Arizona Corporation Commission
Distributed Generation & Interconnection Workgroup Meeting

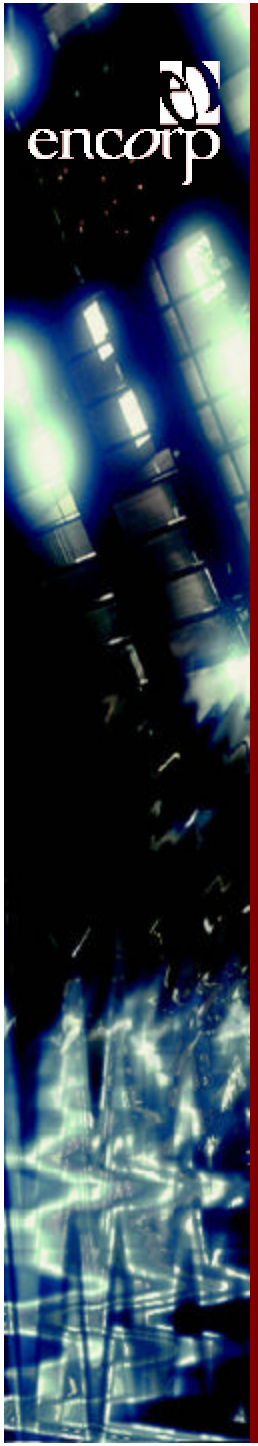
The Business Case for the Virtual Power Plant

Phoenix, AZ - October 25, 1999

Scott A. Castelaz
Vice-President of Marketing & Corporate Development
Phone 312-945-3036 Email castelazsa@encorp.com

Why Are We Here?

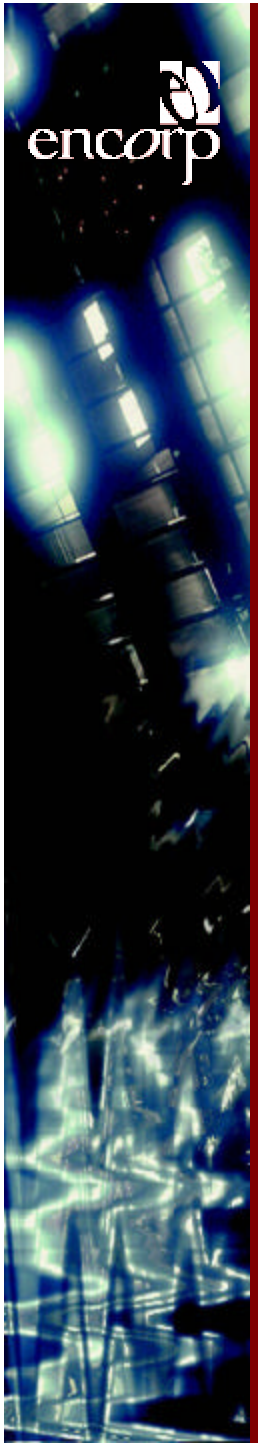
To Discuss the Adoption of ‘Smart Energy Technology’ and Related Interconnection Policy Issues & Impacts



Why is This Important, You Ask?

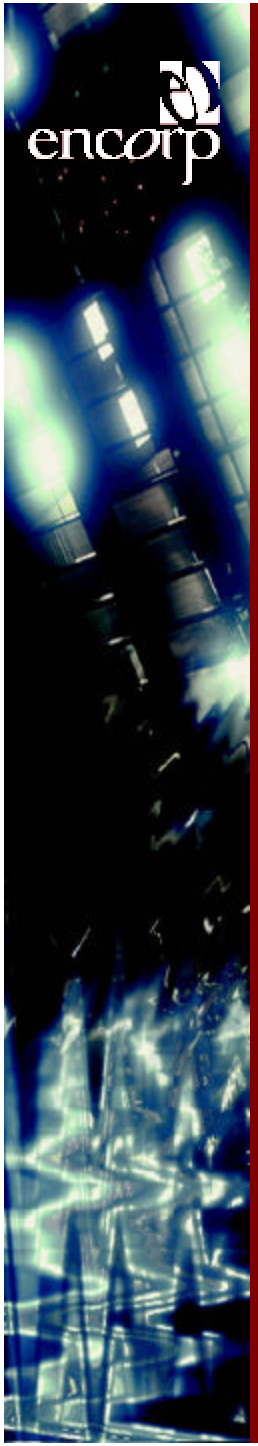
1) Spurs Industry Innovation to Value-Based Solutions
2) Increases Competition Among Suppliers
3) Enhances Customer Choice
4) Information - Based Technology will be the Foundation of the "New Energy Millennium" - IT is already becoming the basis for business in all of society

The Internet Meets the Electron!



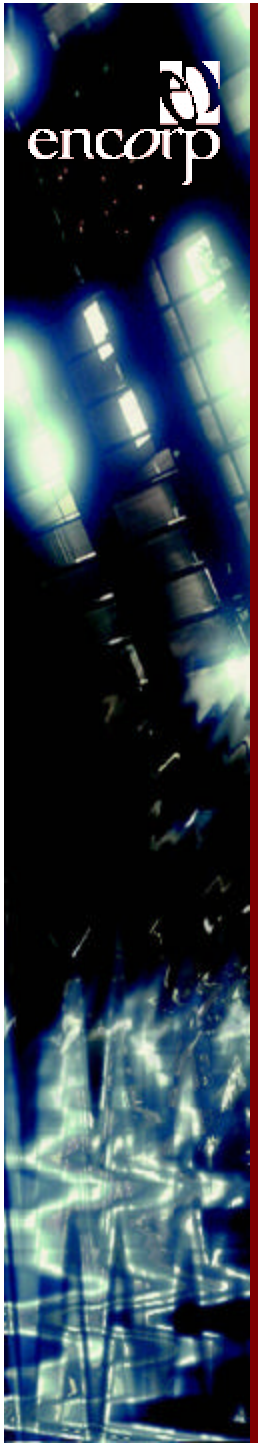
Agenda

- Overview of Virtual Power Plant (VPP) Market Drivers & Grid Interconnection Issues
- DER & the VPP as a Disruptive Technology
- The VPP Value Proposition
- Applications & Solutions



Watt's the Big Deal?

- Tales From the Dark Side - *How's your Grid's Available Peak Capacity this Summer?*
- **Technology innovation + regulatory reform + customer choice are market drivers**
- **New Infrastructure for New Business Model**
- **Interconnection is a Barrier Whose Time Has Come - Birthing Process Without Learning Curve!**
- **Policy Activity on Geometric Rise**



Back to the Future?

- *"Almost every generally accepted view was once deemed eccentric or heretical."*

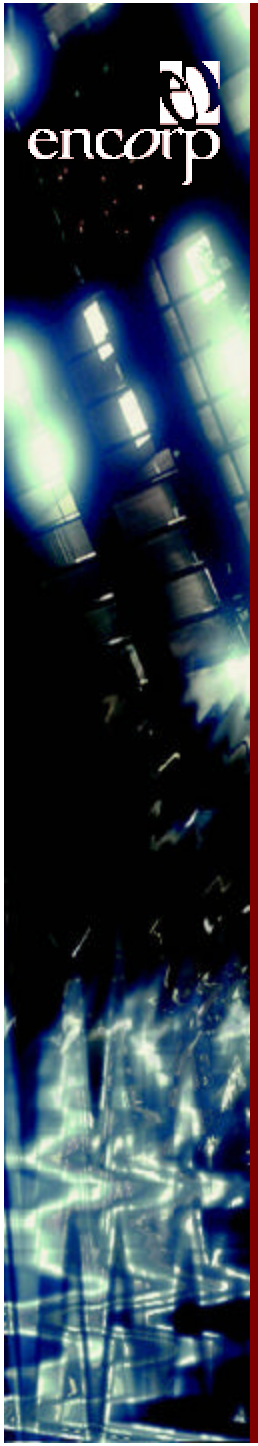
- Stephen Jay Gould, and other leading scholars

- *"A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it."*

- Physicist Max Planck, Scientific Autobiography and Other Papers

Other Brain - droppings:

- ***IBM & DEC on PC's: They're Just Toys!***
- ***Compaq acquisition of DEC: Are PC's driving the market now?***
- ***Conventional belief on FedEx: Who Wants Cheap Overnight?***



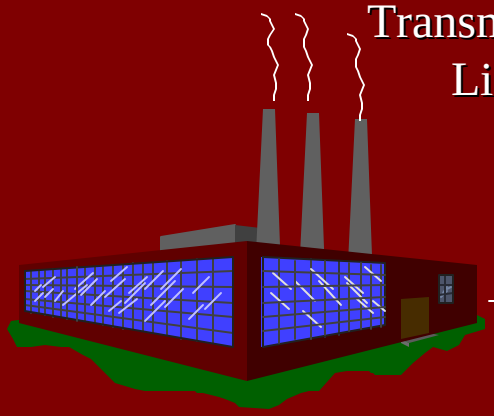
Today's Grid Characterization in North America:

- One-way flow of electricity from source to end use, in general
- Central generation tied to local distribution islands
- Follows Laws of Physics better than Laws of Supply & Demand

Commodity orientation, not value-focused or market-based allocation of T & D investment >> Leads to Under-utilization of assets & lack of true-cost basis to generate, transmit, & distribute electrons as well as ill-defined risk profile

- Legacy IT systems throughout the grid, yet critical end-use information often not captured - by design

Today's Energy Distribution to Customers



Transmission Line

S.S.

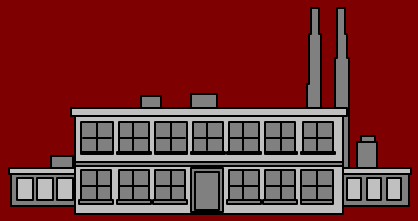
Utility Distribution Substation

Utility or IPP

Growing Constraints with today's distribution systems

Distribution Line

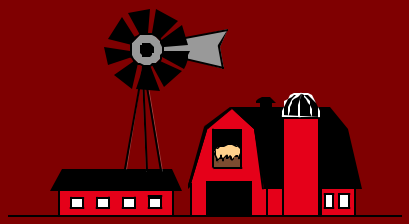
Factories



Cities

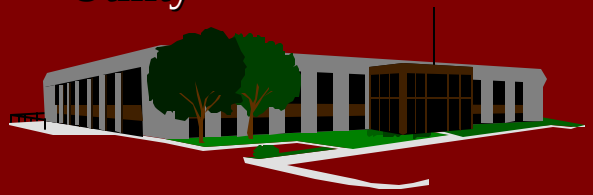
Residential

Rural

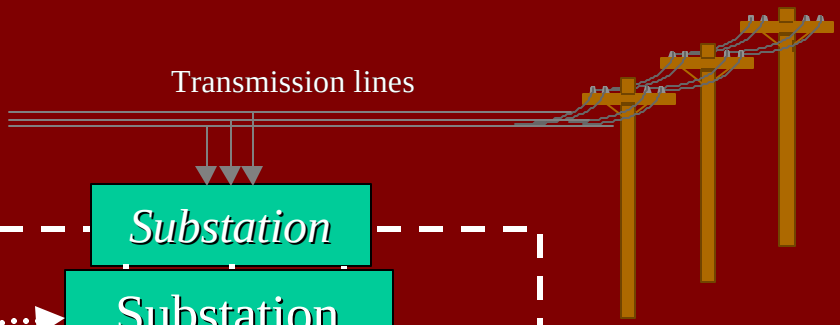


DER's Future? - Total Energy Solution

Utility



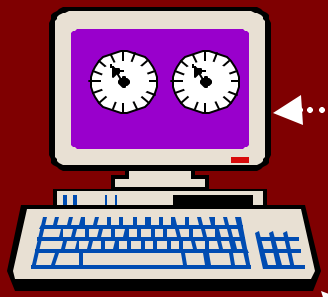
Transmission lines



Substation

Substation Automation

Protective Relays



***en*telligent™ - VPP**
Owned, operated, and administered by end user wheeling power through T & D lines.

Customer #1

load

CPM

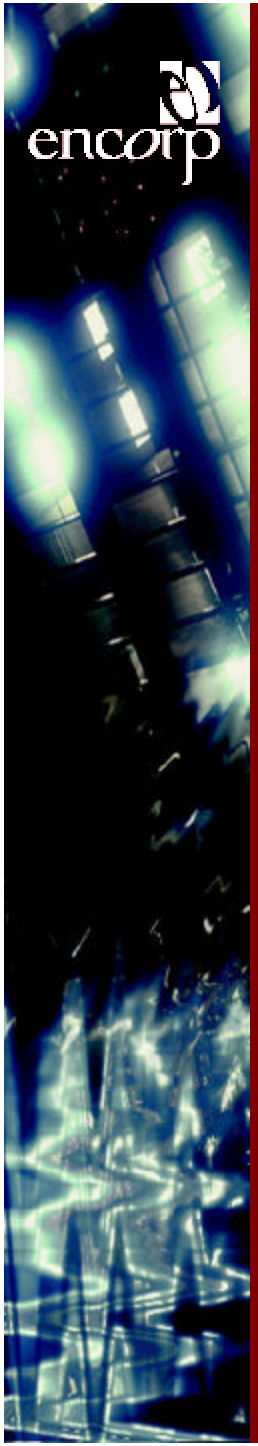
Genset

load

Customer #2

Customer #3

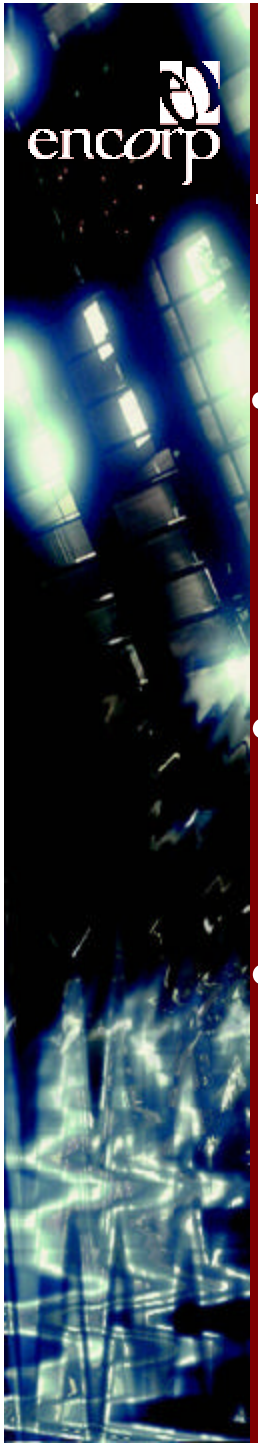
load



DER Interaction with Distribution Systems

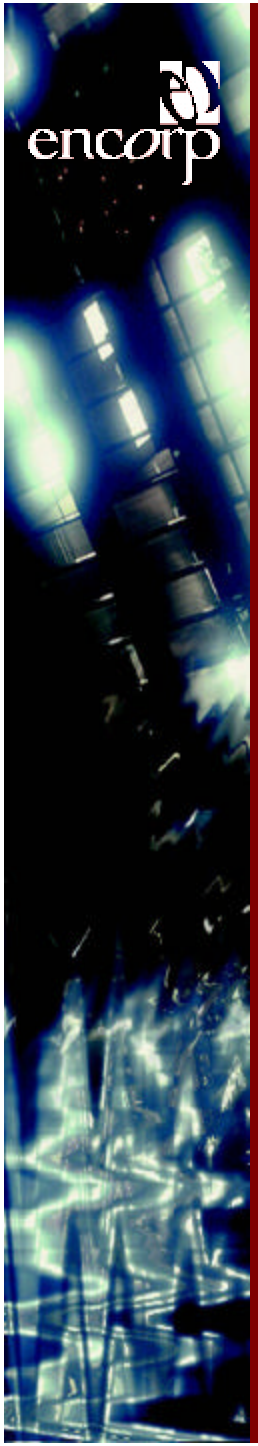
- Depends on Size, Location, & Type of DG
- 3 Major Technical Interactions
- (1) Power Flow, & Capacity Changes that result
- (2) Voltage Level
- (3) Protection Needs

- ***Not Uniform impact along the feeder - can be positive, negative, or none***



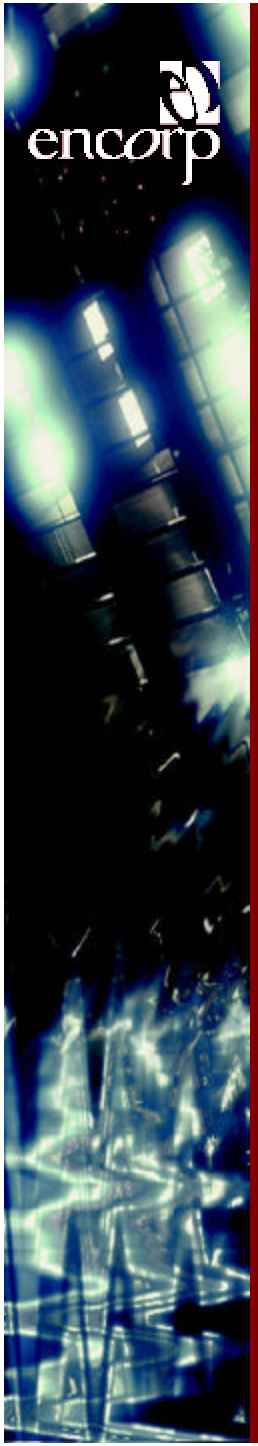
Specific Overriding Interconnection Issues

- GIVENS: (1) Both DER Site and System Safety, and (2) Reliability MUST NOT BE Compromised
- (1) Power Quality, Reliability & Stability
- (2) Safety & Protection for personnel & equipment



Basic Interconnection Equipment

- Power Transformer for generation source
- Metering
- Voltage Transformers for relays
- Visible Safety Disconnect Switch
- Communications for monitoring/dispatch
- Generator Circuit Breaker or Fused Switch
- Synchronism Check Relay (25)
- Over/Under Voltage Relay (27/59)
- Over Current Instantaneous, Inverse Time Relays (50/51, 50/51N)

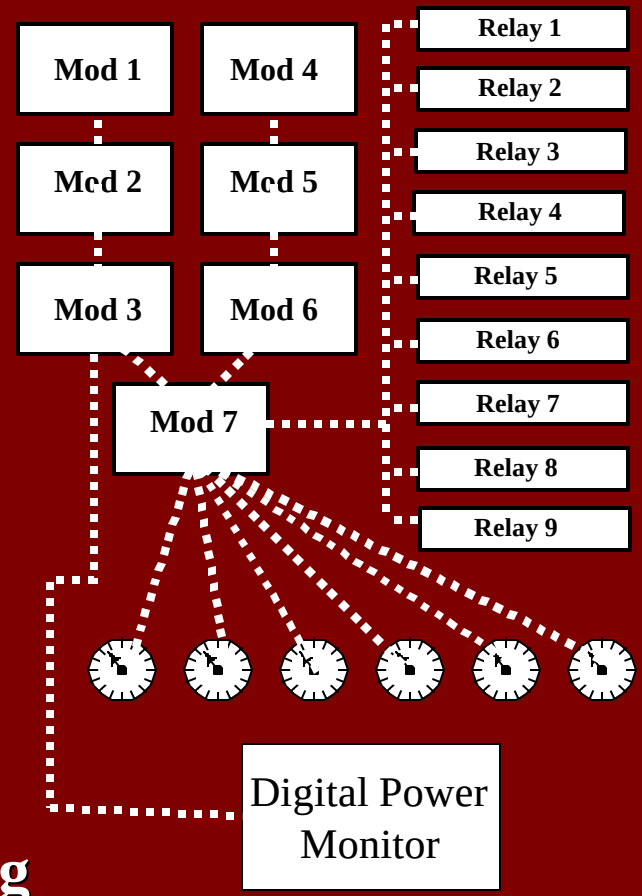


Additional Interconnection Requirements

- Over/Under Frequency Relay (81)
- Voltage - Restrained Over Current Relay (51V-R)
- Directional Power Relay (32)
- Impedance Relay with Timer (21)
- Transfer - Trip Transmitter/Receiver
- Approval from 3rd party or listing agency
- Design, Operation, & Installation Conformance to ANSI, IEEE, NFPA, NEC, IEC, etc

DER needs to be designed like a CAR, not like a Cathedral!

Traditional method



7 Control Modules

+ 9 Protective Relays

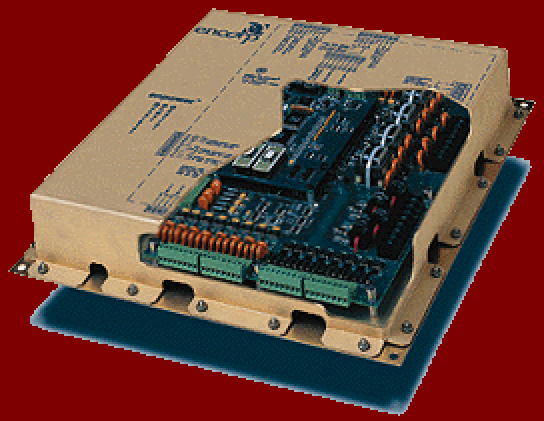
= 16 Different Modules
+ Analog Meters
+ Digital Power Monitor
+ Labor + Custom Engineering

Too much custom labor, engineering time, panel space, and trouble-shooting makes this an unsuitable "wheel " for the "CAR"

A Fully Integrated Solution of Enabling Technology is Critical to DER's Growth

Power Metering

Local & Remote PC Communications Interface

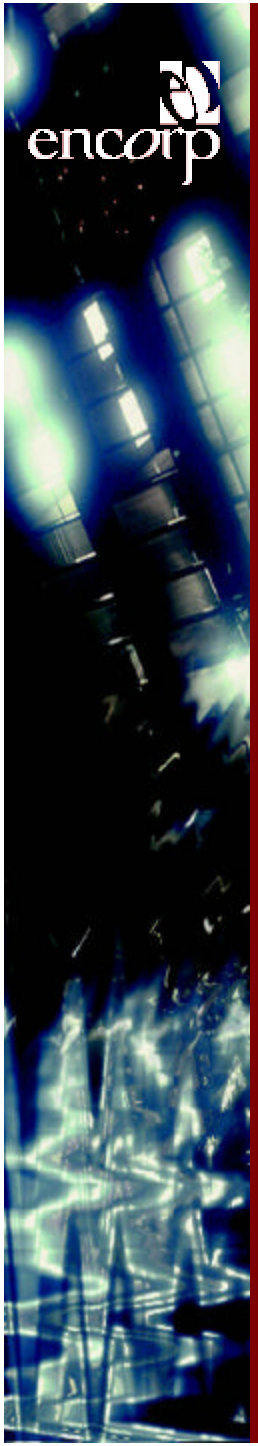


Generator Control Functions

Protective Relays

Power Quality Monitoring

Network Communications for I/O Expandability



DER & Interconnection as a Disruptive Technology & Paradigm Shift

"It's about transforming today's radial, electromechanically controlled grid into an electronically controlled, open-access, smart network."

- EPRI President & CEO Kurt E. Yeager,

Source: S&P Utilities & Perspectives Research Report

DER & Interconnection as a Disruptive Technology & Paradigm Shift

" … we failed to anticipate the dramatic impact new technology had on our basis of competition … and our ability to create value."

- CEO of AT&T, Robert Allen

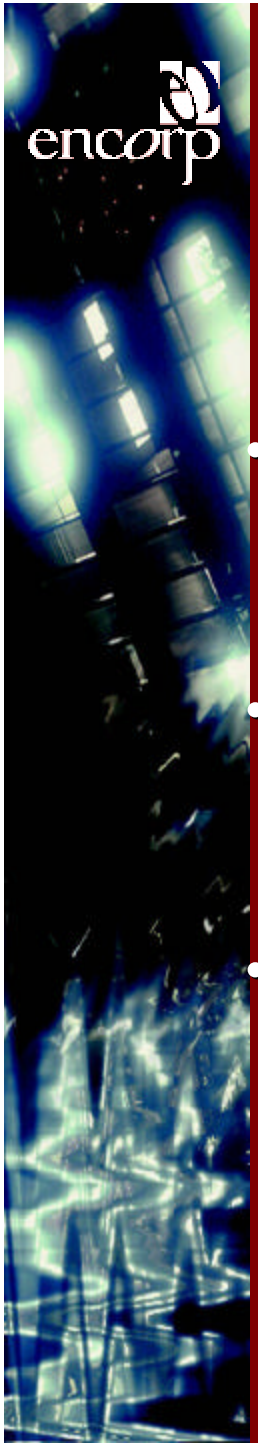
Source: Analyst's Briefing

DER & Interconnection as a Disruptive Technology & Paradigm Shift

"First, disruptive products are simpler and cheaper; they generally promise lower margins, not greater profits. Second, (they) are first commercialized in emerging or insignificant markets. Third, leading firms' most profitable customers generally don't want, and indeed initially can't use, products based on disruptive technologies."

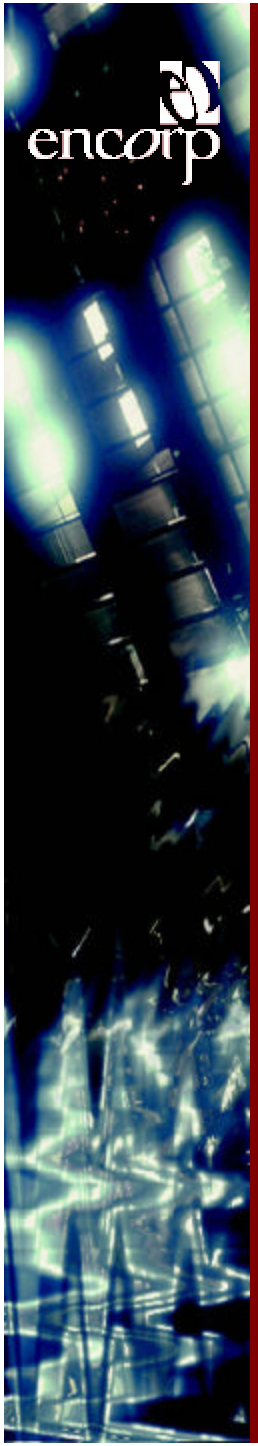
-Clayton M. Christensen, Professor at Harvard Business School

Source: The Innovator's Dilemma book



Utility Perspectives & Interconnection Approaches

- **"Standard Requirement" for an IOU is NOT the same as State - Level DG Interconnect Standard!**
- **Knowledge & Culture Create Understanding & Terminology Gap**
- **IOU/Regulator/Equipment Vendor Perspectives Are Inherently Different by their Perceived Roles in the Standard Development Process**



What criteria goes into a "standard?"

Obvious Criteria:

- **Hardware & Software Equipment**
- **Performance/ Conformance Tests**
- **Application/Functional Requirements**

But don't forget -"It's the PROCESS, STUPID!"

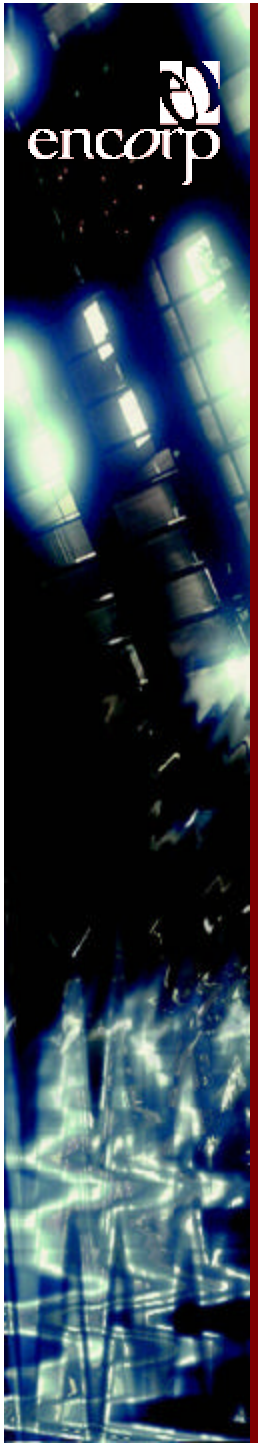
Standards are approximately 1/3 technical, 1/3 contractual/regulatory policy, 1/3 PROCESS TO APPROVE THE OTHER 2/3

How Goes The Interconnection Revolution?

- Often a case of 'Analysis Paralysis' by Castle Keepers
- We are all victims of the past!
- Inertia > Momentum: Why Change, We've been doing it this way forever?

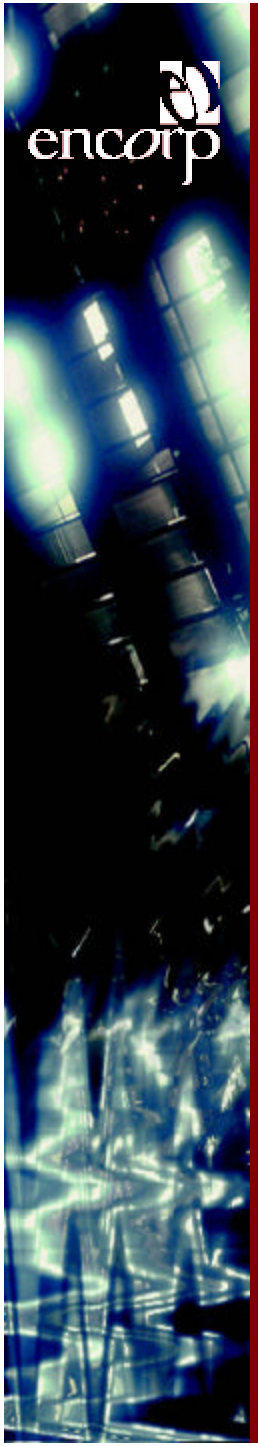
- Big Policy Gap Exists between PURPA QF Cogen Standard and "DG Energy Appliance"

- DER Still mostly a "Hobbyist" or Early Adopter Market(i.e. - it's 1978 in PC time) without a "Killer App"(i.e. - spreadsheet software in PC talk) - Just Kinks in the Armor



Interconnection Implications For DER Market At Present?

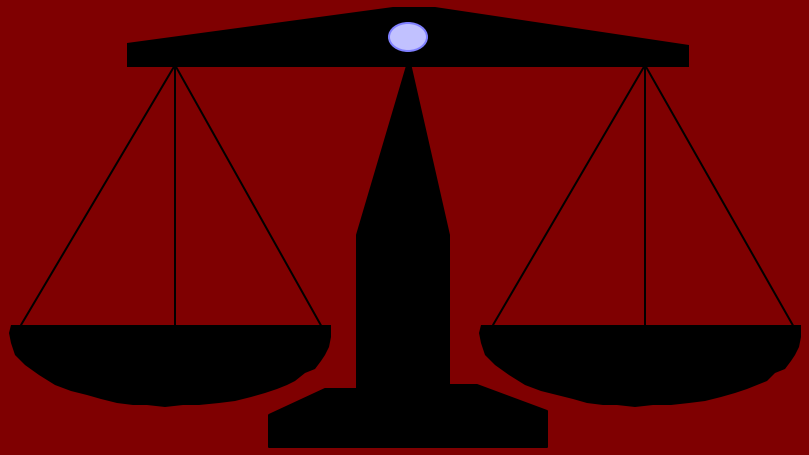
- **Local "Dial Tone", not National or even State-Wide Transparency!**
- **50 Roadmaps categorized by DG technology class (Inverter, Synchronous) and jurisdiction: Texas Fuel Cells, Calif ITG's, NY Gensets!**



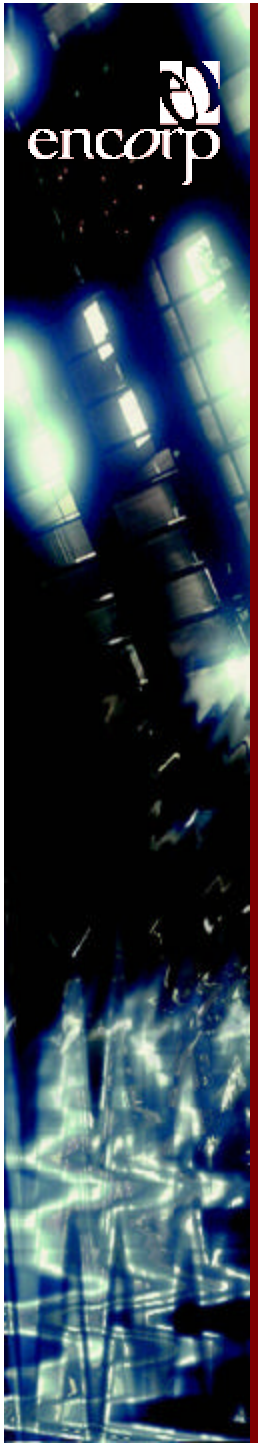
Emerging IEEE Standards

- Significant Consensus Building Leverage
- Major Effort - SCC21
- Working Groups Established at Palo Alto meeting hosted by EPRI
- Unify Over 12 Existing Guidelines Into New Standard
- Meetings every 2 months for 2 years

Regulatory Policy Issues



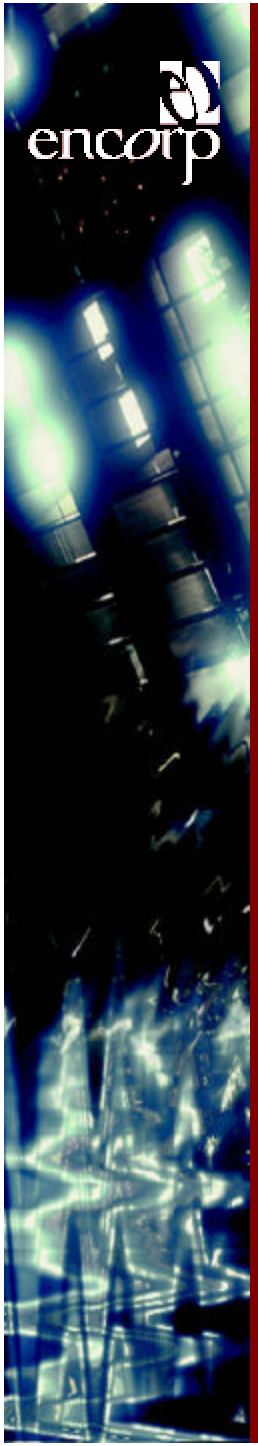
Level the Balance so DG can compete on a Fair Basis



Regulatory Policy Issues

- Removal of arbitrariness, replace by predictability& on equitable basis
- Technical & Contractual Reform
- Guidelines at minimum in near term to allow DG market a real chance
- Update the PURPA - vintage standards from merchant IPP to DG

Policy Must Change With New Learning & New Technology



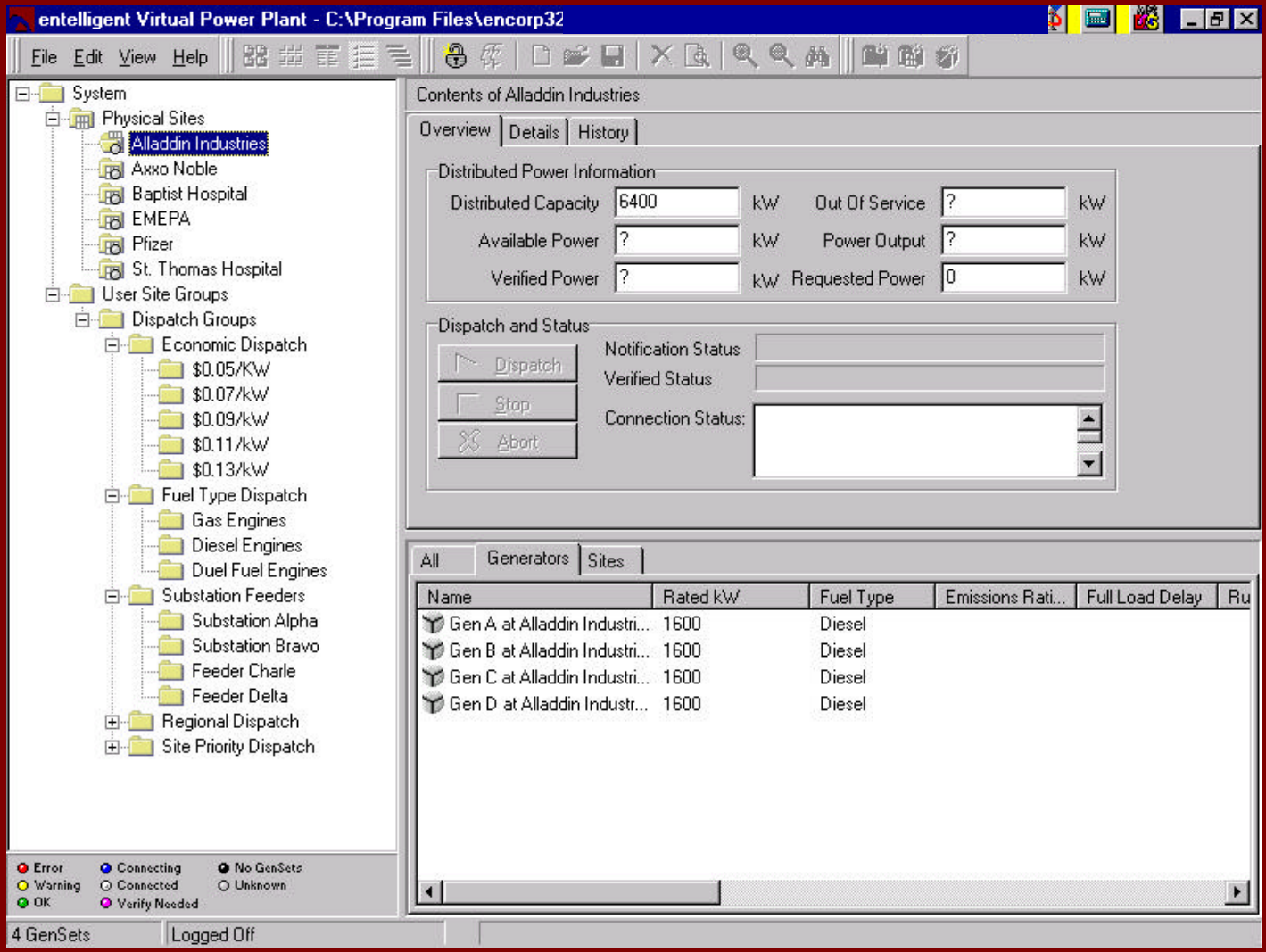
Virtual Power Plant Technology is the Key to Unlocking the Value

- Automated Aggregation Solution
- Remote Monitoring & Control
- Real-Time Economic Dispatch
- Hardware & Software Technology
- All DER Technology Applications
- Peak, Base, or Standby Capacity Use
- Utility, ESCO, Power Marketer, Load Aggregator, or End-User Markets
- Least - cost peak capacity solution

*en*telligent-VMM & VPP
Virtual Maintenance Monitor
Virtual Power Plant

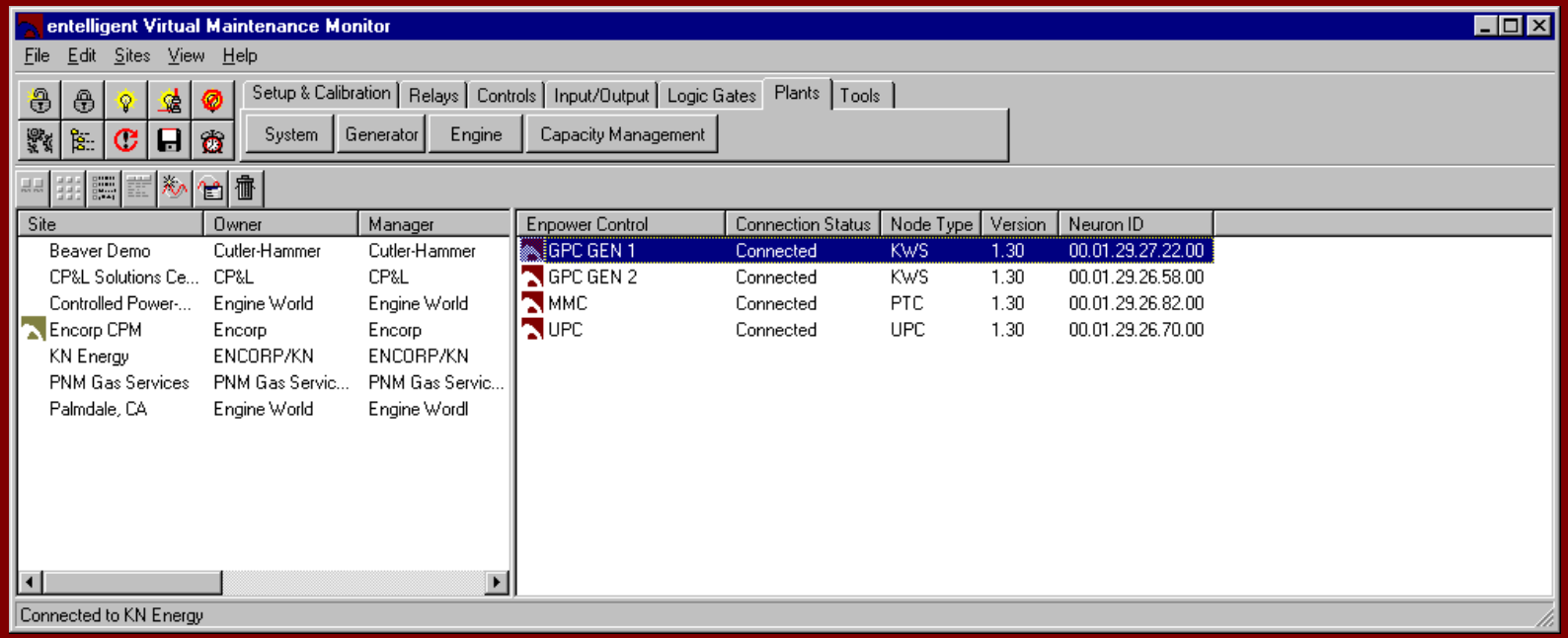
Example screen-shots

*en*telligent-VPP Navigation Screen



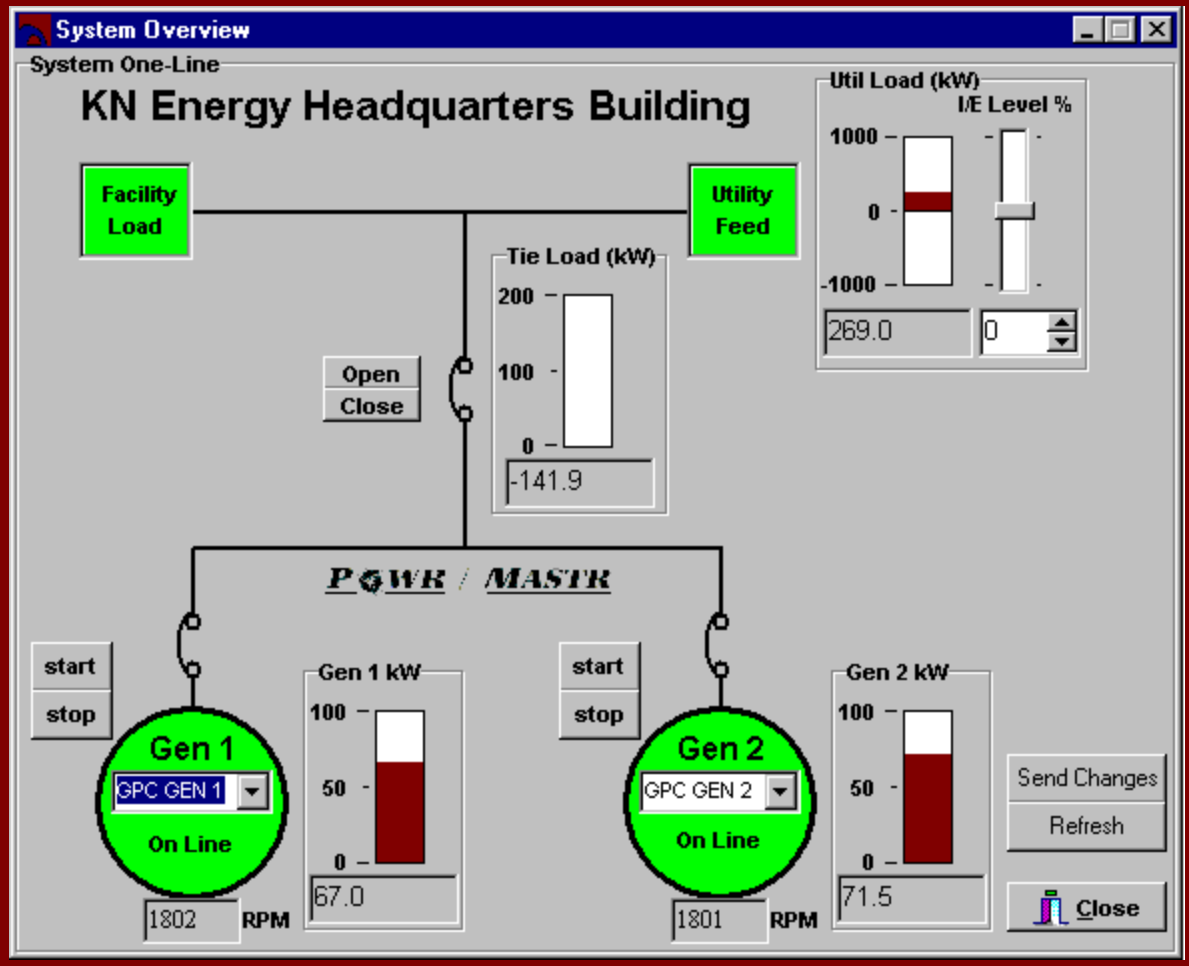
This screen creates a customized, economically optimized capacity solution for remote dispatch and real-time wholesale trading of multiple distributed energy resource sites. Groups can be defined by customer site, substation/grid location, fuel type, generation size, emissions levels, utility rates, and variable O&M cost.

*en*telligent-VMM Navigation Screen



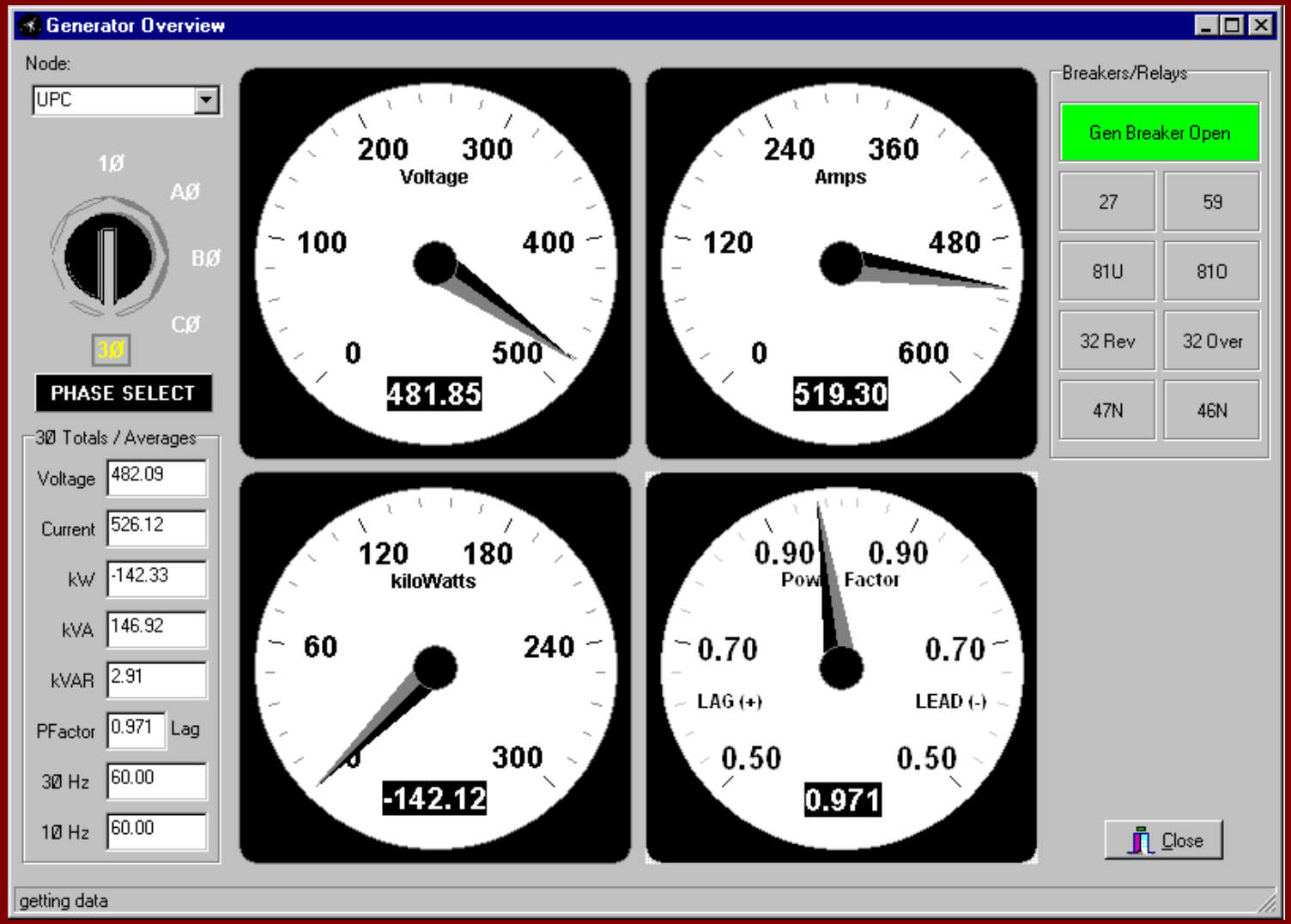
This screen is used for general navigation and site connection to single or multiple distributed energy resource (DER) site(s).

System Overview Screen



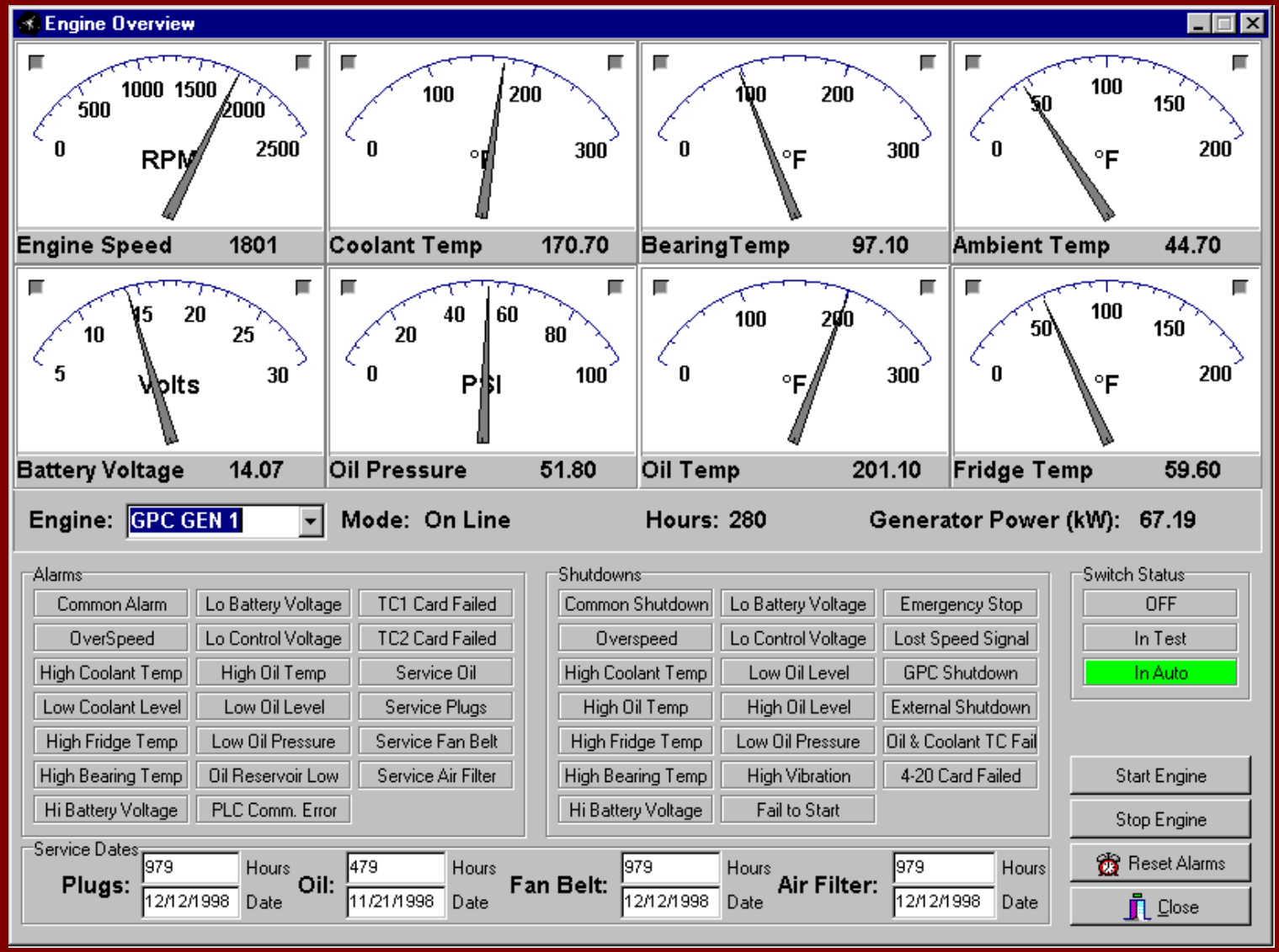
This screen shows a 1-line diagram of the currently selected DER site. Includes breaker status, generator sequence, building load and generator output. Stop/start commands are available from this screen.

Generator Overview Screen



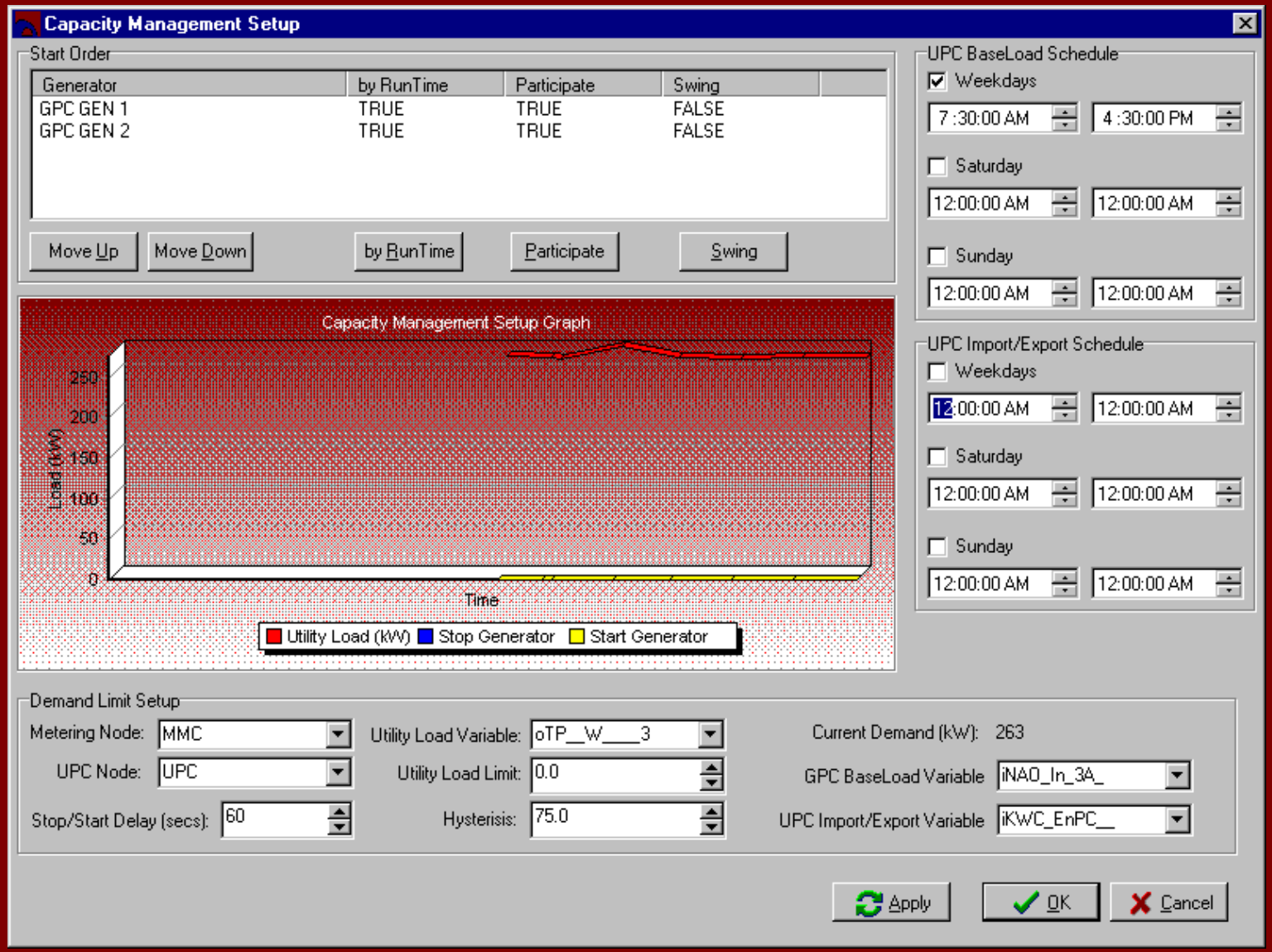
This screen shows the current generator information including voltage, current, kW, power factor and protective relay status. The user may select individual or total phase metering.

Engine Overview Screen



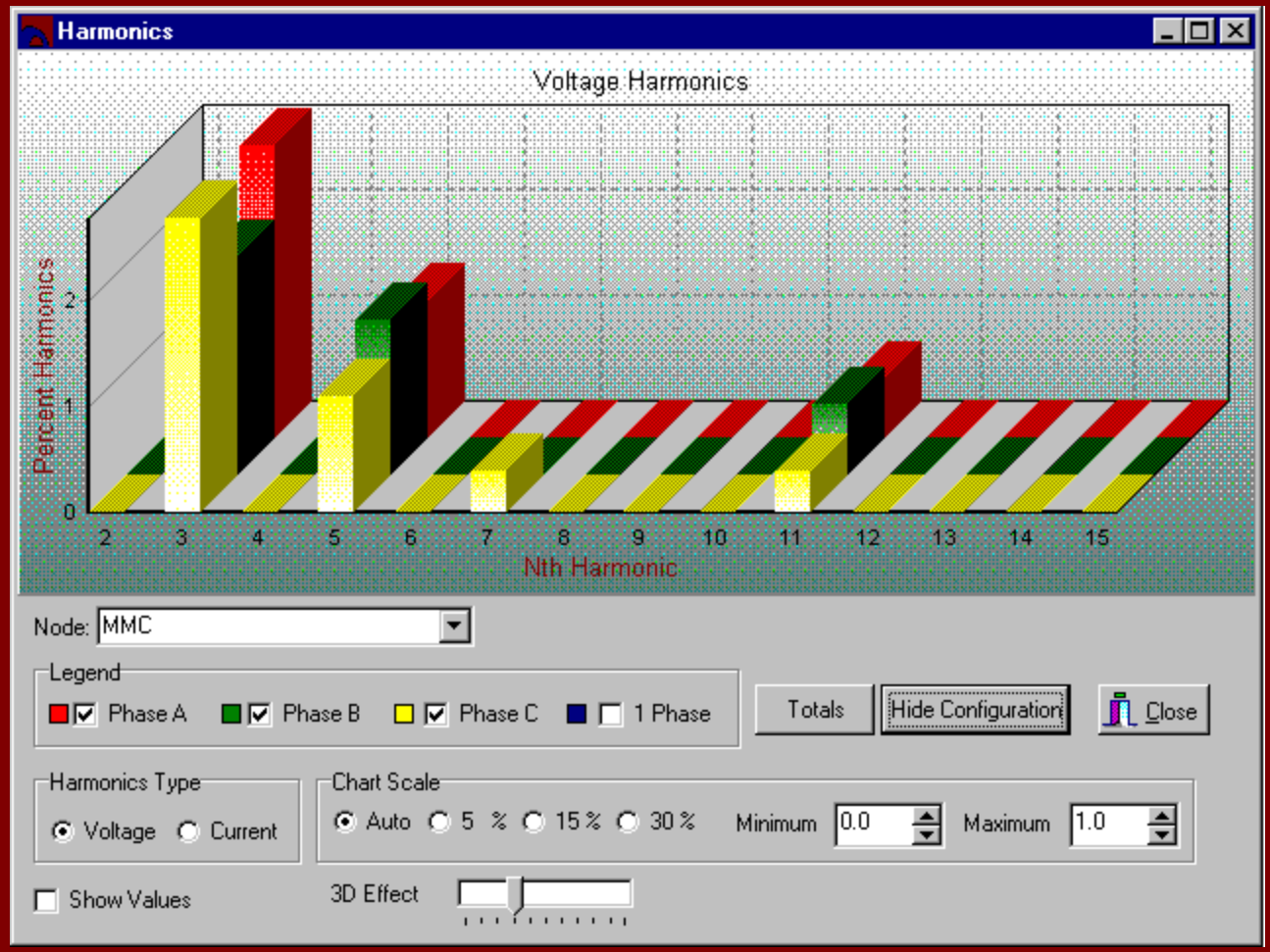
This screen shows current engine information, alarm & shutdown conditions, and maintenance & operation information.

Capacity Management Setup Screen



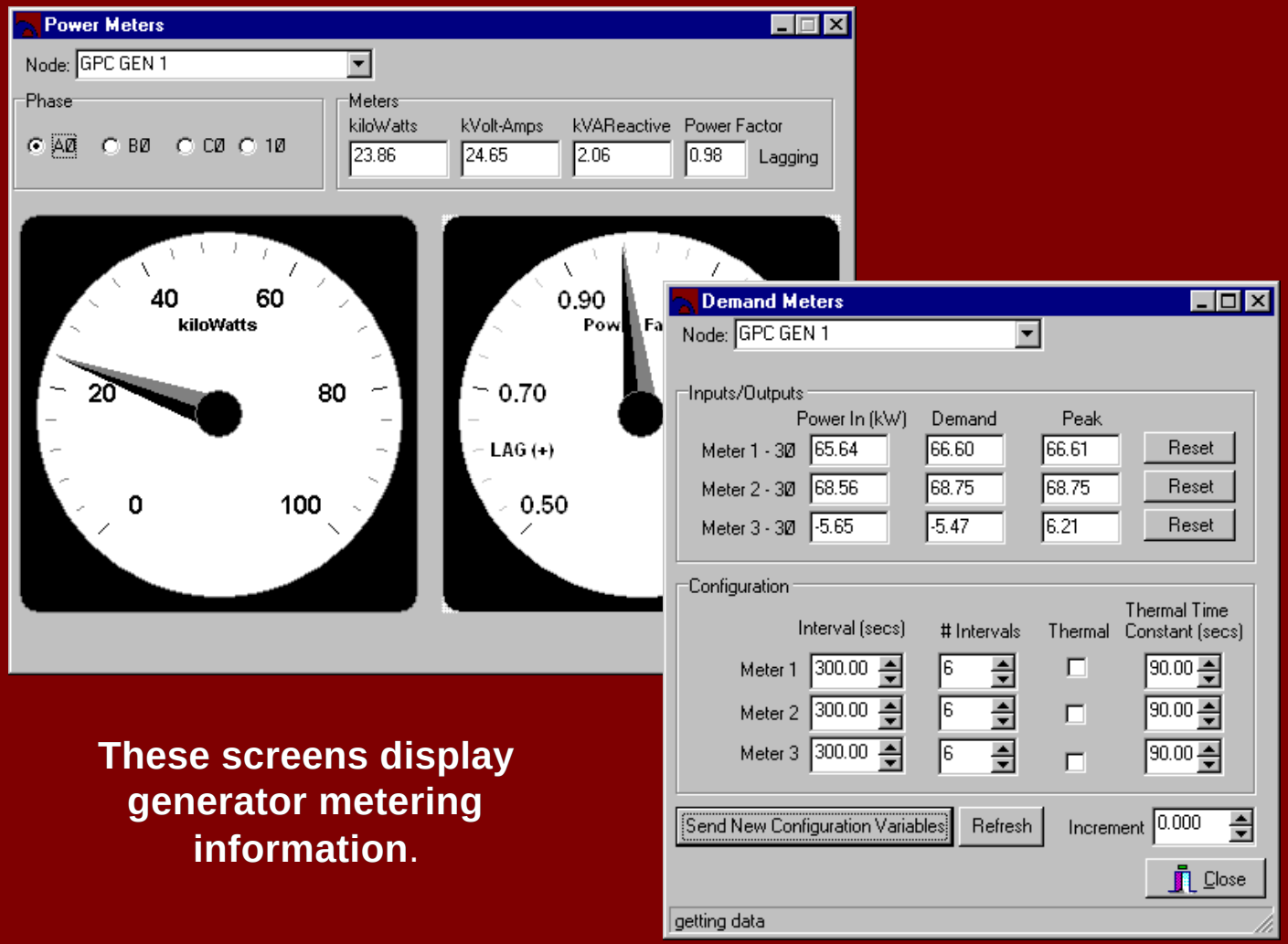
This screen allows the user to perform automatic capacity mgt based on the time of day, days operated and/or building load level.

Harmonics Screen



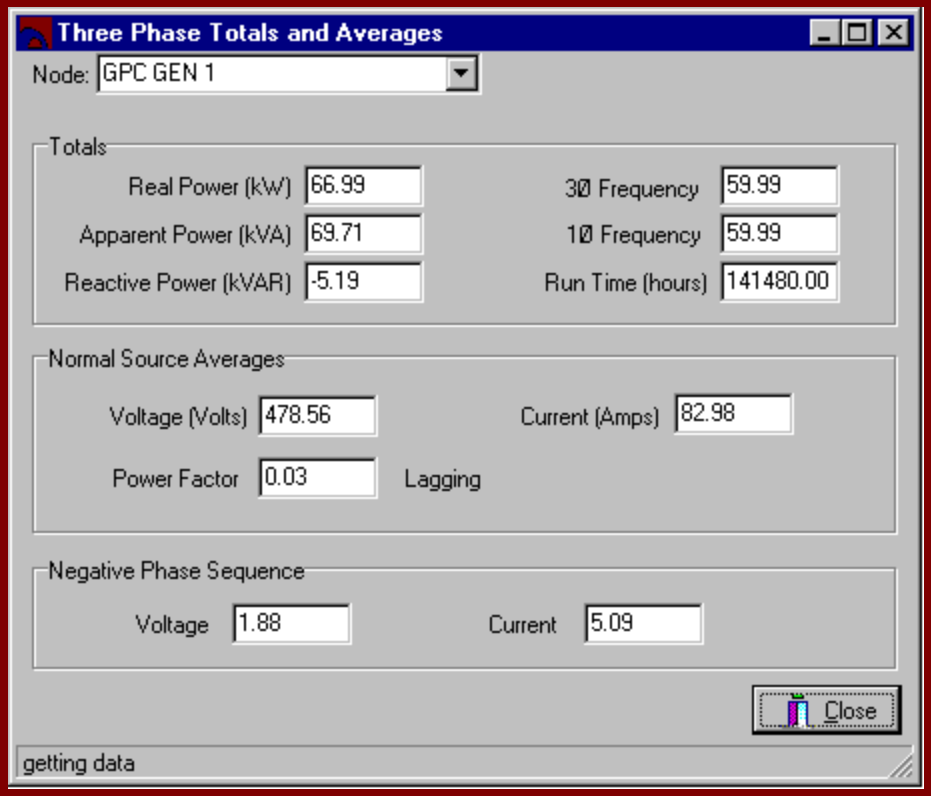
This screen displays harmonics for power quality monitoring purposes, and may display either voltage or current - up to the 15th harmonic.

Demand/Power Meters



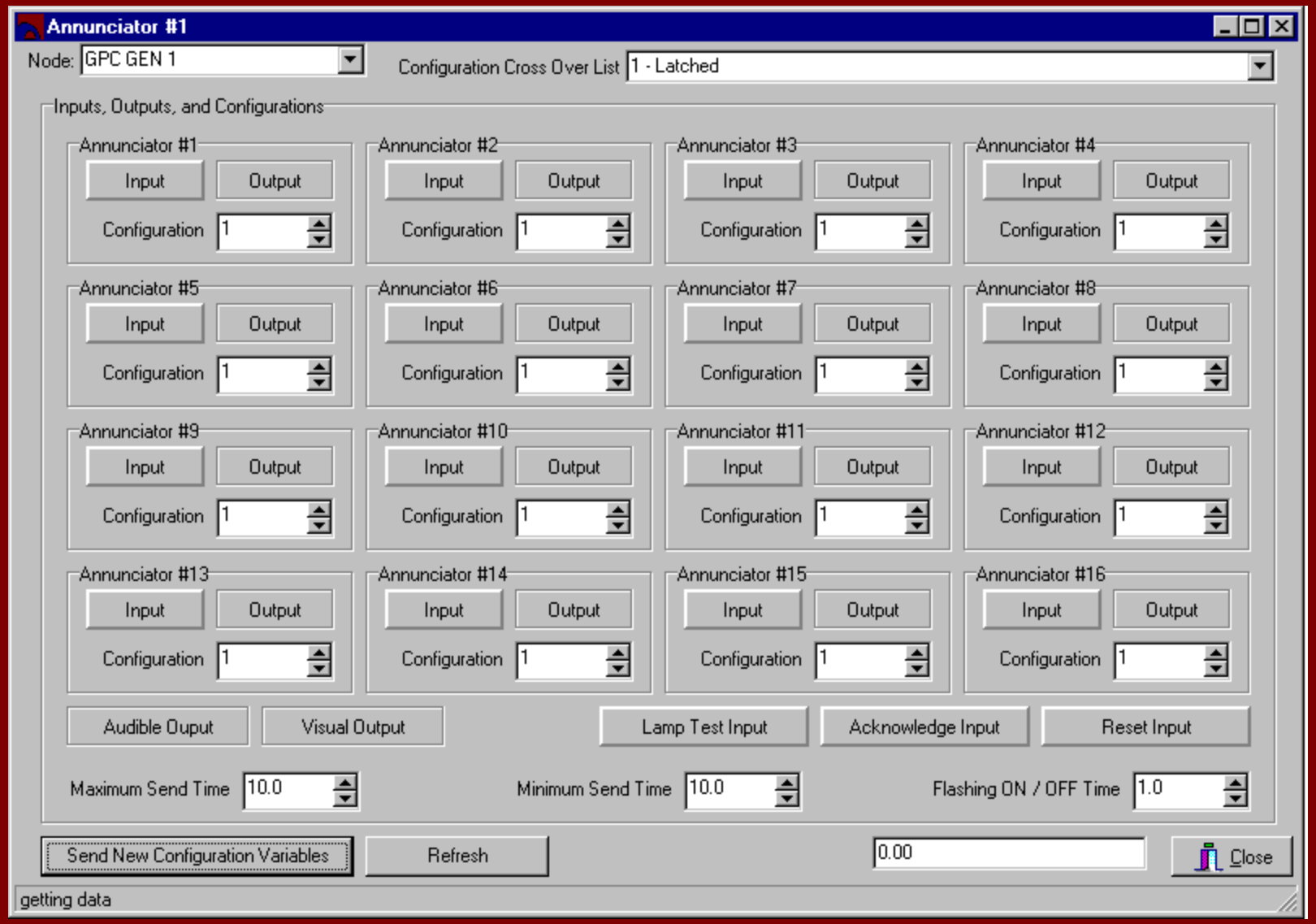
These screens display generator metering information.

Power Display Screen



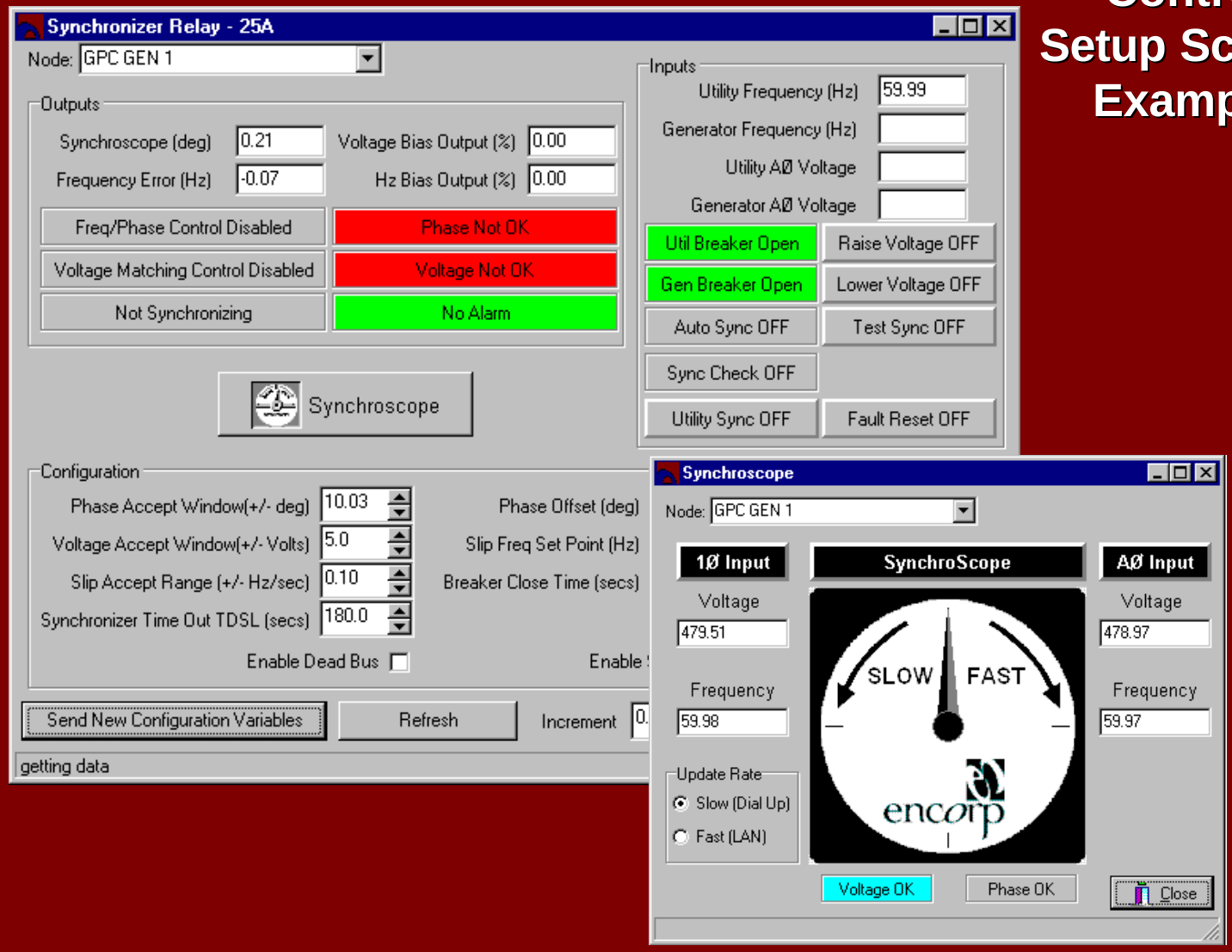
This screen shows current 3-phase Totals and Averages for selected real power (kW), apparent power (kVA) and reactive power (kVAR).

Annunciator Screen



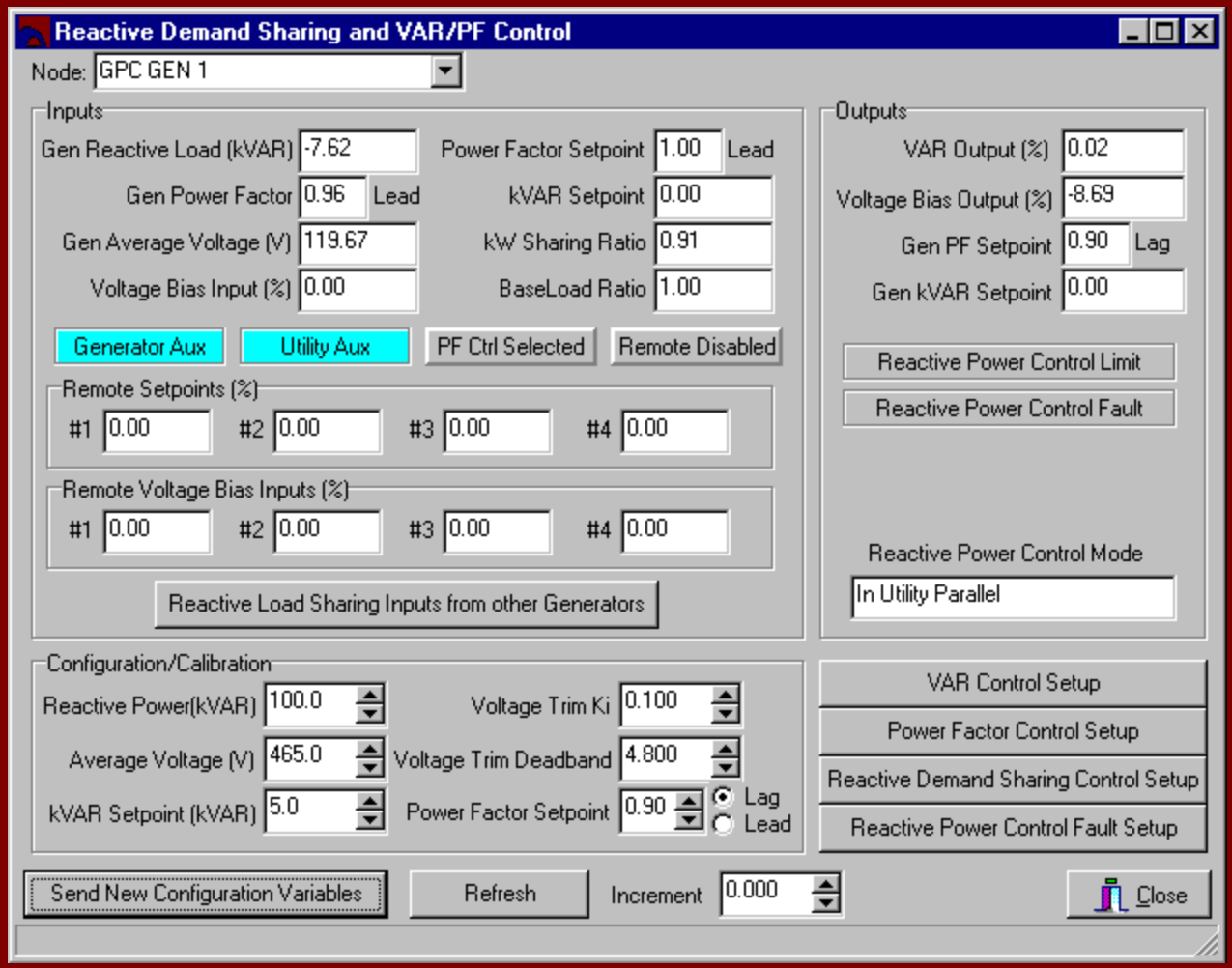
This screen displays alarms and shutdown information and can record and store variables monitored on the *en*power products.

Control Setup Screen Example



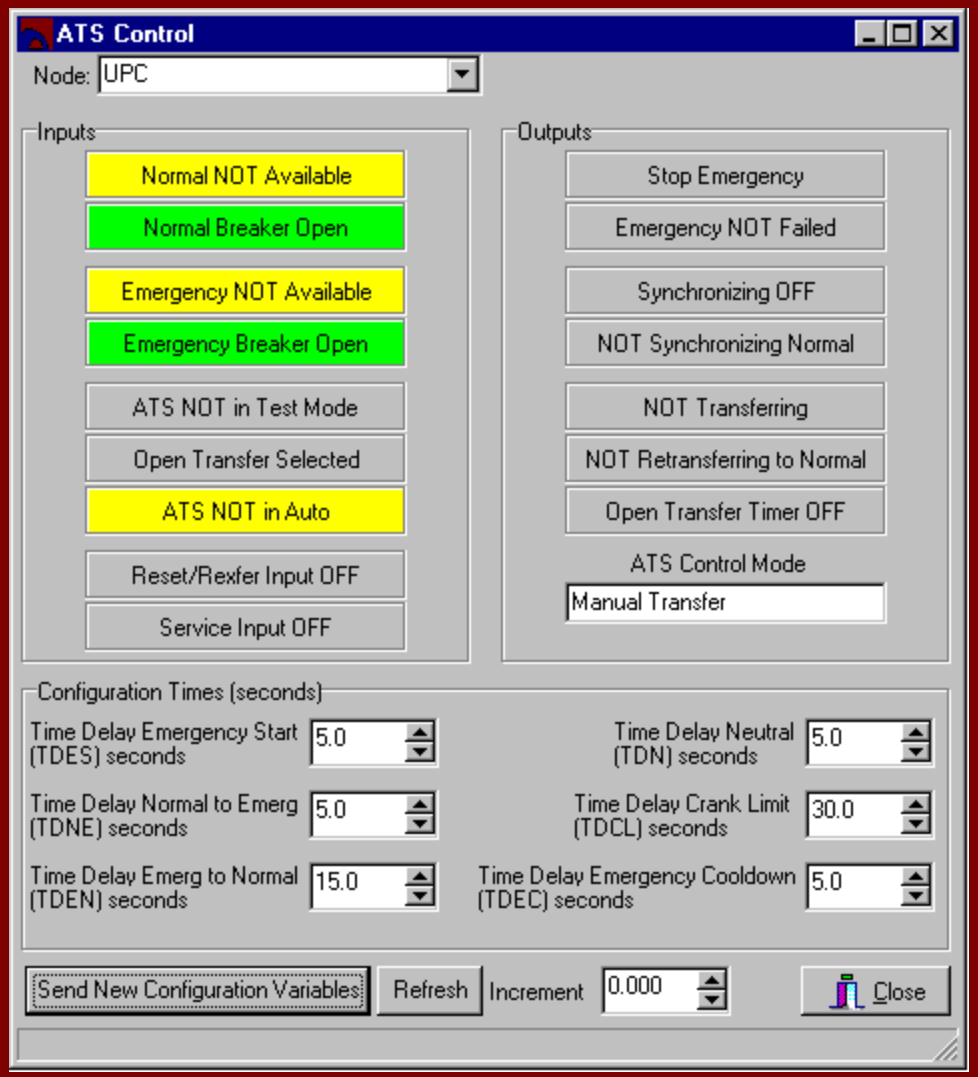
These screens allow the user to configure the synchronizing control, and to monitor the synchroscope during setup.

Control Setup Screen Example



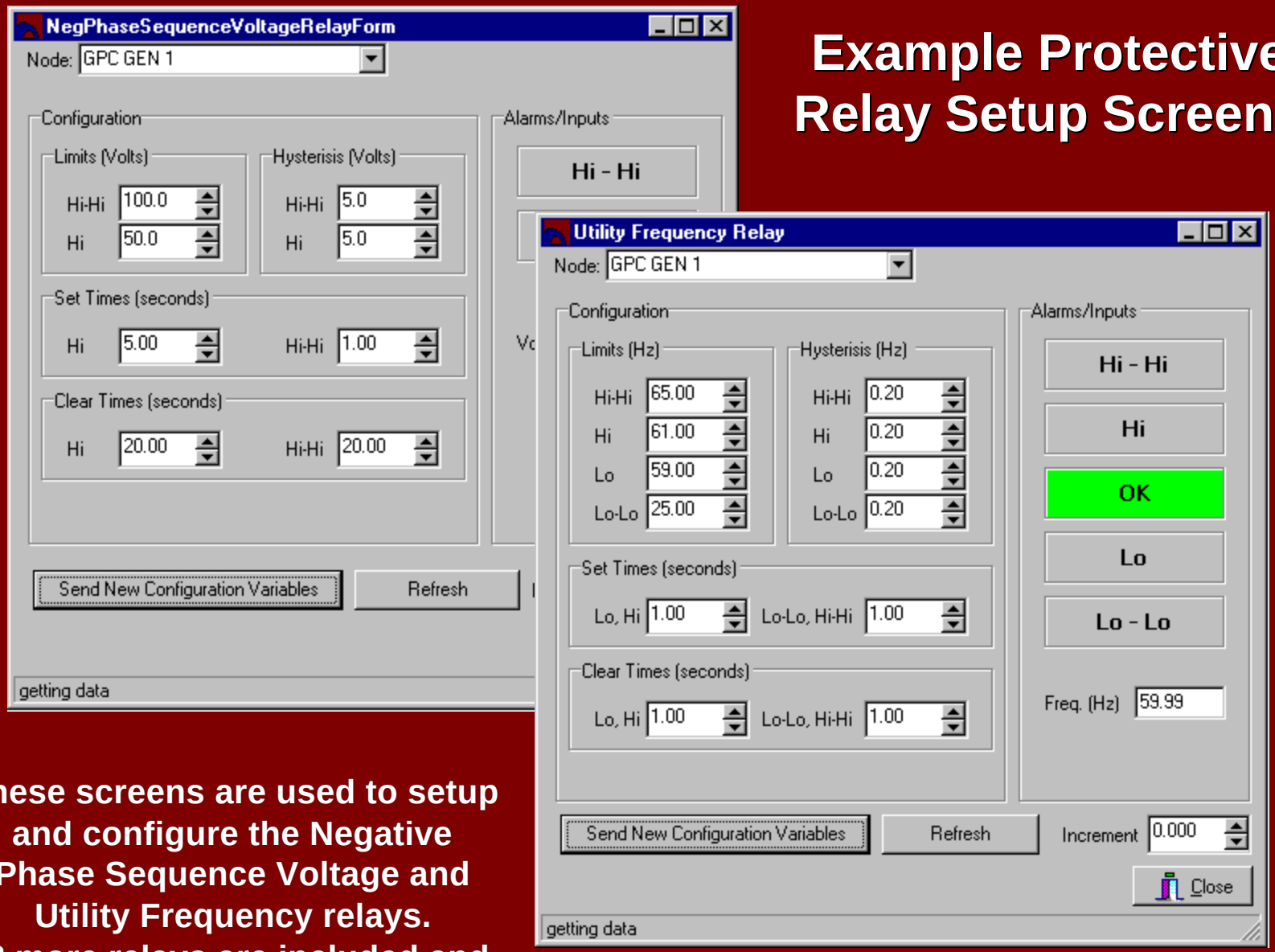
This screen is used to setup and monitor the reactive demand sharing and VAR/PF controls.

Control Setup Screen Example



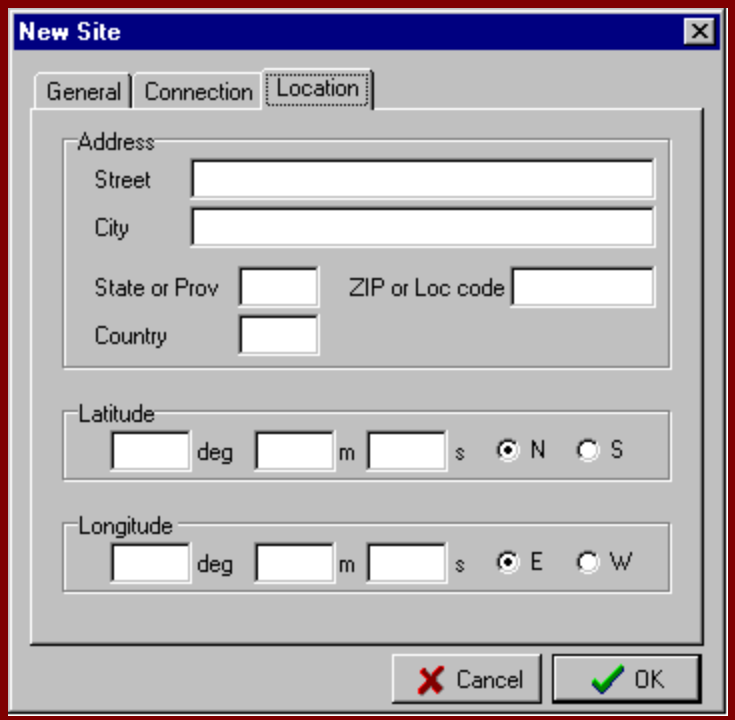
This screen is used to setup and monitor the Automatic Transfer Control.

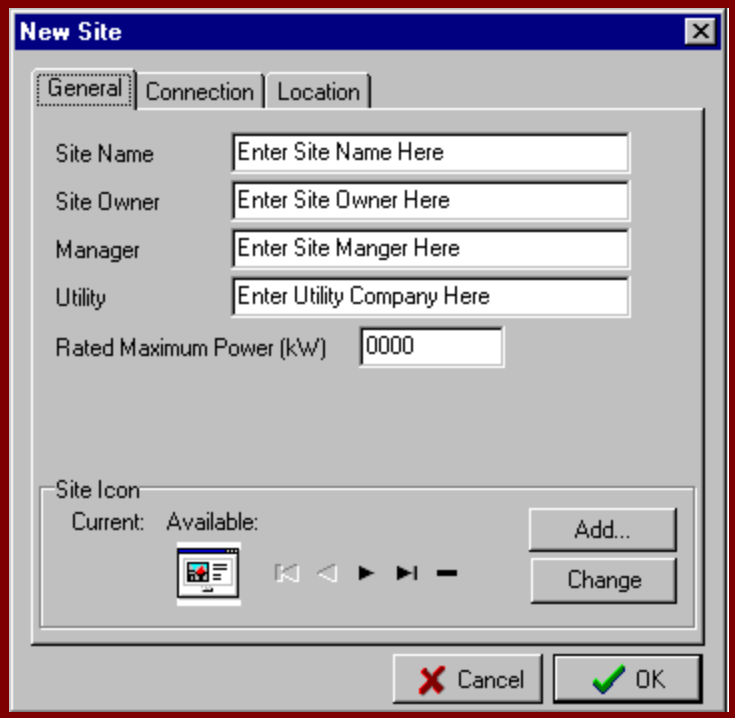
Example Protective Relay Setup Screens



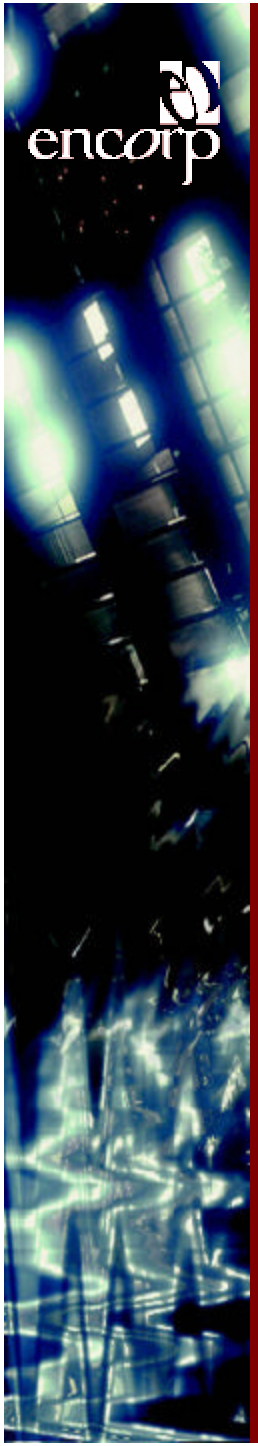
These screens are used to setup and configure the Negative Phase Sequence Voltage and Utility Frequency relays. (8 more relays are included and configurable as shown here .)

Generation Site Properties Screens



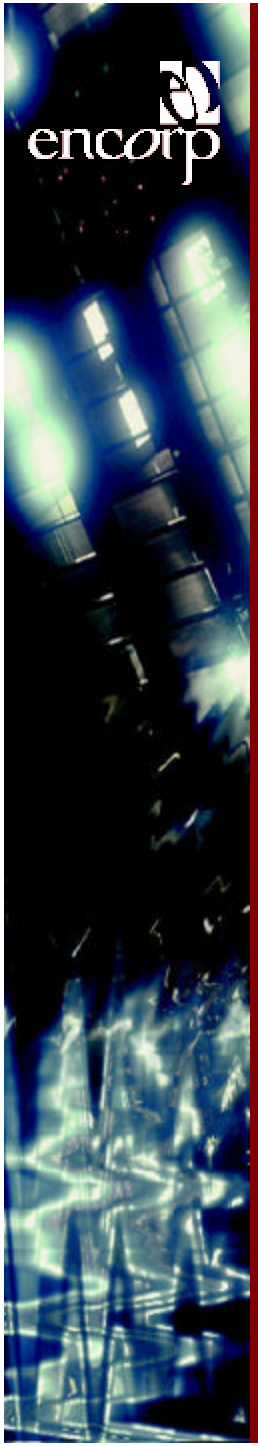


These screens are used to setup and configure new distributed generation sites.



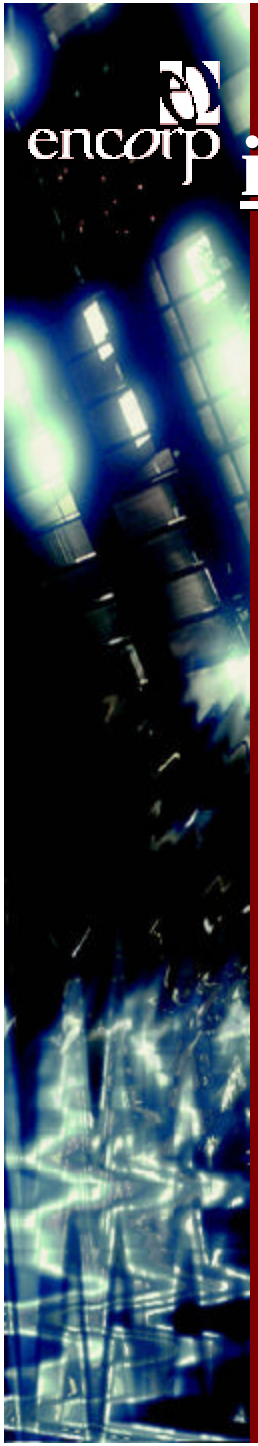
Command, Control, Communications and Grid Interconnection of Distributed Energy Resources - *What's Needed*

- **Mix of control, automation, protection and communication capability to interconnect**
- **Enabling technology that provides "Interconnection in a Box" - shrink the size, cost**
- **Scalable, flexible, intuitive, modular device = microprocessor + artificial intelligence algorithms + open protocol**
- **Technology Neutral Operation & Interconnection - Leverage across the DG technology range**



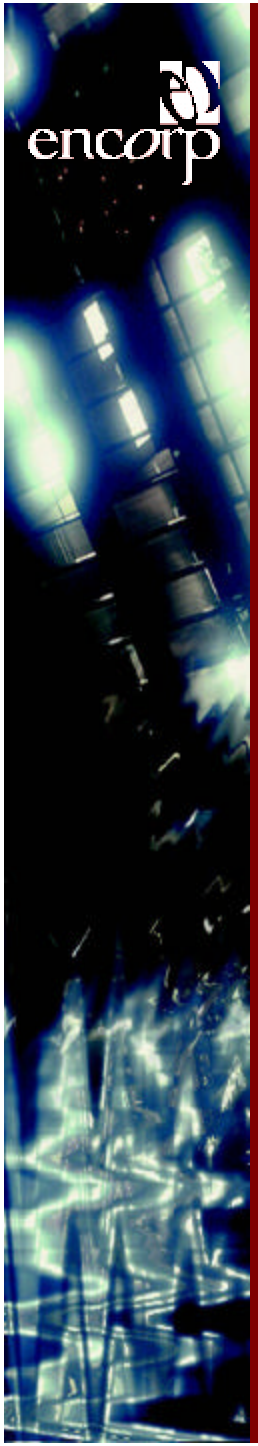
Automation Considerations for your DER or Micro-Grid Applications

- Product that address different rate structures
  - Real-time pricing, Time-of-use pricing, Coincident demand rates, Interruptible rates
- Controls that work with a variety of existing engines, generators, switchgear & PLC equipment, as well as Emerging DER Technology such as Micro-turbines, Fuel cells, PV,etc
- System functionality to address peak sharing, base load, import/export control, automatic transfer, open & close transition, soft loading & unloading of power
- Controls that communicate using current & future communication media
  - Telephone, Cellular, Internet, Microwave, Radio, Satellite



What other technology is needed to interconnect and perform more advanced applications?

- External “system -level” control to integrate multiple fuel cells, and/or other DG units to one another and the grid >
- Master Gateway Device - really a router/bridge communication, plus some embedded intelligence



The ANSWER?
The *en*power - RTU

- **An adaptation of *EN*CORP's proven hardware product that further leverages the VPP solution**
- **Provides a cost-effective optimized solution for small (30-200kw) & inverter-based DER**
- **Tailored for Micro-turbines, Fuel Cells, Wind Power, & Hybrid Power Systems**
- **For economic optimization of single unit/site or aggregated DER assets**
- **'Plug & Play' operations & maintenance capability**
- **Interface to the UDC, PX, or ISO for 'roll-up' of hundreds of DER into a Virtual Power Plant**

Tomorrow's Market - A Brave New World?

- **More choices?** **Same "Dial Tone" for all DG across the US?**

•End - to - End Value -Based Customer Solutions: Sell the benefit of the technology, not the technology itself!

- **Mass - Customization for All: McD's meets Thomas Edison**
- **Energy Appliances?**

- *DG will be a physical & financial play, due to enabling Info Tech which will provide neural networks, genetic-based control algorithms, and enterprise level middleware for bulk-level optimization of the electricity Supply & Demand, and "omni-directional" power flow, in response to spot/future power market signals*