Expert Operator Decision Making and the Impact of PMUs

NASPI Working Group Meeting
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Presented By
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Outline

- Expert Operator Decision Model
- Mental Models for Stability Analysis
- Applications of PMU data, analyses and visualizations

An Expert Operator Decision Model

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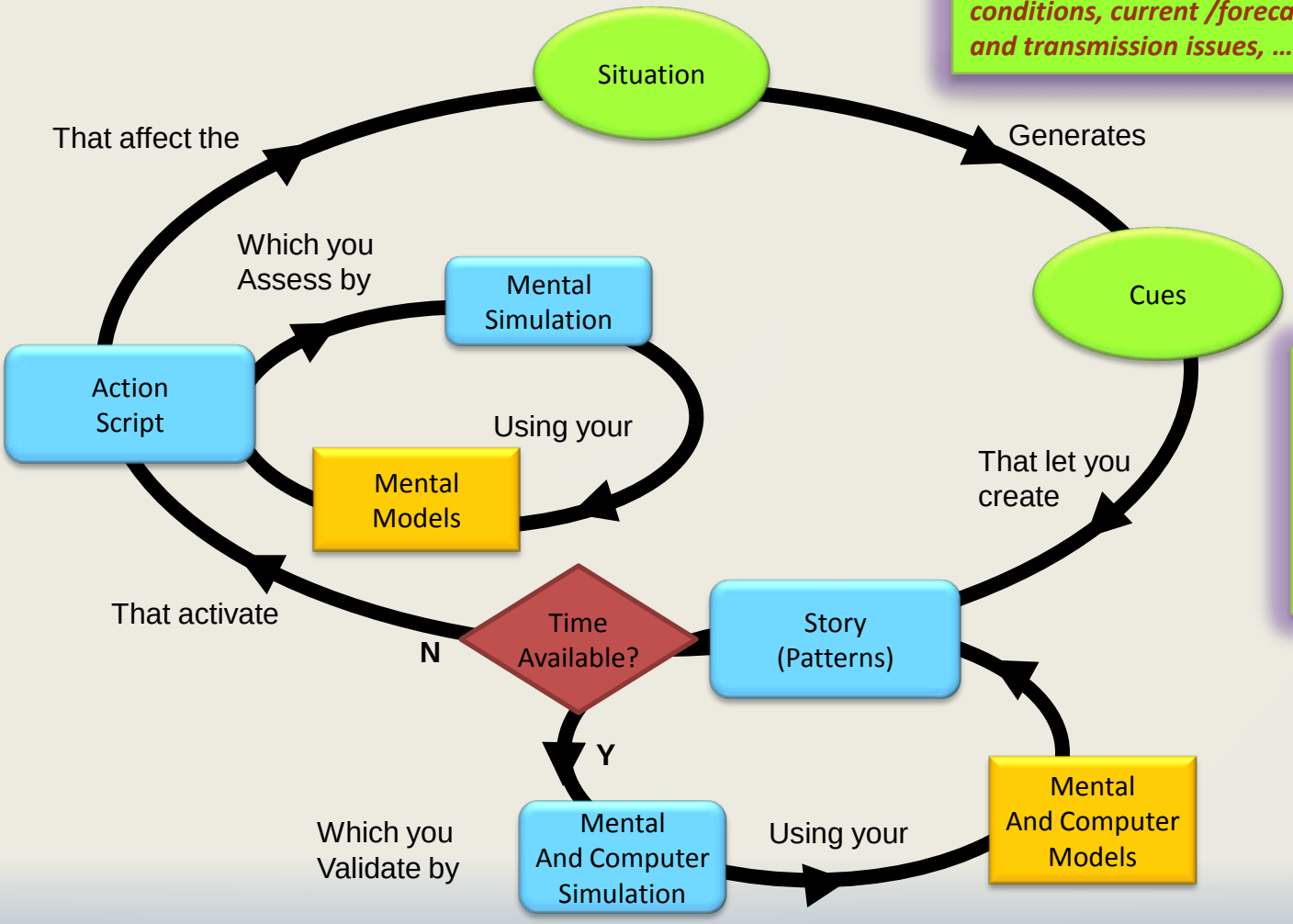
Critical Decision Making

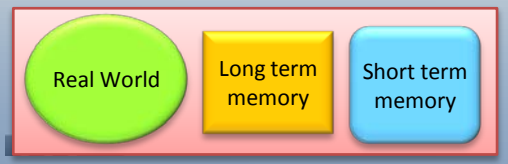
The Challenge of Decision Making

Operator Decision Model

State of the system depends on time of day, weather conditions, current /forecasted system load, generation and transmission issues, …



Cues are on hundreds of displays (system summary, alarm logs, abnormal summaries, charts, map boards) that reflect thousands of variables



Levels of Situation Awareness

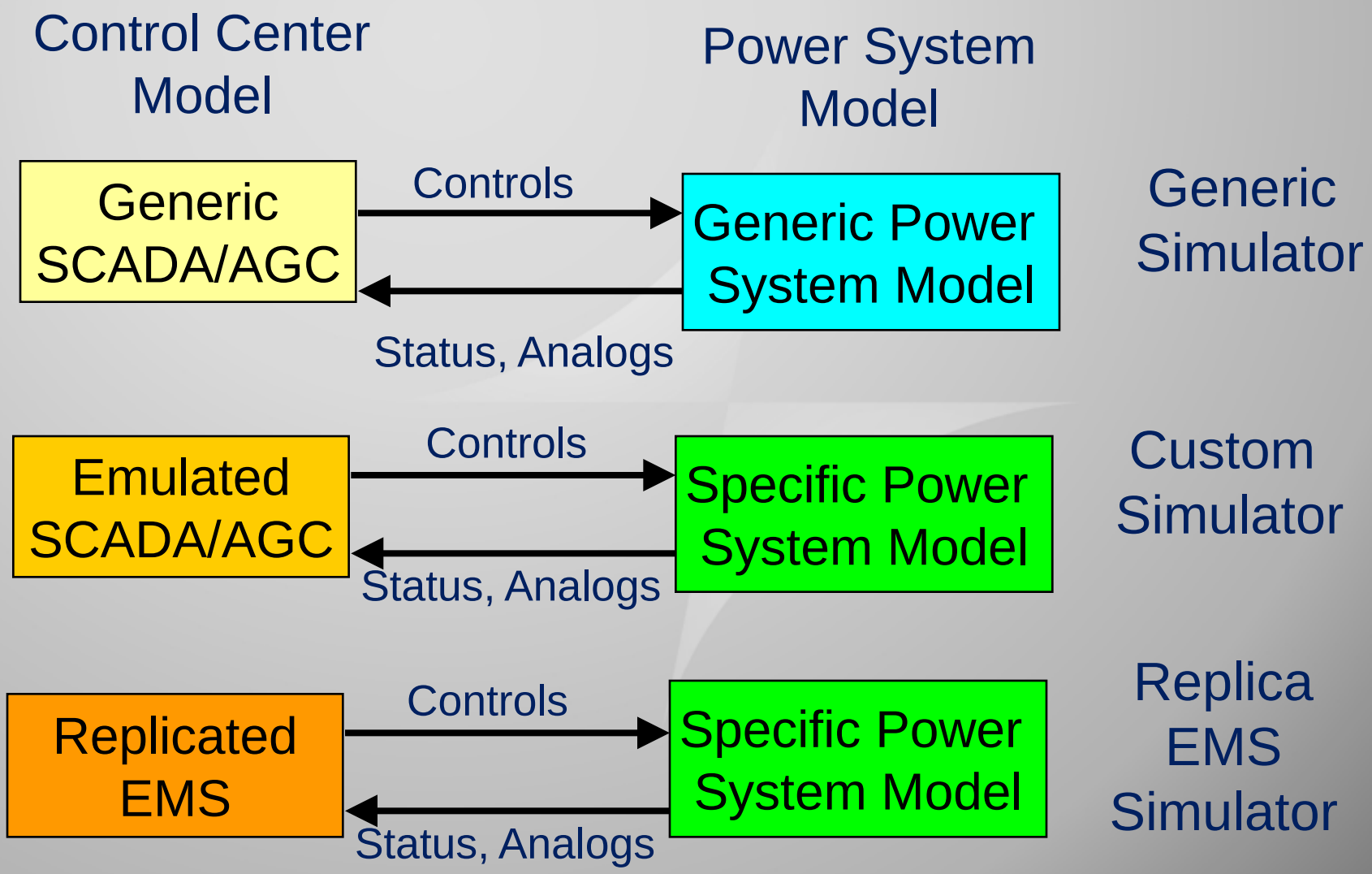
- Level 1: What:
  - Perceiving critical factors in the environment.
- Level 2: So What:
  - Understanding what those factors mean, particularly when integrated together in relation to the person's goals.
- Level 3: Now What:
  - Understanding what will / may happen in the near future.
  - Understanding the impact of contingencies

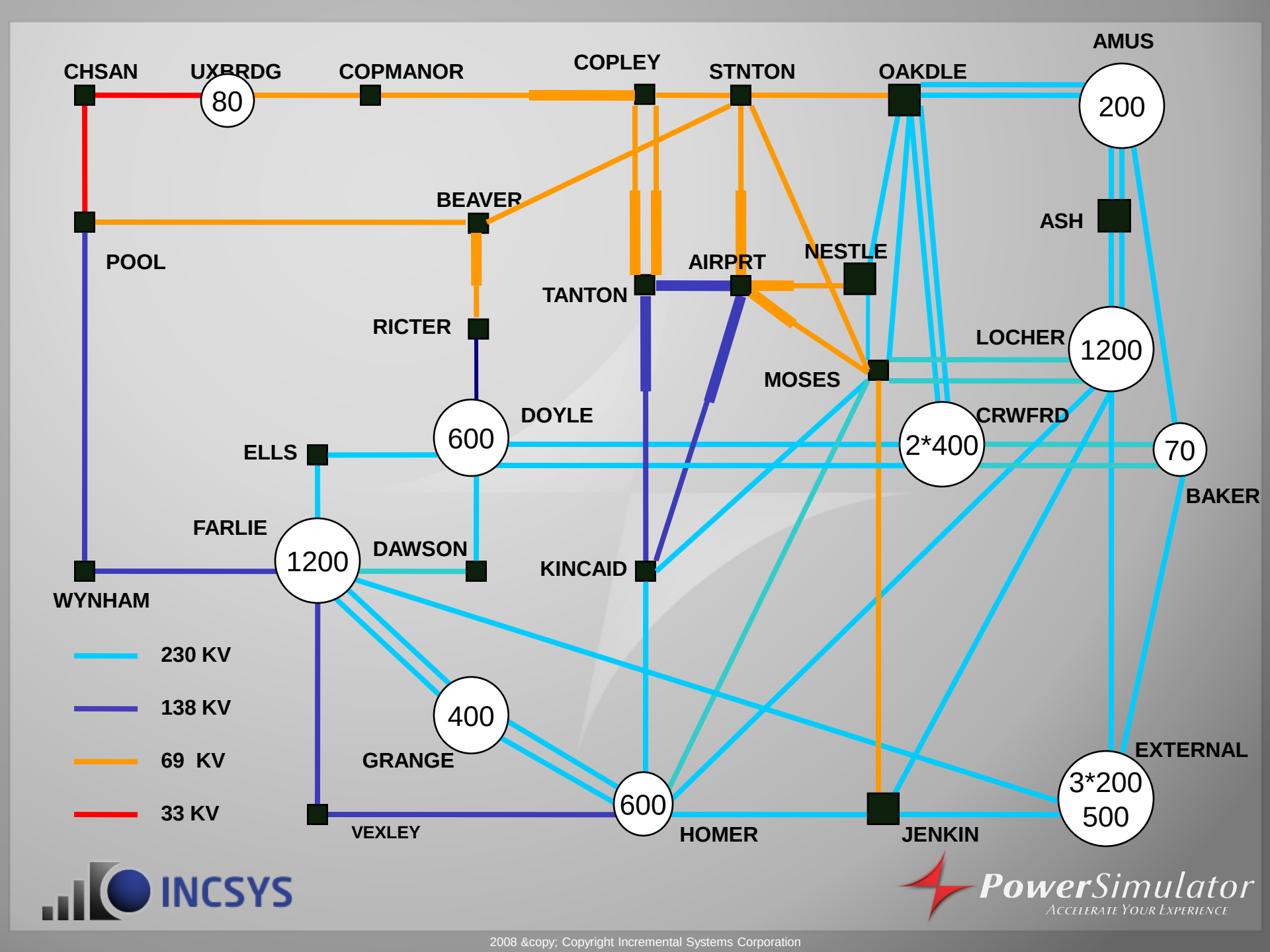
Source: Dr. Mica Endsley

The Expert Operator Decision Model has been developed collaboratively with leading cognitive scientists and system operator trainers

- Based on Recognition Primed Decision model of Dr. Gary Klein; founder of Naturalistic Decision Making.
- RPD model introduced to Power Operations by Doug Harrington with support from Glen Boyle and Mike Sitarchyk of PJM
- Integrates Three levels of Situation Awareness developed by Dr. Mica Endsley.
- Integrates development of consistent and valid STORY as proposed by Dr. Marvin Cohen.
- Enhancements were motivated by Chuck Johansen of SOS International
- First paper presented at 9th NDM conference with Dr. Frank Greitzer PNNL; Pay Ey SOS Intl. and Marck Robinson PowerData.
- Cognitive Task Analysis Framework developed with Peter Dauenhauer IncSys, Tamara Wierks Quality Training, Marck Robinson PowerData and Frank Grietzer PNNL

Simulator Configuration Options





Operators Trained with Generic PALCO System

Organization	Number
CETAC	600
ERCOT	600
FRCC	200
PJM	540
SERC	600
WECC	650
	3190

PJM: Four Simulation Sessions - Four teams per session – Four operators per team – 36 logged on Users

Iraq Ministry of Electricity National Dispatch Center

- Located Al Ameen, Iraq
- New and Incumbent Engineers
- Generic PSM for principles
- Custom Iraq Model
- Remedial Action Schemes

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Scenario Debrief and Interview

Northern California Restoration Drill

Situation Awareness Analysis of Debriefing Transcript

Interviewer	Participant
Walk me through any interesting things you were looking at.	
	I took a look at the list, some were not a concern, in case the storm came through in a direction that I was not anticipating.
	When we are dealing up here in the 115 not the 230 it is not as severe a contingency for me as it is down here with all my generation by the nuke unit where everything is concentrated
	I was particularly interested in the Farlie-Grange the Grange-Homer. Maybe the Crawford Baker and the Crawford Doyle outages . That was not a huge concern for me.
How about Locher Ash?	
	It creates some problems. The overloads that it is creating are not as threatening to me as the ones down here on Farlie to Grange.
How about Crawford to Baker 1 and 2?	
	Yeah it is a bit of a problem but it was not terrifying for me. I kind of skipped on to the next.

Incorrect Critical Assessment

Incorrect Critical Assessment

Applications for Evaluation of PMU data Applications and Visualizations

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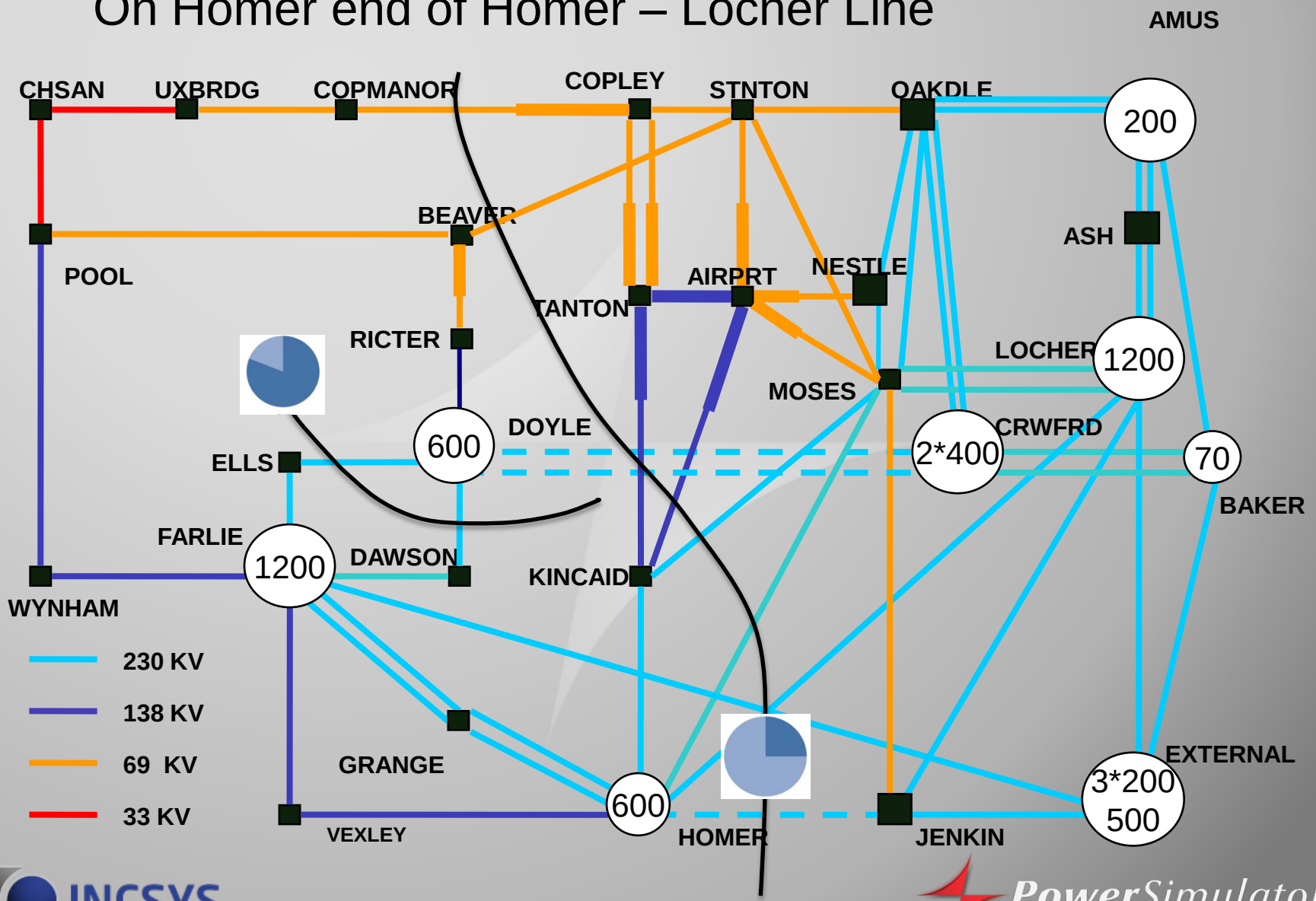
Energy Margins for Normal 5 cycle fault clearing On Homer end of Homer – Locher Line



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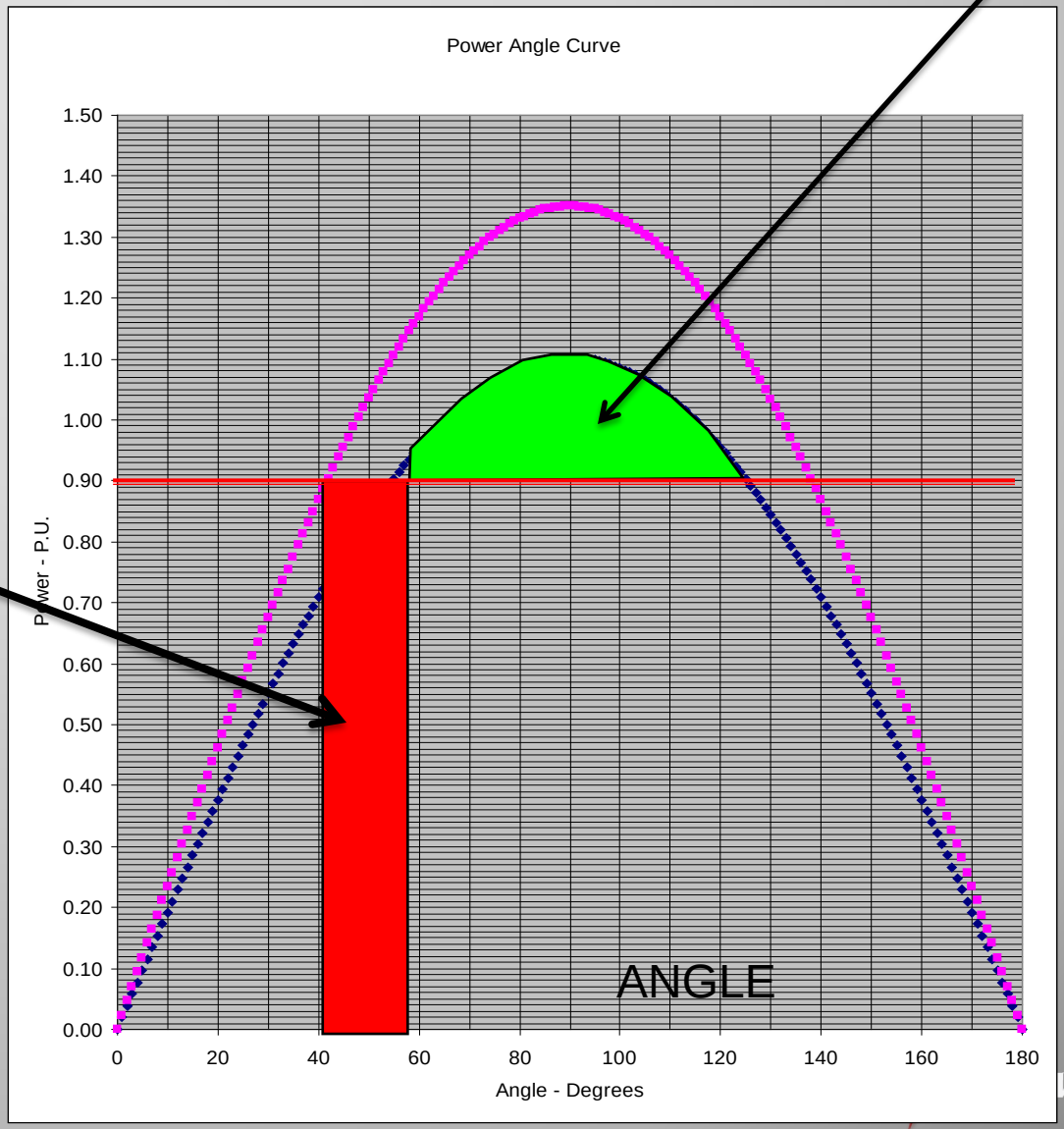
Equal Area Criteria

POWER

Kinetic Energy Into Rotor Area During Fault



Potential Energy Absorbed By Network After Fault

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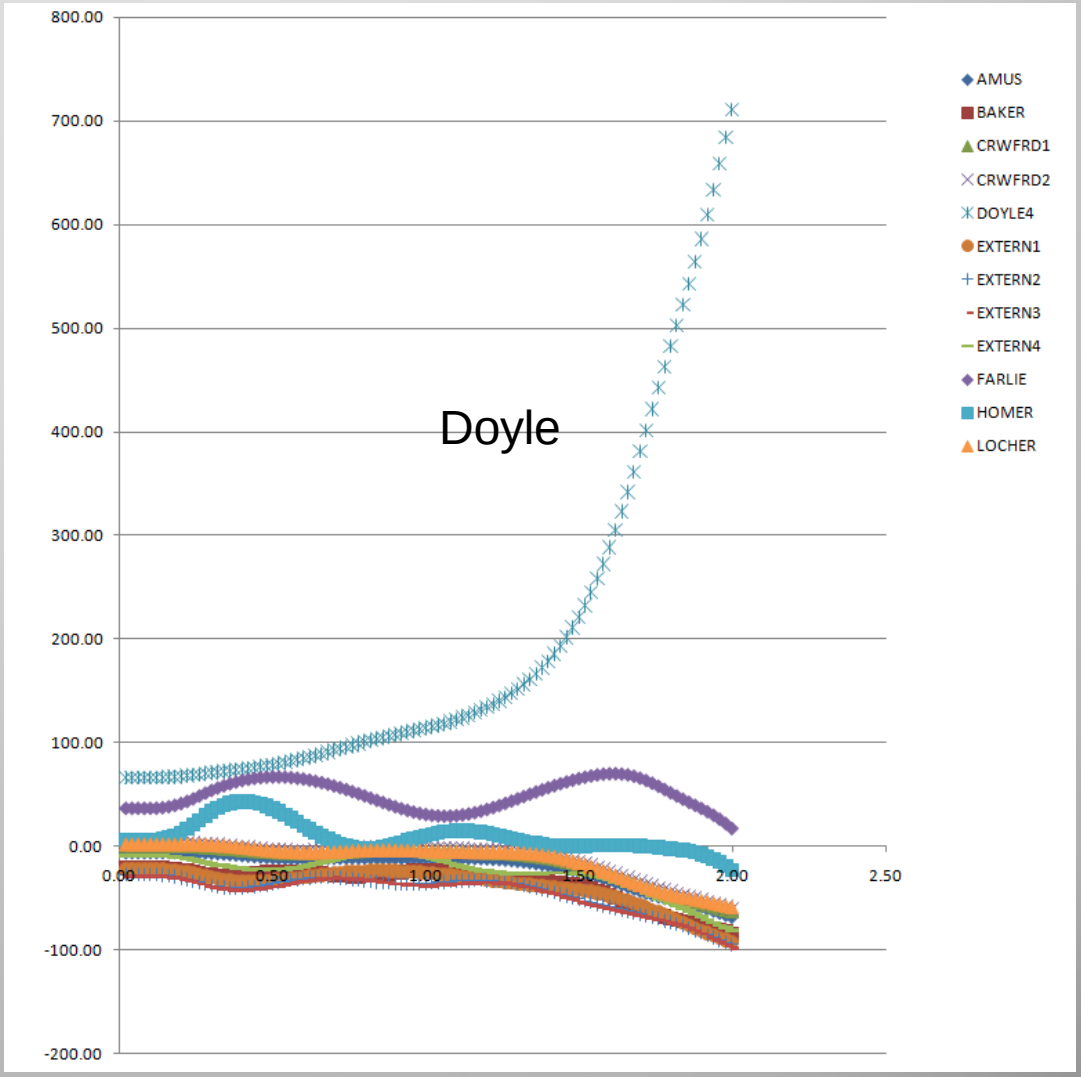
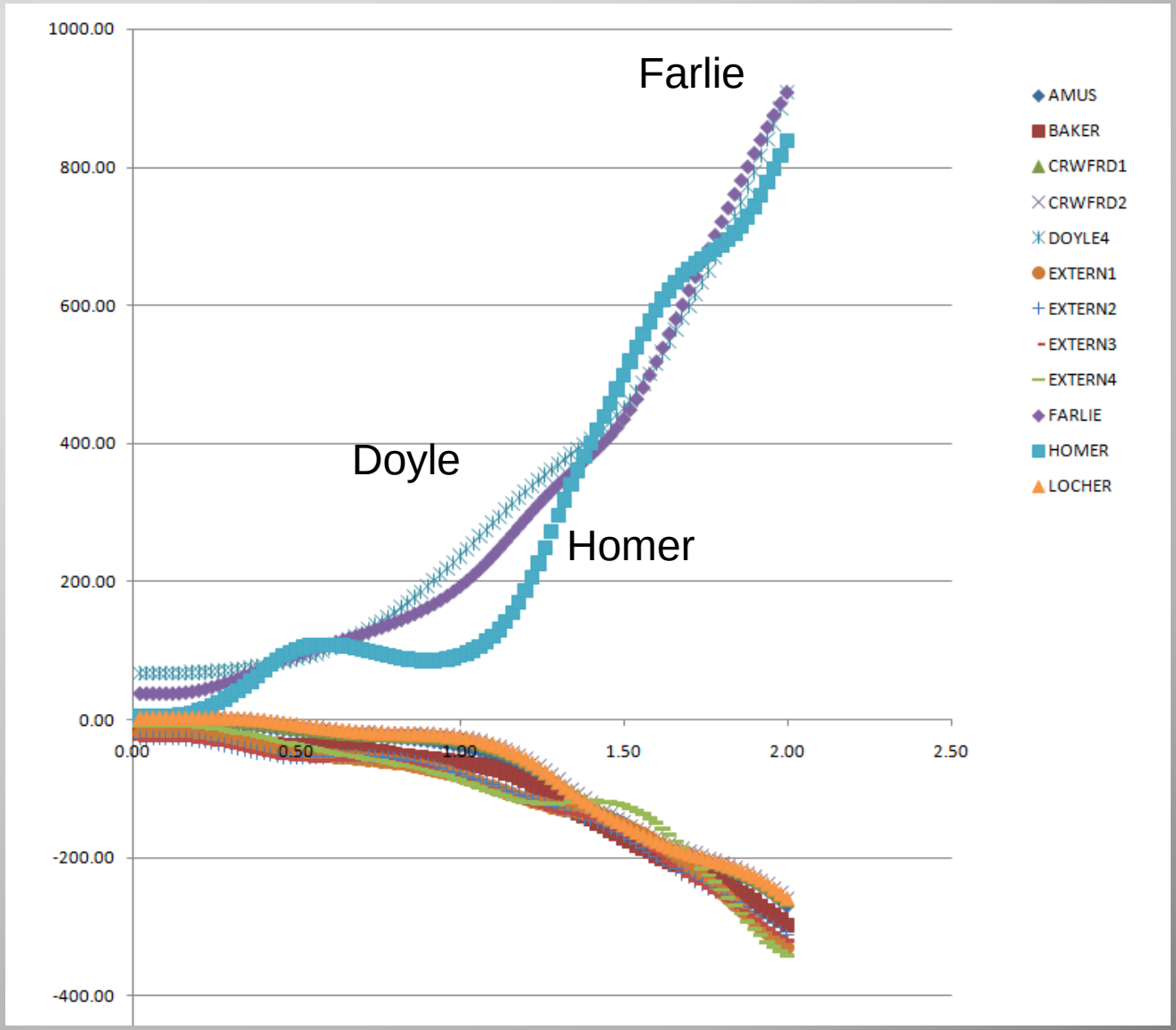
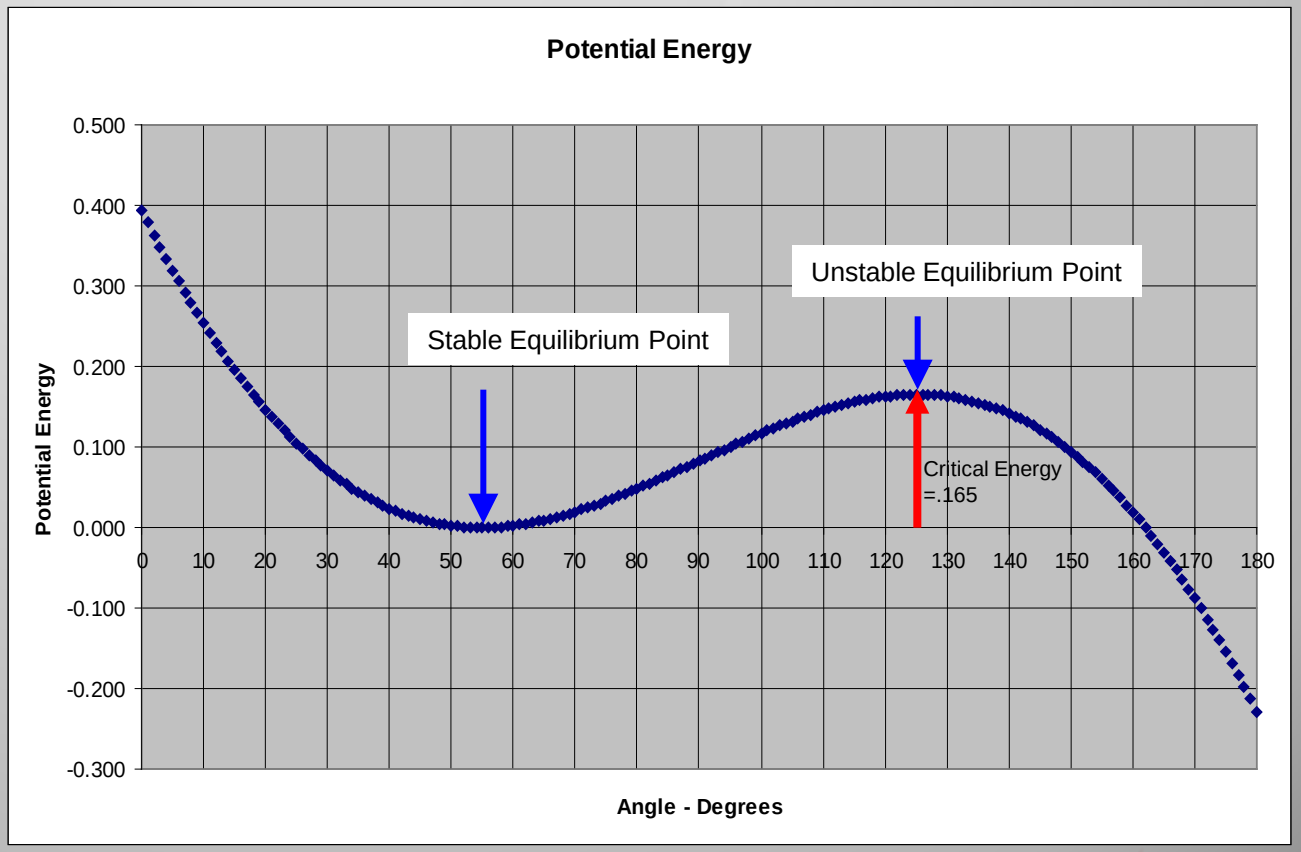
0.15 Second Clearing Time
CRA-DOY 1 & 2 Out



0.3 Second Fault Clearing Time
CRA-DOY1 & 2 Out



Calculation of Critical Energy



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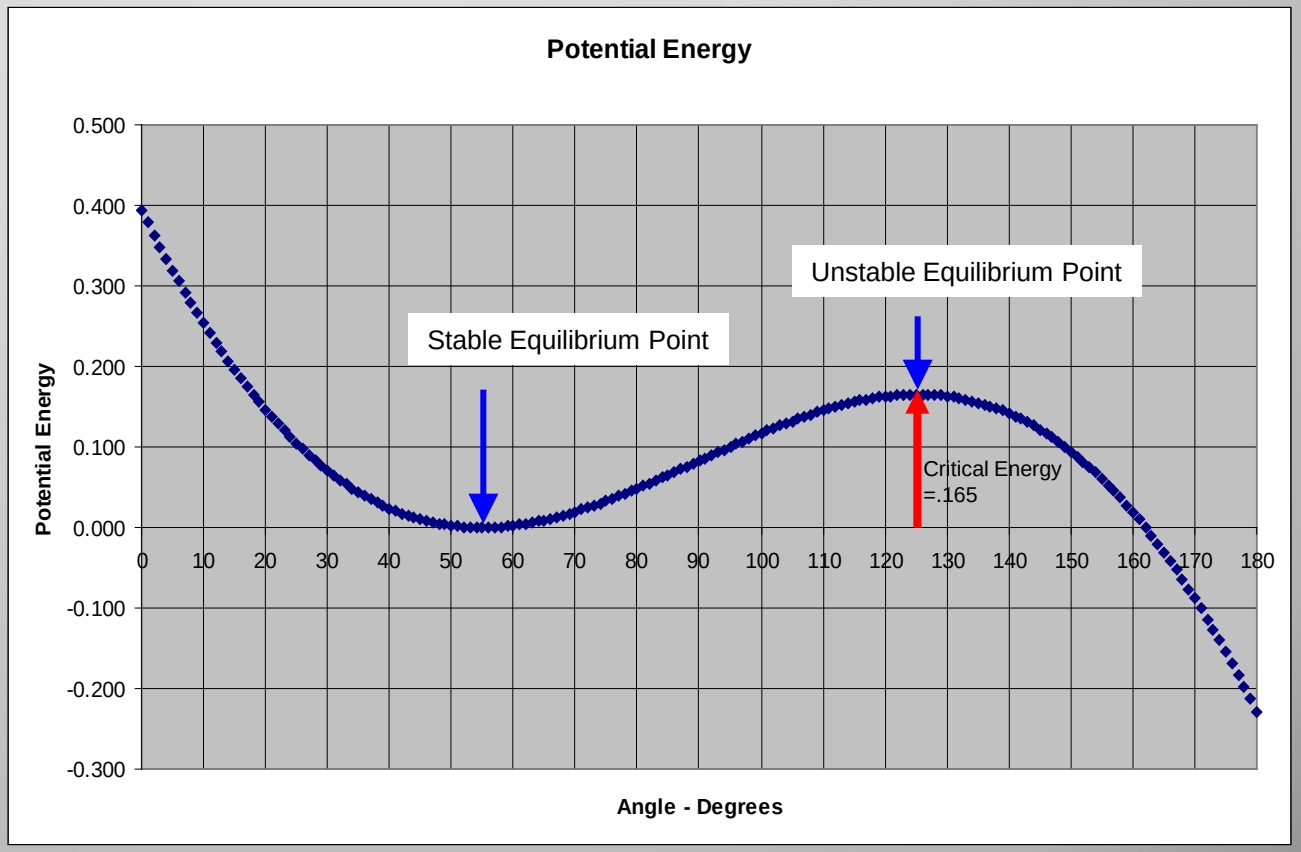
Calculation of Critical Energy



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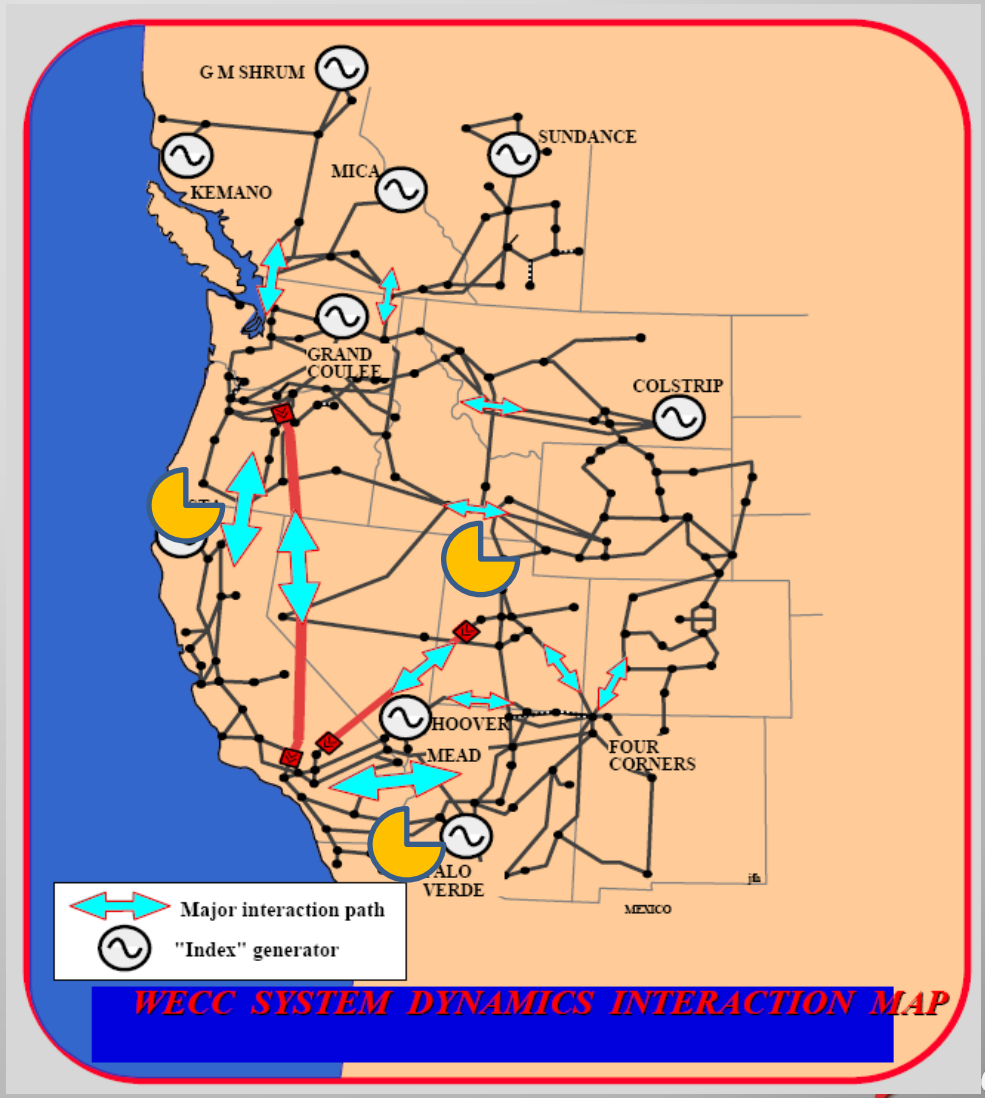
Energy Margins will be Displayed for Critical Paths



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Patterns for Monitoring Stability

- Critical Boundary of Separation
- Unstable for normally cleared faults
- Unstable for delayed fault with stuck breaker
- Low damping
- Large steady state angle separation
- Change in critical Boundary of Separation

Patterns for Restoration

- Extent of System Islands
- Standing Phase Angles
- Virtual Synchro-scope for all breakers
- Line end open
- Line out of service
- Identification of Bad status using redundant angle and MW flow data.

Conclusions

- PMU applications and visualizations need to be processed by system operators using mental models and mental simulations to build a “STORY”.
- The foundation of mental models and mental simulations is being laid by NERC certified training organizations using Generic, Custom and Replica Simulators.
- New PMU applications and visualizations can be systematically evaluated using Generic, Custom and Replica Simulators.