E2Tech Distributed Generation Forum
Portland, ME

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Executive Summary

- Distributed Generation – electric / thermal generation that is located at or near the load or site
- It is not a single technology but a group of technologies or renewable energy that can use a variety of fuels to provide reliable electricity, mechanical power, or thermal energy at a factory, university campus, hospital, or commercial building—wherever the power is needed
- Reduce energy cost or dependence
- Improve reliability and reduce disruptions
Proven Technology & Results

- DG has been around in one form or another for more than 100 years; it is proven, not speculative.
- Despite this proven track record, DG remains underutilized
- Now with mix of Renewable energy & conservation
- Current market conditions, lack of understanding, and technical barriers continue to impede full realization of DG’s potential.
Benefits of DG Applications

- DG positively impacts the health of local economies and supports national policy goals in a number of ways. Specifically, DG can:
  - *Enhance our energy security* by reducing our national energy requirements and help businesses weather energy price volatility and supply disruptions
  - *Advance our climate change* and environmental goals by reducing emissions of CO2 and other pollutants
  - *Improve business competitiveness* by increasing energy efficiency and managing costs
  - *Increase resiliency of our energy infrastructure* by limiting congestion, load reduction, offsetting transmission losses, and disaster recovery
  - *Improve energy efficiency* by capturing heat that is normally wasted
Traditional System Losses

More than two-thirds of the fuel used to generate power in the U.S. is lost as heat.

Source: DOE Energy Information Administration Annual Energy Review 2007
What is Distributed Generation

- Can be Cogeneration or CHP:
  - Concurrent production of electrical & thermal (heating / cooling) energy from a single fuel source.
  - Two (or more) outputs for a single input

- Technology
  - Prime Mover (Mechanical) burning fuel source coupled to an electric generator (Electric) and heat recovery unit (Thermal)
  - Renewable sources – Solar or wind
  - Sized to meet users thermal base load

- Distributed Generation
  - Located at or near the point of consumption
  - Avoids electrical transmission losses
  - Behind the meter, NET metering, or PPA
DG Technologies

- **Combustion Turbine**
  - 500 kW to 250 MW
  - 75+% Overall Efficiency
  - High Pressure Steam
  - Noise & HP Gas Supply

- **Micro-Turbine**
  - 30 kW to 250 kW
  - 75+% Overall Efficiency
  - Hot Water or LP Steam

- **Reciprocating Engine**
  - Up to 5 MW
  - 80+% Overall Efficiency
  - Hot Water, LP & HP Steam
  - Noise & Maintenance

- **Biomass Boiler / Backpressure Steam Turbine**
  - 30 kW to 500 MW
  - 80% Overall Efficiency
  - LP or HP Steam
  - Long startup

- **Fuel Cell**
  - 5 kW to 2 MW
  - 85% Overall Efficiency
  - Hot water, LP & HP Steam
  - High capital cost

- **Renewable Energy**
  - Solar PV
  - Solar Thermal
  - Micro-Wind
| Technology       | Available Sizes (kW) | Power Efficiency (Overall) | Part Load Efficiency | Unit Cost Range/Unit (kW) | Net Installed Cost/Unit (kW) | Part Load Costs/Unit (kW) | Net Installed Availability | Net to Gross Efficiency | Net to Gross Load | Startup Time | Fuel Type | Noise Level | Thermal Output | Advantages                                                                 | Disadvantages                                                                 |
|------------------|----------------------|-----------------------------|----------------------|---------------------------|-----------------------------|---------------------------|--------------------------|--------------------------|------------------|-------------|-----------|------------|----------------|----------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Steam Turbine    | 50kW to 250 MW       | 15-38%                      | 80%                  | $260,000-$3,000            | $1,200-$2,000               | N/A                       | High                     | N/A                      | N/A              | > 5,000     | N/A        | LP/HP steam | High          | Slow Startup, low power to heat ratio, wide range of heat output, long working life, low emissions | Slow Startup, low power to heat ratio, wide range of heat output, long working life, low emissions |
| Recip Engine     | < 5 MW               | 22-40%                      | 70-80%               | $1,100-$1,500             | $400-$550                   | N/A                       | High                     | N/A                      | N/A              | < 1 minute | Natural gas, propane, biogas, fossil fuel | High hot water & LP steam | High maintenance costs, lower heat output & limited applications, relatively high emissions, cooling requirements, noise |
| Gas Turbine      | 500 kW to 250 MW     | 22-36%                      | 70-75%               | $1,200-$1,500             | $400-$550                   | N/A                       | High                     | N/A                      | N/A              | 10 min to 1 hr | Natural gas, propane, biogas, fossil fuel | Hi overall eff., low emissions, high grade heat output, no cooling required | Require hi press gas, fuel off site, high startup cost |
| MicroTurbine     | 30 kW to 250 kW      | 18-27%                      | 65-75%               | $3,000-$4,000             | $1,100-$1,500               | N/A                       | High                     | N/A                      | N/A              | 1-5 minutes | Natural gas, propane, biogas, fossil fuel | Fewer moving parts, compact size & weight, low emissions, no cooling required | High costs, fuel off site, high startup cost, limited or lower temp. applications |
| Fuel Cell        | 5 kW to 2 MW         | 30-60%                      | 54-60%               | $5,000-$5,500             | $1,500-$2,000               | N/A                       | High                     | N/A                      | N/A              | 3-7 days   | Methane, hydrogen, propanes, hydrocarbons | Low hot water, LT & HP steam, low emissions, no noise, no cooling required | High costs, low durability, fuels require processing unless pure hydrogen is used |
DG – Fuel Types & Markets

- **Fuel Types:**
  - Natural Gas – supplied from Utility, CNG, or LNG
  - Propane
  - Fuel Oil – Low Sulfur Diesel
  - Landfill Gas – requires scrubbing or cleaning of the gas
  - Biogas – Anaerobic Digesters (Municipal, Agricultural, Food Waste) and Wood Gasification
  - Hydrogen – Fuel Cell
  - Biomass – Wood, wood waste, Crop residue, MSW, Food waste

- **Markets**
  - Education – Colleges, Universities, and Schools
  - Hospitals & Nursing Homes
  - Real Estate – Apartment buildings, office complexes, neighborhoods
  - Hotels & Conference Centers, Spas, Ski Resorts
  - Food Services – Refrigerated storage, Food waste
  - Industrial / Process
  - Municipal – Public buildings, Water & Wastewater, Correctional Facilities
  - Misc. – Museums, Data Centers
Existing DG / CHP Capacity

Sites by Fuel Type
- Coal 7%
- Biomass 5%
- Other 4%
- Wood 4%
- Waste 5%
- Oil 6%
- Natural Gas 69%

Capacity by Fuel Type
- Coal 14%
- Biomass 1%
- Other 1%
- Wood 2%
- Waste 8%
- Oil 1%
- Natural Gas 73%
DG / CHP Capacity by Market Type
Installed DG / CHP by State
DG / CHP Target Applications

- Relatively high electric and thermal loads
- Thermal energy loads – hot water, steam, or chilled water
- High operating hours or consistent load of greater than 4,000 hours per year
- Consistent load is desired
- Double as emergency power
Drivers for Distributed Generation

- Large Electrical & Thermal Loads & Cost
  - Trying to reduce energy costs
- Un-reliable Utility power or fuel sources
  - Ability to isolate and run in island mode
- Mission critical load sources
  - Hospital / Healthcare
  - Data Centers
  - Military base
- Other Factors – Carbon Footprint, Energy Independence, or aging infra-structure
- Advance technology and Automation
  - SmartGrid connectivity and data
Example - Waste Water Application

- DG / CHP Fuel – Biogas or Sludge Incineration
- Electrical Offset or Independence
- Waste Water Thermal Applications:
  - Anaerobic Digester Temperature Control and Biogas production
  - Fats, Oil, and Greases (FOG) Heating
  - Sludge Heating / Drying
  - Building Heat / Cooling
  - Domestic Hot Water
Microgrids

- Microgrids are DG systems with added benefit or different drivers
- Driven by recent natural disasters or weather related events:
  - Massive disruption in service for extended periods
  - 80% of the residents of the state of Connecticut were without power for days or weeks
  - Utility planned on 10% of rate base to be without power at a given time
Microgrid - continued

- Should provide additional benefit to the community or grid restoration plans
  - Smartgrid or technology improvements
  - Development of Renewable Energy or Stored Energy
  - Increased efficiency
  - Demand management
  - Power additional areas or sites near by
- Can be connected to electric grid or stand alone
- Requires additional electrical interconnection automation and infrastructure
- Insurance policy against service disruption
Example Microgrid Site
Closing Summary – DG and Microgrids

- Energy Neutrality - Reducing Dependency - Reliability
- Purchased Energy Costs will continue to increase
- Traditional Systems are less efficient
  - CHP provides 2 outputs with one fuel input
- Take advantage of Rebates & Incentives ($$)
- 50% Less emissions and GHG
- Natural disaster or Utility disruption – Microgrid
- Advance technology – SmartGrid and Data / Load Management
- Improve infrastructure and reliability