SMUD Energy R&D Program

Microgrid Demonstration – Lessons Learned

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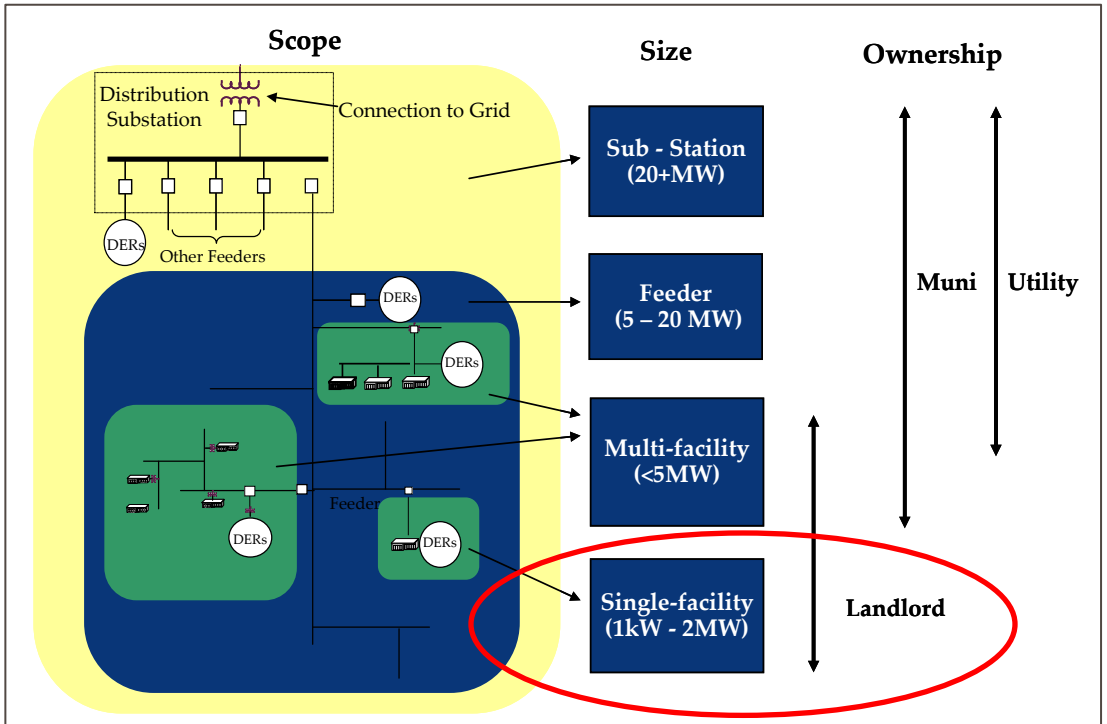
SMUD's Microgrid Definition

- A Smart Grid concept
- "Integrated energy system consisting of interconnected loads and distributed energy resources which as an integrated system can operate in parallel with the grid or in an intentional island mode"
- Microgrids can vary in scope, size, and ownership

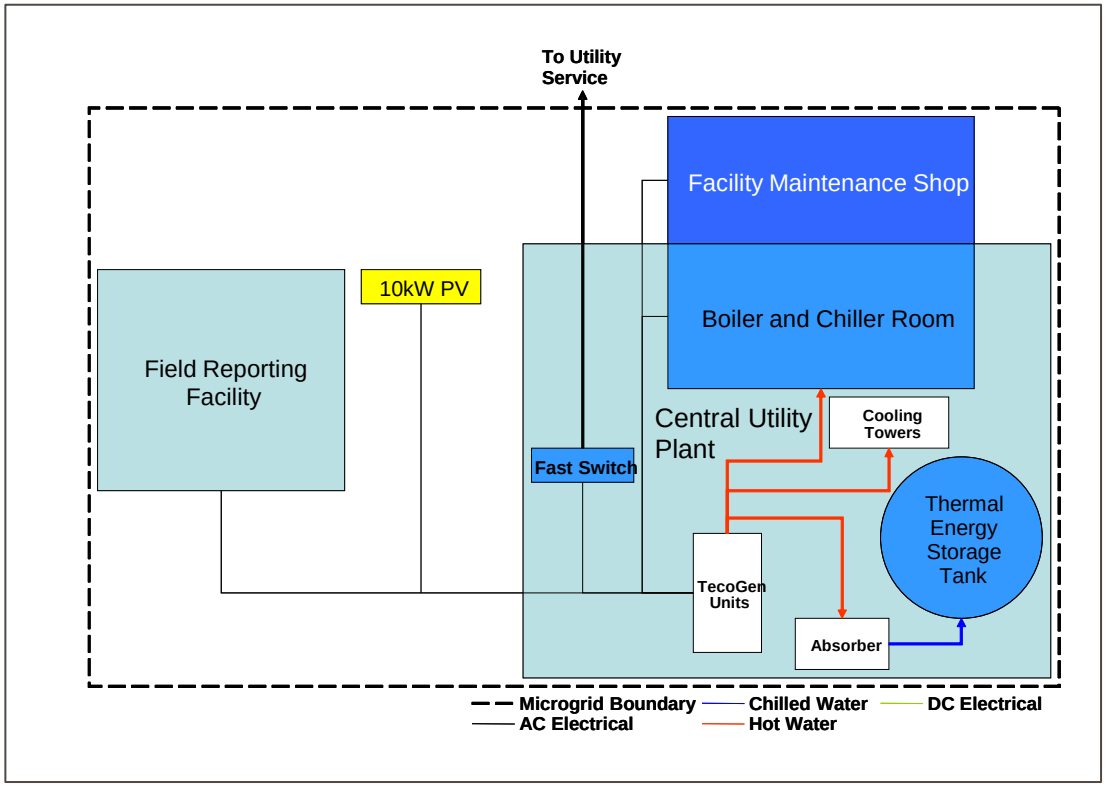


Source: US DOE/CEC Microgrids Research Assessment, Navigant Consulting Inc., May 2006

SMUD project demonstrates single-facility scale microgrid which could be feasible for C&I customers.

SMUD Microgrid Project Overview

- California Energy Commissioned funded project - $2.9M over 3 years
- Partners include DE Solutions, TecoGen, NREL, CERTs, Univ. of Wisconsin
- Real world performance
- Integration and interoperability with demand responsive load control, advanced reciprocating engines, PV, and thermal energy storage
- Seamless separation and isolation from utility grid and resynchronization
- Feeder peak load reduction
- Technical and operational distribution system implications of exporting power from a microgrid



SMUD Microgrid Project Overview

Enabling Technologies

- 3-100kW natural gas engines
- 1200 amp-rated smart switch
- Seamless separation and isolation from utility grid and resynchronization

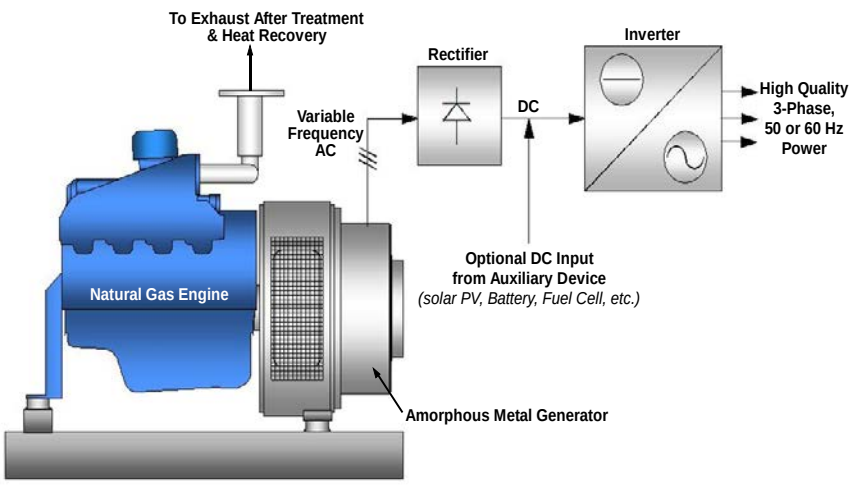
Existing Systems

- 10kW PV
- 123-ton absorption chiller
- 1 new centrifugal chillers (500 ton) and existing chillers (600 and 200 ton)
- 4 existing natural gas fired boilers
- 15,000 ton-hour chilled water energy storage (760,000 gallons)

TecoGen Natural Gas Fired Generators

TecoGen CHP Systems

- First engine driven product with UL certification for “utility safe” interconnection
- First product to commercially offer CERTS controls algorithms for microgrid operation (Droop control)
- First engine to meet 2007 California air emission standard
- Features:
  - Water-cooled permanent magnet generator
  - Operated over wide speed range to optimize fuel efficiency
  - Power electronics converts variable frequency to 60 Hz
  - 700,000 BTUh recoverable heat
  - 82.4% (LHV) overall efficiency
  - Provides 230°F hot water



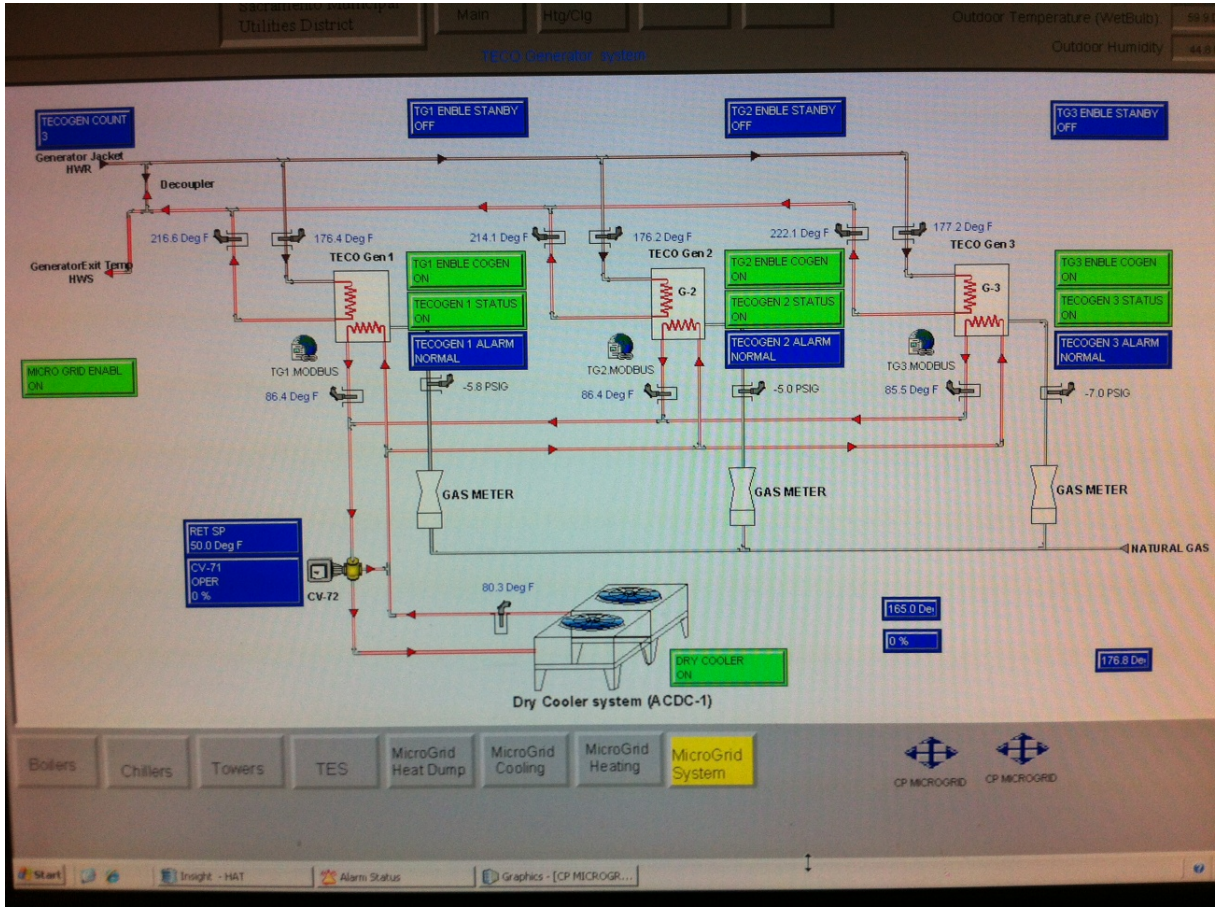
INV-100 Advanced Power Generation Technology

Thomas & Betts Cyberex Smart Switch

- SuperSwitch3 by Cyberex
- Digital Power Static Transfer Switch
- Features:
  - 1200 Amps
  - 480 V, 3-Phase, 3 wire + gnd, 60 Hz
  - 1 Bypass Switch
  - 100 kA withstand
  - Hockey Puck Style SCR (Type – II)
  - Comprehensive metering, monitoring, control and alarms
  - Color LCD Display
  - Remote and Local Control, and Bypass
  - Incorporates proprietary CERTS Smart Switch controls

Data Acquisition and Control

- Siemens Apogee automation system controls CUP
- Collects, stores, and processes performance data for microgrid
  - 1-second sample rate, averaged over 1 minute
  - Except PQ data
- PMI PQ Monitors installed at six locations monitoring
  - Frequency
  - Voltage
  - Current
  - Power
  - Reactive Power
  - Phase angle
  - Power Factor
  - Harmonics
- Handheld portable emission analyzer for exhaust emission measurements



Grid-Connected Operation

- Connected to 21 kV Feeder supplying loads in the Central Utility Plant (Field Reporting Facility in the future)
- Excess electricity exported back to grid
- Priority use for waste heat given to space heating; cooling is secondary
  - Existing heating system is shut off between May and September
- When cooling, CHP system absorption chiller charges TES tank
  - Absent heating load, absorber dispatched 24/7 for this purpose
- TecoGen INV-100 units are expected to have a 92 % availability factor
- Absorption chiller sized to operate off recovered heat from two or all three INV-100 units
  - Should only one INV-100 be in operation, the absorption chiller will not operate
- System includes a dump radiator to enable full-load CHP system operation regardless of the demand for heat

Islanded Operation

- Microgrid CHP system can “seamlessly” transition to islanding mode during grid disturbance
  - Non-critical loads in the CUP/FRF will be tripped
  - Noncritical loads include electric chillers and yet to be determined select air conditioning loads in FRF
- Remaining sensitive and critical loads will be prioritized and tripped off line as required (load shedding)
  - Must be tripped instantaneously to avoid under frequency tripping of INV-100s
  - Load shedding not likely needed unless one or two engines are down
- CUP is served from three INV-100 units through a 480V bus
- Recovered heat used in like-fashion to grid connected mode
- Smart Switch will automatically resynchronize microgrid when feeder is reenergized

Monitoring and Verification

Monitoring system collects data needed to quantify technical and economic performance

- Overall CHP system performance relies on ASERTTI test protocol and includes
  - Electrical efficiency
  - System efficiency including thermal utilization
  - Availability
  - Emissions
  - Electrical production
  - Hot and cold water production
  - Fuel usage
  - Fuel costs
  - Electricity cost savings
  - Energy cost savings
  - O&M costs
- Electrical parameters monitoring includes
  - Voltage
  - Current
  - Volt-ampere reactive power (commonly known as VAR), a measure of reactive power in AC electrical systems
  - Power quality
  - Grid-connected and islanded operations

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Testing Results

- TecoGens have proven ability to almost instantaneously ramp up/down during an islanding event – adjusting their power output to match existing load within the microgrid
- TecoGens do not need to be dispatched at the same power levels prior to an islanding event – machines will use frequency droop control to “figure out” appropriate load sharing requirements
- Power quality settings of the TecoGens and the Smart Switch must be finely tuned, taking into account response time of utility protective devices and desired sequence of events during a utility outage
- Testing a utility “outage” event is harder than one might think!

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Lessons Learned

- Take the time to understand the critical and non critical loads for a potential CHP/Microgrid customer – this will ensure you properly size onsite generation and thermal/cooling components
- New technology will always need to be customized, field testing will help you and the technology vendors better understand how the products are intended to work in specific real world applications (Smart Switch re-connect, TecoGen trip points, etc.)
- Utility operators will need to be brought into these projects early on so that they can get comfortable with this new type of customer installation (island, automatic reconnect)
- Make sure you have buy in from all internal/external customers when commissioning and testing these deployments (you WILL drop all loads and black out the test bed at least once….or three times)

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Next Steps

- M&V on demonstration project
- Update interval analysis for estimate of cost effectiveness
- Engineer out costs to improve cost effectiveness
- Update CHP market assessment
- Identify potential for broader CHP-based microgrid applications within SMUD's service territory

Thank you