Distributed Energy

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What is Distributed Energy?

Distributed energy is power generated (and often heat captured) at the point of use.
Distributed Energy Includes:

- Electric Generation Equipment
  - Reciprocating Engines
  - Turbines / Microturbines
  - Fuel Cells
  - Renewable Resources

- Heat Recovery Systems
  - Hot Water
  - Steam
  - Exhaust Gases

- Thermally Activated Technologies
  - Absorption Chillers
  - Desiccant Dehumidification
  - Thermal Storage
Advanced Prime Mover Status:

Efficiency and durability have been improved, but applications and regulators “raise the bar”

- CARB2007 emissions not achieved
  - but is only a point in time
- Storable fuels for disaster mitigation and remote sites
- Renewable fuels to capitalize on “free” fuel
- Improving electrical efficiency
Thermal Technology Status

Long used for industrial applications and district heating

New era for compact, effective thermal devices
  - **Design** for integration rather than adapt for integration
  - Higher electrical efficiency means less waste heat, at lower temperature
  - Widening application space: residential to industrial
Energy Reliability and the State of the Electric Grid: Aging Infrastructure & Congestion Impact Reliability

Aging Infrastructure
- Century old technology
- National Security issues
- $330B industry
- Estimated $100B to modernize

Increasing Congestion
- More expensive generators used
- Market transactions increasing

<table>
<thead>
<tr>
<th>Voltage Range (kV)</th>
<th>Power Range (MVA)</th>
<th>Number</th>
<th>Avg. Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>115-765</td>
<td>100-1,200</td>
<td>5,000</td>
</tr>
<tr>
<td>Medium</td>
<td>65-345</td>
<td>10-100</td>
<td>110,000</td>
</tr>
<tr>
<td>Small</td>
<td>35-245</td>
<td>1-10</td>
<td>65,000</td>
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Reliability
- Customer outages significant
- Outages Average 100 – 220 min/yr
- Impact as high as 40% of annual revenues
The grid faces additional challenges

2006
- 1% renewable
- 20% nuclear
- 30% natural gas
- 49% coal
- 1,000 gigawatts
  - Hybrids, No PHEVs
  - Electrically-sensitive equipment (8 hrs/yr)
- 140 control areas
  - Energy Mgt Systems (<1%)
  - 180,000 miles wires
  - ~10 million DG units
- Blackouts
  - Aging Infrastructure
  - Vulnerability of assets

2035
- 20% renewable
- 40% nuclear
- 10-20% natural gas
- 20-30% clean coal
- 50% Demand growth
  - Load curves – increased peaking
  - Plug-in hybrids (could increase demand 25%)
  - More electrically sensitive equipment (2.5x)
  - Power loss of 32 sec/yr

- Complexity of Grid
  - Expanding footprint, overlay of markets, “closer to the edge”

- Vulnerability of Energy Infrastructure
  - Interdependencies of electric and energy systems

- Nodes within control area increase 5-10x
- Energy Mgt Systems (70%)
  - Additional 30,000 miles needed
  - ~22 million DG units (2.5x increase)
- Infrastructure protection
- Increased globalization
- Materials and resource limitations
- All-hazard risks will continue to increase
Local Voltage Control Can Be Supplied by Distributed Energy to Improve:

- Power quality by correcting unbalance and harmonics.
- Load efficiency by controlling voltage to the optimum level for efficiency.
- Distribution efficiency by reducing losses.
- Reliability by increasing the margin to voltage collapse.
- Transfer capability, decrease congestion, and lower prices.
Distributed Generation is Already in Place

- Distributed Power Units in Lower Manhattan, September 2001
  - Grid Support

- Reduced Operating Costs at Ft. Bragg
  - 5 MW turbine integrated with 1,000 Refrigeration Ton waste-heat chiller and HRSG
  - Supervisory control system developed to optimize cost using time of day pricing
  - Provision of reliable power to base
Energy Reliability
Energy Security
Energy Efficiency
Economic Development
Environmental Stewardship

Distributed Energy Benefits
Benefits of Distributed Energy

**Energy Reliability**
1. Improved power quality
2. Business continuity
3. Reduced grid congestion
4. End-of-the-wire supply
5. Short lead-time, off-the-shelf, modular technology

**Energy Security**
6. Reduced system vulnerability
7. Disaster Mitigation
8. Disaster Recovery

**Energy Efficiency**
9. Improved fuel efficiency (fuel economy)
10. Optimized use of scarce natural gas resources
11. Eliminates line losses

**Economic Development**
12. Lower cost for new electricity than new central generation and T&D
13. Improved energy cost predictability
14. No ratepayer investment required (generation or T&D)
15. Creates new high-tech manufacturing sector, domestic and export
16. Creates local jobs for installation, operation and maintenance
17. Supports competitive electricity market structure

**Environmental Stewardship**
18. Reduced emissions per unit of useful output
19. Reduces land-use impacts and NIMBY objections
20. Reduces fresh water use
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Energy Reliability

- Reliability problems come from the grid itself.
- Distributed energy does not require the grid.
- Distributed energy can, however, support the grid.

8/13/03  8/14/03

The August 2003 Blackout
Lessons Learned from August 2003 Blackout

- Grid and population are vulnerable to large-scale disruption
  - 50 million North Americans affected
  - Cell phones inoperable
- Cost as much as $6 billion NYC, NYSERDA and DOE post-blackout reviews:
  - Many emergency backup generators failed (e.g. for hospitals and communications)
  - CHP systems performed as designed
With regularly used Distributed Generation, the lights and water stayed on...

Health Care Facilities
- Montefiore Medical Center, Bronx, NY
- Botsford Health System Kidney Center, Livonia, MI
- Elderwood Healthcare - Oakwood Nursing Home, Williamsville, NY

Public Services
- Central Park Police Station
- Britannia Water Treatment Plant, Ottawa, Canada

Federal Facility
- WestPoint Military Academy Residential Officer Housing
With Distributed Generation and Combined Heat and Power, manufacturing stayed on...

- Frito Lay Queens, NY
- Smoked Fish MFG, (Manhattan, NY) Saved > $300K
- Maple Lodge Farms Canada
- Oak Tree Farm Dairy (Northport Shore, NY)
- Entenmann’s Bakery (Bay Shore, NY)
Conclusion on Reliability:

Distributed energy provides significantly greater reliability than central generation and T&D alone, and could prevent billions of dollars in outage losses every year.
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Energy Security: What Did We Learn from Katrina?

LOUISIANA ELECTRIC OUTAGE
Percent Customers W/O Power by County

- 0% - 10% (Green)
- 10% - 20% (Light Green)
- 20% - 30% (Yellow)
- 30% - 40% (Orange)
- 40% - 50% (Red)
- 50% - 60% (Dark Red)
- 60% - 70% (Even Darker Red)
- 70% - 80% (Very Dark Red)
- 80% - 90% (Black)
- 90% - 100% (Black)

TOTAL OUTAGE AS OF 9-16-05 322,000 CUSTOMERS 21 PERCENT

HURRICANE KATRINA
TOTAL CUSTOMERS: 9,081,968
TOTAL CUSTOMERS W/O POWER: 883,000
TOTAL PERCENT W/O POWER: 10%
PERCENT OUTAGE 08-27-2005 7:00 AM
- 18 Monroe County
- 38 Broward County
- 54 Miami-Dade County

Managed by UT-Battelle
for the Department of Energy
Baptist Medical Center, Jackson, Mississippi

- 624 bed hospital, 3,000 employees
- 3.2 MW gas turbine CHP system – installed 1994
- Steam regularly used for hot water, sterilization and absorption chillers

- Grid down for 52 hours starting August 29, 2005 due to Katrina
- Combined heat and power system ran islanded and provided power, hot water and air conditioning
- Baptist Medical Center remained nearly 100% operational; the only hospital in the area to do so
Conclusion on Security:

Distributed energy can keep critical health and emergency services functioning, along with vital public and economic functions, during a natural disaster or terrorist attack.

(Caveat: fuel supplies required!)
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Energy Efficiency

America’s electric grid efficiency has stagnated at about 32% efficiency

Fossil Electric Generation Efficiency (at plant, W/O T&D)

Source: EIA, Annual Energy Review 1996
DE and Energy Efficiency

Distributed Energy as CHP more than doubles the electric grid’s energy efficiency

Diagram showing the energy loss in separate and combined heat and power systems.
Conclusion on Efficiency:

Distributed energy can cut fuel consumption per unit of output to half or a third of conventional usage, especially natural gas supplies now in heavy demand.
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Distributed Energy Costs Less

The cost of meeting the need for new power in the U.S. in 2020:

$ Billions

% DG of Total US Generation

- New Cent. Gen.
- New Dist. Gen.
- T&D
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Environmental Stewardship

= energy efficiency
fuel diversity
distributed energy

- Reduces greenhouse gases
- Reduces criteria pollutants
- Conserves fresh water
- Husbands fuel resources
- Ready for bio-fuels and bio-fuel creation processes
- Cuts land-use impacts and NIMBY problems
Why DG Isn’t More Broadly Used: Only FOUR of the Twenty Benefits Accrue to the User

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Questions?