



**FERC Technical Conference
Increasing Real-Time and Day-Ahead Market Efficiency
through Improved Software**

Smart Wire Grid Inc.



Power flow control for the Grid



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Power flow control for the Grid

How do we get to Market Efficiency? Hardware or Software?

- Most software is being developed with existing hardware in mind
- Even with the best software we can only get so far
- We need integrated dynamic and adaptive control & management systems with advanced, intelligent hardware and adaptable, expandable software



We should Think Technology: integrated hardware & software

- Dynamic, fine grained controllability of power flows
- Networked, cyber secure, software enabled, reliability management systems
- Distributed, cost effective, flexible, fast to produce & deploy

Results

- Superior economics for Transmission Owners/Utilities
- Utilities/ISOs avoid high-cost generation
- Reduced cost for end-customers



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Changes line impedance to redirect electricity away from congested lines towards underutilized lines

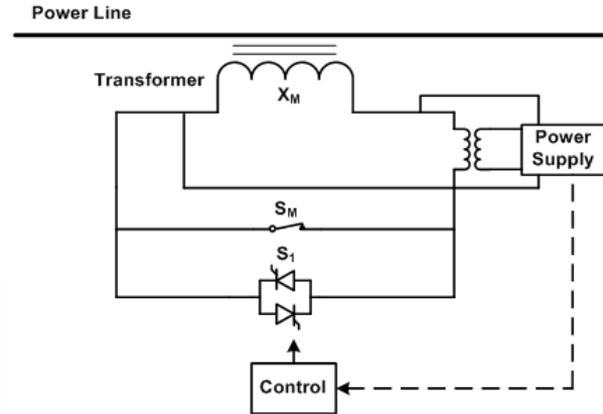
- Increases transmission system capacity by 10-30%
- Installed along transmission lines; no substation work
- Enhances reliability and resiliency of the system

True technology solution

- Networked hardware and open, adaptive software
- Dynamic control for complex flow problems
- Intelligent self organizing capability

Rapid Deployment

- Easy installation 7 minutes per DSR
- Install on live lines - no outage required
- Minimal planning - no permitting required



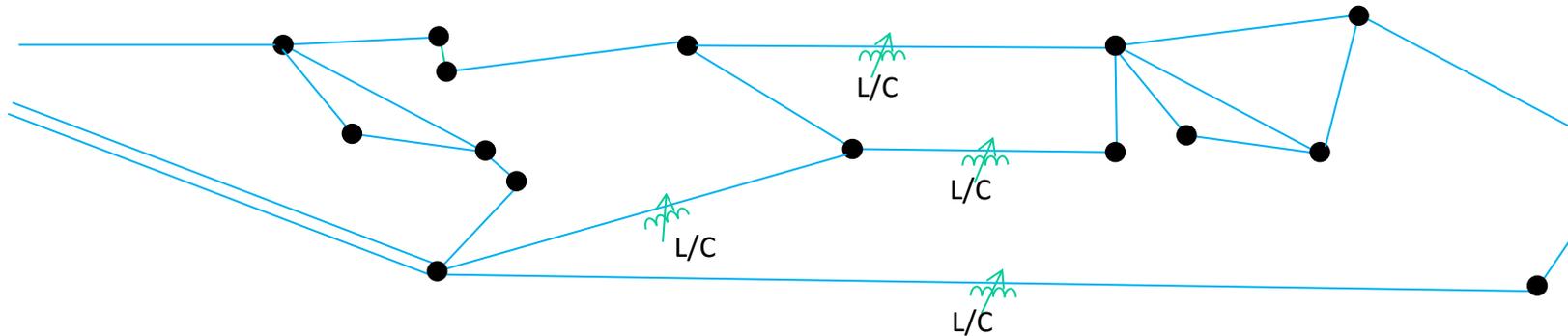
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Hardware Enables Sophisticated Software Solutions

Flexibility is the Key to Market Efficiency

Future market requirements are uncertain – flexible flow control increases adaptability



Target Applications:

1. **Reliability**
2. **Congestion Relief**
3. **Market Efficiency**
4. **Intelligent Networks**

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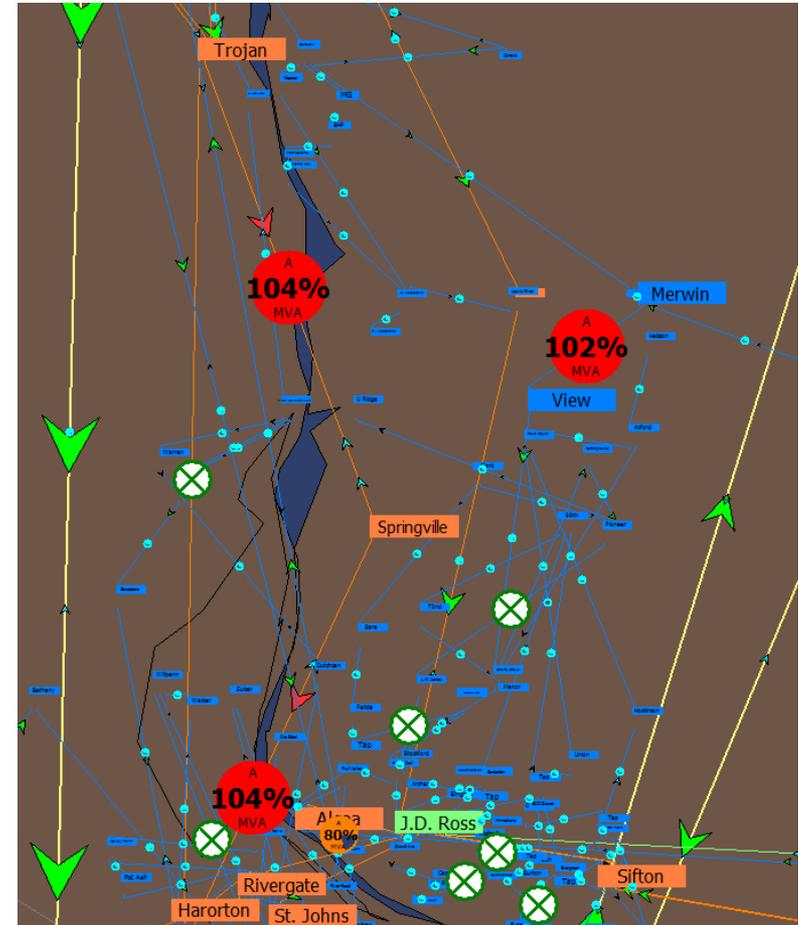
Reliability Applications: N-1

- Based on 2013 Heavy Summer
- Outage of Trojan - Haroton results in 3 thermal overloads:

Facility	Voltage (kV)	Overload (%)
Trojan - Springville	230 kV	104
St. Mary's - Springville	230 kV	104
View Tap - Merwin	115 kV	102

- Conventional solution:

Facility	Action	Est. Cost (\$M)
Trojan - Springville	Recon	18.8
St. Mary's - Springville	Recon	2.0
View Tap - Merwin	Recon	2.1
TOTAL		22.9

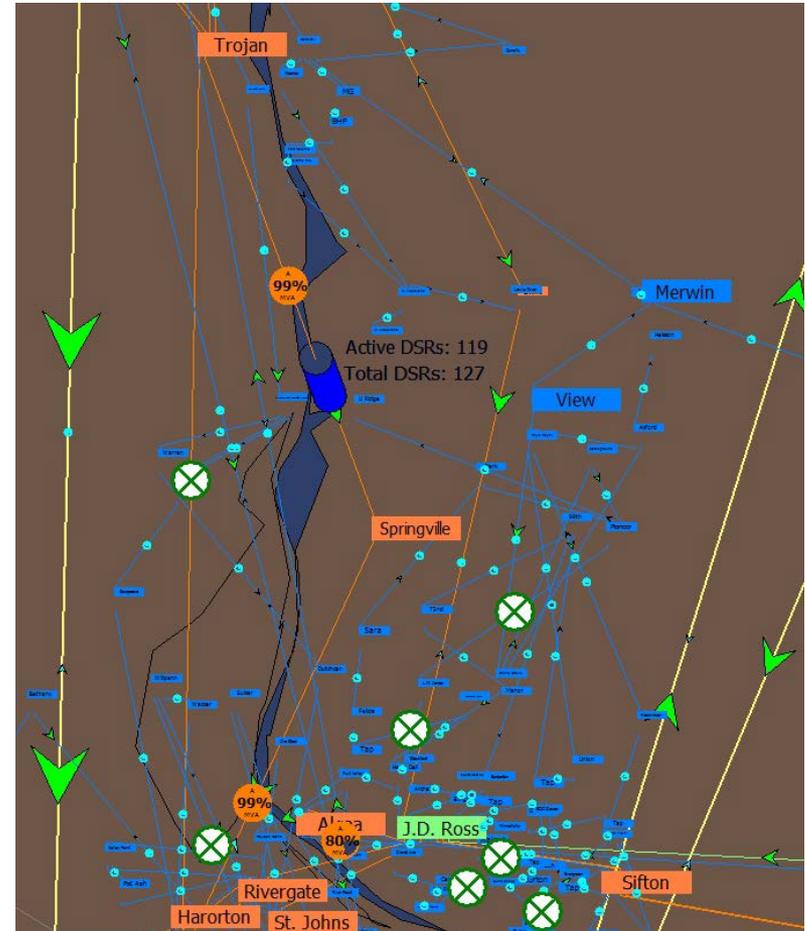


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- Alternative solution combines reconductoring with DSRs:

Facility	Action	Est. Cost (\$M)
Trojan - Springville	DSRs	3.9
View Tap - Merwin	Recon	2.1
TOTAL		6.0

- Result
 - Estimated \$16.9 M in savings relative to conventional solution
 - 42 circuit-miles of avoided reconductoring
 - Capital freed up for strategic projects
 - Outage windows reduced
 - Solution completed in shorter time span

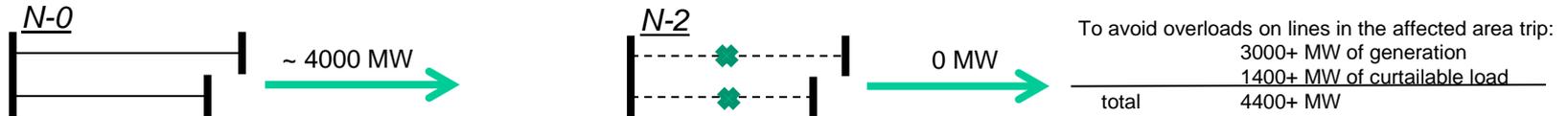


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Reliability Applications: RAS/SPS Simplification

DSRs contribution to Remedial Action Scheme (RAS)

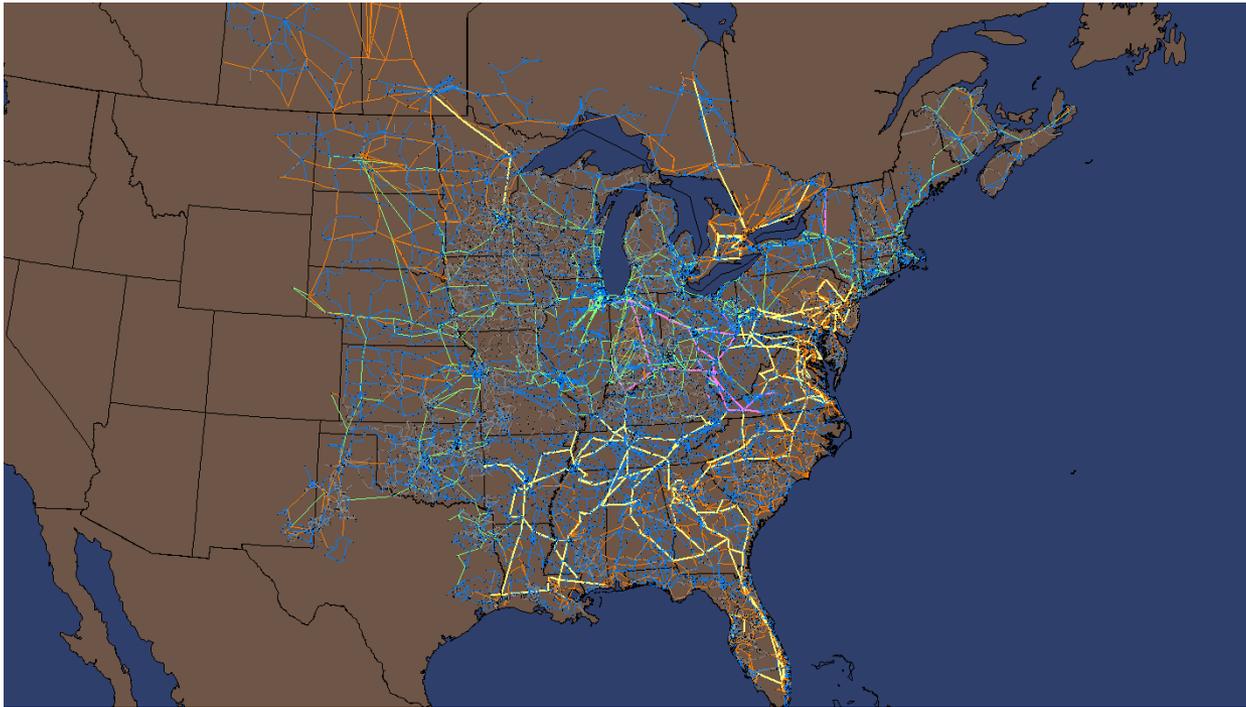


Scenario (DSR and ckt count are cumulative)	Generation Not tripped (MW)	Curtailable Load Not tripped (MW)	Total Capacity Preserved (MW)	Non-interrelated overloads (%)
1 – 111 DSRs 1 circuit	671	0	671	<u>1.2</u> Total 1.2
2 – 651 DSRs 3 ckts	671	530	1201	6.4 <u>0.6</u> Total 7.0
3 – 1341 DSRs 5 ckts	671	871	1542	9.9 <u>3.4</u> Total 14.5
4 – 2013 DSRs 9 ckts	671	1039	1710	0.6 11.4 9.9 <u>4.6</u> Total 26.5

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Congestion - OPF

- Exercise:** 2012 summer peak planning case
- Focus:** East coast RTO area with total of 3000 modules placed on 6 lines
- OPF Solution:** 1.4% reduction in Final Total Cost Value
6.1% reduction in Average Bus Marginal Cost

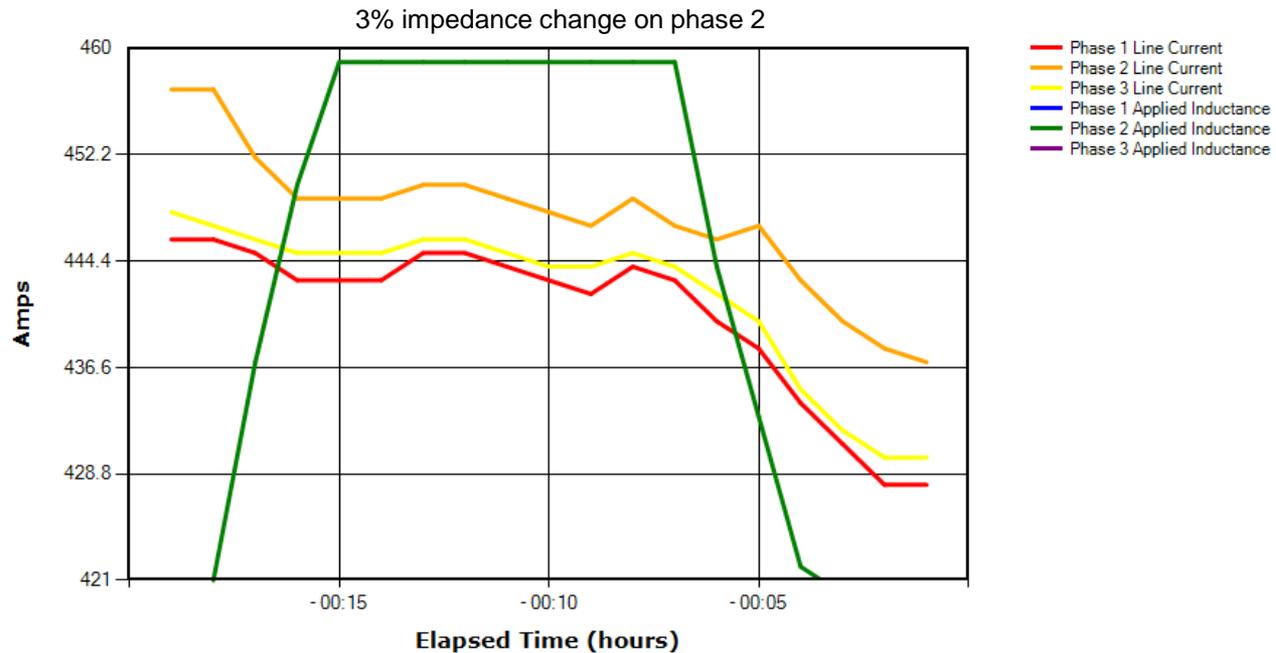


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Market Efficiency – Phase Balancing

Hardware & software combine to balance phase loading –
increasing capacity; reducing losses; reducing equipment damage



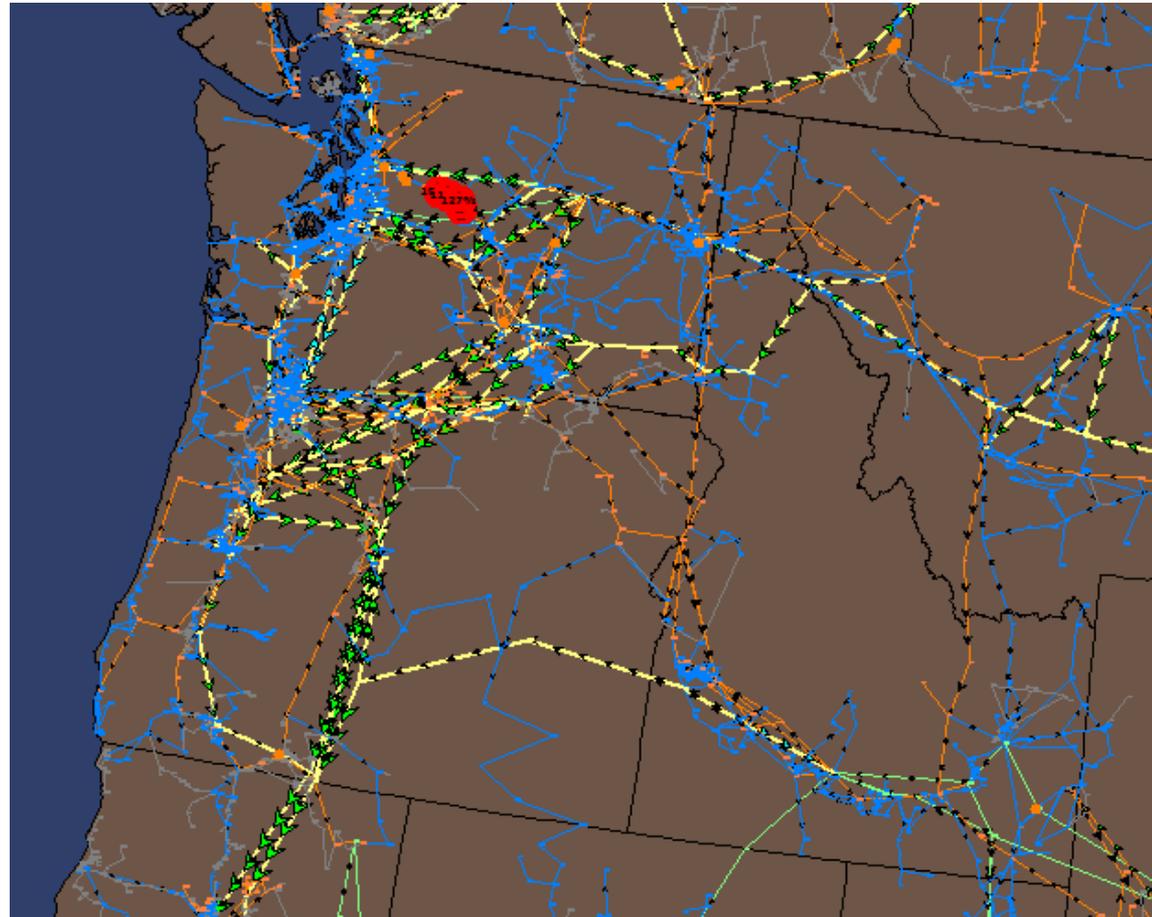
What is the accuracy of State Estimation with an unbalanced system?

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Market Efficiency – Beyond Congestion

- WECC 2014 Heavy Spring case
 - 0 MW wind generation
 - Base case has N-0 overloads
 - Base case export schedule:

Receiving Area	Export (MW)
PG&E	4880
BC Hydro	1000
Sierra	94



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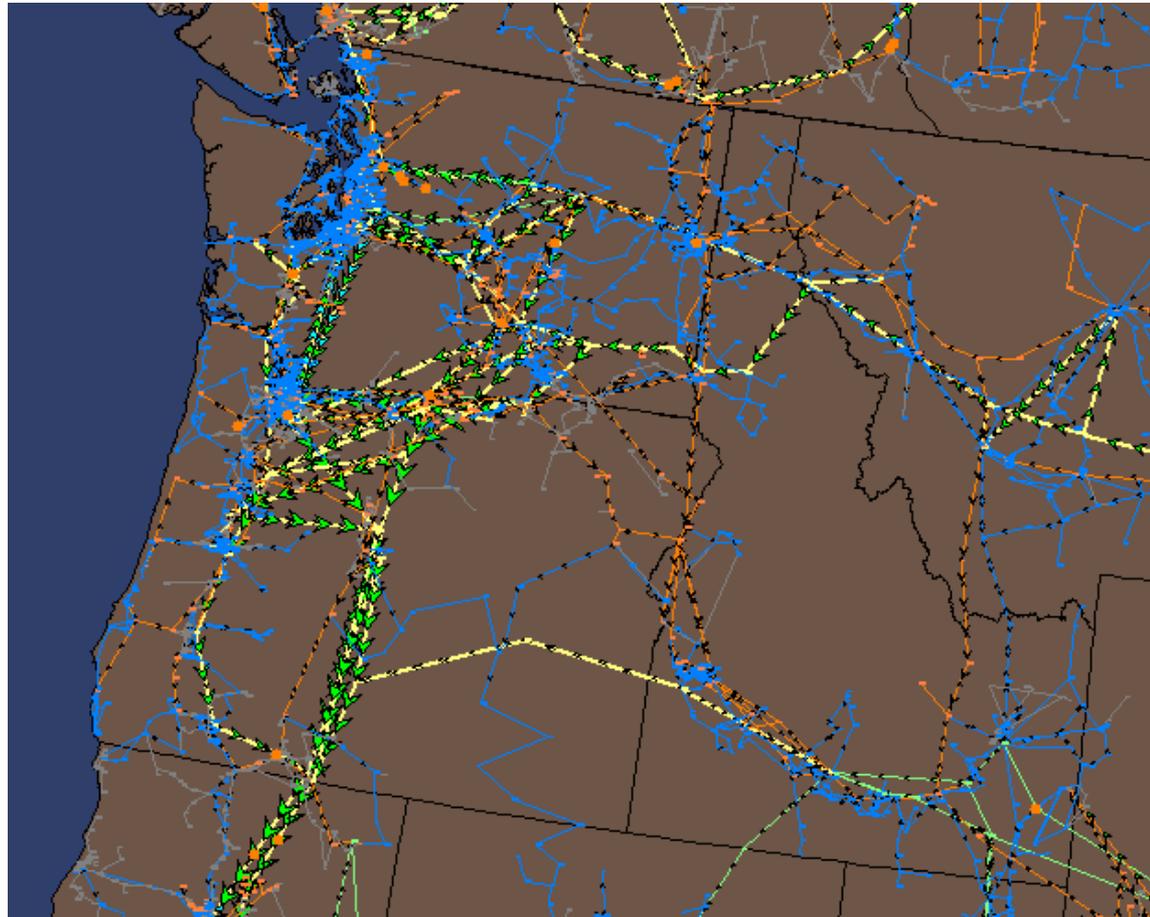
Market Efficiency – Super OPF?

- Hydro output equal to base case
 - 2.8 GW of wind generation
 - Resulting export schedule:

Receiving Area	Export (MW)
PG&E	7180
BC Hydro	1471
Sierra	138

- Upgrades:
 - 4,962 DSRs
 - 7.3 circuit-miles of reconductoring
- Cost: \$58M or \$21/kW wind capacity delivered

Advanced technology enables multi-criteria optimization



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Expanding Control of Power Flows Creates Innumerable Possibilities

Combining Flow Control and DLR enables dynamically updated flow management

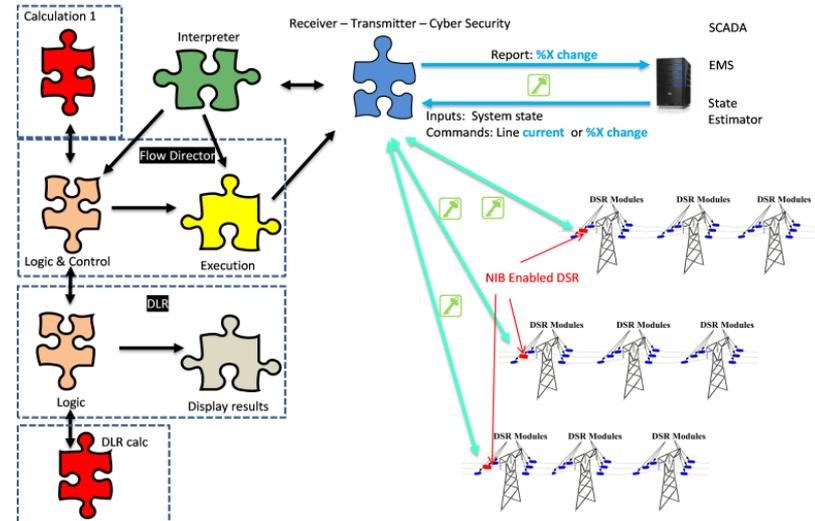
- Increased capacity utilization without risk of overloads
- Greater visibility and control for operators

Other combinations

- Auto RAS/SPS
- Dynamic OPF combining: Flow Control + DLR + AC OPF + Phase Balancing + ???
- Sub-synchronous resonance removal

What's needed?

- For Reliability and Congestion applications - Deployment
- For more advanced Market Efficiency – Review of Market rules; further development of software to leverage the technology



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