Calling Out the DOGS: Results and Development of the Distributed On-Site Generation Screening (DOGS) Tool

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ABSTRACT

This paper summarizes results from an assessment and prioritization project completed for Alliant Energy Service Company, Inc. ("Alliant") of the potential for customer-sited/distributed generation (DG) for all customer classes within their electric and gas utility service territories. The purpose of the assessment was to assist Alliant in identifying and ranking the potential for customer-sited generation at typical residential, small and large commercial, industrial and agricultural customer locations. A focus of the assessment was the overall impact to the utility system as a result of the installation of economically viable customer-sited distributed generation.

In step-by-step fashion, this paper presents the critical information that was necessary for developing a spreadsheet model "calculator" for use in determining the cost effectiveness of various customer-sited generation applications. First, the operating characteristics associated with a set of potentially viable, commercially available distributed generation technologies were researched. Load profiles of the utility's typical customer types were then developed and grouped by SIC code. Drawing from the technical information of the technologies and customer profiles, the spreadsheet model "calculator" was developed. This calculator was used to assess the potential for on-site generation by customer group based on typical customer load profiles. Finally, the impact to the utility was estimated at two different rates of potential implementation.

Key subject areas addressed in this paper include:

1. Identification and characteristics of a set of commercially available DG technologies;
2. Listing of customer groups and building types to be modeled as potential on-site generation candidates, based on SIC codes;
3. Overview of the distributed/on-site generation screening model;
4. Prioritized ranking of potentially viable on-site/distributed generation applications for each customer group reviewed (from model results); and,
5. Discussion of economic potential (kW impacts) within the Alliant utility system as a result of the potential installation of projects illustrating a maximum 20-year payback.

Introduction

This report summarizes results from secondary research, model development, and technology screening efforts performed by GDS Associates, Inc. in late 2001 to assess and prioritize the potential for customer-sited/distributed generation for all customer classes within Alliant Energy Service Company, Inc.'s (Alliant) distribution utility electric and gas service territories in Minnesota and Iowa. GDS was contracted to help Alliant identify and rank the potential for customer-sited generation at typical residential, small and large commercial, industrial and agricultural customer locations. This information could then be used by Alliant to help discuss specific technology options with appropriate customers, where they would most likely be found cost-effective.

In addition to performing secondary research to collect critical information and operating characteristics on potentially viable distributed/on-site generation technology types, a major component of this project was the development of a spreadsheet model "calculator" for use in determining the cost effectiveness of various customer-sited generation applications. The calculator was used to assess the potential for on-site generation by customer group based on typical customer load profiles. In total, over 400 unique scenarios yielded positive payback results. As a follow-on to this project, the calculator was designed to be used by the utility's field representatives as a screening tool for individual customers.

The final step in the analysis involved determining an estimated potential impact to Alliant in the event that the cost effective projects were installed. The economic potential was estimated at a 10% implementation rate as well as 100% implementation to present a range of the total potential for installation of cost-effective on-site generation projects.

Step One: Assessment of Distributed Generation Technologies

Based upon GDS' knowledge and secondary data review, five different distributed generation technologies were identified for consideration in this analysis. As shown in Table 1, five of these technologies were deemed to be commercially available (Reciprocating Engines, Microturbines, Fuel Cells, Wind Turbines, and Photovoltaic Modules). A summary of key operating characteristics and cost information is provided for each technology in Table 2. GDS' analysis efforts for Alliant focused on those technologies that were either already commercially available and had a proven track record of reliable operation or were considered emerging technologies that offered strong potential in the near future.

Table 1. Technology Availability and Target Customer Sectors

Distributed Generation Technology	Target Market Sectors (for mature technologies)	Installed Capacity (MW)
Reciprocating Engines	Small and Large Commercial, Industrial, Agricultural	75,000
Microturbines	Small and Large Commercial, Agricultural	40
Fuel Cells	Small and Large Commercial, Industrial	40
Wind Turbines	Residential, Small and Large Commercial, Industrial, Agricultural	4,660
Photovoltaic Modules	Residential, Small and Large Commercial, Agricultural	181

Sources: Resource Dynamics Corporation, 2003. Wind and Solar Data: DOE/NREL, 2002.

Table 2. Distributed Generation Technology Profile

Technology	Target Market Sectors	State of Development	Operation & Maintenance	Installed Cost Range ($/kW)	Operating Fuels	Electric Power Output Range	Thermal Output Range (Btu/kWh)	Operating Temp	Operation Specs.	Physical Plant Footprint (ft^2/kW)
Reciprocating Engines	Comm., Indust.	Commercially available.	Costs ~ $0.008 - $0.015/kWh *(GRI, 1999)*	$500 - $1,600/kW *(EIS, 2001 and Sweeney, 2003)*	Natural gas Propane Gasoline Dual Fuel Diesel Heavy Oil	10 kW-10 MW @ 21% - 43% eff. *(EIS, 2001)*	1,000 - 5,000	316°-500°F	1.0-45 psig	0.1-31
Mirocturbines	Res., Comm. & Agricultural greenhouses	Commercially available. Primarily <1 MW	$0.005-$0.01 per kWh. *(GRI, 1999)*	$1,800-$2,200/kW *(Rutkowski, 2003)*	Natural gas Propane Diesel Waste-Fuels	30-200 kW @ 25-30 eff. *(EIS, 2001)* CHP ~ 70%-90%	4,000-15,480	400°-635°F	3-100 psig	0.15-0.35
Fuel Cells	Low Temp: Res, Comm High Temp: Comm, Indus	Development, Testing and Demonstration	$0.005-$0.01/kWh (low-temp.) *(GRI, 1999)*	$4,500/kW (low-temp) *(Trocciola, 2003)* (Case studies indicate range of $5,000 - $10,000/kW)	Natural gas Propane Butane Diesel	Low Temp: 2-250 kW @ 30-40% eff. High Temp: 100–1 MW @ 45 - 55% eff *(EIS, 2001)*	PAFC: 3,500-8,000 PEM: 2,000-3,250 MCFC: 1,400-1,800 SOFC: 540-1,100	140°-250°F 135°-165°F 170°-710°F 350°-420°F	15-50 psig pipeline pressure 15-45 psig n/a	4 0.6-3.0 1-4 1.1-1.2
Wind Turbines	Res, Comm.	Commercially available.	$0.005/kWh-$0.02/kWh *(GRI, 1999)*	$950/kW-$3,000/kW *(Cohen & Wind, 2001)*	<50kW: Wind >8mph >50kW: Wind>10mph Cut-in speed: 8mph 1.5 MW: 27 mph *(Cohen & Wind, 2001)*	1-2,000 kW @ 25% eff *(Cohen & Wind, 2001)*	None	None	n/a	<50kW: 15-90 >50kW: 0.24-110 4-5 acres per turbine, 900-1500 kW≈145-194 sqft/kW
Photovoltaic Modules	Res, Comm.	Commercially available.	$0.001-0.004/kWh *(GRI, 1999)*	$5,000-$10,000/kW *(GRI, 1999)*	Global solar radiation (direct and diffuse)	10 watts to 100 kW	None	None	n/a	538

Step Two: Development of Typical Load Profiles

In developing load profiles, service territory rate tariffs and the utility-specific demographic information were collected from Alliant, along with average monthly energy (kWh), demand (kW) and natural gas usage data. For commercial, industrial, agricultural and other non-residential (C/I/A/&NR) customer areas, this demographic information was sorted by the major standard industrial classification (SIC) codes and grouped into the customer sector categories identified in Table 3.

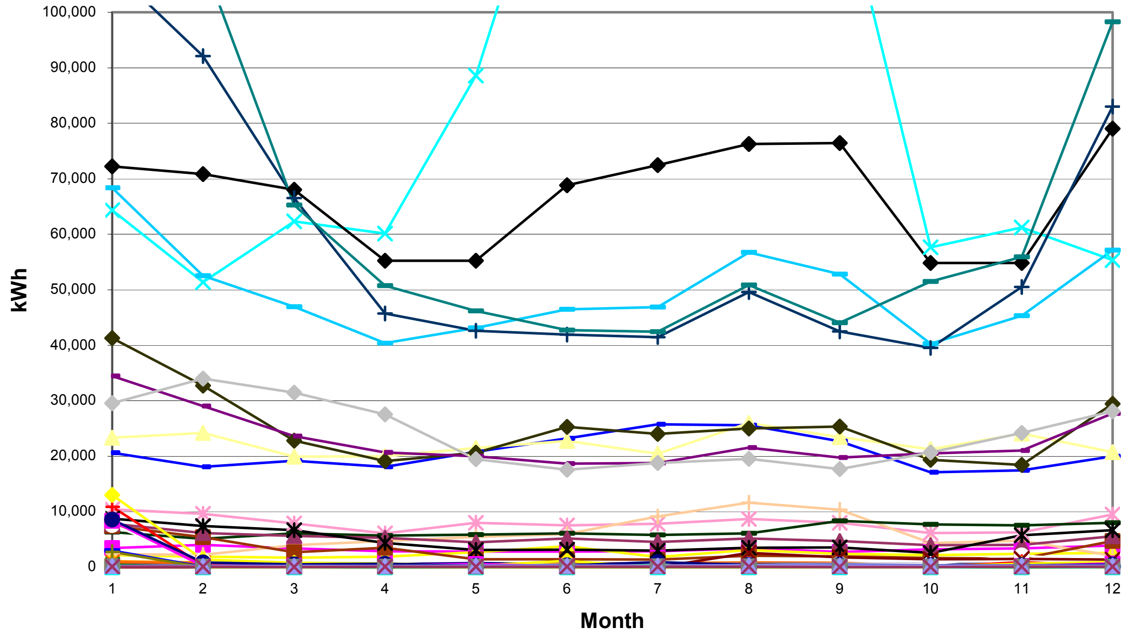
Table 3. Customer Sector/Building Type Categories

Customer Category/Type	Sub-Grouping	Applicable Rate Tariff
Residential - Single Family	Electric heat Gas heat	Residential Residential
Commercial - Assembly (SIC 84 - 86)	Large Small	Large Power & Lighting General Demand Metered
Commercial – Health Care (SIC 80)	Large Medium Small	Large Power & Lighting Large Power & Lighting General Demand Metered
Commercial - Hotel/Motel (SIC 70)	Electric heat Gas heat	Large Power & Lighting General Demand Metered
Commercial – Housing (SIC 65)	Apartment Building	Large Power & Lighting
Commercial - Office (SIC 60 - 67, 73)	Small Large	General Demand Metered Large Power & Lighting
Commercial – Services/NEC (SIC 73)	Large Medium Small	Large Power & Lighting Large Power & Lighting General
Commercial - Retail (SIC 52 - 59)	Large Medium Small	Large Power & Lighting Large Power & Lighting General Demand Metered
Commercial - School (SIC 82 - 83)	Large Medium Small	Large Power & Lighting Large Power & Lighting General Demand Metered
C/I - Sewerage System (SIC 49)	Typical Usage	Large Power & Lighting
C/I - Warehouse (SIC 42)	Large Small	Large Power & Lighting General Demand Metered
C/I - Wholesale Trade (SIC 50 - 51)	Large Medium Small	Large Power & Lighting Large Power & Lighting General Demand Metered
C/I - Manufacturing (SIC 20 - 39)	NEC Large Medium Small	Large Power & Lighting Large Power & Lighting Large Power & Lighting General Demand Metered
Agricultural - Dairy & Livestock (SIC 02)	Large Small	Large Power & Lighting Farm Rate
Government/Public Admin (SIC 91 - 97)	Large Medium Small	Large Power & Lighting General Demand Metered General

Source: Alliant Energy Service Company, Inc., 2001

Typical load profiles were then developed for each C/I/A/&NR building type by: (1) plotting the actual monthly average load profiles for all customers within each SIC major industry grouping; (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" customer profile from within each sub-grouping to represent that customer category. Figure 1 provides a sample of this load profile graphing and sub-group identification process for the health care industry within Alliant's service territory.

Figure 1. Sample Customer Load Profile Graph – Health Care



In this graph of the health care industry sector (SIC Code 80), it can be seen that all customer load profiles share very similar shapes throughout the year. Also, this graph shows three distinct usage level groupings (*i.e.*, a high use group with average monthly energy ranging between 40,000 and 100,000 kWh; a medium usage group with average monthly energy ranging between 20,000 and 40,000 kWh; and a small use group with average kWh per month usage below 15,000). In this example a "typical" customer profile was estimated by choosing a customer whose usage fell in the middle of each range.

Average monthly load profiles for "typical" residential customers were developed using downloaded residential data files for the West-Central United States Region available through Regional Economic Research, Inc. (RER's) eShapes® publicly accessible database on their website at www.rer.com/eshapes. This information was then proportionally scaled to reflect the Alliant's average residential customer usage.

Step Three: Development of the Distributed/On-Site Generation Screening (DOGS) Model

After assessing the various technologies available and developing the typical customer load profiles, the next component of project activity was to develop a simple, flexible spreadsheet model that could be used to determine the cost effectiveness of various distributed/on-site generation applications and to assess the potential for on-site generation by customer group based on the previously developed typical customer load profiles. The screening model was designed to allow for the calculation of simple paybacks for a variety of technology and customer application scenarios so that results could be ranked and prioritized to identify the utility's most likely candidates for on-site generation within each customer class. As a follow-up to this project, the calculator was designed for use by utility field representatives as a screening tool when discussing potential onsite generation opportunities to individual customers.

A multi-stepped process was used in development of this distributed/on-site generation screening calculator. First, as part of secondary research activities, 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. Some of the more useful tools identified include:

- GDS in-house generation analysis spreadsheet information and related tools.
- **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 customers 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 were scheduled to include the capability to evaluate other distributed resources.
- Other sample on-site cogeneration developer spreadsheet models used primarily for determining gen-set sizing for specific customer applications.

A general conceptual model framework was then developed to best meet the client's stated needs. A summary of this framework is presented below:

Spreadsheet Model Framework

The model is a Microsoft® Excel 2000 workbook file divided into worksheets as follows:

<u>Title Sheet</u> (identifies spreadsheet and parties)

- GDS & Utility Logo Graphics
- Model Title
- Date

Instructions (provides user with all the information needed to effectively run the model) Text sheet includes 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 sheet not write-protected)

- Customer 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, gas, 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 and tariff data)

- Multi-choice lookup table with actual tariff information for electricity and gas

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 - Customer/Facility Type (typical characteristics)

- Multi choice lookup table with monthly consumption information for all of the customer-type profiles developed

Finally, based on this framework, a spreadsheet model was developed and tested to ensure proper functionality and suitable flexibility to meet technology assessment, customer group screening, prioritization and ultimate field representative's specific needs. Figure 2 illustrates the layout of fields included in the Summary spreadsheet of the model.

Figure 2. Distributed On-Site Generation Screening Tool Results Summary

DISTRIBUTED/ON-SITE GENERATION SCREENING MODEL

Prepared by GDS Associates, Inc. for Alliant Energy Service Company, Inc. - October 2001

Results Summary

Customer Summary

Usage Profile: Health Care - Small		
Annual Electric Usage:	206,928	kWh
Max Peak Demand:	0	kW
Total Weighted Rate:	0.0940	$/kWh
Annual Electric Cost:	$19,443	$/yr
Heating Fuel Usage:	1,449	therms/yr
Heating Fuel Rate:	$1.043	$/therm
Heating Cost:	$1,511	$/yr
Total Energy Cost:	$20,954	$/yr

Customer Type - Facility Subgroup

Sample Health Care Facility
County General

Generator Performance & Economics

Total Generation:	131,400	kWh/yr
Heat Available:	6,351	therms/yr
Heat Displaced:	6,351	therms/yr
Total Generator Fuel:	16,556	annual
Total Fuel Cost:	$11,093	$/yr
Variable O & M Costs:	0.0075	$/kWh
Fixed O & M Costs:	15	$/yr
Total Operating Cost:	$12,528	$/yr
Operating Cost:	$0.095	$/kWh
Electric Cost Savings:	($182)	$/yr
Heat Cost Savings:	$6,622	$/yr
Total Energy Savings:	$6,440	$/yr
Total Installed Cost:	$58,500	

Selected Generator Unit(s)

Manufacturer:	Capstone	
Model:	330	
Technology:	Microturbine	
Fuel:	Natural Gas	
Heat Rate:	12,600	btu/kwh
Waste Heat Available:	4,833	btu/min
Waste Heat Utilized:	1,208	btu/min
Installed Cost (each):	$58,500	per unit
Unit Capacity (each):	30	kw per unit
Number of Units:	1	
Total Generator Capacity:	30	kw

Simple Payback - Estimated # of Years

Electric Only:	(322)	years
Electric & Thermal:	9	years

Step Four: Customer Group/Technology Screening and Prioritization

Prior to running the model for the various combinations of generation technology and customer profile, it was necessary to first screen the on-site generation technologies to determine the potential for application within various customer groups. The spreadsheet model was then used to calculate a simple payback for each technology selected for installation at specific customer type locations. Finally, for each customer type modeled, technologies were ranked, prioritized, and summarized to show those technologies most likely to be viable within specific customer categories. Each of these steps is summarized in more detail below.

Linking Technologies to Potentially Viable Customer Group Applications

Based on results from the secondary research activities, combined with GDS' existing knowledge and data sources, a qualitative screen was performed on each of the initial group of five distributed generation technologies. When performing this screening, the following utility-specified measure screening criteria were used:[1]

- Distributed generation technology is not mature;
- Poor utility match due to demographics or other reasons;
- Better technology available (inferior unit); and
- Benefits and/or costs are not quantifiable.

Results from this screening were presented in Table 1, which showed those technologies most likely to have applicability within particular customer groups. These categorizations were subsequently reviewed and reasonably verified based on model screening results.

Simple Payback Calculations for Customer-Specific Applications, Ranking and Prioritization

Various size combinations of appropriate technologies were analyzed for each customer group and building type using GDS' distributed/on-site generation screening (DOGS) model. In total, more than 2,000 unique scenarios were run through the model. Twenty-seven separate generator size and type configurations were evaluated for each of forty-three individual customer sub groups at both a 90% and 50% capacity factor.[2] Where applicable, a maximum heat recovery value of 50% was also applied.

The utility's rate tariffs and average customer load profile data for each typical customer group was modeled along with critical installation cost and operating characteristics of each of the technologies being assessed. Resulting simple payback information was recorded for each scenario run so that technologies could be rank ordered and a prioritized list of potentially viable customer-sited generation applications could be created. Table 4 includes an excerpt from the technology-payback ranking, a prioritized list sorted by technology and sub-sorted by shortest to longest payback.

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[1] These criteria were consistent with the utility's DSM qualitative screening criteria.

[2] Capacity factors of 20% and 33% were used when assessing the potential viability of wind and photovoltaic, respectively.

Table 4. Sample of Technology-Payback Ranking for Scenarios Analyzed

Scenario Description: Customer Type/Sub-Group	Scenario Description: Technology	Simple Payback (yrs)
C/I Manufacturing - Small	MicroTurbine - 75 kw, 50%CF/50%WH	5
C/I Manufacturing - Small	MicroTurbine - 75 kw, 90%CF/50%WH	5
Commercial Schools - Small	Recip/D - 11 kw, 90%CF/50%WH	5
Commercial Health Care - Small	Recip/D - 11kw, 90%CF/50%WH	5
Commercial Office - Small	Recip/D - 11kw, 90%CF/50%WH	5
Commercial Personal Srvcs - Small	MicroTurbine - 30 kw, 90%CF/50%WH	6
Commercial Personal Srvcs - Small	MicroTurbine - 45 kw, 90%CF/50%WH	6
C/I Manufacturing - Small	MicroTurbine - 60 kw, 90%CF/50%WH	6
Commercial Personal Srvcs - Small	Recip/D - 11kw, 90%CF/50%WH	6
C/I Manufacturing - Small	MicroTurbine - 30 kw, 90%CF/50%WH	7
C/I Manufacturing - Small	MicroTurbine - 45 kw, 90%CF/50%WH	7
C/I Mining - Small	MicroTurbine - 60 kw, 90%CF/50%WH	7
C/I Manufacturing - Small	Recip/D - 11 kw, 90%CF/50%WH	7
C/I Mining - Small	Recip/D - 11 kw, 90%CF/50%WH	7
C/I Mining - Small	Recip/D - 68 kw, 90%CF/50%WH	7
Commercial Schools - Small	Recip/NG - 10 kw, 90%CF/50%WH	7
Commercial Health Care - Small	Recip/NG - 10kw, 90%CF/50%WH	7
Commercial Office - Small	Recip/NG - 10kw, 90%CF/50%WH	7
C/I Mining - Small	MicroTurbine - 30 kw, 90%CF/50%WH	8
C/I Mining - Small	MicroTurbine - 45 kw, 90%CF/50%WH	8
C/I Utilities/Transp. - Cable TV	Recip/D - 11 kw, 90%CF/50%WH	8
C/I Manufacturing - Small	Recip/D - 68 kw, 90%CF/50%WH	8
Commercial Personal Srvcs - Small	MicroTurbine - 75 kw, 50%CF/50%WH	9
Commercial Health Care - Small	Recip/D - 11kw, 50%CF/50%WH	9
Commercial Personal Srvcs - Small	Recip/NG - 10kw, 90%CF/50%WH	9
Commercial Personal Srvcs - Small	MicroTurbine - 60 kw, 50%CF/50%WH	10
Commercial Schools - Small	Recip/D - 11 kw, 50%CF/50%WH	10
Government - Small	Recip/D - 11 kw, 50%CF/50%WH	10
Commercial Office - Small	Recip/D - 11kw, 50%CF/50%WH	10

Step Five: Estimating the Potential Impact to Utility

The technical potential for on-site generation applications of technologies showing paybacks of 5 years or less and 10 years or less were totaled and summarized to estimate the potential impact to the utility system. Wind and photovoltaic systems were considered electric-only and all other technologies were considered as combined heat and power installations. Due to capital-intensive nature of on-site generation investments, and the divergence from customer's key business line, only 10% of those meeting the payback criteria were estimated as likely to be installed. However, in order to illustrate the full economic potential, both 10% implementation and 100% implementation were presented to the utility. It is noted that economic potential estimates will vary greatly depending on the assumptions used in the screening model to calculate simple payback and that paybacks were calculated using numerous simplifying assumptions regarding utility rates, fuel costs, technology installation costs, and other items necessary for the analysis. Table 5 illustrates the results of the impact analysis conducted for Alliant's Iowa service territory.

Table 5. Potential Impact of Distributed Generation Installations

	5 Year Payback		10 Year Payback	
Economic Potential Category	**10% (kW)**	**100% (kW)**	**10% (kW)**	**100% (kW)**
Total Distributed Generation Potential	7,392	73,918	27,484	274,840
Combined Heat & Power Only	7,392	73,918	9,334	93,340

Conclusion

As described in this paper, the DOGS model, and related analysis, was successful in meeting Alliant's needs for identifying potential customer-sited distributed generation opportunities and for determining the estimated impact to their system as a result of such installations. It should be noted, however that, as with any computer model simulation, the results are as accurate as the underlying assumptions used to drive the model's economic and engineering analysis.

From a broad, utility-system perspective, the DOGS model results offered a reasonable estimate of which customer sectors might be most likely to install on-site generation and what the potential level of that generation could be under certain circumstances. Armed with this service-territory-specific information, utilities can more effectively focus their resources relating to potential business opportunities and obstacles associated with on-site generation.

On a more site-specific basis, the DOGS model can also be used by a field engineer to estimate the cost effectiveness of on-site generation for a customer. In this case, the field engineer would enter actual utility consumption data as well as operating characteristics relating to the proposed system's capacity factor and potential heat recovery factor. The customer, and/or the field engineer, could then use the model results to determine whether the cost of a more detailed project assessment was warranted.

Post-Script

The results of the study described in this paper were included in an Alliant regulatory filing to the Minnesota Public Utilities Commission. Since this filing, the Minnesota Department of Commerce has reviewed the study and noted that the relatively small estimate of distributed generation potential (at the 5-year or less payback level) is partly due to the exclusion of incentives for various fuels and/or technologies. By including state and federal incentives for wind projects to the DOGS model inputs, the Department found that a 660 kW wind turbine met the five-year payback criteria for several customer profiles. The Department has recommended that Alliant update the distributed generation analysis for their next Integrated Resource Plan filing. Alliant has subsequently contracted with GDS to conduct the update to the analysis, which will be underway in May 2003.

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