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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

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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.

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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

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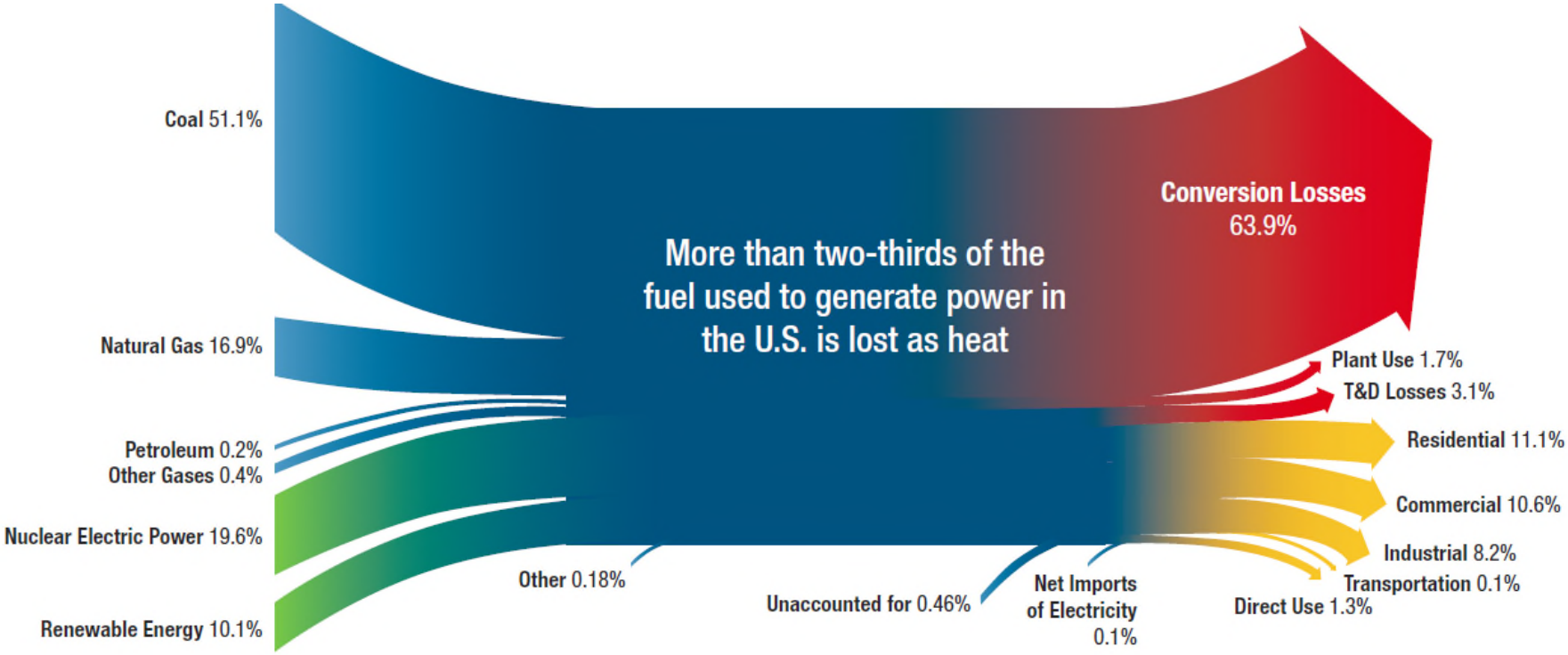
Traditional System Losses



Source: DOE Energy Information Administration Annual Energy Review 2007

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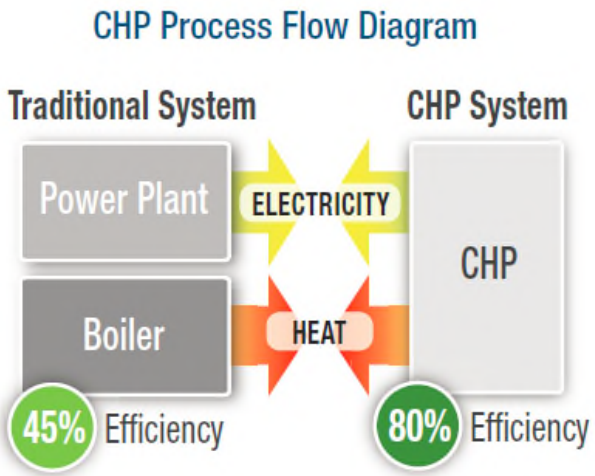
What is Distributed Generation

- 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**



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DG Technologies

- **Combustion Turbine**
  - 500kW 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

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DG Technology Comparison

Technology	Available Sizes	Power Efficiency	Overall Efficiency	Part Load	Est. Installed Cost ($/Kwe)	Est. O&M Costs ($/Kwe)	Availability	Hours to Overhaul	Startup Time	Fuel Press (psig)	Fuel Types	Noise Level	Thermal Output	Advantages	Disadvantages
Steam Turbine	50kW to 250 MW	15-38%	80%	Fair	430-1,100	< 0.005	Near 100%	> 50,000	Long & depends on size	N/A	N/A	High	LP - HP Steam	Hi overall eff., wide range of heat output, long working life, hi reliability	Slow Startup, Low power to heat ratio
Recip Engine	≤5MW	22-40%	70-80%	Good	1,100-2,200	0.009-0.022	92-97%	25,000-50,000	< 1 minute	1.0 - 45	Natural gas, biogas, propane, landfill gas, diesel fuel	High	hot water & LP steam	Hi power eff thru range of output, flexibility, low cost, island mode operation, ease of maintenance, low press gas	Hi maintenance costs, lower heat output & limited applications, relatively hi emmissions, cooling requirements, noise
Gas Turbine	500 kW to 250 MW	22-36	70-75%	Poor	970-1,300	0.004-0.011	90-98%	25,000-50,000	10 min to 1 hr	100-500	Natural gas, biogas, propane, fuel oils	Moderate	heat, hot water, LP & HP steam	Hi overall eff., Low emmissions, High grade heat output, no cooling required	Require hi press gas, Poor eff at low loads, output falls as ambient temp rises
MicroTurbine	30 kW to 250 kW	18-27%	65-75%	Fair	2,400-3,000	0.012-0.25	90-98%	20,000-40,000	1-5 minutes	50-80	Natural gas, biogas, propane, fuel oils	Moderate	heat, hot water, LP steam	Fewer moving parts, compact size & lite weight, low emissions, No cooling required	Hi costs, low mechanical eff., limitted or lower temp. output & applications
Fuel Cell	5 kW to 2 MW	30-63%	55-80%	Good	5,000-6,500	0.032-0.038	> 95%	32,000-64,000	Long - 3 hrs to 3 days	0.05 - 45	hydrogen, natural gas, propane, methanol	Low	hot water, LP & HP steam	Low emmissions, low noise, hi eff over load range, modular	Hi costs, low durability, fuels require processing unless pure hydrogen is used

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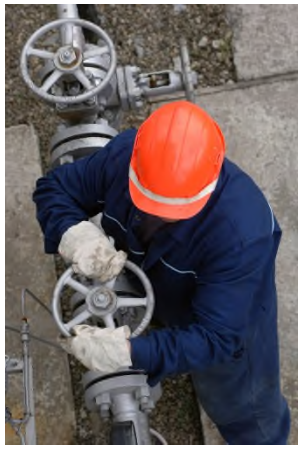
DG – Fuel Types & Markets



- **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

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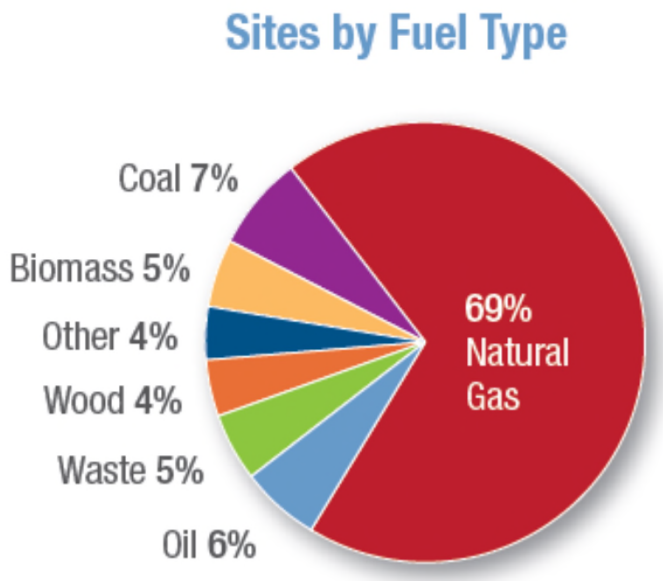
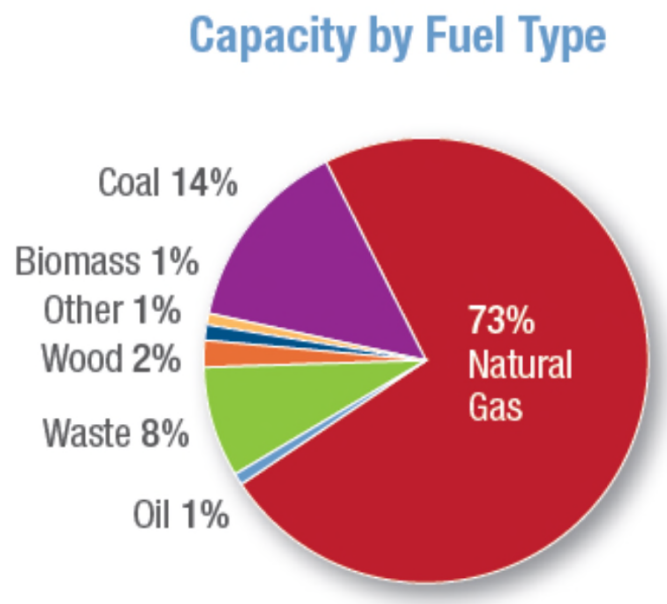
Existing DG / CHP Capacity





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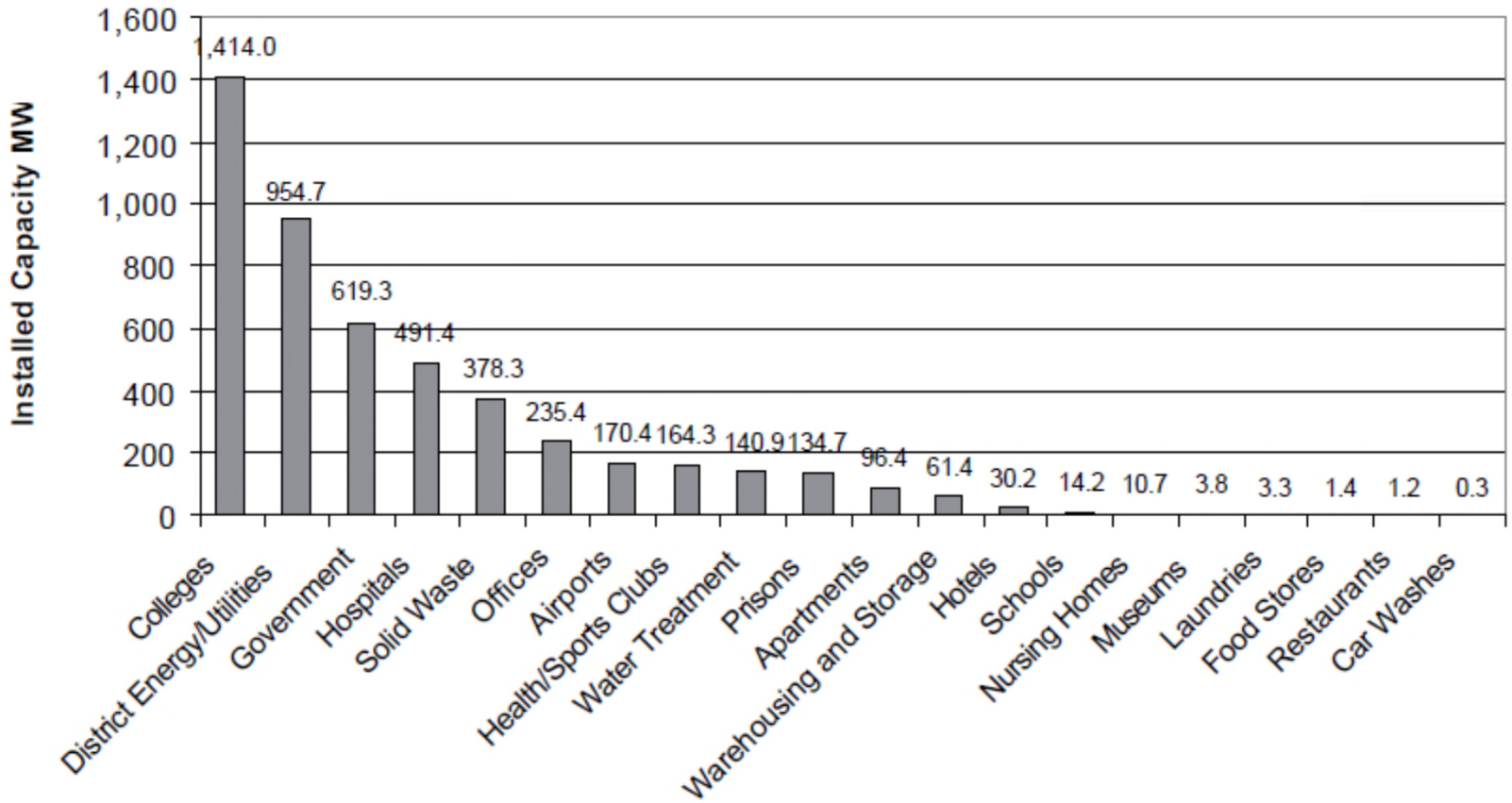
DG / CHP Capacity by Market Type



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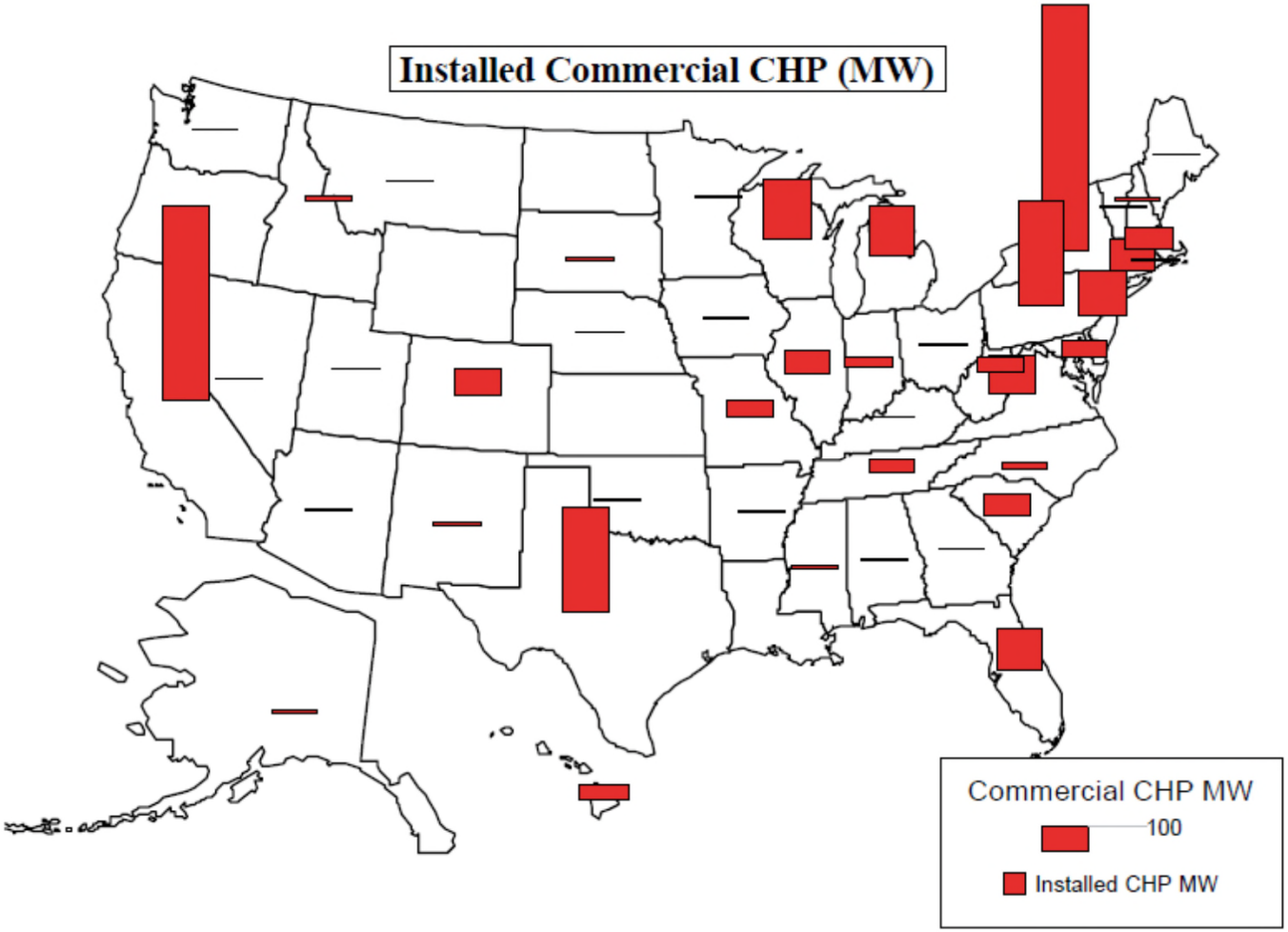
Installed DG / CHP by State



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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

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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

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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

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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

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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

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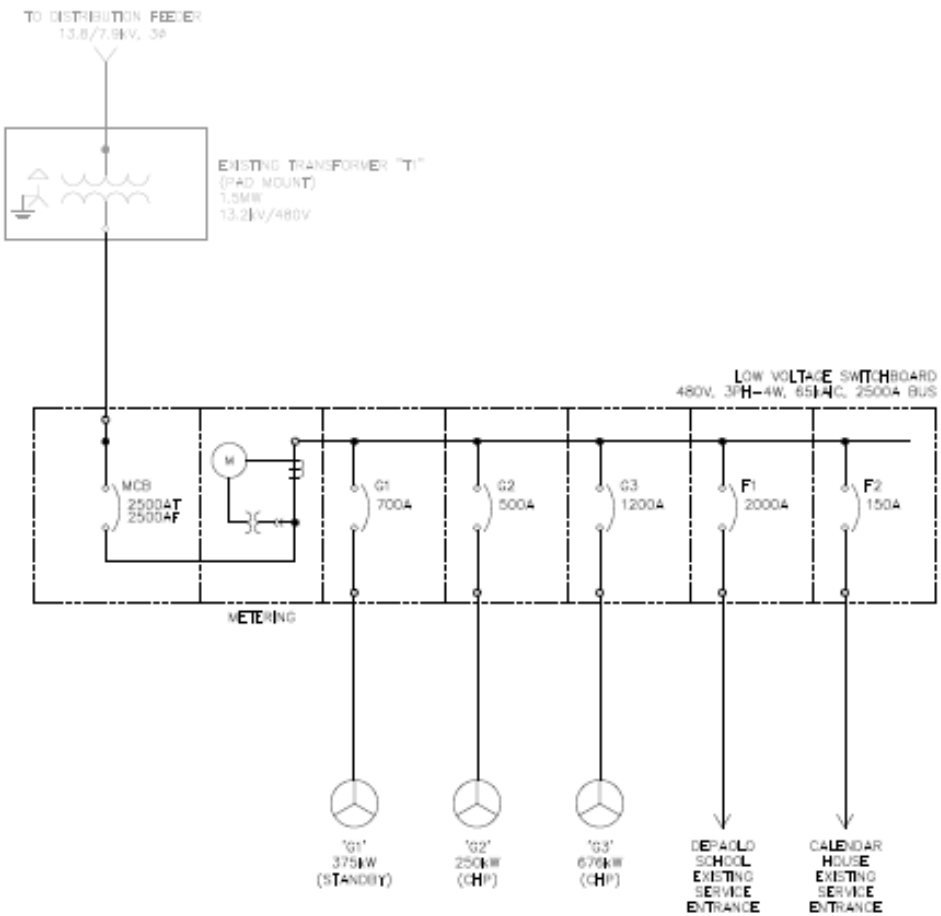
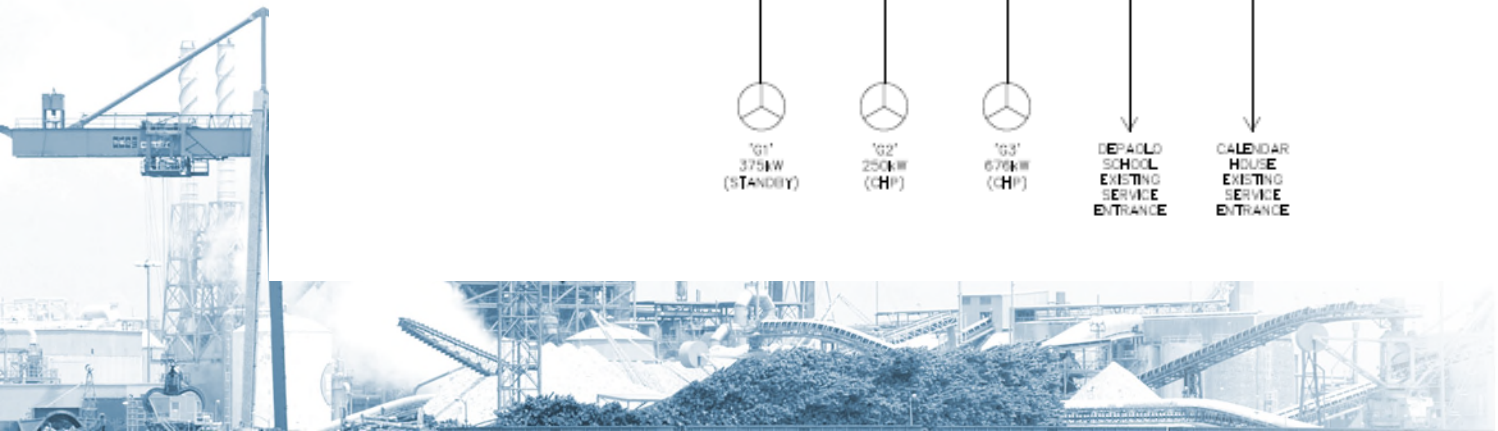
Example Microgrid Site





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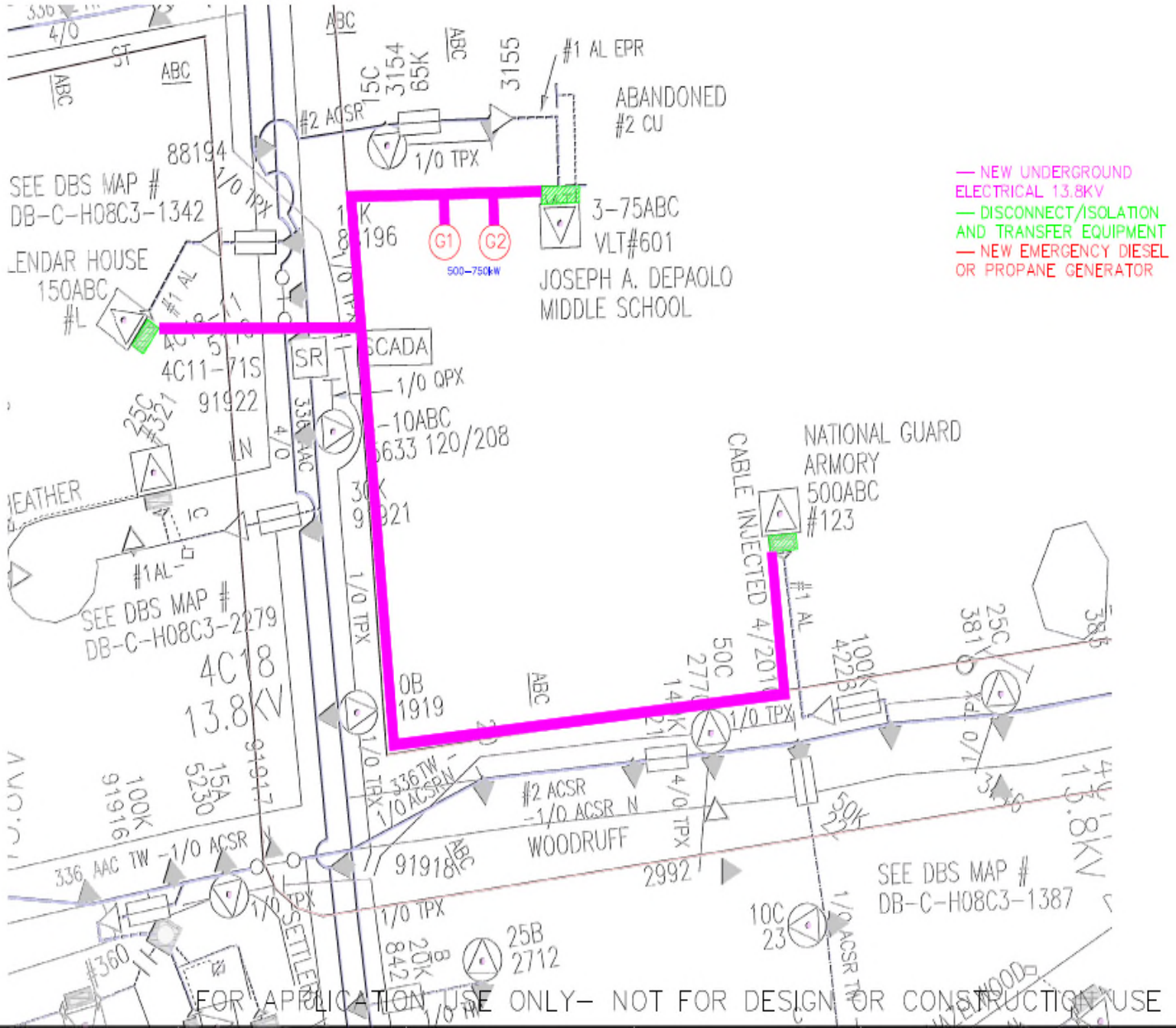

— NEW UNDERGROUND ELECTRICAL 13.8KV
— DISCONNECT/ISOLATION AND TRANSFER EQUIPMENT
— NEW EMERGENCY DIESEL OR PROPANE GENERATOR

MICROGRID ELECTRICAL DISTRIBUTION UPGRADE LAYOUT (PRELIMINARY)

MICROGRID SOUTHINGTON, CT

MICROGRID CT SECD PROGRAM APPLICATION

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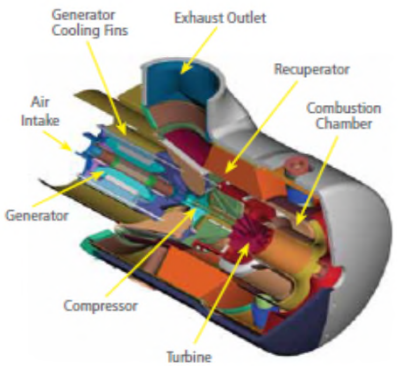
Closing Summary – DG and Microgrids

- 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
- Mix in Energy Conservation – Lighting, Insulation, Etc.
- Advance technology – SmartGrid and Data / Load Management
- Improve infrastructure and reliability



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