RENEWABLE ENERGY / DISTRIBUTED GENERATION TECHNOLOGIES IDENTIFICATION AND TARGET MARKET RESEARCH STUDY

FOR THE

NEW HAMPSHIRE ELECTRIC COOPERATIVE

ADDENDUM NOVEMBER 19, 2007

INITIAL FINAL REPORT
MARCH 17, 2004

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Addendum Note: *All the addendum additions and updates are easily located by italicized text through out the document.*

ACKNOWLEDGEMENTS: Key individuals from the New Hampshire Electric Cooperative were involved in the provision of important data and reviews leading to the drafting and finalization of this report *and supplemental addendum.* We would like to specifically acknowledge the contributions and support of Keith McBrien, Tom Palma and Jim Bakas.

Section 1: Introduction

This report *and addendum* summarizes results from secondary research, model development, and technology screening efforts performed for the New Hampshire Electric Cooperative (NHEC) by GDS Associates, Inc. to assess and prioritize the potential for installing member-sited distributed generation, including renewable generation sources. *This effort was originally presented in an initial final report dated March 17th 2004. The report has been updated through this addendum to document market and commodity changes that have occurred since March, 2004. There have been significant changes in energy and fuel prices since the original study. The scope of work for this addendum was limited to only updated capital costing and operating costs. In addition, two technologies were added to the mix of technologies assessed in the original report. The technologies added were Solar water heating and Micro CHP (combined heat and power). Results from these additions have been incorporated into this addendum report as follows:*

(1) Updated the information summarized in a single table, including: key size, installation and operating costs, and other important technical characteristics of a number of commercially available renewable and distributed generation technologies potentially appropriate for installation in New Hampshire/NHEC's service territory; (Revised Tables 1 & 2)

(2) Updated an existing renewable/distributed generation cost-effectiveness/simple payback screening model to reflect NHEC rates and territory-specific fuel costs;

(3) Added and updated incentive information to include Federal Tax credits and changes in the report and model. This allowed for simple input of incentive summary cost information and links to the project technologies.

This report summarizes results from secondary research, model development, and technology screening efforts performed for the New Hampshire Electric Cooperative (NHEC) by GDS Associates, Inc. to assess and prioritize the potential for installing member-sited distributed generation, including renewable generation sources. As noted in NHEC's Utility Specific Core Energy Efficiency Program Filing 2003 Update dated April 7, 2003, this study addresses the following items:[1]

(1) Identify and summarize in a single table; key size, installation and operating costs, and other important technical characteristics of a number of commercially available renewable and distributed generation technologies potentially appropriate for installation in New Hampshire/NHEC's service territory;

[1] See page 13 - footnote #4 of NHEC's April 7, 2003 filing – Docket No. DE 01-057.

(2) Develop energy/load profile information for typical NHEC residential, small, medium and large commercial and industrial building and business types (sorted by industry types for NHEC key accounts);

(3) Update an existing renewable/distributed generation cost-effectiveness/simple payback screening model to reflect NHEC rates and territory-specific fuel costs;

(4) Use model to identify which technologies and size combinations are most appropriate for potential installation at which typical NHEC member types (e.g., residential, small, medium, large commercial, industrial, etc.) and building/business characteristics (e.g., electric heat, propane heat, retail, office, manufacturing, hotel/motel, healthcare, school, government, etc.); and

(5) Estimate the economic potential for installation of renewable and distributed generation technologies within NHEC's service territory.

NHEC in it's efforts to identify and rank the potential for renewable and distributed generation technologies at typical residential, small and large commercial and industrial member locations contracted with GDS Associates to help with those efforts. In addition to performing secondary research to collect critical information and operating characteristics on the various generation technologies that are commercially available, another component of this project involved the revision of a GDS-developed spreadsheet model for use in determining approximate payback periods associated with various technology applications. This revised model was used to assess the potential for installing generation technologies based on typical NHEC member load profiles.

In total, the model identified over 140 potentially viable member-sited distributed generation scenarios. As a follow-on to this project, the model was designed to be used by NHEC's field representatives as a screening tool for more site-specific analyses at individual member locations.

A brief summary of results, *included addendum technologies*, is presented in Section 2. This summary is followed by a discussion of the methodologies used by GDS when performing its work (Section 3). Finally, the report ends with a discussion of noteworthy market conditions and other related observations (Section 4).

Section 2: Summary of Results

This section includes a presentation of results from the following key addendum activity areas:

(1) General overview of Mirco Combined Heat and Power MCHP technology

(2) Current MCHP technology updates;

(3) Solar water heating technology overview;

This section includes a presentation of results from the following key activity areas:

(1) Identification of renewable and distributed generation technologies assessed and characteristics of each technology;

(2) Development of a listing of member groups and building types to be modeled as potential on-site generation candidates;

(3) Revision of GDS's distributed generation screening model for NHEC;

(4) Prioritized ranking of potentially viable renewable and distributed generation applications showing the associated generation technologies for each member group reviewed; and

(5) Estimated economic potential for the installation of on-site renewable and distributed generation technologies within NHEC's service territory.

A. Technologies Assessed

Based upon GDS's existing libraries of information and supplementary secondary data reviews, including the MCHP and Soar Water Heating technologies described as part of this addendum below (see sub paragraphs 1, 2 & 3), eleven distributed generation technologies (including five renewable technologies) have been identified. As shown in Table 1 immediately below the addendum technology descriptions, ten of these technologies are considered to be commercially available (three fuel-type configurations of reciprocating engines, fuel cells, microturbines, hydroelectric power generation[2], wind turbines, photovoltaic modules, MCHP and solar water heating),

[2] A majority of the viable small/dispersed hydroelectric power generation sites in NH have already been developed under previous state (LEEPA) and federal (PURPA) small power producer regulations. These operating facilities are currently producing electricity and selling 100% of their output under long term contracts to PSNH or other purchasers in the wholesale market. For this reason, and due to the significant difficulties associated with the permitting and development of additional small hydro

and one technology is identified for information purposes but currently remains in the pre-commercial demonstration and development stage (Stirling Engines). A summary of key operating characteristics and cost information for each technology is provided in Table 2.

1. *MCHP Technology Overview*

Residential Combined Heat and Power – The MCHP[3]

There is an increasing urgency for affordable, reliable and practical means to reduce energy consumption and environmental impact in the residential and small commercial market. Considerable strides have been made in the energy efficiency of home appliances and lighting and in the performance of windows, insulation and weatherization techniques.

Alternative forms of energy are also emerging in the residential market; however, they are not always cost effective or feasible options for existing homes. The Micro Combined Heat and Power system (MCHP) offers another option for energy savings through an existing infrastructure that is applicable in most residential homes, and has a relatively short term return on investment.

What Is It? *A micro combined heat and power (CHP) system simultaneously produces useful heat and power for a residence. Micro CHP units range in capacity from about 1 kW to 6 kW and are about the size of a major appliance. The system is located somewhere on the property – in the basement, hanging from a wall, underneath the sink, or outside. This system offers noteworthy opportunities to boost the profitability of an energy company's supply business as well as providing significant environmental benefits. With CHP's being popular in Europe and Japan after thousands of installations, some manufacturers are starting to reach out to the U.S. market. There are numerous types of packages in the market when looking to buy a micro CHP, but the most effective way to apply the technology is to buy the micro CHP unit along with a natural gas-fueled warm air furnace or boiler for supplemental space heating.*

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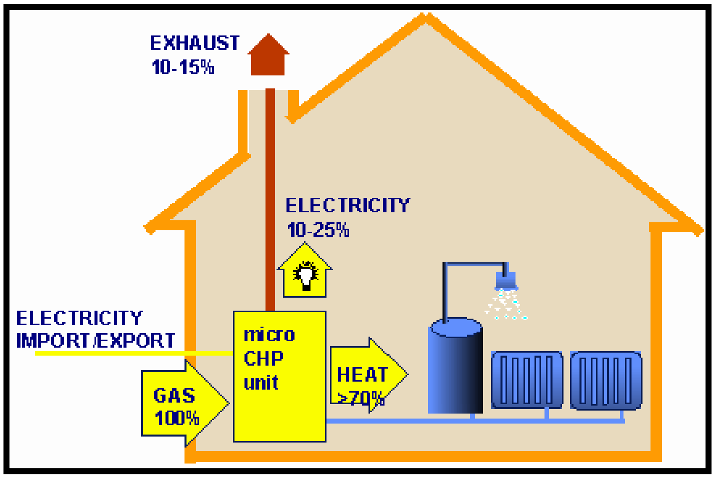
projects (at existing or proposed new dams) in the region, new hydroelectric power generation was not considered in this renewables/distributed generation technologies assessment.

[3] *Roberts , Amber, "Residential Combined Heat and Power" Spring 2007 Transactions*



How Does it Work? *The CHP engine consumes natural gas to supply electricity and heat for the residence. A total of around 70 – 80% of the gross energy value of the gas is converted into heat, chiefly in the form of hot water which is used for space heating and domestic hot water. Between 10-25% is converted into electricity, and the remainder (5-15%) is lost in flue gases. Whereas in a conventional gas central heating boiler converts 80% of the energy into heat and the remaining 20% is lost in the flue gases.*[4]

For more information on each technology see "The Micro-CHP Technologies Roadmap" developed by the US Office of Energy Efficiency and Renewable Energy (EERE). Found at www.eere.energy.gov

Why Buy a Micro CHP? *The system generates electricity while providing heat to the home. Any electricity that is not immediately used in the home will be applied as a credit against future power use. This system is called net-metering and the benefit of net metering for micro CHP owners are currently available in about 10 states and is continuing to expand. Along with gaining credits toward power usage, homeowners will also significantly reduce their monthly electric bill during the heating season. Environmental benefits are also yielded with a micro CHP installation. One U.S. manufacturer, Climate Energy, is expected to yield a 30% reduction in harmful carbon dioxide emissions as compared with conventional heating appliances and grid supplied electricity with it's system.*

Results and Conclusions of a Benefit/Cost Test *The development of a benefit-cost ratio for the system done by GDS took into account some actual data derived from test sites in Massachusetts included standard assumptions used in evaluating high efficiency furnaces. The base case was an 80 percent AFUE furnace, and it was assumed that the MCHP system would act as a replacement unit and not an early retirement system. The useful life of the system as suggested by the manufacturer was estimated at 15 years, 5 years less than most high efficiency furnaces. The incremental cost, kW production per hour, and annual run hours were also provided by the manufacturer. The analysis of annual estimated savings in gas (mmbtu) combined with the annual estimated savings in electricity (KWh) resulted in a benefit-cost ratio (BCR) of 2.54. A BCR over 2.0 for gas equipment is a very encouraging indication of energy savings.*

[4] Gas usage and figure from Wisconsin Power Control website.

Main Assumptions

Useful Life	*15 years*
Annual Run Time	*4,500 hours*
Incremental Cost	*$6,500*
Annual kWh Production	*1.2* 4,500 hours = 5,400 kWh*
Annual btu Output (mmbut)	*13,840*4,500 hours = 62.28 mmbtu*

Results

mmbtu Savings from Basecase to Furnace w/ MCHP	*71.6 mmbtu*
kWh Savings from Basecase to HE Furnace w/ MCHP	*5,502.0 kWh*

Conclusion *The MCHP is a technology that provides a bridge to the gap between conventional appliances and renewable energy alternatives for small commercial and residential customers. The cost effectiveness of the MCHP is more practical than most renewable options, and the infrastructure exists through the conventional heating equipment market to bring the MCHP system into the marketplace through heating contractors and distributors. The U.S. MCHP market will surely expand with continued adoption and development of the technology.*

2. Current MCHP Technology Update;[5]

The existing CHP units available on the market today provide combined heat and power with forced hot air. The units currently require natural gas. The commercially available machines do not have back up power capabilities. The units were made commercially available in the United States this year (2007). The target market that was identified for initial U.S. installations is New England. Climate Energy teamed with KeySpan Energy Services earlier in 2007 and KeySpan has been offering customers a $2000 rebate to install MCHP systems.

Climate Energy's next generation of MCHP units is being designed for hydronic applications, in addition to forced hotair, and are expected to have domestic water heating capabilities. The hydronic generation type units are expected to become commercially available in Q3 of 2008. The incremental cost is expected to be the same as the air unit at $6,500.

A future unit also looks to incorporate emergency heat and power operation capabilities. This unit has an expected commercialization date of Q1 2009. The back power unit is expected to be able to provided up to 2 kW and provided heat capabilities if needed. If no heating is required (during a summer outage for example) then 2.2 kW is expected to be available.

Climate Energy is also working on a system that utilizes propane as opposed to natural gas. The propane power unit is anticipated for a Q3 2009 commercialization date. The incremental cost is predicted to be the same as the hot water and air units at $6,500.

3. Solar water heating;

Solar water heating systems utilize virtually the same components for residential and commercial applications,. The relative number of collectors and some slight pumping system modifications need to be made for larger systems. A typical residential application requires between 40 and 60 square feet of collector surface area. To simplify modeling of solar water heating systems in this analysis, one system is modeled with the capability for adding units as necessary to meet specific residential, commercial and industrial load requirements. For each unit added, the surface collector is increased by 60 square feet. When sizing solar water heating systems, it is important to consider the needs of the water heating application and to first invest in insulating the distribution system to maximize the sun's free heating capability.

In the Northeast it is critical to ensure that the solar water heating system be freeze resistant. This is not optional in NHEC's service territory.

[5] LoFonda, Phillip, Yankee Sciencetific Inc., Medfield, MA, November 13, 2007

Table 1: Key Characteristics of DG Technologies[6] (Updated 11/13/07)

Technology	Key Characteristics	
	Pros	**Cons**
Reciprocating Engine – Diesel	Low first cost Easy to maintain Good for Stand-by < 8 seconds to start-up	High emissions High noise levels Poor heat recovery Short “shelf life” of diesel
Reciprocating Engine – Propane/Natural Gas	Low first cost/low emissions < 8 seconds to start-up	Higher cost than diesel Less efficient than diesel
Reciprocating Engine – Methane (Landfill/Bio-Gas)	Low first cost Low emissions	Higher cost than diesel Less efficient than diesel
Microturbine – Natural Gas	Low emissions Good heat recovery Smaller footprint High power density	Requires high pressure gas Higher cost than engines Poor at load following (DC)/1-3 minutes to start-up Efficiency decreases with air temp (peak times) Not conducive to frequent starting & stopping
Fuel Cell	Low emissions/very quiet No stack required	Very expensive Several minutes to over an hour to start-up
Wind Turbine*	No emissions No fuel cost Low operating cost	Not dispatchable Requires steady wind
Photovoltaic Module*	No emissions No fuel cost Low operating cost	Expensive NH insolation is moderate
Hydroelectric Power*	No emissions No fuel cost Low operating cost	High first cost associated with environmental permitting, plant investment and project development Limitations on site availability for new developments
*Solar Water Heating**	*No fuel costs.* *No combustions.*	*Moderate paybacks* *Visual impact*
Micro CHP	*Takes advantage of waste heat* *Reduce net emissions*	*High capital costs* *New technology*
*Biomass CHP**	*Renewable resource* *Low fuel costs.*	*High capital costs* *Moderate to high maintenance costs.*
Stirling Engine	Accepts all fuels High efficiency	Not commercially available Very heavy

[6] Renewable technologies are noted with an asterisk (*)

Preliminary Operation Characteristics of Renewable Distributed Generation Technologies to be Analyzed

Table 2: Distributed Generation Technology Summary (updated 11/13/07)

Technology	Target Market Sectors	Average Annual O&M Costs[4] ($/kWh)	Installed Cost Range[3] ($/kW) (includes CHP)	Operating Fuels: Type	Operating Fuels: Cost[1]	Electric Power Output Range[2]	Thermal Output Range (Btu/kWh)	Operating Temp	Operation Specs.	Typical Fuel Consumption (Btu/kWh)
Reciprocating Engines	Res., Comm., Indust.	$0.008-$0.015 per kWh	$900-$1,400/kW	Natural gas	*$1.15/therm*	10 kW-10 MW @ 21% - 43% eff.	1,000 - 2,000 (1-2 lbs steam)	316°-500°F	1.0-45 psig	Diesel 9,500-13,000 Natural Gas 12,000-15,000
				Propane	*$2.497/gal*					
				Diesel	*$2.37 /gal*					
				Bio-gases[2] (methane)	*$0*					
Mirocturbines	Res., Comm. & Agricultural greenhouses	$0.005-$0.01 per kWh (higher is used as "peaker")	$1,500 -$2,200 (natural gas)	Natural gas	*$1.15/therm*	30-2000 kW @ 25-30 eff.	5,000-8,000 (5-8 lbs steam)	400°-635°F	3-100 psig	Natural Gas 15,000-19,000
			$2,500-$3,500 (bio-gas)	Propane	*$2.497/gal*					
				Bio-gas[2]	*$0*					
Fuel Cells	Low Temp: Res, Comm	*$0.005-$0.01 per kWh*	*$4,500-$5,500/kW*	Natural gas	*$1.15/therm*	Low Temp: 2-250 kW @ 30-40% eff.	6,800-7,500 (6-7 lbs steam)	Low Temp: 140-250°F	15-50 psig	9,000-11,000
	High Temp: Comm, Indus			Propane	*$2.497 /gal*	High Temp: 100 - 2,000 kW @ 45 - 55% eff		High Temp: 1200°F		
				Bio-gas[2]	*$0*					
Wind Turbines	Res, Comm.	$0.005-$0.03 per kWh	*<20kW: $3,500-$7,500*	<50kW: Wind >8mph	n/a	1kW – 3.6 MW @ 25% eff	None	None	n/a	n/a
			20-250kW: $2,500-$5,400	>50kW:						
			>500kW: $2,000	Wind >10mph						

Preliminary Operation Characteristics of Renewable Distributed Generation Technologies to be Analyzed

Table 2: Distributed Generation Technology Summary (updated 11/13/07)

Technology	Target Market Sectors	Average Annual O&M Costs[4] ($/kWh)	Installed Cost Range[3] ($/kW) (includes CHP)	Operating Fuels		Electric Power Output Range[2]	Thermal Output Range (Btu/kWh)	Operating Temp	Operation Specs.	Typical Fuel Consumption (Btu/kWh)
				Type	Cost[1]					
Micro Combined heat and power	*Res, Comm.*	*$.005-$0.01 per kWh*	*$3,000- $4,000 per kW*	*Natural gas with forced hot air*	*$1.15/therm*	*1.2 kW*	*60,000 Btuh*	*n/a*	*n/a*	*n/a*
Photovoltaic Modules	Res, Comm.	$0.001-0.004 per kWh	$8,000-$10,000/kW	Global solar radiation (direct and diffuse)	n/a	10 watts to 100 kW	None	None	n/a	n/a
Solar Water Heating	*Res, Comm.*	*$0.001 per kWh*	*$3,000/kW*	*Global solar radiation (indirect to gycol loop in Northern climates*	*n/a*	*n/a*	*7,000*	*varibale*	*n/a*	*n/a*
Bio-Gas Driven Project	Sewer Treatment, Agricultural	$0.005-$0.01 per kWh	$2,500-$3,500/kW	Bio-Gas	*$0*	30kW - 75kW Microturbines	Propane 11,500-13,000	n/a	n/a	n/a
Biomass	*Comm.*	*$0.0075 per kWh*	*$4,000/kW*	*Wood Chip*	*$40.00 per ton*	*50 kW*	*10,000*	*varibale*	*n/a*	*n/a*
Not Commercially Available										
Stirling Engines	Res, Small Comm.	$0.015 +/- (Less O&M required w/free-piston type)	$1,700-2,300	Natural Gas Propane Bio-gas		25 & 50 kW prototypes	1,200	<200°F	2 psig	n/a

1. *Fuel costs per NH Office of State Planning and Energy Programs website, Oct. 05, 2007*
2. Bio-gas is assumed to be available at no cost and that the infrastructure costs to capture and scrub the gas has already been incurred.
3. Installed costs for DG technologies include equipment, site preparation, and engineering fees. Fees associated permitting and interconnection may not be included and
4. Operation and maintenance expenses reflect an estimate of all necessary costs throughout equipment life, including major overhauls.

B. Member Sectors/Building Type Categories

For the purpose of this analysis, NHEC members were grouped into a number of member sectors and/or building type categories. Major category groupings include:

- Residential (general, space heating, electric thermal storage, and water heating);
- Condominium Association;
- Commercial (malls/strip malls);
- Education;
- Farm (dairy, etc.);
- Government;
- Healthcare;
- Hospitality;
- Industrial;
- Recreation;
- Retail; and
- Other Large, Medium and Small C&I Members.

Table 3 identifies the specific categories and associated sub-groupings that were considered as having the potential for on-site generation (including renewable generation). The commercial and industrial categories were selected using NHEC's Key Account industry type designations. Residential categories were grouped by energy usage and heating types. In addition to NHEC's residential and key member industry types, sixteen additional commercial and industrial categories were identified based on annual peak demand (Under 11 kW to Over 250 kW). Load profile information (average monthly kWh, kW, and associated load profile data) was estimated for a "typical" member within each of these categories using NHEC-provided member data to the greatest extent possible. For modeling purposes, each member category was broken into sub-groups and applicable 2004 rates were identified.

For each of the NHEC member groups shown in Table 3, a number of potentially appropriate on-site/distributed generation technologies were assessed. Table 4 lists which technologies were assessed for each specific NHEC commercial, industrial and residential member group. Results from GDS' member group/technology screening assessments are summarized in Section 2.D below.

Table 3 - Member Type Categories

Member Type	Sub-Grouping	Applicable Rate
Residential	Electric Heat Electric Thermal Storage Propane Heat Oil Heat Wood Heat	Residential–Electric Heat, B Residential–ETS, OPH Residential, B Residential, B Residential, B
Condo Association	Seasonal - Summer Seasonal - Winter Year Round	B, LB3, B3, LGT**
Commercial	All Commercial	B, B3
Education	College / Campus Elementary / High School	B, LB3, B3, P, LGT**
Farm (dairy, etc.)	Dairy Aquaculture Other	B, B3
Government	Water & Sewer Municipality US Post Office	B, LB3, B3, P, LGT**
Healthcare	Hospital Other Healthcare	B, LB3, B3, LGT**
Hospitality	Seasonal - Summer Seasonal - Winter Year Round	B, LB3, OPB3, P, LGT**
Industrial	Large – Single Site Small – Single Site Scattered Sites	B, LB3, B3, P, PSGDS, LGT**, DEF
Recreation	All Ski Areas	PGSKI, B, LB3, B3, LGT**
Retail	Grocery Bank Other Retail	B, LB3, B3, P, LGT**
Other	Large C&I (Over 250 kW) Large C&I (101–250 kW) Medium C&I (51-100 kW) Medium C&I (26-50 kW) Small C&I (11-25 kW) Small C&I (Under 11 kW)	PGSKI, B, LB3, B3 P, B, LB3, B3 B, LB3, B3 B, B3 B, B3 B, B3

Table 4: Mapping of DG Technology to NHEC Residential and Member Industry Type (Updated 11/13/07)

NHEC Member Industry Type	Potential DG Technologies for Assessment	Unique Industry Characteristics
Residential (electric heat and non-electric heat) [7]	PV, Wind, Small Diesel Engine, *MCHP*, *Solar water heating*	Small systems, year round and seasonal use
Condo Association[7]	PV, Wind, Reciprocating Engine (all fossil fuels), Fuel Cell, Microturbine[8], *MCHP*, *Solar water heating*	Including year round and seasonal use
Commercial (Mall/Strip) [7]	Wind, PV, Reciprocating Engine (all fossil fuels), Fuel Cell, Microturbine[8], *MCHP*, *Solar water heating*	Peak shaving, need for standby/emergency power
Education	Wind, PV, Fuel Cell, Reciprocating Engine (all fossil fuels) Microturbine[8], *MCHP*, *Solar water heating*	High visibility for "green" power, need for standby/ emergency power
Farm (dairy, produce, etc.)	Wind, PV, Reciprocating Engine (all fuels), Fuel Cell, Microturbine, Biogas *MCHP*, *Solar water heating*	Availability of biogas fuel, opportunities for siting of wind and PV systems
Government[7]	Wind, PV, Reciprocating Engine (all fossil fuels), Biogas Engine, Fuel Cell, Microturbine[8], *MCHP*, *Solar water heating*	Standby power for storms, access to biogas (landfill, wastewater treatment)
Healthcare[7]	Wind, PV, Reciprocating Engine (all fossil fuels), Fuel Cell, Microturbine[8], *MCHP*, *Solar water heating*	Critical need for high quality, reliable power and standby/emergency generation
Hospitality[7]	Wind, PV, Reciprocating Engine (all fossil fuels), Fuel Cell, Microturbine[8], *MCHP*, *Solar water heating*	Standby for elevators and other critical services

[7] *All fossil fuel based systems are no longer viable less natural gas based systems. NHEC has very limited available to natural gas. The current price of diesel for example as remained well over $2.25 per gallon for over three years and there is no indication of a downward trend. In fact the opposite holds true and the price for transportation diesel has held at over $3.00 per gallon of the last three months.*
[8] *Fuel Cells and Micro turbines generally have much more attractive paybacks when utilizing available bio-gas.*

Industrial	Wind, PV, Reciprocating Engine (all fossil fuels), Fuel Cell, Microturbine[8,9], *MCHP*, *Solar water heating*	Heat recovery for use in various industrial processes, continuous operation, peak shaving, need for high power quality and standby/emergency power
Recreation (Ski Areas)	Wind, PV, Reciprocating Engine (all fossil fuels), Fuel Cell, Microturbine[8], *MCHP*, *Solar water heating*	Opportunities for location of wind, high seasonal off-peak power needs for snow making, standby and emergency power
Retail[7]	Wind, PV, Reciprocating Engine (all fossil fuels), Fuel Cell, Microturbine, *MCHP*, *Solar water heating*	Power quality (banks), standby/ emergency power needs
Other Large, Medium and Small C&I[9]	Wind, PV, Reciprocating Engine (all fossil fuels), Fuel Cell, Microturbine[8]	Power quality, peak shaving, standby/ emergency power needs

C. Distributed Generation Screening Model

All of the technologies where updated in the Addendum Report. Micro CHP and Solar water heating were added to the technologies. There was also significant effort put into updating the Solar PV and Wind sectors which have been heavily publicized as having had significant industry growth.

An existing distributed/onsite generation technologies screening model developed by GDS was customized for this analysis and for use as a tool by NHEC personnel to help with future field assessment of the feasibility of distributed electric and combined heat and power generation projects (including renewable technologies) at member-specific residential, commercial and industrial sites. For this current analysis, the model has been loaded with typical average monthly electricity usage profiles for the various NHEC member group/facility types identified in the tables above. Performance and cost information for different generation alternatives, as well as electricity rate tariffs currently in effect for NHEC's members were also included in the revised screening model.

In order to utilize this model effectively, NHEC staff (user) must enter applicable information into a "Model Input" worksheet for each member type/facility to be evaluated. Key model input areas include:

- Member Information;
- Electrical Energy Cost;
- Heating Fuel Cost;

[9] Steam turbine technologies are also potentially applicable for certain process heat intensive industries. Given the limited application in NHEC territory, these technologies are not included in this current assessment.

- Energy Usage;
- Generator Preferences; and
- Generator Fuel Cost.

All areas of the model requiring direct user input are shaded in blue. Brief instructions for user inputs are provided in *italics*, where needed, directly on the Model Input sheet itself. It is important to note that the reasonableness of results is dependent upon the user's understanding and interpretation of the member's energy usage (*i.e.*, the accuracy of the member's load profile) and the generation units (and associated technical data) selected to meet that usage.

Key unit dispatch, financial and economic aspects of this model utilize simplifying assumptions. Due to a wide range of member operating situations and business structures as well as the existence of varying renewable and distributed generation incentives, hourly load tracking, life cycle costing, and after-tax economics are not addressed in this model. Although State and Federal tax credits for certain renewable technologies are generically accounted for in the model, these and other items should be carefully addressed as part of a more detailed, site-specific evaluation prior to making any firm commitments or investment decisions.

D. Prioritized Ranking

The screening model was used to run more than 7,200 separate scenarios to assess all unique combinations of member category and technology types. Based on results from these member and technology scenarios, a prioritized ranking was created. Results from this ranking are presented in Table 5 and 6. These tables show the highest ranking, potentially viable, technologies for each member type and subgroup.

Table 5 – Detailed Listing of Potentially Viable Technologies by Member Subgroup (Updated 11/13/07 Please reference Notes for details)

Member Type / Sub-Group	Technology Configuration (Technology / Size / Fuel / Capacity Factor / Waste Heat Factor)
Residential - Basic Non-Electric Heat-Propane	None with payback of 10 years or less
Residential - Basic Non-Electric Heat-Oil	None with payback of 10 years or less
Residential - Basic Non-Electric Heat-Wood	None with payback of 10 years or less
Residential - Basic Electric Heat	None with payback of 10 years or less
Residential - Elec Heat - ETS - Controlled	None with payback of 10 years or less
Residential - Basic w/controlled DHW	None with payback of 10 years or less
Commercial - Large	Wind Turbine, 250 kW, None, 24% CF, 0% WH
Commercial - Large	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Commercial - Medium	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Commercial - Medium	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Commercial - Small	None with payback of 10 years or less
Condo Association - Large	Wind Turbine, 250 kW, None, 24% CF, 0% WH
Condo Association - Large	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Condo Association - Seasonal Summer	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Condo Association - Seasonal Summer	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Condo Association - Seasonal Winter	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Condo Association - Seasonal Winter	Reciprocating Engine, 11 kW, Bio-Diesel, 90% CF, 50% WH
Condo Association - Seasonal Winter	Reciprocating Engine, 11 kW, Diesel, 50% CF, 50% WH
Condo Association - Seasonal Winter	Reciprocating Engine, 11 kW, Bio-Diesel, 50% CF, 50% WH
Condo Association - Seasonal Winter	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Condo Association - Seasonal Winter	Wind Turbine, 10 kW, None, 24% CF, 0% WH
Condo Association - Seasonal Winter	Wind Turbine, 1 kW, None, 24% CF, 0% WH
Education - Campus	Wind Turbine, 250 kW, None, 24% CF, 0% WH
Education - Campus	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Education - District	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Education - Large Campus	Reciprocating Engine, 250 kW, Diesel, 90% CF, 50% WH
Education - Large Campus	Wind Turbine, 660 kW, None, 24% CF, 0% WH
Education - Large Campus	Wind Turbine, 250 kW, None, 24% CF, 0% WH
Education - Large Campus	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Education - Large District	Wind Turbine, 660 kW, None, 24% CF, 0% WH
Education - Large District	Wind Turbine, 250 kW, None, 24% CF, 0% WH
Education - Large District	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Farm - Dairy	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Farm - Other	None with payback of 10 years or less
Farm - Aquacultural	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Government – Large Municipal	Wind Turbine, None, 660 kW, 24% CF, 0% WH
Government - Large Municipal	Wind Turbine, None, 250 kW, 24% CF, 0% WH
Government - Large Municipal	Wind Turbine, None, 100 kW, 24% CF, 0% WH

Member Type / Sub-Group	**Technology Configuration**
Government - Large Water & Sewer	Micro-turbine, Bio-Gas, 45 kW, 90% CF, 50% WH
Government - Large Water & Sewer	Micro-turbine, Bio-Gas, 60 kW, 90% CF, 50% WH
Government - Large Water & Sewer	Micro-turbine, Bio-Gas, 75 kW, 90% CF, 50% WH
Government - Large Water & Sewer	Micro-turbine, Bio-Gas, 30 kW, 90% CF, 50% WH
Government - Large Water & Sewer	Wind Turbine, None, 660 kW, 24% CF, 0% WH
Government - Large Water & Sewer	Micro-turbine, Bio-Gas, 60 kW, 50% CF, 50% WH
Government - Large Water & Sewer	Micro-turbine, Bio-Gas, 75 kW, 50% CF, 50% WH
Government - Large Water & Sewer	Micro-turbine, Bio-Gas, 45 kW, 50% CF, 50% WH
Government - Large Water & Sewer	Micro-turbine, Bio-Gas, 30 kW, 50% CF, 50% WH
Government - Large Water & Sewer	Wind Turbine, None, 250 kW, 24% CF, 0% WH
Government - Large Water & Sewer	Wind Turbine, None, 100 kW, 24% CF, 0% WH
Government - Large Water & Sewer	Fuel Cell, BioGas, 250 kW, 50% CF, 50% WH
Government - Medium Municipal	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH
Government - Medium Municipal	Wind Turbine, None, 100 kW, 24% CF, 0% WH
Government - Medium Municipal	Wind Turbine, None, 30 kW, 24% CF, 0% WH
Government - Medium Water & Sewer	Micro-turbine, Bio-Gas, 45 kW, 90% CF, 50% WH
Government - Medium Water & Sewer	Micro-turbine, Bio-Gas, 30 kW, 90% CF, 50% WH
Government - Medium Water & Sewer	Micro-turbine, Bio-Gas, 60 kW, 50% CF, 50% WH
Government - Medium Water & Sewer	Micro-turbine, Bio-Gas, 75 kW, 50% CF, 50% WH
Government - Medium Water & Sewer	Micro-turbine, Bio-Gas, 30 kW, 50% CF, 50% WH
Government - Medium Water & Sewer	Micro-turbine, Bio-Gas, 45 kW, 50% CF, 50% WH
Government - Medium Water & Sewer	Wind Turbine, None, 100 kW, 24% CF, 0% WH
Government - Small	None with payback of 10 years or less
Government - Small Water & Sewer	None with payback of 10 years or less
Government - US Postal	None with payback of 10 years or less
Healthcare - Hospital	Wind Turbine, None, 100 kW, 24% CF, 0% WH
Healthcare - Hospital	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH YRT[10]
Healthcare - Large Hospital	Wind Turbine, None, 660 kW, 24% CF, 0% WH
Healthcare - Large Hospital	Wind Turbine, None, 250 kW, 24% CF, 0% WH
Healthcare - Large Hospital	Wind Turbine, None, 100 kW, 24% CF, 0% WH
Healthcare - Other	Wind Turbine, None, 100 kW, 24% CF, 0% WH
Hospitality - Large Seasonal, Summer	Wind Turbine, None, 250 kW, 24% CF, 0% WH
Hospitality - Large Seasonal, Summer	Wind Turbine, None, 100 kW, 24% CF, 0% WH
Hospitality - Large Seasonal, Winter	Wind Turbine, None, 100 kW, 24% CF, 0% WH
Hospitality - Large, Year Round	Wind Turbine, None, 660 kW, 24% CF, 0% WH
Hospitality - Large, Year Round	Wind Turbine, None, 250 kW, 24% CF, 0% WH
Hospitality - Large, Year Round	Wind Turbine, None, 100 kW, 24% CF, 0% WH
Hospitality - Seasonal Summer	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH YRT
Hospitality - Seasonal Winter	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH YRT
Hospitality - Seasonal Winter	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH
Hospitality - Seasonal Winter	Wind Turbine, None, 100 kW, 24% CF 0% WH
Hospitality - Seasonal Winter	Reciprocating Engine, Diesel, 11 kW, 50% CF, 50% WH YRT
Hospitality - Seasonal Winter	Wind Turbine, None, 30 kW, 24% CF 0% WH
Hospitality - Year Round	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH YRT
Hospitality - Year Round	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH
Hospitality - Year Round	Wind Turbine, None, 100 kW, 24% CF 0% WH
Hospitality - Year Round	Reciprocating Engine, Diesel, 11 kW, 50% CF, 50% WH YRT
Hospitality - Year Round	Wind Turbine, None, 30 kW, 24% CF 0% WH
Industrial - Large	Wind Turbine, None, 600 kW, 24% CF 0% WH
Industrial - Large	Reciprocating Engine, Diesel, 250 kW, 90% CF, 50% WH YRT
Industrial - Large	Wind Turbine, None, 250 kW, 24% CF 0% WH
Industrial - Large	Wind Turbine, None, 100 kW, 24% CF 0% WH
Industrial - Large	Reciprocating Engine, Diesel, 250 kW, 90% CF, 50% WH
Industrial - Large	Reciprocating Engine, Diesel, 250 kW, 50% CF, 50% WH YRT

[10] YRT – This designation identifies where the waste heat is being used on a year-round basis.

Member Type / Sub-Group	Technology Configuration
Industrial - Large Lumber	Wind Turbine, None, 250 kW, 24% CF 0% WH
Industrial - Large Lumber	Wind Turbine, None, 100 kW, 24% CF 0% WH
Industrial - Medium	Wind Turbine, None, 250 kW, 24% CF 0% WH
Industrial - Medium	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH YRT
Industrial - Medium	Wind Turbine, None, 100 kW, 24% CF 0% WH
Industrial - Medium	Reciprocating Engine, Diesel, 68 kW, 90% CF, 50% WH YRT
Industrial - Medium	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH
Industrial - Scattered Site	Wind Turbine, None, 30 kW, 24% CF 0% WH
Industrial - Small	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH YRT
Industrial - Small	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH
Industrial - Small	Wind Turbine, None, 30 kW, 24% CF 0% WH
Recreation - Ski Area, Main Account	Wind Turbine, None, 660 kW, 24% CF, 0% WH
Recreation - Ski Area, Main Account	Wind Turbine, None, 250 kW, 24% CF, 0% WH
Recreation - Ski Area, Medium Sub-Account	Wind Turbine, None, 100 kW, 24% CF, 0% WH
Recreation - Ski Area, Medium Sub-Account	Reciprocating Engine, Diesel, 11 kW, 90% CF, 50% WH
Recreation - Ski Area, Medium Sub-Account	Wind Turbine, None, 30 kW, 24% CF, 0% WH
Recreation - Ski Area, Small Sub-Account	None with payback of 10 years or less
Retail - Large	Wind Turbine, 660 kW, None, 24% CF, 0% WH
Retail - Large	Wind Turbine, 250 kW, None, 24% CF, 0% WH
Retail - Large	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Retail - Large Bank	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Retail - Large Bank	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Retail - Large Bank	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Retail - Large Grocery	Wind Turbine, 660 kW, None, 24% CF, 0% WH
Retail - Large Grocery	Wind Turbine, 250 kW, None, 24% CF, 0% WH
Retail - Large Grocery	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Retail - Medium	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Retail - Medium	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Retail - Medium	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Retail - Medium Bank	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Retail - Medium Bank	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Retail - Small	None with payback of 10 years or less
Retail - Small Bank	None with payback of 10 years or less
Other - Under 11 kW (Camp)	None with payback of 10 years or less
Other - Under 11 kW (Communications)	None with payback of 10 years or less
Other - Under 11 kW (Commercial)	None with payback of 10 years or less
Other - 11 - 25 kW (Assembly)	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Other - 11 - 25 kW (Commercial)	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Other - 11 - 25 kW (Commercial)	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Other - 11 - 25 kW (Church)	None with payback of 10 years or less
Other - 26 - 50 kW (Convenience)	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Other - 26 - 50 kW (Convenience)	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Other - 26 - 50 kW (Convenience)	Reciprocating Engine, 11 kW, Diesel, 50% CF, 50% WH
Other - 26 - 50 kW (Convenience)	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Other - 26 - 50 kW (Wholesale)	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Other - 26 - 50 kW (Wholesale)	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Other - 26 - 50 kW (Research)	None with payback of 10 years or less

Member Type / Sub-Group	Technology Configuration
Other - 51 - 100 kW (Commercial)	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Other - 51 - 100 kW (Commercial)	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Other - 51 - 100 kW (Orchards)	Micro-Turbine, 45 kW, Bio-Gas, 50% CF, 50% WH
Other - 51 - 100 kW (Orchards)	Micro-Turbine, 30 kW, Bio-Gas, 50% CF, 50% WH
Other - 51 - 100 kW (Orchards)	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Other - 51 - 100 kW (Restaurant)	Reciprocating Engine, 11 kW, Diesel, 90% CF, 50% WH
Other - 51 - 100 kW (Restaurant)	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Other - 51 - 100 kW (Restaurant)	Wind Turbine, 30 kW, None, 24% CF, 0% WH
Other - 51 - 100 kW (Restaurant)	Reciprocating Engine, 11 kW, Diesel, 50% CF, 50% WH
Other - 51 - 100 kW (Restaurant)	Wind Turbine, 10 kW, None, 24% CF, 0% WH
Other - 101 - 250 kW (Fast Food)	Wind Turbine, 250 kW, None, 24% CF, 0% WH
Other - 101 - 250 kW (Fast Food)	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Other - 101 - 250 kW (Health Club)	Wind Turbine, 250 kW, None, 24% CF, 0% WH
Other - 101 - 250 kW (Health Club)	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Other - 101 - 250 kW (Restaurant)	Wind Turbine, 100 kW, None, 24% CF, 0% WH
Other - Over 250 kW	Wind Turbine, 250 kW, None, 24% CF, 0% WH
Other - Over 250 kW	Wind Turbine, 100 kW, None, 24% CF, 0% WH

YRT = year round thermal, CF = capacity factor and WH = waste heat factor

Note; Solar water heating was run for each customer profile. The average was between 13 and 17 years. The shortest payback was 13 years for a residential member with propane heat. The annual capacity factor of 14% was used for utilization rate. The 14% rate was derived from NREL solar resource maps and capacity factors for the NHEC service territory.

The MCHP was run with propane (even though not commercial available today) No units had a payback without the KeySpan Incentive. The best case scenario was a residential unit with the $2,000 incentive and natural gas at $1.15 per therm - the simple payback was still 20 years.

Table 6 – Summary of Payback Ranges for Member Categories[11] (Updated 11/13/07)

Member Type / Sub-Group	Technology Configuration	Typical Simple Payback (yrs)
Residential	*Solar water heating*	***13+***
Commercial	Wind Turbine, Reciprocating Engine	**7-11**
Condo Association	Wind Turbine, Reciprocating Engine (Diesel)	**6-15**
Education	Wind Turbine, Reciprocating Engine (Diesel)	**4-9**
Farm	Wind Turbine	**10-12**
Government	Wind Turbine, Micro-Turbine (Biogas), Fuel Cell (Biogas)	**3-11**
Healthcare	Wind Turbine, Reciprocating Engine (Diesel)	**4-11**
Hospitality	Wind Turbine, Reciprocating Engine (Diesel)	**4-11**
Industrial	Wind Turbine, Reciprocating Engine (Diesel)	**4-11**
Recreational	Wind Turbine, Reciprocating Engine (Diesel)	**5-11**
Retail	Wind Turbine, Reciprocating Engine (Diesel)	**4-11**
Other	Wind Turbine, Micro-Turbine (Biogas), Reciprocating Engine (Diesel)	**5-11**

[11] Paybacks could vary significantly depending on actual project costs and operating details. This analysis included estimated costs for site development, engineering, equipment purchase, installation, fuel (where applicable) and fixed and variable O&M. Additional costs associated with permitting and electrical interconnection have not been included, and could be substantial.

E. Economic Potential and Summary Observations and Conclusions

The estimated economic potential for distributed/on-site generation installations (including renewable generation) in NHEC's service territory is summarized in Table 7[12]. These estimates are based on the assumptions specified in the Methodologies section of this report, including estimated market participation rates of 5%, 10%, and 25% of the MWs associated with the potentially viable scenarios identified in the analysis. General observations regarding the market conditions and/or technology-specific circumstances that may help or hinder achievement of this potential are noted in Section 4.

Table 7 – Distributed Generation Economic Potential (MW)

	Percentage of the Potentially Viable Scenarios		
	5%	**10%**	**25%**
Distributed Generation Potential	6.6 MW	13.1 MW	32.7 MW

[12] Based on results from this analysis, the maximum technical potential (without consideration of the multitude of economic, political, market , site, member specific appropriateness and acceptance, etc. constraints and realities that might otherwise impact abilities for actual development) for distributed/on-site generation within NHEC's service territory was determined to be approximately 130 MW. A more realistic estimation would be the market/economic potential, which is approximated in Table 7.

Section 3: Methodology

This section describes the methodologies that were used to conduct each of the major activities required for this renewable and distributed generation options identification and assessment project.

A. Secondary Research

This project included extensive secondary research activities to identify various applicable distributed generation technologies and key performance/cost input information for use in the spreadsheet assessment tool. In addition to information available through GDS' own libraries and experience with renewables and other distributed generation resources, the following list of documents and data sources were reviewed:

- "Distributed Generation: All Hype or Hope?" Workshop presented by Apogee Interactive, Inc. and Related Materials - November 2003;
- "Keeping the Lights On and the Power Green" Northeast Energy Efficiency Council (NEEC) Annual Conference, Related Presentations;
- Securing a Place for Biomass in the Northeast United States: A Review of Renewable Energy and Related Policies – 2003, Northeast Regional Biomass Program;
- U.S. DOE's "Current Renewable Energy Projects in New Hampshire" listing as of 10/31/03;
- NH Public Utilities Commission Restructuring New Hampshire Docket, Section F. Renewable Energy Resources, 1/22/02;
- Energy Info Source's Distributed Generation: Technologies, Opportunities, and Participants 2nd Edition – August 2001;
- Presentation: Combined Heat and Power (CHP): Applications of Distributed Power Overview of Opportunities and Market Prospects, Distributed Power Conference Washington, DC – 9/25/00; and
- Manufacturer's generator specifications.

ADDENDUM Research

- *LoFonda, Phillip, Yankee Sciencetific Inc., Medfield, MA, November 13, 2007*
- *Roberts , Amber, "Residential Combined Heat and Power" Spring 2007 Transactions*
- *Massachusetts Technology Collaborative Project data Archive October 2007*
- *U.S. Department of Energy, Energy Efficiency and Renewable Energy Project data sheets 9/28/2007*

Documents and data sources were also reviewed to identify potential "calculator" tools and related functionality for later evaluation and use as guides in revisions to GDS' existing distributed generation technology assessment and screening tool. Some of the more useful tools identified included:

- GDS in-house generation analysis spreadsheet information and related tools;
- HOMER Version 2.06 – Designed by the National Renewable Energy Laboratory (NREL) as an optimization model for distributed power – 2003;
- Apogee Interactive, Inc. – Review of simple DG screening tool;
- D-Gen Pro – Designed by Architectural Energy Corp. for the Gas Research Institute, this model determines the economic feasibility of gas-fired distributed power generation and evaluates cost-effective applications of on-site power generation;
- GenSize '96 - Created by the Onan company, a generator manufacturer, to assist their members in determining which Onan stationary, liquid cooled generator set configurations will meet the needs of a project's load requirements;
- QuickScreen - Designed under the auspices of the National Renewable Energy Laboratory, this screening tool attempts to identify the best distributed resource (DR) sites within a given electric utility and determine economic feasibility. This QuickScreen Beta version was developed to evaluate distributed photovoltaic (PV) generation, but future QuickScreen versions will include the capability to evaluate other distributed resources; and
- Other sample on-site cogeneration developer spreadsheet models used primarily for determining generator sizing for specific member applications.

Finally, service territory rate tariffs and NHEC's member demographic information was collected from Company sources, along with average monthly energy (kWh), demand (kW) and class-level load profile data.

B. Energy and Load Profile Information Development

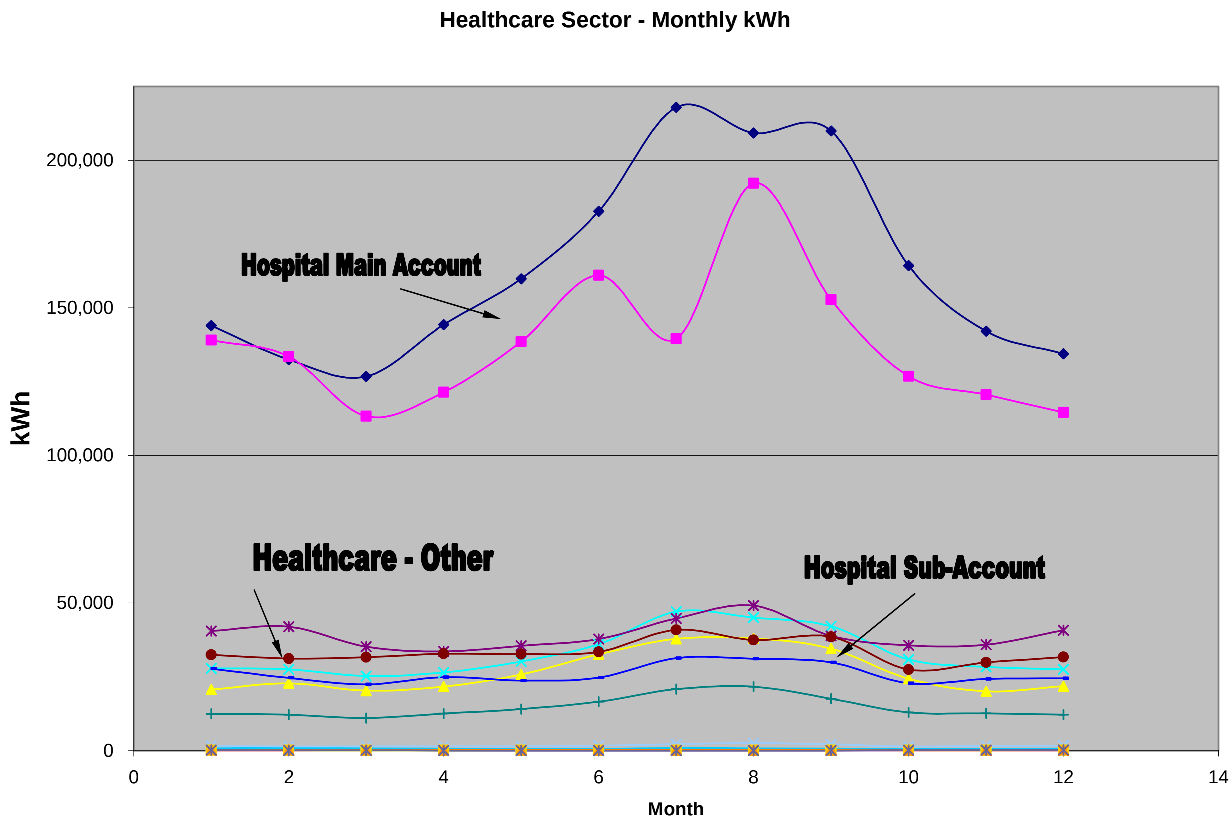
Typical load profiles were developed for each of the identified member types by:

(1) Plotting the actual monthly average load profiles for all members and within major industry grouping where appropriate;

(2) Viewing the graphical representations to identify any obvious usage patterns and obvious sub-groupings (large, medium and/or small); and

(3) Selecting a "typical" member profile from within each sub-grouping to represent that member/building type category. Figure 1 provides a sample of this load profile graphing and sub-group identification process, using the healthcare sector as an example.

FIGURE 1 - Sample Member Monthly kWh Load Profile Graph



In this graph of NHEC's healthcare sector, it is shown that the monthly kWh profiles of the members share similar shapes throughout the year (with definite trends in usage by size). In this example three "typical" member profiles can be estimated by choosing a member whose usage falls in the middle of the range for each size grouping (*i.e.*, a load shape can be chosen to represent the main account of a large hospital; a non-hospital healthcare facility; and a sub-account of a hospital). Typical BTU usage profiles (for space and water heating loads) were developed for NHEC commercial and industrial member categories through building simulations using DOE's Energy-10 software[13]. These values were then used in determining the amount of potential thermal load that could be served by waste heat from a generator.

Average monthly load profiles for "typical" residential members were developed using NHEC billing data. Profiles were generated for both electrically heated and fossil-fuel heated households. For non electrically-heated homes, typical BTU usage profiles were developed using REM/Rate residential building simulation software.

[13] Energy-10 is the software component of Designing Low-Energy Buildings with Energy-10, a collaborative project of the National Renewable Energy Laboratory's Center for Buildings and Thermal Systems, the Sustainable Buildings Industry Council, Lawrence Berkeley National Laboratory, and the Berkeley Solar Group.

C. Distributed Generation Screening Model Update

Another major category of project activity was the refinement of an existing GDS spreadsheet model that can be used to calculate the payback of various distributed generation applications and to assess the potential for on-site generation by member group based on typical member load profiles. This screening model was designed to allow for the calculation of simple paybacks for a multitude of technology and member application scenarios so that results could be ranked and prioritized to identify NHEC's most likely candidates for on-site generation within each member class. As a follow-on to this project, the calculator has been designed to be used by field representatives as a screening tool for individual members.

A multi-stepped process was used in revising this distributed generation screening model. First, as part of the secondary research activities discussed above, GDS reviewed its existing models and in-house information base, along with identifying and assessing the functionality of a number of other publicly available models. A general conceptual model framework was then developed to best meet NHEC's stated needs. A summary of this framework is presented below:

Spreadsheet Model Framework:
The model is an MS Excel 2000 workbook file divided into worksheets as follows:

Title Sheet (identifies spreadsheet and parties)

- GDS and NHEC Graphics
- Product/Model Title
- Date

Instructions (provides user with all the information needed to effectively run the model)
Text sheets to include information directed to user regarding:

- Purpose and intended use of model
- Instructions - how to use the model; both step-by-step instructions and prose guidance on input assumptions
- Qualifications of data tables included in model
- Qualifications/limitations of model output information

Inputs (user entered info sheet - the only non-write protected sheet)

- Member and Facility identity information
- Facility Type/Characteristics (multi choice and user defined)
- Electricity Load and Fuel Usage (monthly kWh, kW, and btu values)
- Facility and Process Heat Requirements/Usage
- Rate Inputs (electric, propane, fuel oil - multi choice)
- On-Site Generation Technology Inputs (technology type, fuel source, installation costs, operating costs/characteristics, etc. - multi choice)

Summary (provides model results table for multiple technologies)

- A printable summary table with bottom line annual cost savings and simple payback for selected technology and application scenario

Data - Rates (rate data)

- Multi choice lookup table with actual tariff information for electricity

Data - Technology (characteristics)

- Multi choice lookup table with information on several different DG prime mover technology characteristics and sub-tables with specific performance information for different installed capacities

Data - Member/Facility Type (typical characteristics)

- Multi choice lookup table with usage pattern (monthly) information for several different member types

Incentives

- Information-only table showing state and federal incentives for renewable energy applicable in New Hampshire. Values from this table were applied, where quantifiable, when calculating paybacks for particular renewable technologies.

Finally, based on this framework, the spreadsheet model was revised and tested to ensure proper functionality and suitable flexibility to meet technology assessment, member group screening, prioritization and ultimate field representative's specific needs.

D. Member Group/Technology Screening and Prioritization

A critical set of activities associated with this project required: (1) determining which on-site generation (including renewable) technologies have potential for application within various member groups; then (2) using the spreadsheet model to calculate a simple payback for each technology selected for installation at specific member type locations; and finally, (3) for each member type modeled, ranking technologies and prioritizing and summarizing results to show those technologies most likely to be viable within specific member categories. Each of these steps is discussed in more detail below.

Linking Technologies to Potentially Viable Member Group Applications:
Based on results from our secondary research activities, combined with GDS' existing knowledge and data sources, a qualitative screen was performed on each of the initial group of generation technologies. Results from this screening were presented in Table 3, which showed those technologies most likely to have applicability within particular member groups. These categorizations were subsequently reviewed and reasonably verified based on model screening results.

Simple Payback Calculations for Member-Specific Applications, Ranking and Prioritization:
Various size combinations of appropriate technologies were analyzed for each member group and building type using the revised distributed generation technology analysis and screening tool. In total, more than 7,200 unique member, technology, fuel and size combinations were run. Results from these runs and associated rankings and prioritization are summarized in Table 4 (Section 2.D) above, for the most cost-effective technology/member combinations.

E. Economic Potential Estimates

The final activity associated with this project required the estimation of economic potential for distributed/onsite generation (including renewable generation) within NHEC's service territory. In determining economic potential, applications for technologies showing paybacks of 10 years or less were considered to be potentially viable. Economic potential was then estimated based on an assumption that only 5% of the MW associated with those technology scenarios are likely to be ultimately installed. Results assuming a 10% and 25% install rate are also shown to provide perspective. An upper bound for this analysis would be the 100% point (130.8 MW).. Other key assumptions made when developing these economic potential estimates include:

- End-use load profiles for "typical members" serve as proxy profile for the entire member group;

- As long as at least one technology within a specific member group has an estimated simple payback of 10 years or less, that entire group is considered potentially viable for distributed/onsite generation technology installations; and

- The number of members for each "typical" member group was based on estimates provided directly by NHEC. In total, 13 major member groups (11 commercial/industrial and 2 residential) were assessed, as follows[14]:
    - Residential – Electric Space Heat
    - Residential – General Use
    - Condo Association*
    - Commercial*
    - Education*
    - Farm
    - Government*
    - Health Care*
    - Hospitality*
    - Industrial*
    - Recreation*
    - Retail*
    - Other

The number of members in the commercial and industrial groupings were based on estimates provided by NHEC but may not fully capture the total number of members that actually exist within each grouping. Residential counts for NHEC members were also based on NHEC-provided estimates.

In closing, it is important to remind readers that the economic potential estimates and simple paybacks included in this report will vary greatly depending on actual member counts, participation rates, individual member economic and payback preferences, and numerous other simplifying

[14] Groups noted with an asterisk "*" reflect member categories designated by NHEC in their "Key Accounts" members tracking system. The Electric Transmission category was removed from this study per a conversation with NHEC staff.

assumptions used in the screening model including end-use profiles, utility rates, technology installation costs, etc. More detailed analysis and member-specific assessment shall be conducted before actual distributed/onsite generation investment decisions are made.

Section 4: Noteworthy Market Conditions and Observations

This section provides a summary of noteworthy market conditions, technology circumstances and general observations that could impact the development of renewables and other customer sited distributed generation projects within NHEC's service territory.

Per the U.S. Department of Energy web site as of October 31, 2003, there are a total of 190 renewable energy facilities in New Hampshire, broken down as shown in Table 8 *(not updated as part of the addendum activities summarized above).*

Table 8 – Current Renewable Energy Projects in New Hampshire

Renewable Energy Technology	Number of Operating Facilities	Total Installed Capacity (kW)
Hydro	113	368,707
Photovoltaic	45	76
Biomass	19	167,213
Wind	13	89
Total	190	536,085

Many of these facilities have been operating throughout the state (including some in NHEC's service territory) since the 1980s and early 1990s and could provide excellent insights and field operational histories for consideration. Following are a few anecdotal observations that can be made from this considerable history:

- Hydro – As noted previously in this report, the potential for additional hydroelectric power development is limited since nearly all of the feasible sites at existing dams have already been developed (and construction of sites where new dams or significant environmental permitting would be required is highly unlikely).

- Wind – This analysis has shown wind energy projects to be the most cost effective technology across all NHEC member groups. The economics, however, of these wind projects do not reflect the reality that energy producing windmills with capacity factors of 24%, as assumed in the modeling, cannot be sited everywhere. As part of this study, it is not feasible to discern which member classifications could potentially be suitable for wind projects because locations vary among classifications. Based on historical information here in New Hampshire, only limited development of wind generators has evolved. This has been due (in part) to the lack of availability of developable locations within New Hampshire where there are sustainable winds (between 8 MPH and 20 MPH) necessary for sufficient power generation to offset initial installation cost investments and to cover ongoing operation and maintenance expenses. Maps are available through the U.S. Department of Energy and other sources that show locations within New Hampshire where potentially viable wind resources exist.[15] Siting and permitting issues are also critical obstacles to broader development of wind generation.

- *Photovoltaics – The initial cost for materials and installation of PV systems remains a major obstacle to broader use of this technology as a resource in New Hampshire and elsewhere in the region. Installed cost still remains a significant barrier to increased market penetration. There has been wide spread media coverage of predicted manufacturing efficiency gains and electrical output gains on PV systems. At the writing of this Addundum report there still remains no strong evidence that solar PV installation and equipment costs have come done. In fact the most recent report on the subject, released in October 2007 by the National Renewable Energy Lab (NREL), indicated that the strong demand and limited production capabilities globally for Solar PV has driven the costs upward to over $10,000 per kW installed.*

- *Biomass – Use of wood and other biomass sources for fuel remain viable in New Hampshire. Although not assessed as a technology in this current analysis, wood stoves are a major source of supplemental (and often primary) heat for many homeowners in NHEC's service territory (~10%) and across the state. In the lumber industry and other site-specific applications, biomass is already being used as an integral part of kiln drying and/or related processes where economic to do so. The wood products and manufacturing industries offer examples within NHEC service territory where such installations have been made. In these examples, the ready availability of wood waste has made these types of projects even more cost-effective. The supply chain for wood fuel remains plentiful and the costs per ton have remained about the same for over 8 years at $25-$30 per ton.*

- Bio-Diesel – Waste oils from restaurant cooking processes and ethanol from corn, etc. can be used as a fuel source in specific applications (subject to availability of sufficient quantities for generation, or for more limited peak shaving purposes). The hospitality industry provides one example where bio-diesel is being used. In our modeling, this fuel source did not yield many cost-effective applications, mainly due to the fact that the cost for the fuel and associated generating equipment could not be offset by the annual kWh used by the appropriate NHEC member categories (*i.e.*, typical restaurant energy usage was too small to offset the capital and operating costs associated with the bio-diesel fuel and generation technology).

- Other Biogas (methane) Sources – This analysis has shown biogas-fueled generators to be cost-effective in a number of member category areas. However, given the limited availability of these fuels (landfills, wastewater treatment facilities, dairy farms, etc.), use of bio-gas as a fuel source would have to be restricted to locations were direct access to the fuel (and affordable collection systems) could be made available.

- Fossil-Based On-Site Electric Generation and Co-Generation Facilities – Given the relatively high electric rates that have existed over the past 20 years in the Northeast, a majority of the larger commercial and industrial facilities in the region have at one time or another considered installation of on-site electric generation systems (either as a tool with their local utilities for

[15] See *A new Hampshire Consumer's Guide – Small Wind Electric Systems* as published in U.S. DOE, Energy Efficiency and Renewable Energy, June 2003. Based on data from this June 2003 DOE report, the potential for wind capacity in NH is relatively low.

negotiation of a special rate arrangement, or for power quality, standby, back-up, or peak shaving purposes). Where significant space, water or process heating needs also existed in these facilities, co-generation has also typically been assessed and/or installed where it was found to be economical to do so. *The market trend data for oil has been on a steady rise for the past few months and at the time this addendum report was written, oil was over $90 per barrel a new record high. It is highly unlikely that oil will fall below $2.50 a gallon over the 2007/2008 heating season. Instead, it is anticipated that oil prices will remain high for the near future.*

- Fossil Fuel Costs – The relatively high price of oil (diesel, etc.) fuel for use in on-site generators often results in operating costs for small scale electric generation and co-generation facilities that are prohibitive. In this current analysis, our model attempts to recognize economies of scale that can be gained through volume discounts on fuel for commercial and industrial on-site generators. However, results still show that paybacks are significantly impacted by the high cost of fuel. Siting and environmental permitting issues can also impact the economics for project development and operational feasibility.

- Natural Gas – Given the limited availability of natural gas (delivered via pipeline) in communities served by NHEC, no scenarios were run within this current analysis using natural gas as a fuel type.

- Fuel Cells – The high first cost of this technology continues to make it one of the less viable technologies assessed in this report.

- Net Metering, Interconnection Issues, Standby and Back-Up Charges[16] – Regulations in New Hampshire allow for the interconnection of small electric (and renewably-fueled) generators to directly offset retail electric purchases (net metering), subject to certain size and other limitations. In addition, utility-specific interconnection requirements must be complied with (for protection against over and under voltage, over and under frequency, abilities to energize a de-energized line, local and broader system stability and reliability, etc.). Finally, issues surrounding potential standby and back-up charges have not been included in this current analysis, but could have additional implications on the costs and willingness for NHEC members to install on-site generation/co-generation units.

[16] Actual review of the most current NH regulations on net metering, utility interconnection and other related issues was outside the scope of this assessment. However, these items are important and should be researched more carefully when determining actual costs and considerations that would be incurred by NHEC members for installation of on-site generation.