Economics of Distributed Generation: T&D Applications

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Resource Dynamics Corporation

What's the DG Buzz About?

- Restructuring promises opportunities for DG solutions
  - Price spikes cause concern
  - Numerous applications are cited, including grid support
- Other innovative market solutions surfacing
  - High growth in non-DG peaking capacity
  - Flat rates for peaky commercial customers
- Plethora of DG technologies in marketplace
  - New technologies being commercialized
  - Ambitious improvements slated for old standbys
- Interconnection debate continues
- Environmental restrictions add complexity
  - High price regions overlap with non-attainment areas
  - NOx control cost burdens smaller units

What is Distributed Generation (DG)?

- Power generation from 30-10,000 kW
  - Reciprocating Engines
  - Microturbines and Industrial Turbines
  - Fuel Cells
- Distributed within transmission and distribution system
- Generally operated parallel to grid

DG Cost and Performance

Technology	Engine: Diesel	Engine: NG	Microturbine	Turbine	Fuel Cell
Size	30kW – 10+MW	50kW – 6+MW	30-200kW	.5 – 10+MW	100-3000kW
Installed Cost ($/kW)[1]	300-500	500-800	500-900	400-700	900-3300
Elec. Efficiency (LHV)	36-43%	28-42%	18-32%	21-40%	40-57%
Overall Efficiency[2]	~80-85%	~80-85%	~80-85%	~80-90%	~80-85%
Variable O&M ($/kWh)	0.005 - 0.015	0.007-0.020	0.004-0.01	0.003-0.008	0.0019-0.0153
Footprint (sqft/kW)	.22-.31	.28-.37	.15-.35	.02-.61	.9
Emissions (gm / bhp-hr unless otherwise noted)	NO_x: 7-9 CO: 0.3-0.7	NO_x: 0.7-13 CO: 1-2	NO_x: 9-50ppm CO: 9-50ppm	NO_x: <9-50ppm CO:<15-50ppm	NO_x: <0.02 CO: <0.01

[1]Cost varies significantly based on siting and interconnection requirements, as well as unit size and configuration.
[2]Assuming CHP

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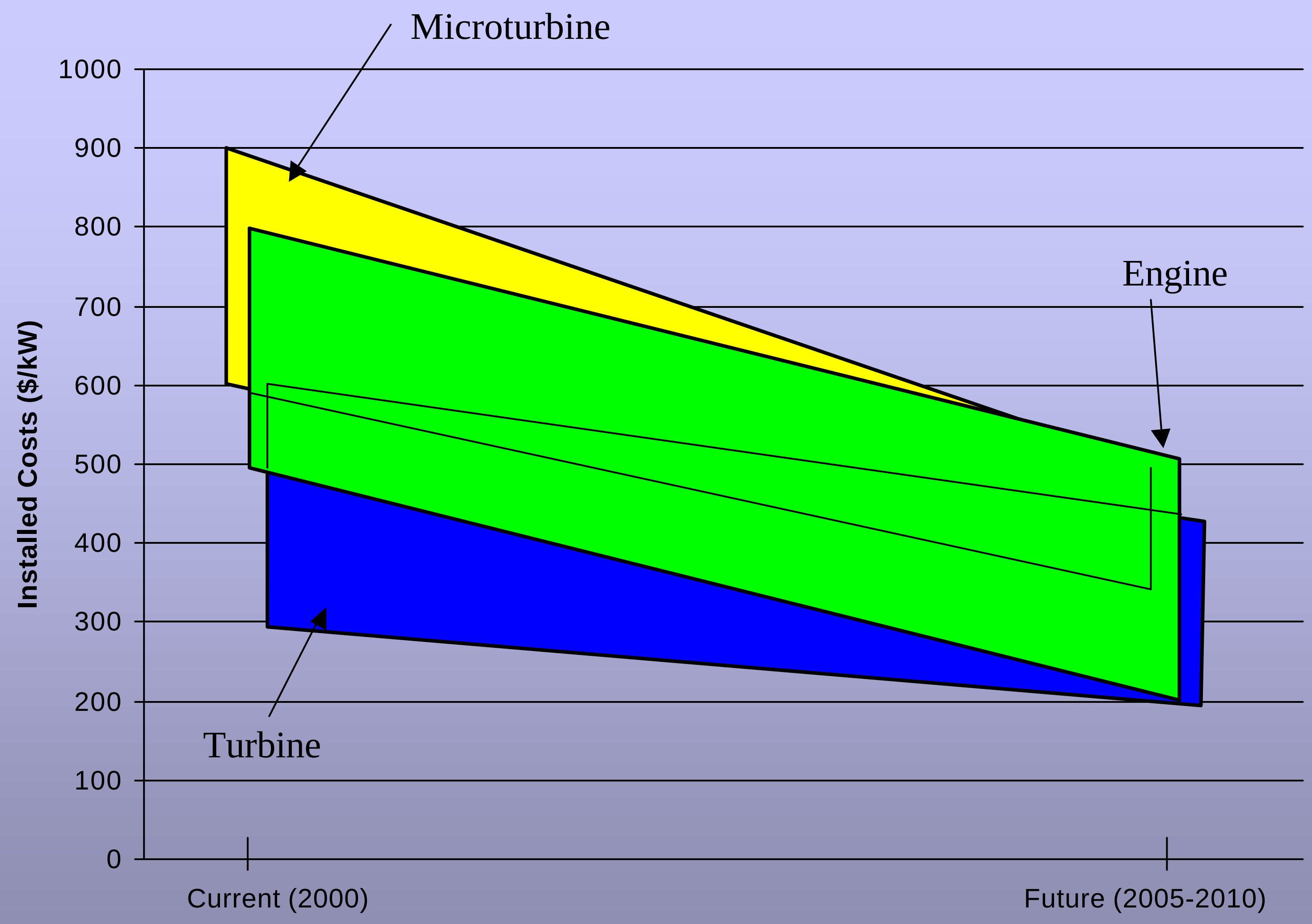
Critical Price and Performance Issues

- Installed Costs
  - Engines typically have advantage
  - Interconnection and permitting can be a major adder
  - Add on emissions controls can kill projects
- Efficiency
  - Fuel cells typically have highest efficiency, followed by engines
  - Better efficiency leads to lower fuel cost and CO_2 emissions
- Emissions
  - Engines, especially diesel, have high emissions of NO_x, CO, and particulates and may be difficult to site
  - Fuel cells have virtually no emissions due to the lack of combustion process, though minor emissions from fuel reformer
- Useful Thermal Output
  - Turbines and fuel cells produce higher quality heat than engines and are better suited for cogeneration applications, especially where steam is required

Projected Cost Reductions



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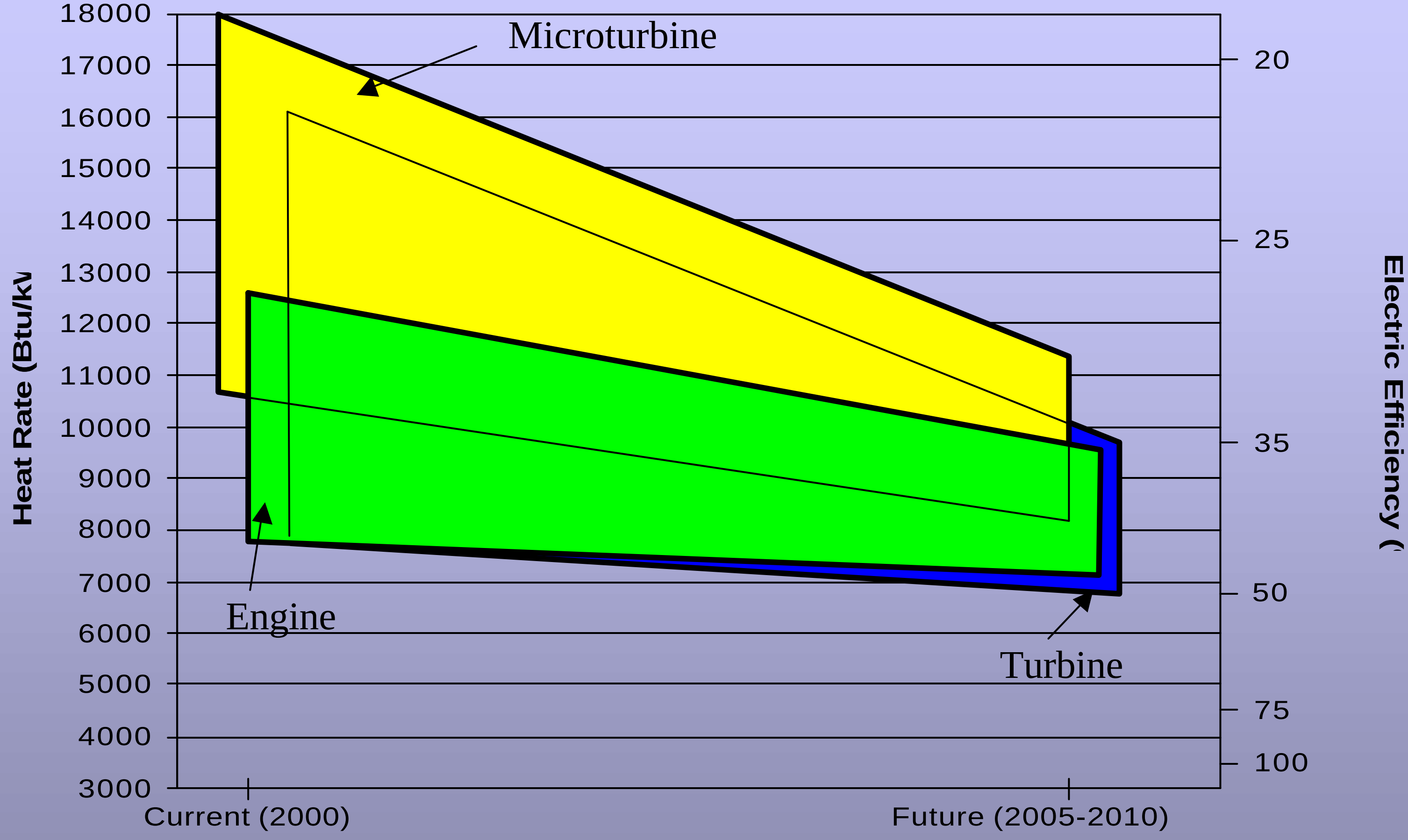
Projected Efficiency Improvements



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DG Applications

Application	Description
Continuous Power	Requires power on a nearly continuous basis, typically at least 6,000 hours per year.
Combined Heat and Power (CHP)	Applications utilize waste heat as useful thermal output, and typically operate 6,000+ hours annually.
Peak Shaving	Units typically operate 200-3000 hours per year during periods when high demand charges apply.
Standby/ Emergency Generation	Applications typically driven by the reliability (perceived or real) of the grid, or code requirements.
Mechanical Drive	Units drive shaft-driven equipment such as gas compressors, air compressors, refrigeration units, chillers, and pumps.
Grid Support	Applications may use DG to defer transmission or distribution system upgrades, reduce transmission losses, or provide voltage support.
Emerging Applications	Premium power, "green" power or DC applications.

Economics of Grid Support Applications

- Economics driven by cost of alternatives
  - T&D upgrades
  - Continuing high line losses
  - Voltage support (e.g. capacitors)
- Other benefits accrue
  - Value of generation
  - Flexibility of DG units
- Regulatory issues may present obstacles, depending on unit ownership
  - Can wires companies own generation assets?
  - Sharing of grid benefits with customers or 3rd parties

T&D Deferral: Example

- City of Eastport projects that its peak load will exceed its existing transmission delivery capability (thermal limit) of 350 MW in the near future. Load is expected to grow at 2.5% per year, from 350 MW to 450 MW in 10 years. No internal generation exists.
- A 20 mile, 138 kV line would provide for an additional 100 MW of transfer capability, and would cost an estimated $8 Million.
- Alternatively, generation could be built to defer the new line until the load grows beyond 450 MW:
  - Both diesel and gas-fired generation will be considered. Units would be added as needed, in increments of 10 MW, based on the growth in peak demand.
  - A generation benefit of 3 cents per kilowatt hour applies for displacing generation purchased from the grid.
  - An additional transmission loss benefit of 6% applies (3 % for transmission losses, 3% for transformation losses).

T&D Deferral Example:
DG Not Economic

Transmission Overloading (Hours)	Net Present Value ($000)		Operation Required for DG to Provide NPV (Annual Hours)		Upgrade Cost Required to Justify DG Solution ($000)	
	Diesel	Turbine	Diesel	Turbine	Diesel	Turbine
200	-10,100	-14,000	NA	1,830	19,200	23,700
500	-10,800	-14,200	NA	1,860	20,100	24,000
1000	-12,000	-14,600	NA	1,910	21,400	24,400
1500	-13,100	-15,000	NA	1,950	22,700	24,700

Note: Discount rate of 12%, financing of DG units at 9%. Each DG scenario calls for purchasing of 10 MW of capacity each year to meet load growth, and assumes that a maximum of two units run at part load. Turbine scenario assumes that diesels are purchased in the first year to handle load swings, and turbines purchased thereafter. Diesel scenario assumes that operation is limited to grid support, and that no sales to grid are permitted due to emissions regulations.

DG Applications for T&D Deferral

- Hard to beat cost of traditional T&D measures
- DG applications will likely have their niches
- Factors which may benefit DG
  - Modularity is beneficial when load growth is slow/uncertain
  - DG units can potentially be moved, if load growth stagnates
  - Transmission facilities are becoming more difficult to site
  - Generation could potentially be sold to reduce project costs
- Potential obstacles
  - Regulatory treatment of generation assets held by wires company
  - Emissions regulations and permitting may make DG siting difficult, or may change down the road

Recommendations for Wires Companies and Integrated Utilities

- Evaluate DG along with T&D upgrades
  - Include as an option
  - Assess uncertainty of load growth forecasts
  - Perform sensitivity analysis
- Compare to difficulty of T&D siting
- Follow DG Trends
  - Technology improvements in cost and efficiency
  - Emissions levels, regulations and permitting issues
  - Application of DG for T&D deferrals
- Consider pilot/demo projects