



Interconnection to Electric Utility Grids

Small Systems/ Standardized Interconnections
California Experience

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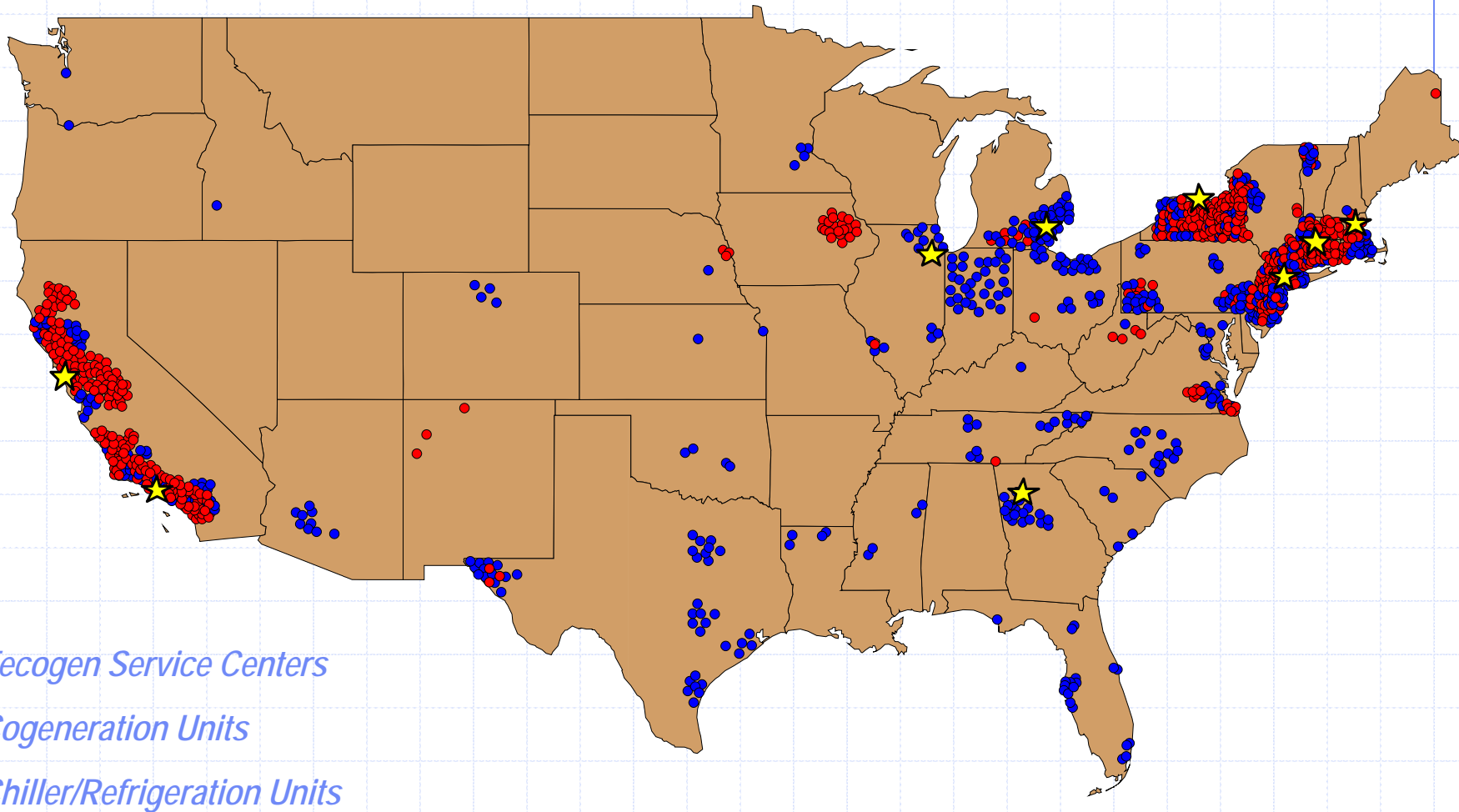
Importance of Interconnection Regulations

- ◆ Distributed Generation Central to Energy Issues Confronting US and World
- ◆ Utility Interconnection is Necessary for Most DG Systems to be Viable
 - Islanded Systems Generally Impractical
 - Renewable Systems
 - ◆ Opportunity Often Non-Coincident With Facility Needs
 - ◆ Export to Grid Maximizes Exploitation
 - CHP Systems
 - ◆ Need High Utilization
 - ◆ Islanded Circuits are too Variable
- ◆ Permitting Can Make or Break Project...
 - Delays, Excessive Engineering Costs, Extra Equipment
 - Small Projects Exceptionally Vulnerable

History of Interconnection

- ◆ PURPA (1977)
 - Regulation Requiring Utilities to Allow Qualified Distributed Resources to Interconnect
 - Forced Union
 - ◆ Contentious/ Mutual Distrust
- ◆ Utility Issues
 - Safety to Utility Workers/ Equipment Damage/Power Quality
- ◆ Individual Utility Interconnect Requirements Developed
 - Variable
 - ◆ State-to-State/Utility-to-Utility/Engineer-to-Engineer/Site-to-site
 - Sometimes Contradictory
- ◆ Severely Damaged Combined Heat & Power (CHP) Industry
 - Small-Scale CHP Disappeared by Early 1990s
 - Alternate CHP Methods Adopted
 - ◆ Engine-Driven Chillers, etc.

Small-Scale CHP Distribution (Tecogen)



Standard Interconnection Processes

- ◆ Rise of New Technologies ~2000
 - Inverter-Based Electric Interface to Grid
 - ◆ Advanced Power Electronics
 - ◆ Convert DC (or Non-Standard AC) to Utility Standard AC
 - ◆ Solar PV, Wind, Fuel Cells, MicroTurbines
 - Inverter Ideal Platforms for Self-protection
 - ◆ React Quickly to Event to Stop Current Flow
 - ◆ Sense Volts, Amps, Phase Sequence, but Also...
 - ◆ Islanded Situation (key)
 - Recognize Power Outage
 - Cease Operation
 - Line Worker Safety Assured
- ◆ Standardized Interconnection Would be Feasible
 - Coincident With Imperative to Reduce Global Emissions

The Promise of “Simplified” Interconnection

- ◆ Certain Projects Considered Inherently Benign
 - Small kW Size
 - Factory Produced Systems
 - ◆ Complete and Uniform Packages
 - ◆ Standard Designs, etc.
- ◆ Standardized Interconnection Process Feasible
 - Predictable/ Inexpensive Process
 - Widespread (Nationwide) Implementation
- ◆ Universal Benefit
 - Project Developers
 - Utility Interconnection Engineers
 - ◆ Extensive Application Burden Relieved

Standard Interconnection Components

- ◆ Two Parts
 - Permit Process
 - "Type-Testing" Standard (Certification to Recognized Standard)
- ◆ Permit Process
 - Enacted Through Government Legislation
 - Contains a Project Screening Process
 - ◆ Some Screens Ask Facility Questions
 - Is Facility Very Large Relative to the DG Machine (good)
 - Is there a lot of DG in the Neighborhood (bad)
 - ◆ Others Ask About the Equipment
 - Type-tested (good)
 - Technology
 - Size (11 kW or less, etc.)
 - Type-Testing Rules
 - ◆ How to Get Recognized
 - ◆ Listing of Equipment that Is Recognized

California Rule 21

- ◆ Published Standard for Interconnection
 - Detailed Process Including Screens
 - Type-Testing Requirements
 - Supplemental Review Process
 - Outcomes
 - ◆ Qualification for Simplified Interconnection Permit
 - ◆ Supplemental Review
 - Secondary Process
 - Utility Has Some Discretion
- ◆ Applies to Investor Owned Utilities (PG&E, SoCal Ed, SDG&E)
 - Some Municipal Utilities Apply Rule 21 (Sacramento/SMUD)
 - Others do not (LA Dept of Water and Power)

Notes About Type-Testing

- ◆ Test Standard Basis
 - IEEE 1547
- ◆ Designed by Diverse Committee
 - Developers/Manufacturers/Utilities/Gov/Academia
- ◆ Technology Neutral
 - Designed Around Inverter System
- ◆ Steps
 - Contract Independent, Qualified Lab
 - ◆ Nationally Recognized Testing Laboratory (NRTL)
 - Construction Review
 - Thorough Test of Sample
 - Certification Listing, Quarterly Inspection at Factory
 - ◆ Consistent Design/ Factory Pre-ship Testing

CA Rule 21 Experience

- ◆ Tecogen 2004 Certification Completed/ CA Listing
 - 60/75 kW Conventional Induction Product
- ◆ Permit Applications to Date
 - All Unsuccessful in Qualification for Simplified Interconnection Despite Certification/Screens Passed
- ◆ Rule 21 Generally Successful
 - Many Inverter Products Interconnected Simplified Process
 - Special Process Granted by PG&E for Tecogen (Compromise)
 - Precedent Set
- ◆ Lessons Learned
 - Growing Demarcation between Conventional Generators and Inverter Systems
 - Simplified Interconnection Becoming Inverter-Only Club

CA Experience (cont.) - Other Lessons

- ◆ Monthly Committee Meetings
 - Excellent System for Development/ Refinement of the Rule
 - Attendance Over Time Problem
 - ◆ Utility Members Become Dominant
 - Tendency to Narrow Project Qualifications in Screens
 - ◆ Essential to Have Balance
- ◆ Type-Testing Review Committee
 - Grant Certification Status (Review Lab Report)
 - Recommend Process be More Straightforward
 - ◆ Tendency to Evaluate the Standard

Lessons (cont.)

- ◆ “Inadvertent Export” Issue
 - Permissible if Anti-Islanding (AI) Protection Present (Certified DG System)
 - If AI missing from System, AI Requirement May be met With Reverse Power Relay at Building/Utility Point of Common Coupling (PCC)
 - Growing Perception of Export as Hazard in Discussions
 - Important to Develop Rules that Allow Export
 - ◆ Net Metering Critical To Economics of Some Applications
 - ◆ Wasteful Policy to Limit Production of Power from Efficient DG Sources
 - ◆ Often Costly to Add Control to Site to Prevent Export
 - Distance Between Equipment/PCC
 - Need Cushion (or very rapid response)

Experience in Other States/Utilities

◆ Massachusetts

- Very Similar Standard to CA Rule 21
 - ◆ Screens/ Path for Simplified Interconnection
 - ◆ No Certification Program
 - ◆ If Certified Elsewhere/ Certified in MA
- Utility Requirements Variable
 - ◆ Simplified Interconnection Path Not Always Followed
 - Extra Relaying/ Outside Disconnect Switch, etc.

◆ New Jersey

- Straightforward
- Generally No Additional Relays

Other States (cont.)

◆ New York

- Certification Listing System in Place (NYSIR)
- However, No State-wide Process for Simplified Interconnection
- Requirements Will Vary by Utility
 - ◆ Generally Predictable
 - ◆ Permitting Time Lengthy in Some Area
- Our Experience Has Been that NYSIR Listing Has Not Provided Path for Simplified Interconnection
 - ◆ Additional Relays Generally Required

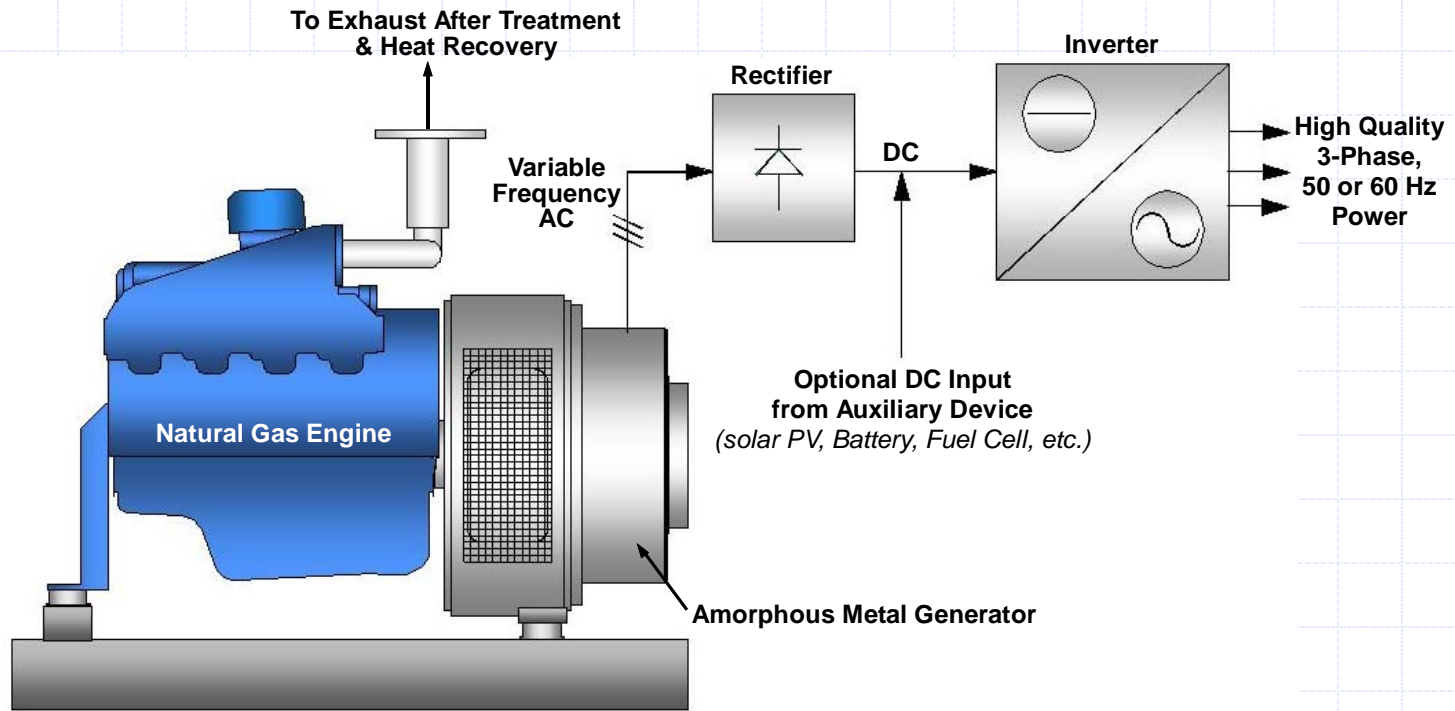
Networks

- ◆ Particular Type Exists in Some Downtown Areas
 - Boston/ NYC/ SF/ Others
 - Narrow Geographical Region
- ◆ Particular Problem If Power Backfed to Utility
 - Harmful to Protective Devices in Network
- ◆ Interconnection Problematic
 - Simplified Interconnection Does Not Apply
- ◆ Barnes Coast Guard Building Demo in Boston
 - DOE Sponsored Research program
 - Successful in Method Applied
 - Costly/ Impractical

Future of Simplified/ Fast Track Interconnection

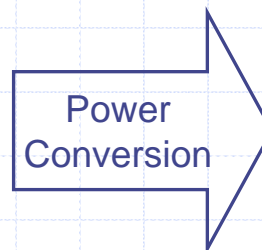
- ◆ Inverter Technology Clearly Favored
 - Technical Reasons
 - ◆ Ability to Sense Island Situation
 - Inverters Systems are Most Widespread in Renewable Technologies
 - ◆ Strong Interest in Streamlining Process, Advancing Technology
- ◆ Type-Testing of Products Necessary Product Feature...
 - System is Small (Control Project Costs/ Schedule)
 - Offer to Customers Important Feature of Net Metering
 - ◆ Qualification Requires Anti-Islanding Feature
 - Solution to City Network Interconnection Will Come From an Inverter-Based System
- ◆ in 2004 Tecogen Decision to Develop an Inverter-Base CHP System
 - Motivation to be Qualified for Simplified Interconnection
 - ◆ UL 1741 Compliant Without Caveats

Tecogen Inverter-Based Product (CM-100)



Engine/Generator Output

RPM	Volts	Freq (hz)	KW
1000	98	135	39
2200	207	297	93
3000	258	405	130



Delivered kW

Volts	Freq (hz)	KW
480	60	37
480	60	88
480	60	123

Inverter Based Product

- ◆ Research Funding Provided by California Energy Commission and Also Sempra Energy
- ◆ 100 kW Rating
- ◆ UL 1741 Certification Underway
- ◆ Interconnected to Con-Ed, Niagara Mohawk and SoCal Ed.
- ◆ Concept Well-Received by Utility Engineers



Advanced Interconnection Systems - CERTS* Microgrid

◆ CERTS Program

- Collaborative Program to Develop Advanced DG Paralleling System
 - ◆ Utilities/ National Labs/ Universities/Manufacturers
- Utility Friendly, While Able to Transition Power Seamless In Event of Utility Grid Problem
- Designed For Multiple Generation Sources on Same Circuit
 - ◆ Operate Entirely Independently While Equally Sharing Power
 - ◆ System Designed to Work With Diverse Technologies (inverter-Based)

*The Consortium for Electric Reliability Technology Solutions (CERTS) was formed in 1999 to research, develop, and disseminate electric reliability technology solutions in order to protect and enhance the reliability of the U.S. electric power system under the emerging competitive electricity market structure. The founding members include four DOE National Labs (Lawrence Berkeley National Laboratory (LBNL), Sandia National Laboratory (SNL), Oak Ridge National Laboratory (ORNL), and Pacific Northwest National Laboratory (PNNL); NSF's Power Systems Engineering Research Center; and the Electric Power Group.

Microgrid Demonstration Program

- ◆ 180 kW Full Scale Test (three Tecogen Prototype Modules)
- ◆ American Electric Power (AEP) Dolan Laboratory, Columbus OH
- ◆ Tests Conducted by AEP Engineers
 - Input From the CERTS Group
- ◆ Phase 1 Testing Very Successful
 - Seamless Transition/ Protection Schemes Demonstrated
- ◆ Phase 2 Underway
 - Advanced Protection Schemes/ Simplifications
- ◆ Incorporated Microgrid Algorithms Into Product
 - IP Licensed From Univ. of Wisconsin
- ◆ Recent Issues of Distributed Energy Magazine (distributedenergy.com) Highlight Project
 - "Microgrids Up And Running" (May/June 2008)
 - "Dream Machine" (Nov/Dec 2007)

CERTS Test Facility at AEP's Dolan Lab Columbus OH

Three Tecogen Units



Final Comments

- ◆ Great Progress in Interconnection
- ◆ Simplified Interconnection
 - Type-Testing/ Certification Methods in Place
 - Work Needed
 - ◆ Expand Regions Having Process
 - Nationally/ Internationally
 - Retain Critical Features
 - ◆ Export Allowed
 - ◆ Expand (not Reduce) Facilities That Qualify
 - Screens
- ◆ Continue Research