00	Cost	0.08
28	821 WESTHANS5	1	Open	0.00	0.00	1.01	YES	YES	3.00	8.00	-2.00	4.00	Cost	0.08
29	842 OLSINGR1	1	Closed	70.00	23.21	1.03	YES	YES	20.00	80.00	0.00	40.00	Cost	0.88
30	843 OLSINGR2	1	Closed	102.79	44.63	1.03	YES	YES	25.00	110.00	8.00	55.00	Cost	1.34
31	844 OLSINGR3	1	Closed	140.00	64.82	1.03	YES	YES	40.00	150.00	0.00	75.00	Cost	1.74
32	845 OLSINGR4	2	Open	0.00	0.00	1.01	YES	YES	0.00	75.00	0.00	55.00	Cost	1.13
33	886 ATKINS1	1	Closed	12.00	1.00	1.00	YES	YES	5.00	12.00	1.00	10.00	Cost	0.51
34	887 ATKINS2	1	Closed	50.00	10.20	1.03	YES	YES	13.00	20.00	0.00	20.00	Cost	0.64
35	888 ATKINS3	1	Closed	5.50	2.08	1.03	YES	YES	4.00	20.00	1.00	10.00	Cost	0.30
36	890 ATKINS4	1	Closed	23.00	2.11	1.03	YES	YES	5.00	23.00	1.00	10.00	Cost	0.23
37	891 ATKINS5	1	Closed	25.00	2.37	1.03	YES	YES	5.00	25.00	1.00	10.00	Cost	0.29
38	892 DAMBRY14	1	Closed	100.00	24.20	1.03	YES	YES	25.00	114.00	5.00	40.00	Cost	1.25
39	920 SPURCR1	1	Closed	12.00	2.84	1.03	YES	YES	4.00	12.00	0.00	6.00	Cost	0.14
40	921 SPURCR2	1	Closed	12.00	3.44	1.03	YES	YES	4.00	12.00	0.00	6.00	Cost	0.14

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Transient Stability Plot

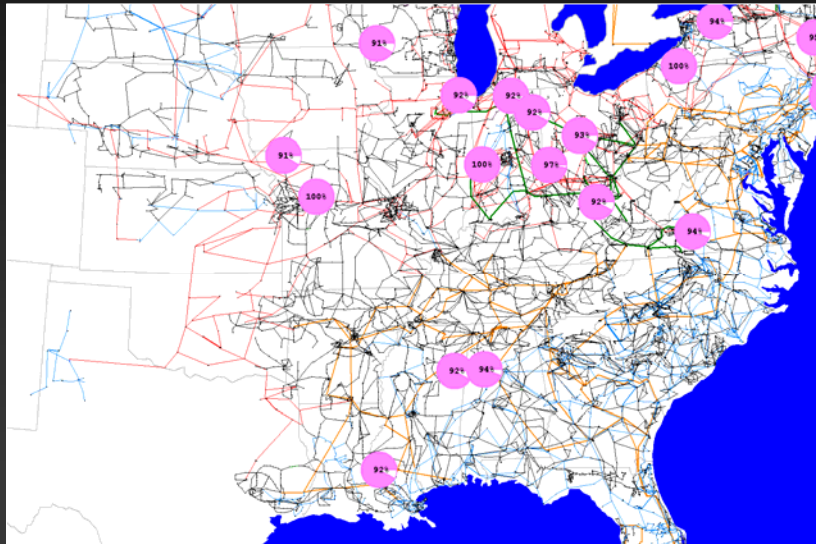


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Dynamic Formatting of Objects

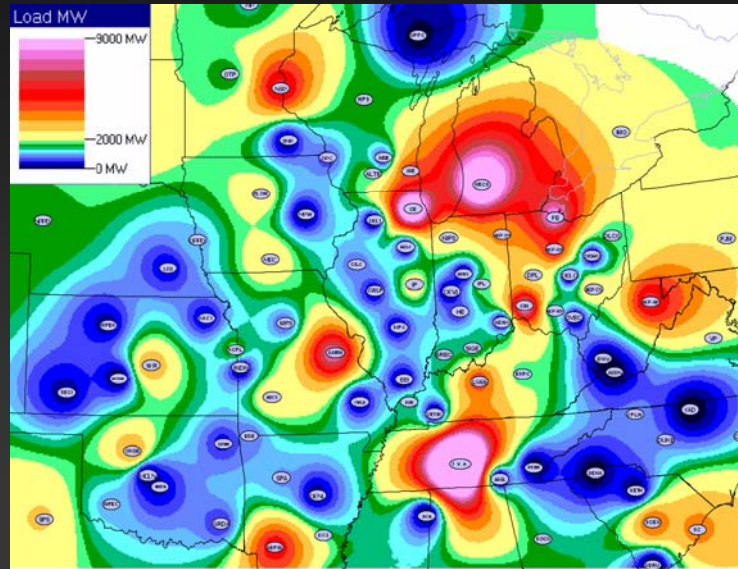


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Area Diagram with Load Contour

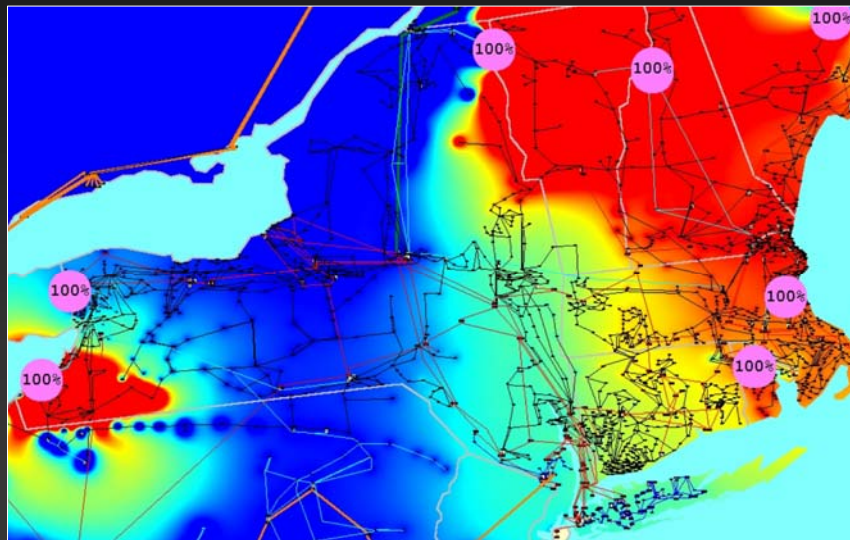


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Price Contour with Constraints

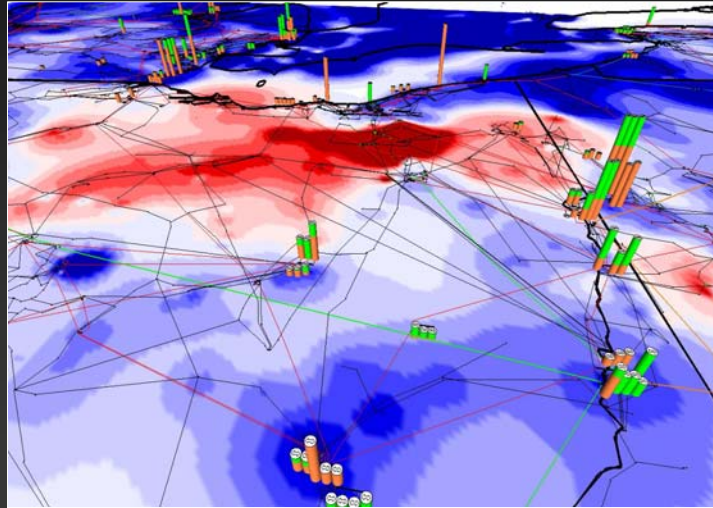
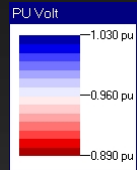


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Contouring with 3D Columns: Reactive Reserves

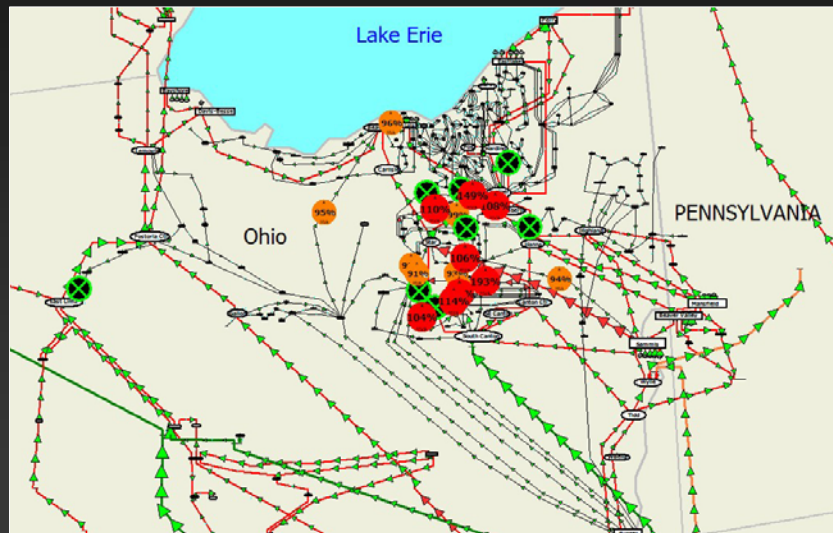


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Line Flows: Without Emphasis Filter

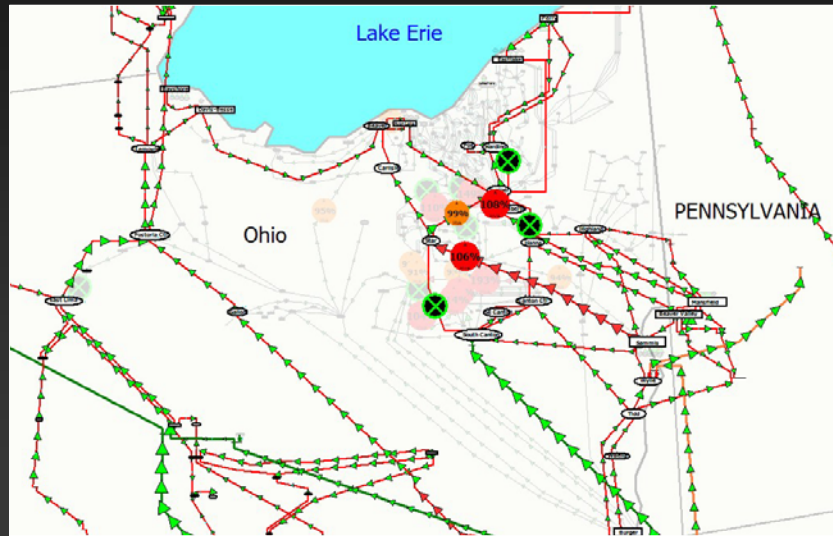


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Line Flows: Emphasis Filter on High Voltage System

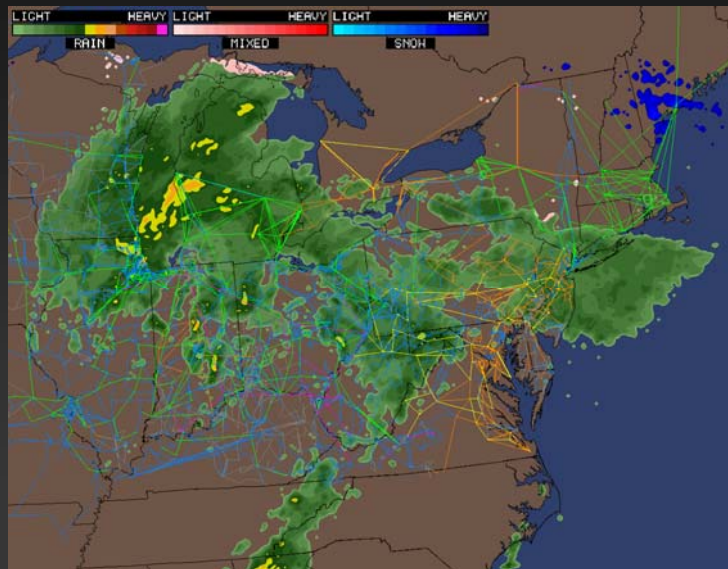


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GIS Objects

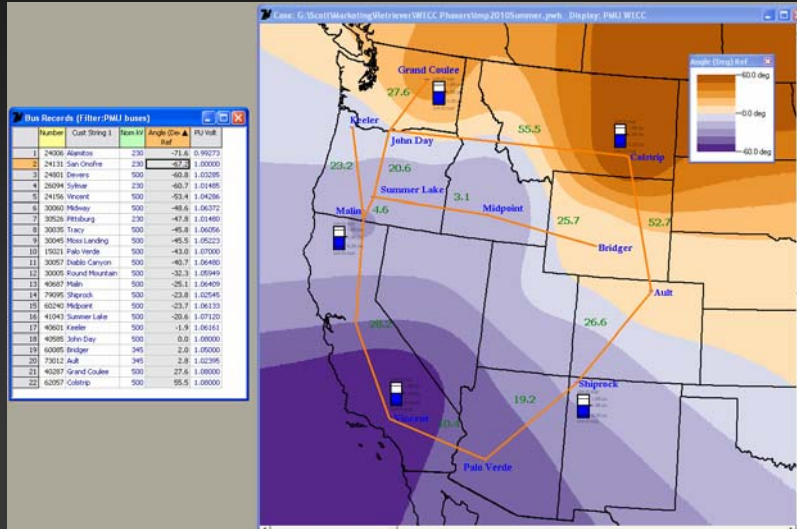


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Phasors: Text, Contour, and Gauges



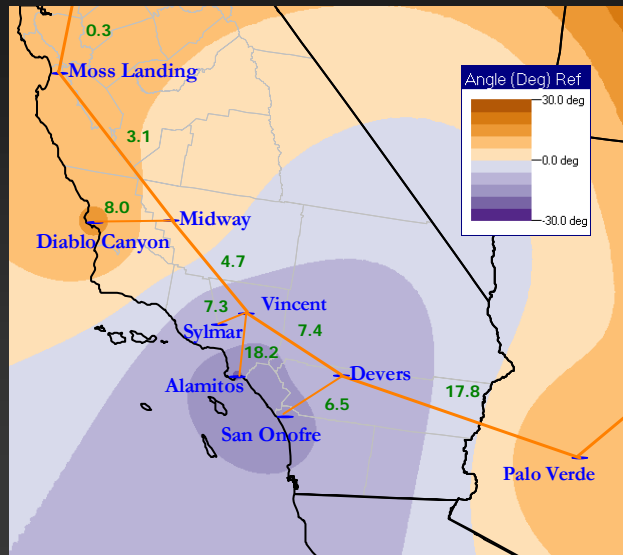
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Phasors: Southern California Detail

- Vincent as Angle Reference



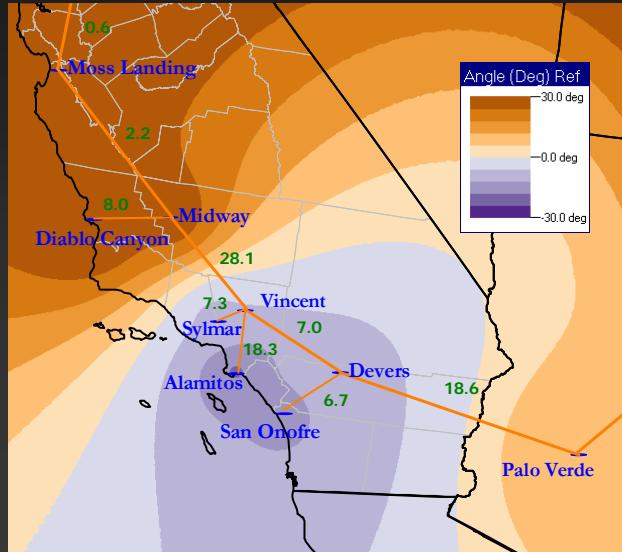
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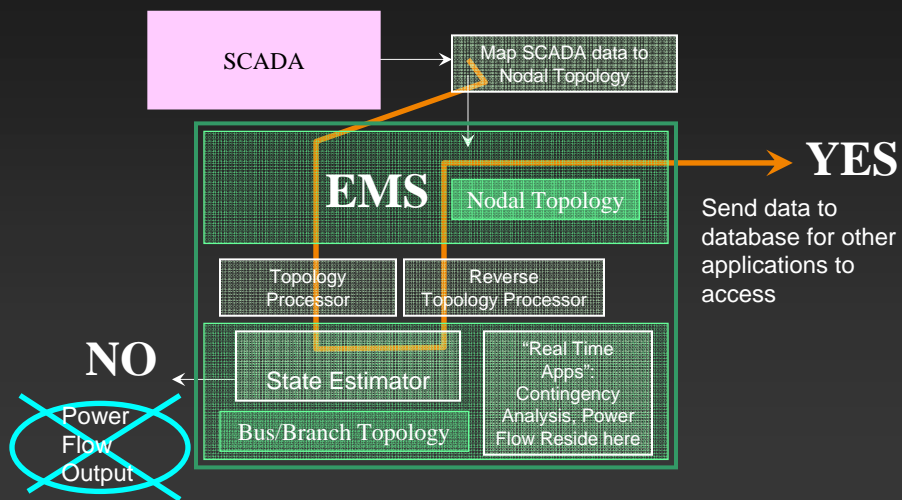


Phasors: Under Contingency

- Loss of Midway-Vincent 500 kV

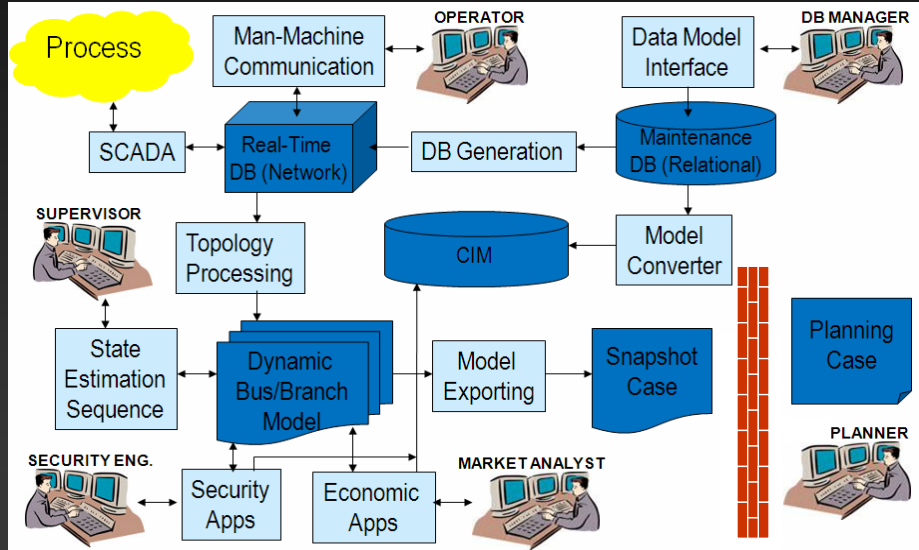


Where should data come from?





Existing Architecture



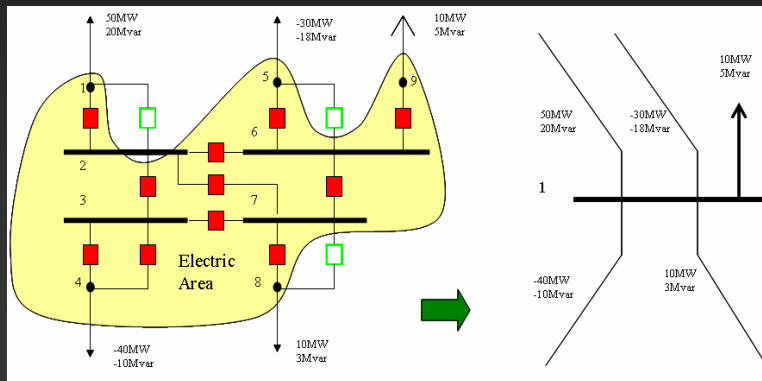
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Real-Time and Planning Models

- Real-Time Model
 - Node/breaker
 - Full topology
- Planning Model
 - bus/branch
 - Consolidated

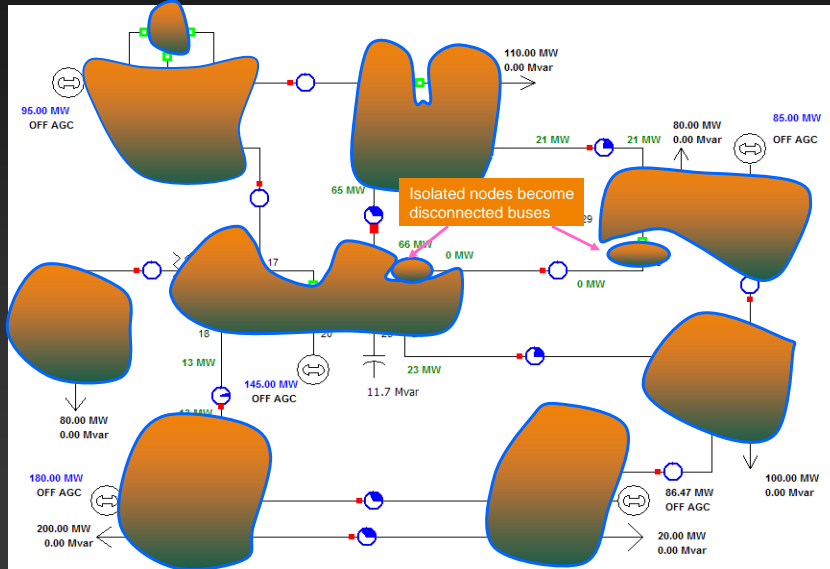


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Node Groups in a 52-Node Case

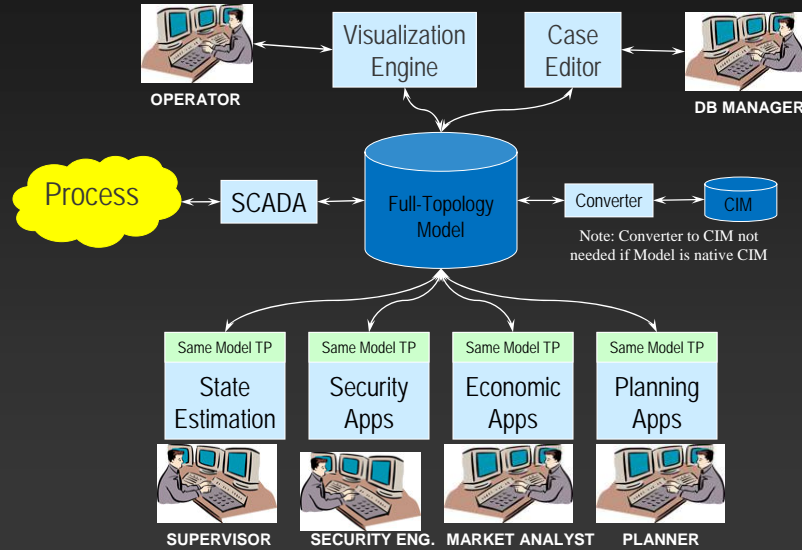


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The Same-Model Proposal



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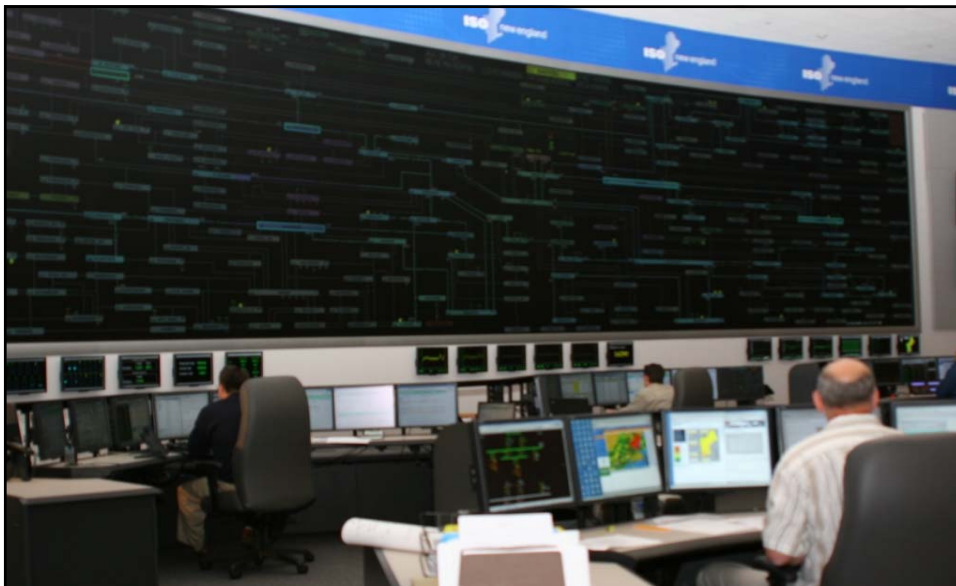
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TVA Control Room



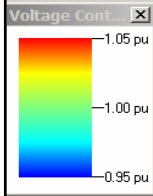
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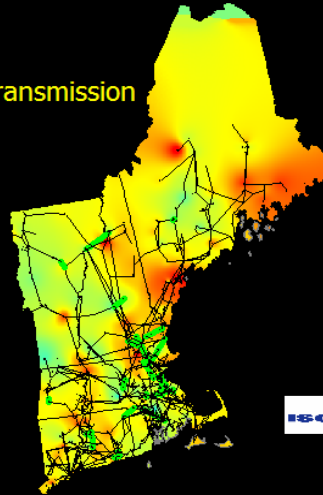
Wallboard: 9*3 array, 12 feet tall, 48 feet wide

Voltage Contour

Courtesy: ISO New England Inc.



Voltage Contour with Transmission

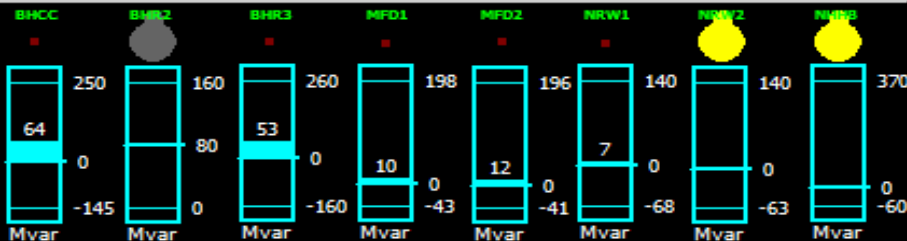
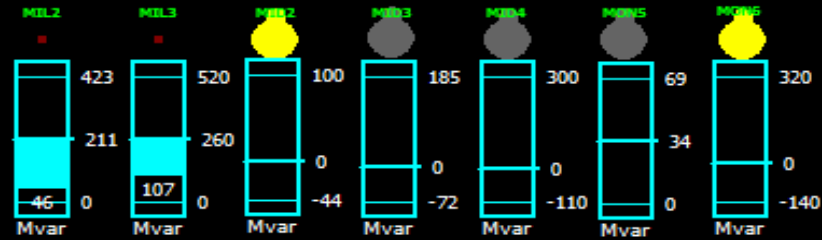


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Mvar Reserve Gauge

Courtesy: ISO New England Inc.

CT



SW-CT



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Summary

- Visualization is an increasingly important part of power system operations
- The amount of data that system operators must process will only increase
- Modern technology should be used in ways that assist operators in making decisions
- Flexibility in data and display format
- Ability to communicate complex data and trends quickly, in a manner that is easily understood