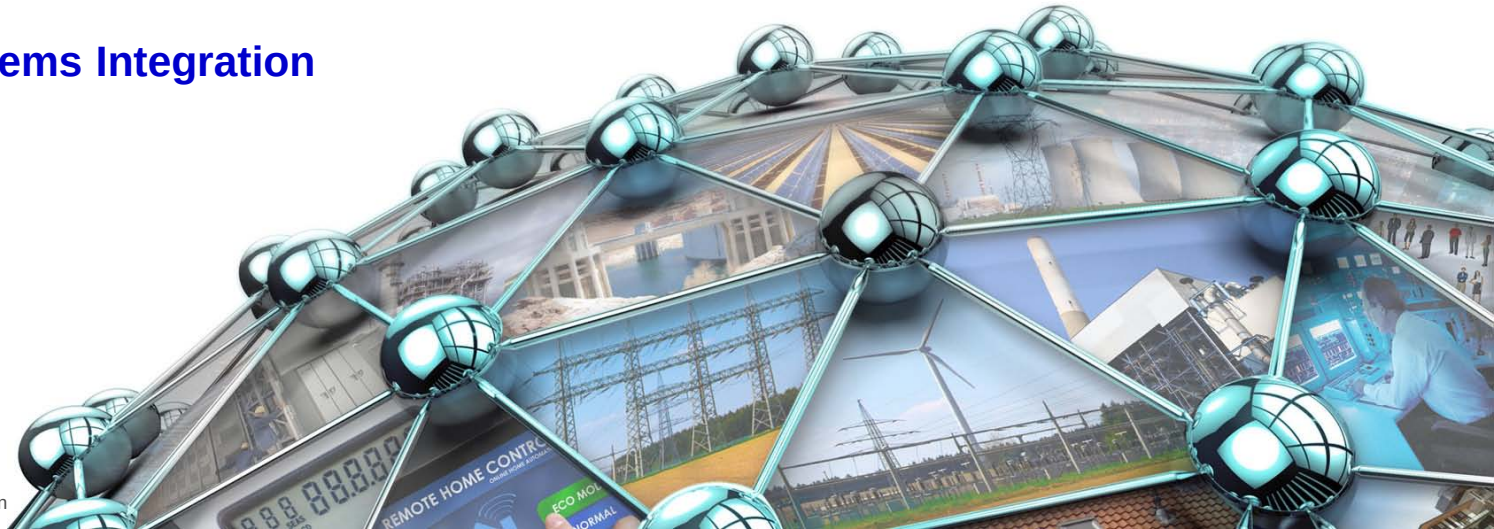
Software Tools and Analysis Methods for Integrated T&D Systems

Mark McGranaghan
Vice President, Power Delivery and Utilization

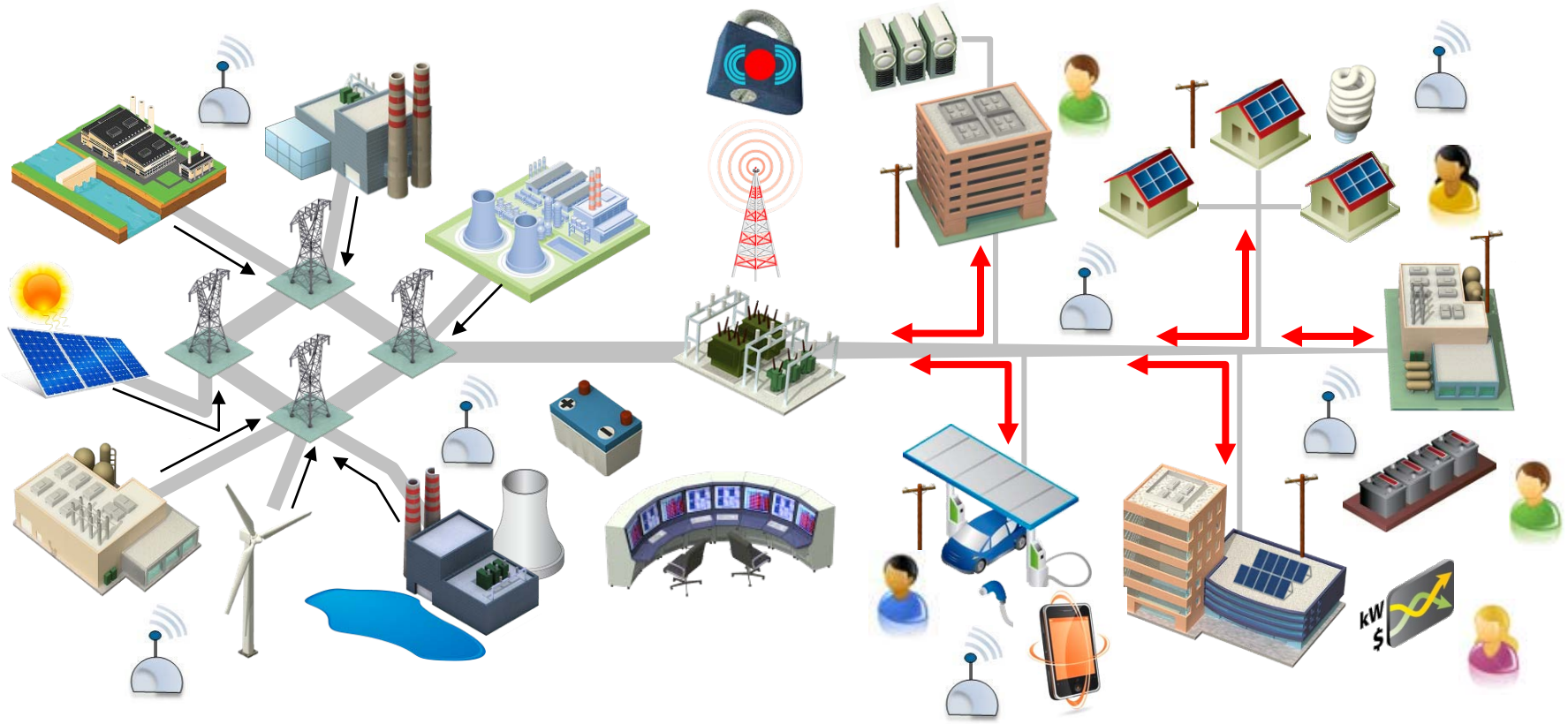
Distribution Systems Integration
October 21, 2014



Agenda

1. Introduction and Objectives – Mark McGranaghan (EPRI)
2. Utility Perspective – Kevin Jones (Dominion Resources)
3. Software provider perspective – Joe Hood (Siemens/PTI)
4. University perspective – Surya Santoso (University of Texas)
5. R&D Perspective and New Approaches – Jeff Dagle (PNNL)

Integrated Grid Vision



Power System that is Highly Flexible, Resilient and Connected and Optimizes Energy Resources

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The Integrated Grid is about Enabling the Customer

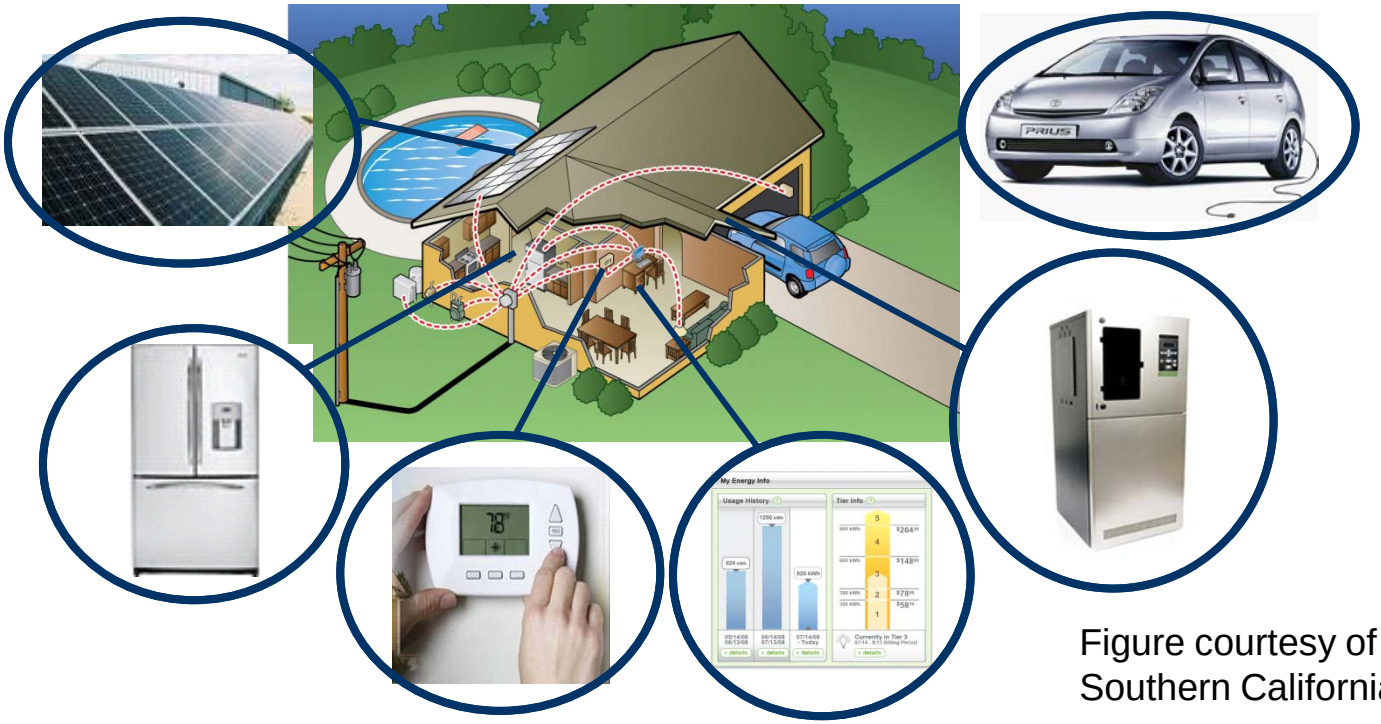

Figure courtesy of
Southern California Edison

The integrated grid allows **Local Energy Optimization** to become part of **Global Energy Optimization.**

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How do we get there?

Framework for Grid Modernization Investment Decisions

Interconnection Technical Guidelines

Integrated Grid Planning & Operations

Informing Policy and Regulation

The Second Decade of Synchrophasors

Five Dimensions to the Success of Synchrophasors for the *Next* Ten Years

CIGRE GOTF Symposium - Houston, TX
Tuesday October 21, 2014
Kevin D. Jones, Ph.D.

The First Decade of Synchrophasors

The Northeast Blackout of 2003 is arguably the strongest catalyst for the more recent success synchrophasors

- TVA Super PDC
  - Gave birth to the openPDC
  - Ready for primetime by the time the SGIG grants came around
- 2008 Hurricane Gustav at Entergy
  - Used synchrophasors to help support an island of ~250k customers
- Acknowledgement by the IEEE
  - C37.118 predates grant work
- Success of FNET
- SGIG & other stimulus grants
  - Dominion project completed **10 years & 5 days** after 2003 blackout

Dominion

What will be critical to success of synchrophasor technology over the *next* ten years?

Top Five Key Dimensions

More Synchrophasors

- Appears obvious but still needs said
  - Value in PMU footprints of all sizes but…
  - Small footprints yield niche applications while large footprints yield applications which are *widespread*, *interoperable*, *prolific*
- Championing sustainable continued deployment
  - Dominion has substation construction standards which dictate PMU/PDC installation for any control house visited for normal project work.
- Some deployment numbers
  - Original grant – 80 PMUs, 39 PDCs, 21 Control Houses in total
  - Up to present day – 141 PDCs
  - After the next 5 years – ~300 Control Houses in total
  - Approximately 0.01% of total capital expenditure on PMUs over next 5 years

Key Takeaway: *Synchrophasors are a fundamental, foundational technology. Bolt-on strategies won't see long term success in this space.*

Dominion

Enterprise Class & Operational Data Analytics

Three Components to Data Analytics

- Next Generation Grid Data Architectures
  - How you get/access/store/move/etc the data
  - Lots of great conversations across the industry right now (GPA, UTK, etc)
- Robust Synchrophasor Data Quality
  - Commitment to data quality is key
  - Need the '*complete package*' for data quality
- Synchrophasor Data Analytics
  - Synchrophasor data is full of information
  - Phasor data analytics impacts most business units in electric transmission
    - *Real time operations, asset management, planning, modeling, etc*

Key Takeaway: *Data is an asset just like a TX or TL. To extract its full value, the complete package of grid data architecture, data quality, and data analytics are critical*

Dominion

Mature Data Visualization

- Data vis. is important inside *and* outside operating room
- Varying degrees of maturity
- Data visualization should be simplistic to drive adoption/trust
  - Seeing PMU data in traditional forms can be very effective for adoption
  - Basic trending, strip-charting, schematic one-lines, frequency topos
  - Host visualization in common areas to '*make synchrophasor data real*'
- Existing tools are not end-all-be-all of data visualization
  - Some have shot for the moon… and flopped
  - Some have seen success with simplistic visualization like basic trending, strip-charting, schematic one-lines, etc but this should not be the last word in data visualization for synchrophasors

Key Takeaway: *Advanced visualizations aren't necessarily mature. Start with simple, trust building interfaces and add complexity as the end user evolves.*

Dominion

A Total Pivot to Open Source

- Our industry has one of the lowest OSS utilization rates
- The evidence for the benefits of OSS are readily available
- Software vendors business models will start to transform
- Why Open Source?
  - Public Domain ≠ Open Source
  - Generating user base provides mechanisms for growth and support
    - *Its all about the numbers!*
    - *Utility industry is very specialized – small numbers*
  - University use increases user base and trains engineers of tomorrow
    - *Bridges technology transfer gap; decreases cost of innovation*
    - *Young talent loves to code*

Key Takeaway: *Open source software will be a game changer for the industry over the next ten years because of the user-developer.*

Dominion

People

- People are at the heart of innovation
  - People make comprehensive substation standards
  - People develop/integrate/utilize word class data analytics
  - People digest information through mature data visualization
  - People form communities to develop the tools of our GOTF
  - People adopt new technologies
- Our industry has not yet mastered…
  - Workforce planning & talent acquisition
  - Self promotion – synchrophasors need to be sexy!
  - Training programs & knowledge retention

Key Takeaway: *Without the right people, any new tool or technology will fail. People are the most critical key to the GOTF*

Conclusion

5 Keys to Success for Synchrophasors

- More Synchrophasors
  - Organic continued deployment through strategic standardization
- Enterprise Class & Operational Data Analytics
  - Next gen. data arch. data quality, analytics for '*complete package*'
- Mature Data Visualizations
  - Start simplistic → build trust → evolve
- A Total Pivot to Open Source
  - The rise of the *user-developer*
- People
  - Hire rockstars

Dominion

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SIEMENS

Software Provider Perspective

CIGRÉ Grid of the Future Symposium

Joe Hood, PE

Product Manager for PSS®E

Siemens PTI

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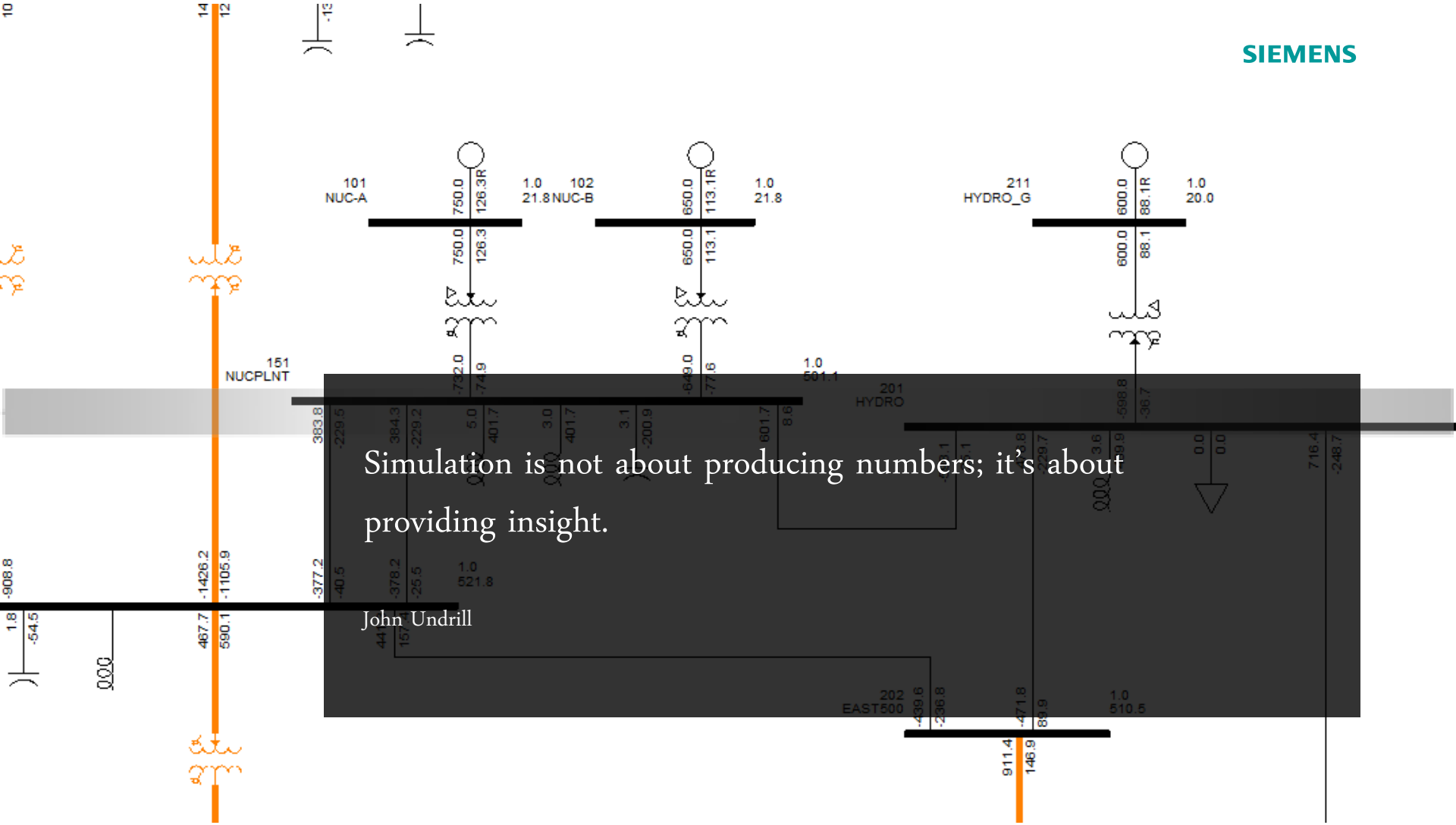

Simulation is not about producing numbers; it's about providing insight.

John Undrill

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Distributed and Cloud Computing

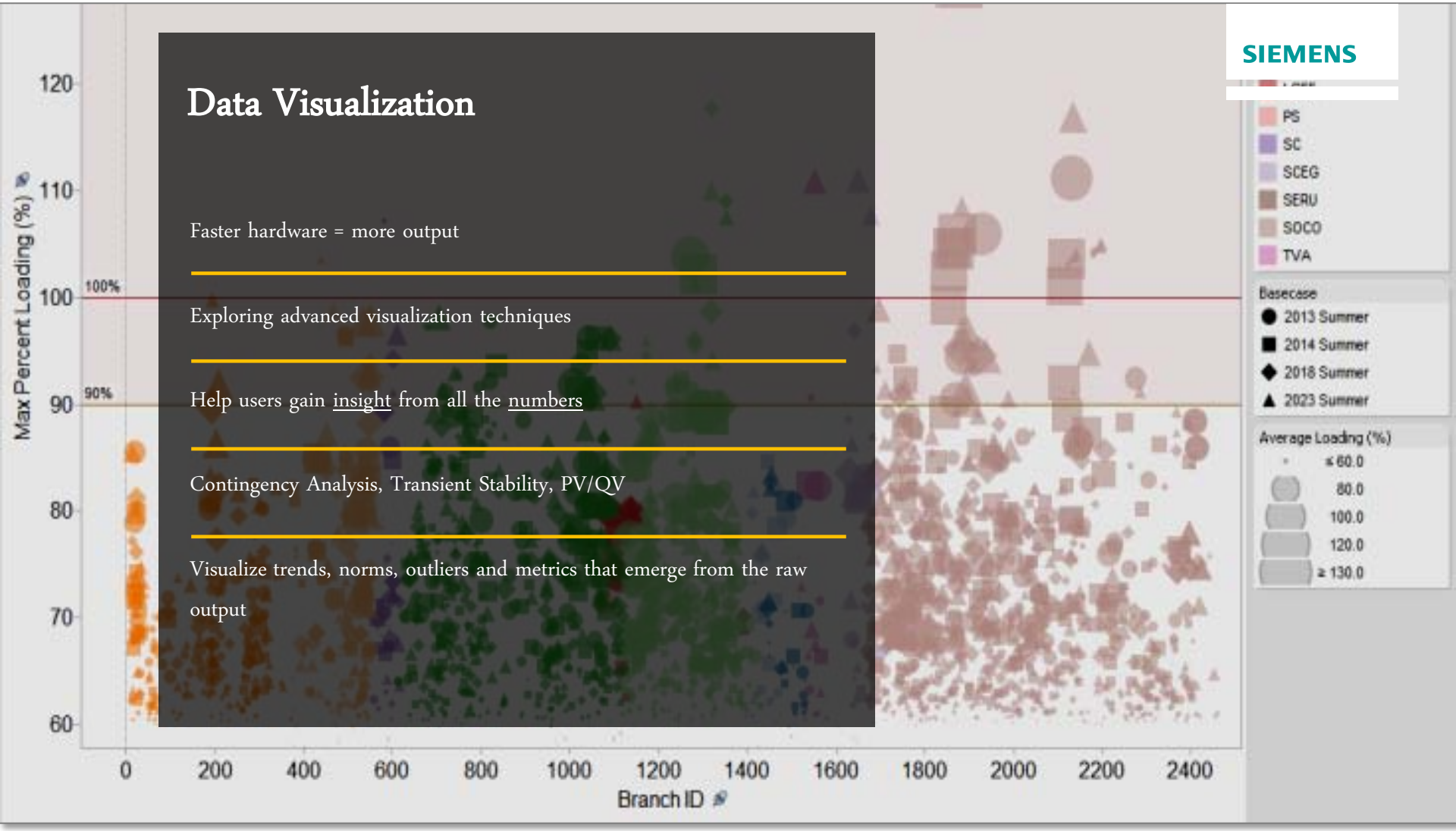
Parallelized simulation engines in PSS® Suite

Millions of powerflow contingencies in minutes

Thousands of dynamic simulations in minutes

True real-time transient stability assessment

Several pilot projects underway



Data Visualization

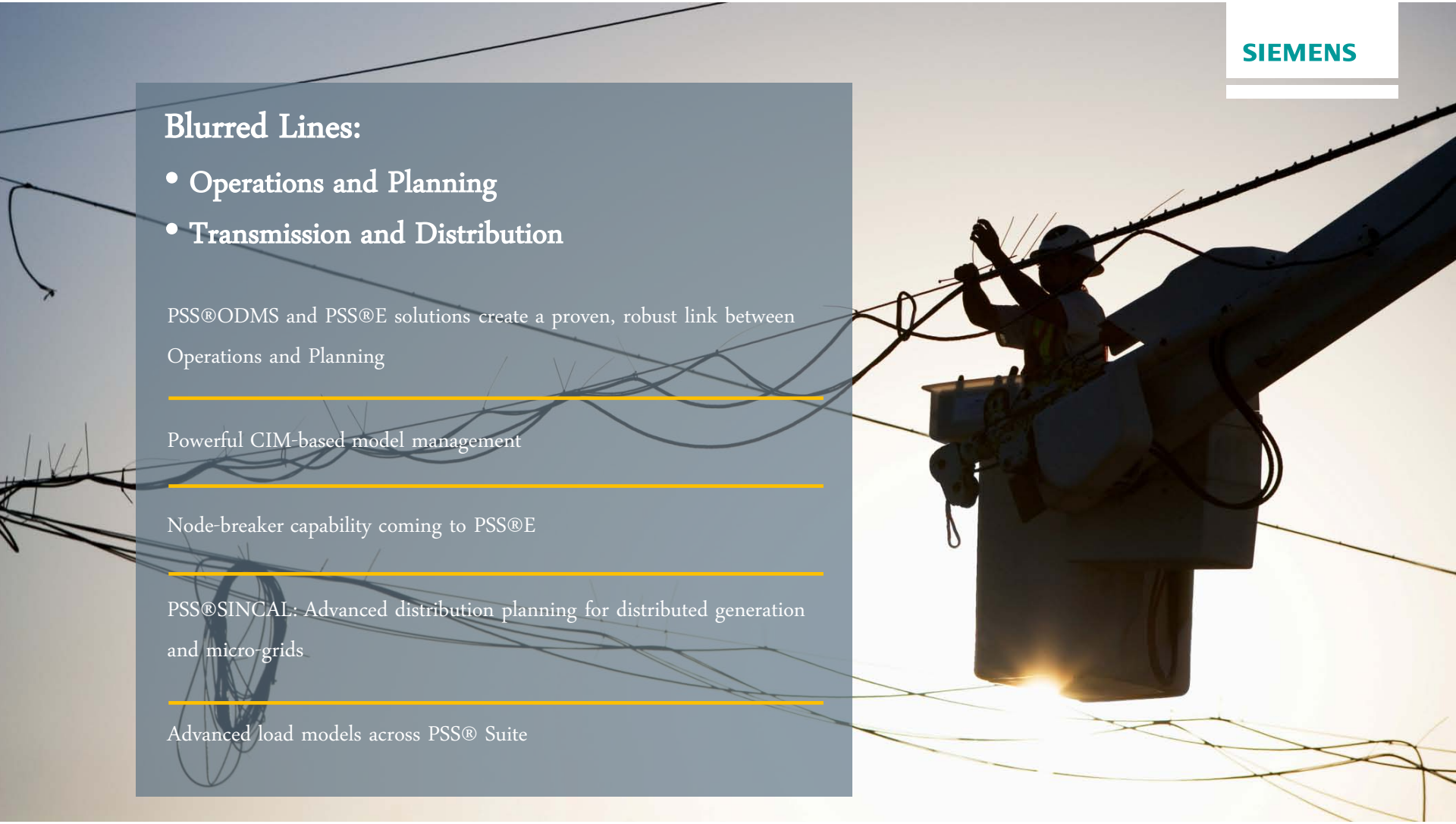
Faster hardware = more output

Exploring advanced visualization techniques

Help users gain insight from all the numbers

Contingency Analysis, Transient Stability, PV/QV

Visualize trends, norms, outliers and metrics that emerge from the raw output



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Blurred Lines:

- Operations and Planning
- Transmission and Distribution

PSS®ODMS and PSS®E solutions create a proven, robust link between Operations and Planning

Powerful CIM-based model management

Node-breaker capability coming to PSS®E

PSS®SINCAL: Advanced distribution planning for distributed generation and micro-grids

Advanced load models across PSS® Suite

SIEMENS

Coming Soon

Webinar: CIMplify your Network Model Management with PSS®ODMS

- November 4, 2014.
- www.usa.siemens.com/network-model-management

PSS®E 34 with Node-breaker Modeling

- Release scheduled for December 2014
- Webinars to follow in January 2015
- Demos and trials will be available

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Software Tools and Methodologies for Future T&D Systems

University Perspective

Surya Santoso
The University of Texas at Austin

Tuesday, Oct. 21, 2014
Houston, TX

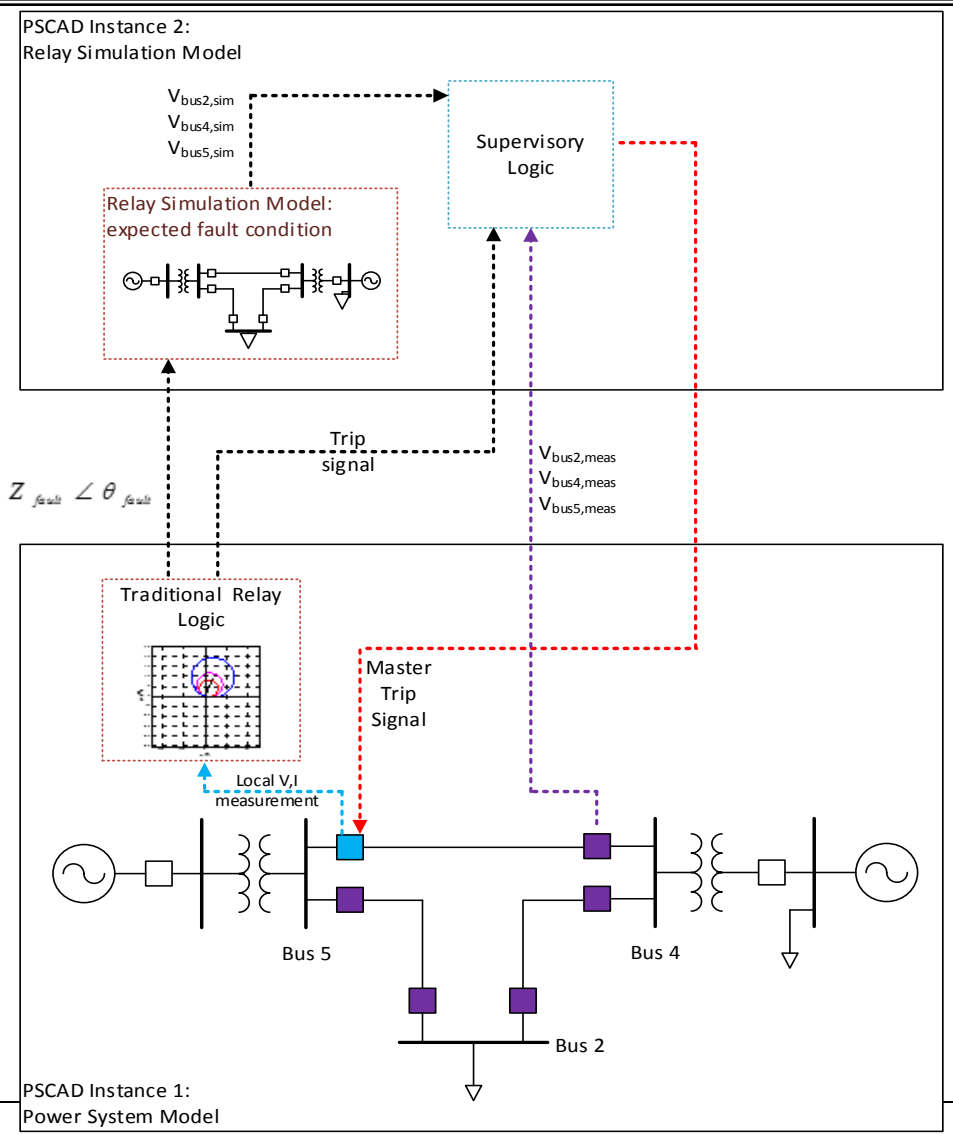
Panel Session on Advanced Tools and Methods for T&D Analysis: University Perspective

- Educating future generation of engineers:
  - B.S. and M.S. degree programs: well-rounded power engineers, knowledgeable in embedded systems, data and signal processing, communication and networks, and software/enterprise systems, ...
  - Ph.D. degree program: research-based with narrow focus on specific subjects in T&D analysis (e.g.: power quality, fault locating methods, network topology)
- Research:
  - Students: Abundance in qualified students applying to Ph.D. program, mature, highly motivated, the cream of the crop.
  - Emphasis: Original contribution on specific topics:
    - Advancing the state of the art
    - Transformative, and high impact.

Panel Session on Advanced Tools and Methods for T&D Analysis

- University-industry collaboration:
  - University: a community of scholars with diverse expertise
  - Industry: real-world, economic reality
  - Research topics should more endogenous than exogenous to the real-world.
- Sample research topics
  - Methods for determining PV hosting capacity in distribution circuits
  - Methods and tools for grid impact and cost-benefit analyses of bulk DER integration.
  - Managing wind and PV variability
  - Future T&D protection systems: incorporating circuit model and faster than real-time simulation in microprocessor-based relays.

Advanced T&D Protection and Relaying



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R&D Perspective and New Approaches

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The Grid of the Future Symposium - hosted by the CIGRÉ (The Council on Large Electric Systems) U.S. National Committee and the Electric Power Research Institute (EPRI)

Panel Session: Software tools and methodologies for modeling, analysis, planning, asset management, and operations of future T&D systems

Houston, Texas
October 21, 2014

Overview

Transmission Reliability

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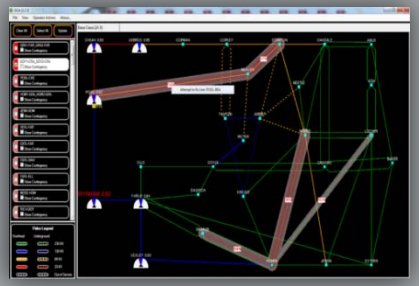
Technology Challenge

Enhance power system reliability by leveraging new measurement systems to provide wide-area visualization, monitoring and control

Our approach: Improve power system performance and transmission reliability by extracting greater value from grid measurements and data. Key elements include:

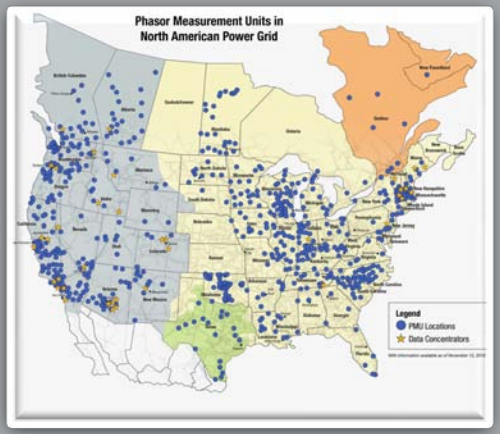
- U.S. DOE's lead for the North American Synchrophasor Initiative (NASPI), a joint effort with the North American Electric Reliability Council (NERC) and industry to build out phasor measurement units (PMUs) across North America, enabling increased situational awareness and control
- Planning models validation through measurement-based analysis
- Decision support tools for operators
  - Mode meter – uses PMU data to improve detection of grid disturbances, enabling greater asset use and preventative measures; deployed in Western Interconnection Synchrophasor Project
- EIOC – providing utilities, vendors and researchers access to real-time grid data for testing in realistic operations environment

Graphical Contingency Analysis



Real-time power flow visualization identifies/prioritizes issues, recommends corrective actions

NASPI



Overview

Grid Analytics

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Technology Challenge

Translate vast amounts of real-time data into actionable knowledge to enable unparalleled grid planning and operations

Our approach: leverage high-performance computing (HPC) and new algorithms to provide real-time tools for prediction and response.

- Accelerating speed of existing tools/functions
  - State estimation
  - "*N*–2" contingency analysis
- Developing entirely new tools/functions
  - Predictive state estimation (dynamic, predictive, fast, global)
  - "*N*–*k*" contingency analysis (decision support for complex issues)
  - Look-ahead dynamic simulation (faster than real-time simulations)
- Integrating currently independent functions
  - Operations and planning
  - Transmission and distribution
  - Power grid and data network

Massive Contingency Analysis

Converging on solutions 10,000x faster via HPC

Fast Dynamic Simulation

Our answer - Future Power Grid Initiative

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- **The Future Power Grid Initiative (FPGI)**
  - A multi year, multi million dollar, interdisciplinary initiative
  - Funded through PNNL's Laboratory Directed Research and Development Program
  - Led by Henry Huang, Ph.D., P.E.
  - and Jeff Dagle, P.E.

- **Approach**
  - Combining PNNL's distinctive capabilities in power systems, data-intensive high-performance computing and visual analytics
    - Designing computational approaches to deliver a new class of real-time tools for grid modeling and simulation
    - Expanding power grid networking to support large scale and secure real-time data flow
    - Advancing state-of-the-art visual analytics to convert very large volumes of multi-domain real-time data into actionable information

PNNL Future Power Grid Initiative

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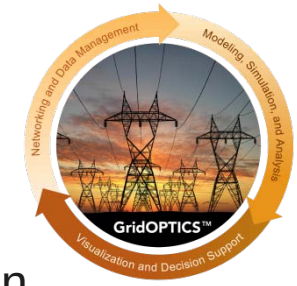

GridOPTICS™ – a suite of tools to enable three fusions:

- Bridging **operation** and **planning** to enable more seamless grid management and control
  - Remove overhead involved in communication between operation and planning
  - Improve response when facing emergency situations
- Integrating **transmission** and **distribution** in end-to-end grid modeling and simulation capable of handling 10^9 devices with uncertainty
  - Understand the emerging behaviors in the power grid due to smarter loads, mobile consumption, and intermittent generation
- Managing interdependency between power **grid** and **data** network (a test lab for power grid data networking is being set up)
  - Enable “all-hazard” analysis
  - Prepare grid operators and planners with the knowledge of data network impact on the power grid