Reliable, Low Cost Distributed Generator/Utility System Interconnect

GE Corporate Research & Development

GE Power Systems Energy Consulting

Puget Sound Energy

Distributed Energy Resources Conference
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Energy Consulting

Program Structure

2001 — 2002 — 2003 — 2004

Base Year

- Fundamental research through virtual testbed
- IEEE P1547 support
- Interconnect conceptual design

Optional Year I

- Interconnect prototyping
- Beta site testbeds
- High DG penetration

Optional Year II

- Demand side management
- Cost optimization
- Beta site testbeds

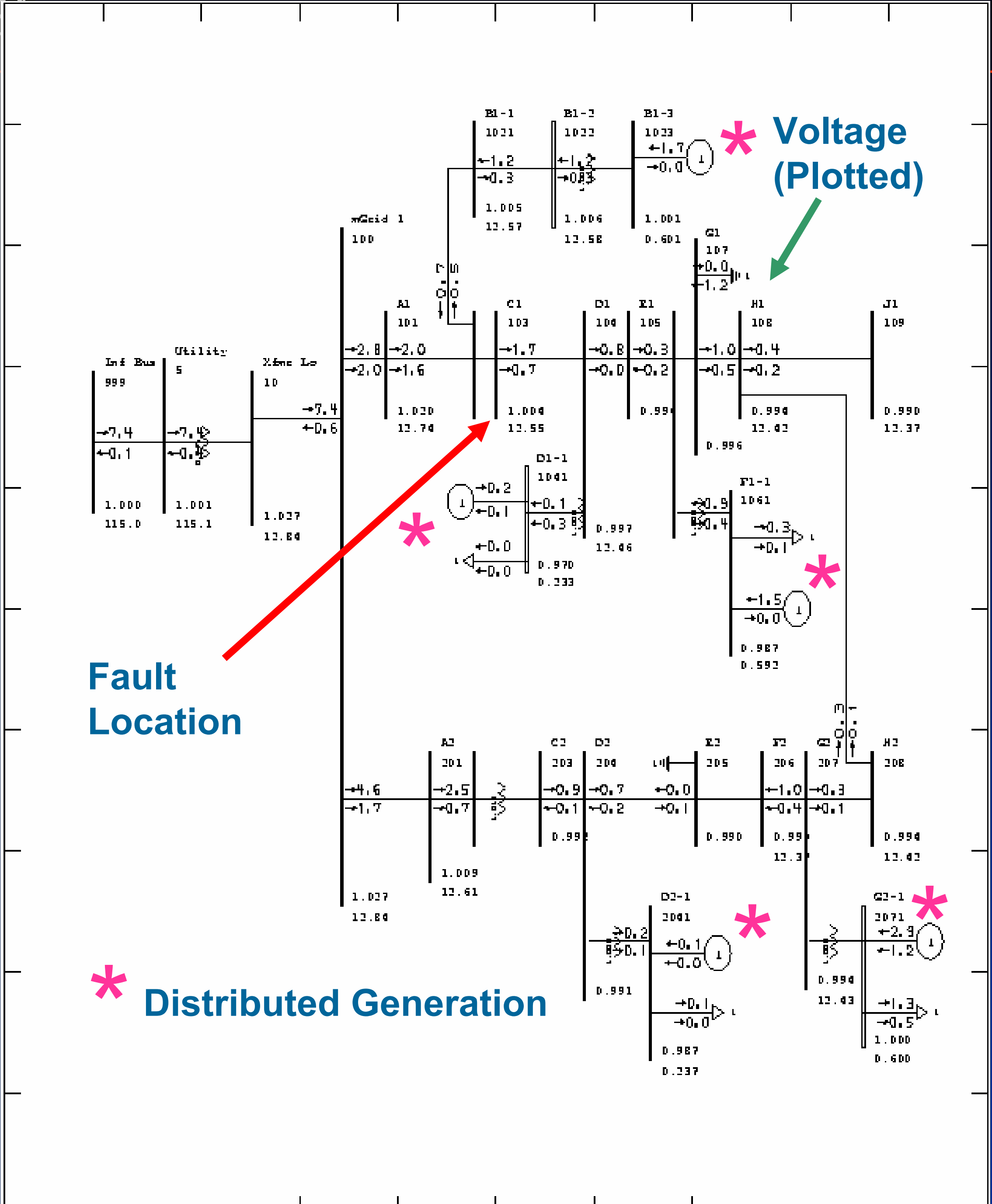
System Interconnection Research

- **Fundamental requirement for defining interconnection system**
- **Quantitative analysis of issues now confronting P1547 initiative**
  - *How realistic are the impacts*
  - *What penetration is required*
- **Integration issues:**
  - *Distribution system voltage regulation*
  - *Fault behavior*
  - *Coordination with system protection*
  - *Island detection*
  - *Impact on system dynamic performance*

A Look at a Future with Higher DG Penetration

- What might DGs do to the dynamics of a distribution feeder?
- What might DGs do to the dynamic of an entire bulk power system?
  - *Will transient stability be affected?*
  - *Will damping be impacted?*
  - *Will voltage stability be affected?*

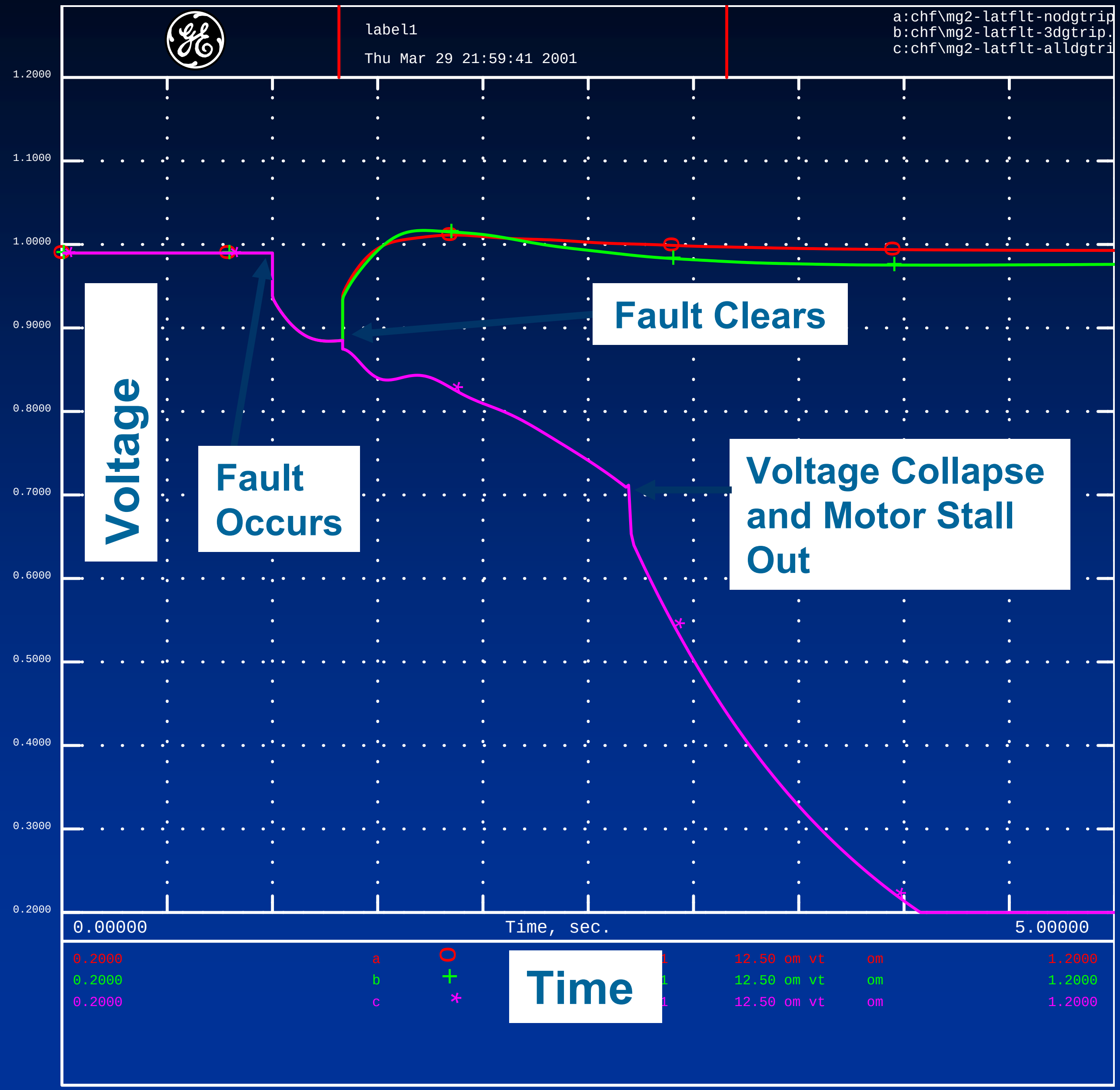
Are there actions that the industry might take now, to make high penetration of DGs beneficial to the power system as a whole?



Sample Distribution System:

- Two 12.5kV Mains
  - 28 node equivalent, including laterals
  - 240v and 600v secondaries with transformers represented
  - Substation LTC
  - 1200 kVAr Shunt bank on #1
  - SVR on Feeder 2
- 13,700 kW Load
  - 2831 kW pumps
  - 6467 kW other motors
  - 4371 kW static load
  - 36 dynamic models
- 6405 kW Distributed Generation
  - 5 equivalents, with dynamic models
  - 2 units with voltage and power regulation functions

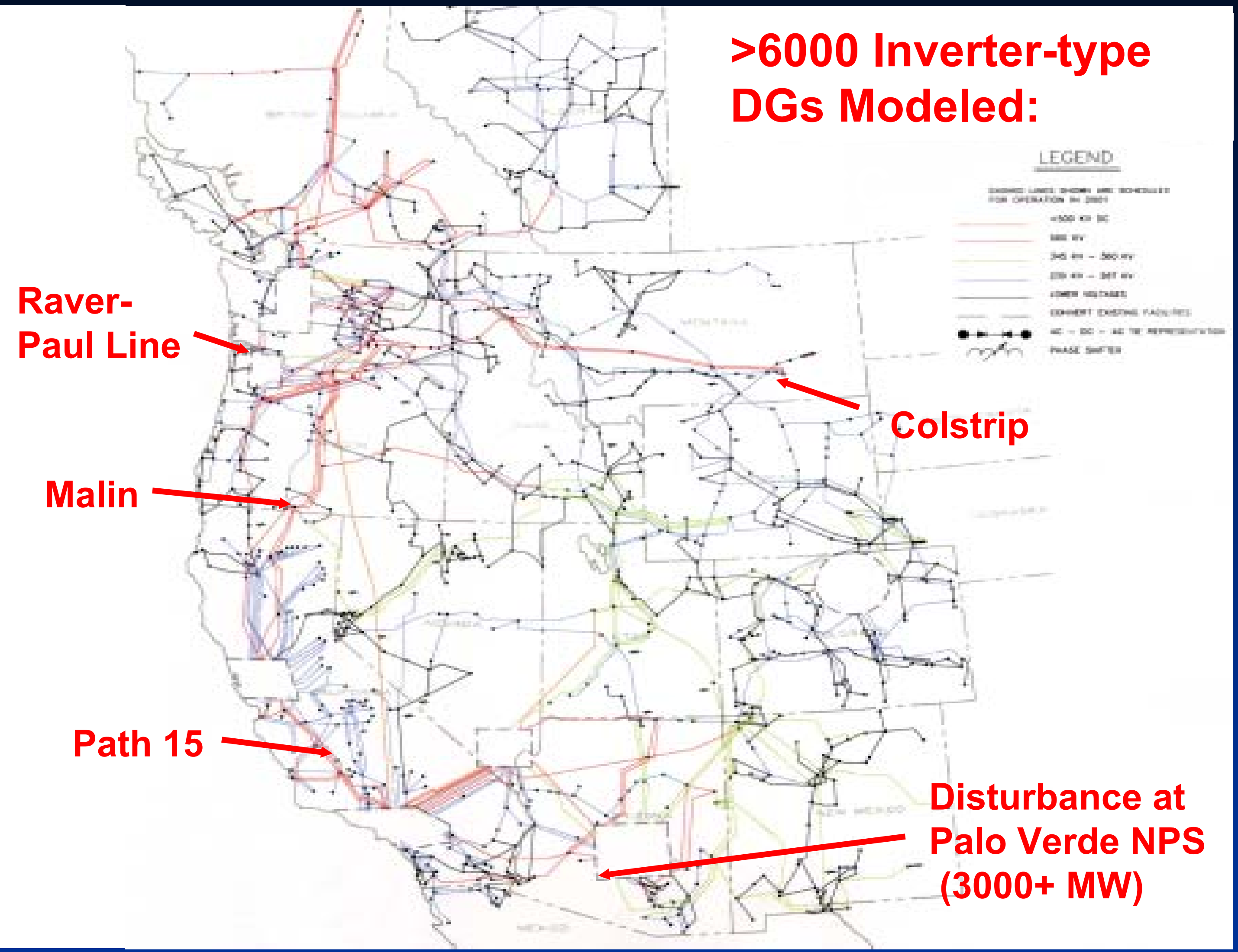
Bus Voltage for 3 Different DG Responses to a Minor Fault

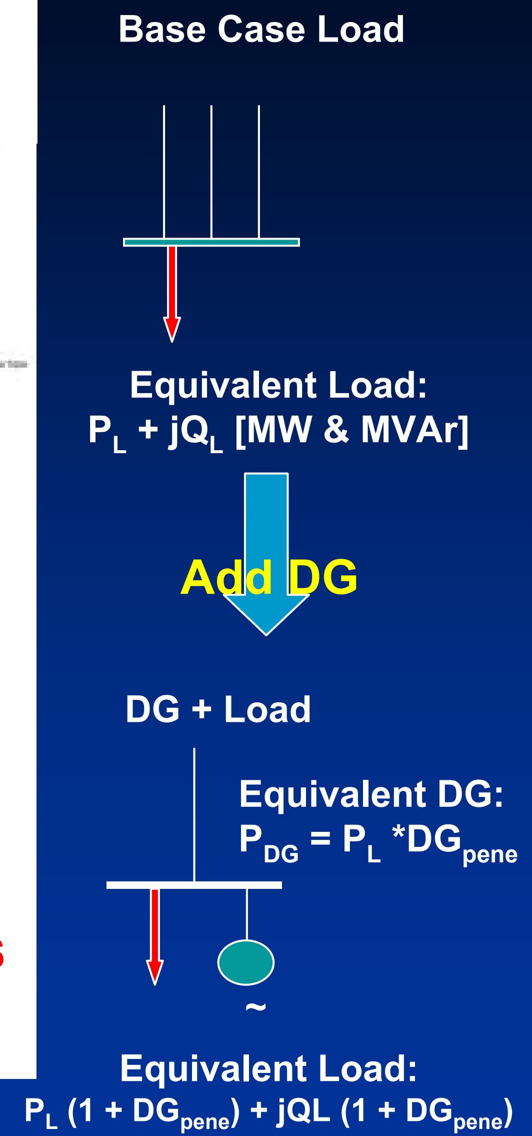


Illustrative Case:

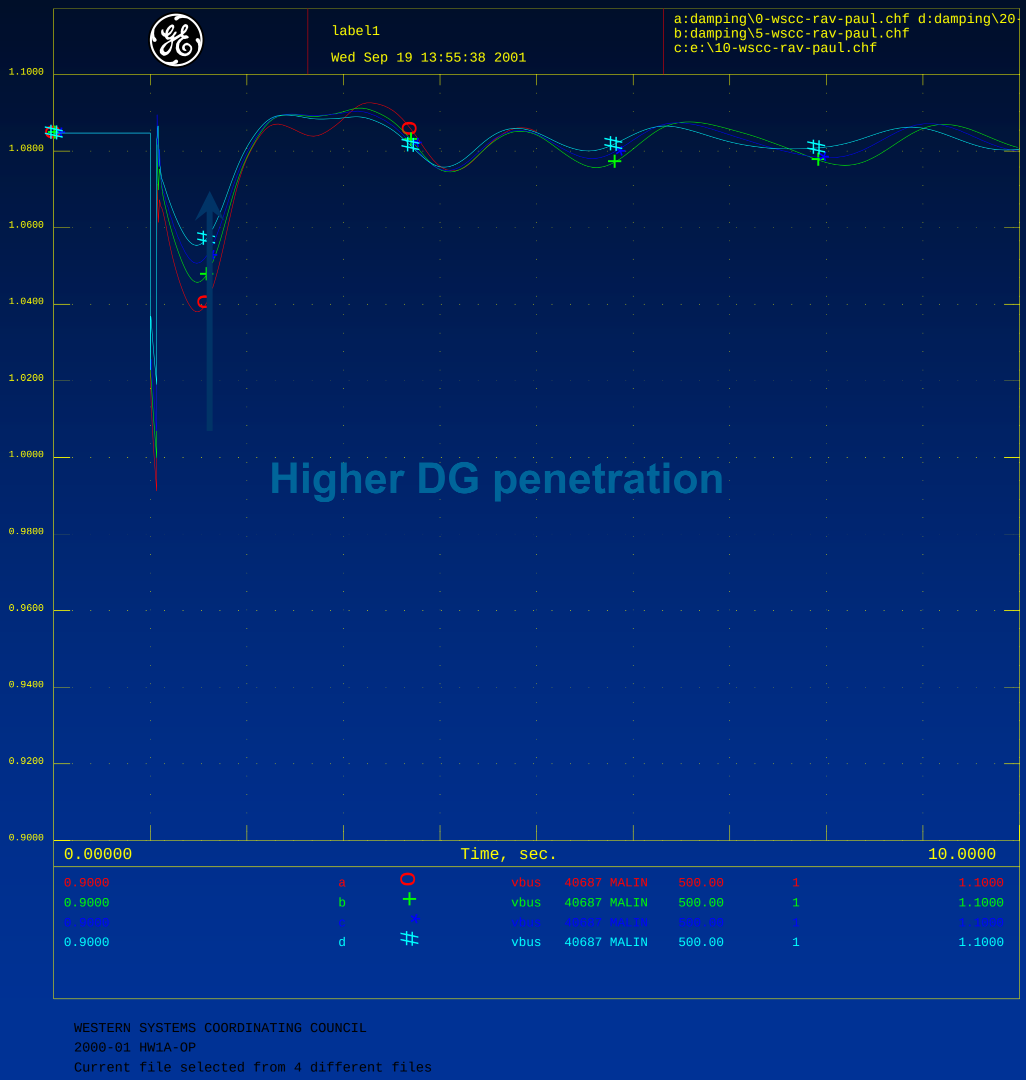
- All DGs remain on line when fault clears (red)
- Small DGs on Feeder #1 trip during fault (green)
- All DGs on Distribution System trip during fault (pink)

DG Impact on Bulk Power System





Bulk Power System Stability

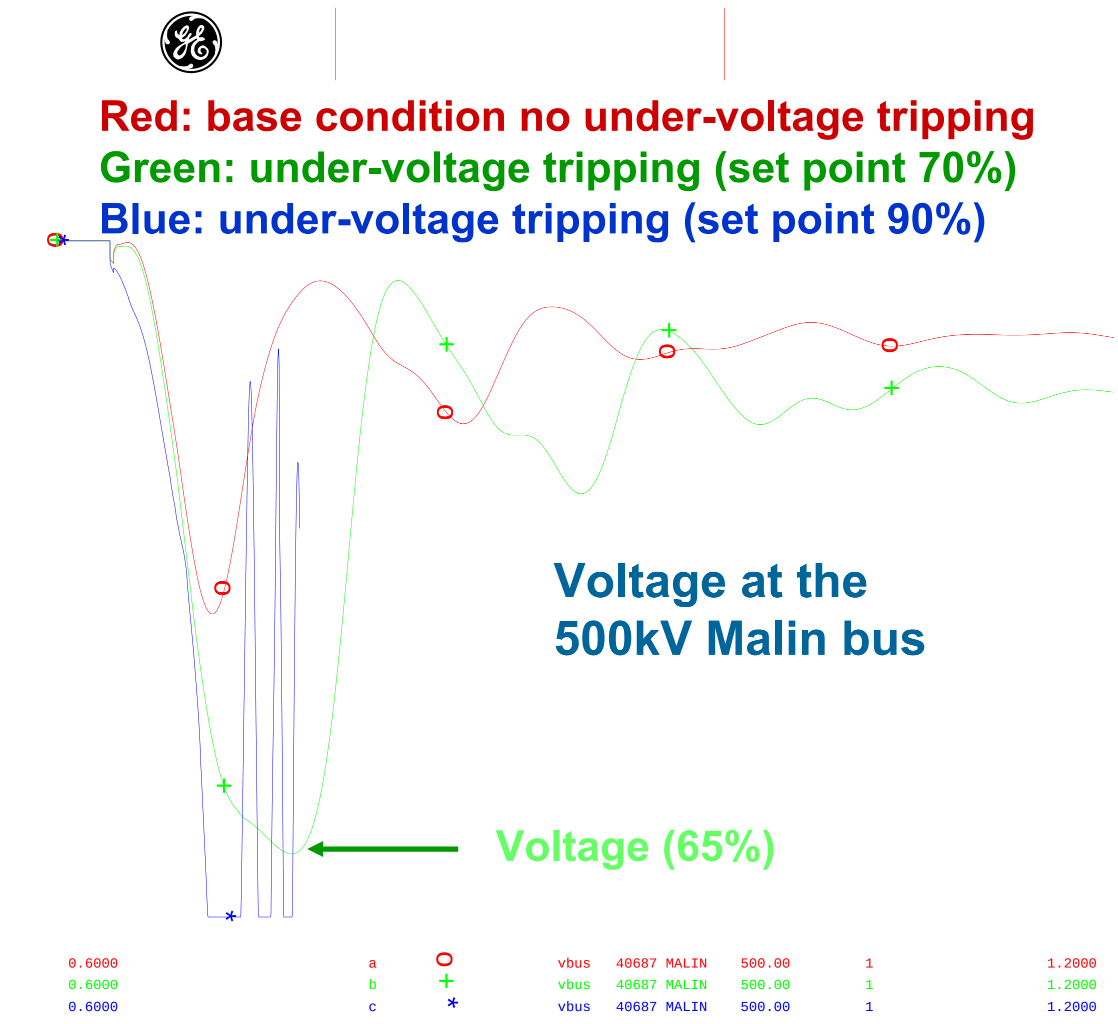


Response to 500kV Line Fault and Trip:

- The case with DG and much higher system loads shows better dynamic response than the base case. (Less excursions and better damping)

- The case illustrates that if widespread deployment of DG occurs *at the loads*, as would be expected, the potential impact on system dynamic performance appears to be beneficial.

DG Low Voltage Tripping Impact on Stability



(20% DG penetration)

- Most new DG standards dictate disconnect for voltages <70% for a specified period.
- These documents specify the *minimum* voltage and the *maximum* time to trip.
- DGs will be in violation if they trip slower or at too low a voltage.
- DGs may trip faster and at higher voltages than this without violation.

The case with the sensitive trip point is very unstable

Summary

- GE interconnect system project is performing crucial investigation of DR impacts on power systems
  - *Quantitative insight into the critical questions*
  - *Some concerns found to be "non-problems"*
- Results are useful to the industry in defining interconnection standards
- The "surface has been scratched"
  - *Fertile ground for further investigation*

Making the correct choices now provides for the future of DR