Appendix B Notes on Distributed Generation In Dane County[2]

Distributed Generation and energy planning

There is a potential mismatch between the utilities that are procuring power generation and ATC (who is providing transmission services) in that distributed generation can assist in both efforts. The transmission value of distributed generation is only a small fraction of distributed generation's potential value as power supply. This situation highlights the need for a process that integrates distributed generation, demand side management and energy efficiency opportunities with transmission and central power plant options. It also highlights the need for a mechanism for identifying the benefits of and sharing the costs of incentives for distributed generation.

The lack of coordinated planning and integrated incentives diminishes the opportunity to develop distributed generation as part of the energy plan for Dane County. There is no mechanism currently in place to fully reflect the value of distributed generation to the electricity network. In the absence of a mechanism to encourage coordinated planning and integrated incentives for distributed resources, it is likely that much of the anticipated load growth in Dane County will be met by new transmission lines through 2012 and beyond.

Distributed Generation in Dane County

This analysis uses the Public Service Commission's definition of distributed generation as dispersed generation of less than or equal to 15 MW. The information reported below is a summary of information obtained from utilities serving in Dane County and the State of Wisconsin's Focus on Energy program.

In the summary table below, systems of less than 20 kW are not included. It is estimated that there are 50 to 100 small distributed solar and wind electric systems distributed around Dane County with rated capacities of 20 kW and less.

Other Installed Systems

- Dane County Rodefeld #2 Landfill, 2.4 MW.
- Madison Metro Sewerage District, two 500 kW units producing 532 kW, 24 hr/day to plant grid.
- Sun Prairie Wastewater Treatment Plant, 150,000 ft3/day biogas @65 percent methane, 30 kW microturbine

Projects Underway

- Dane County Rodefeld #2 Landfill, additional 1.6 MW to be installed by 2005.
- Middleton Landfill (near County P), 30 kW Capstone mircoturbine (being explored by MATC and MGE)

Table 24. Alliant Energy Distributed Generation Systems.

	Number of systems	Total capacity	Reliability	On-peak capacity factor	Ownership	Rough hours per year used
Diesel back up	2	~2 MW			AE, AFI	
Land fill gas	1	500 kW			Dane County, Verona	
Wind	1	35 kW			homeowner	

Table 25. MGE Distributed Generation Systems.

	Number of systems	Total capacity	Reliability	On-peak capacity factor	Ownership	Rough hours per year used
Diesel back up	55	55 MW	98%	1.0	MGE	20

Table 26. WPPI Distributed Generation Systems.

	Number of systems	Total capacity	Reliability	On-peak capacity factor	Ownership	Rough hours per year used
Diesel back up	Not provided	3.9 MW			Site owners	

2 *Derived from analyses prepared by Larry Krom, Focus on Energy and L & S Technical Associates Inc., and Niels Wolter, MSB Energy Associates, September 29, 2004.*

Potential Sites for Distributed Generation

For expanded distributed generation to take root in Dane County, potential host sites need to be identified. Some of the potential host sites are tied to specific resources (e.g., landfill gas is tied to locations where there are untapped landfills). Other potential sites are much more difficult to locate, such as customers with both heat and electricity loads sufficient to be viable for cogeneration.

Below is a list of possible sites for distributed generation:

- Large wind turbine at Epic Systems, 1 to 2 MW, Verona
- Biomass system at Oscar Meier/Kraft, Madison, near airport. Discussions underway for several years.
- Dane County Rodefeld #2 Landfill, 1.6 MW potential within five years
- "Bridges Golf Course" landfill, undeveloped for energy
- Middleton "Refuse Hide-Away" landfill, undeveloped for energy
- Truax Landfill, undeveloped for energy
- Sun Prairie Landfill
- Stoughton Waste Water Treatment Plant, 30 kW microturbine potential

Distributed Generation Technical Potential

Technical potential is an estimate of the amount of distributed generation that would be technically feasible to build, reflecting limits due to the amount of resource that is available. It is not a measure of what is economical to build, nor a projection of what will be built. Typically the technical potential is significantly larger than the economic potential. The amount actually built is often only a small fraction of the economic potential due to the existence of other barriers such as information and other uses for money (e.g., businesses investing in their manufacturing line to increase output rather than building their own electric generators).

Wind Energy Systems

There is estimated to be approximately 70 square miles (182 square kilometers) of developable land for wind turbines in Dane County – 5.7 percent of Dane County surface area. Dane County has an area of 1,238.31 square miles (land and water included). If all of the developable 182 square kilometers were utilized for wind turbines, at 2 MW per square kilometer, an estimated 364 MW of generation capacity could be possible.[3] See Figure B-1 and Table 27.

Table 27. Dane County Wind Resource Areas.

Map No.	Location	Area, square miles
1	East of Sauk City	2.40
2	East of Roxbury	9.98
3	South of Roxbury	5.28
4	South of Mazomanie	3.10
5	North of Black Earth	4.80
6	North of Cross Plains	2.40
7	Northeast of Cross Plains	1.36
8	Northwest of Mount Horeb	6.35
9	Northeast of Mount Horeb	1.19
11	South of Blue Mounds to Mount Horeb	8.92
12	South of Mount Horeb to Verona	2.03
13	Daleyville	8.62
14	Southeast of Daileyville	9.42
	TOTAL AREA	**70.41**

[3] *The following criteria were used in arriving at this estimate: Dane County areas are estimated to be developable if they have an annual average wind speed of 13 – 13.5 mph, at 60 meters above ground, according to the Wind Assessor's Map of Wisconsin - dated 6-30-03. Elevation and contour information are obtained with TopoUSA, a computer topographic map of Dane County with 20 foot contour intervals. The topographic map is scaled and registered with an overlay of the Wind Assessor's Map at 33 percent transparency. This estimate assumes a wind density of 6.7 MW per square kilometer, based on data from EIA (EIA, 2002c), discounted to 2 MW per square kilometer. The discounting is due to wooded hill and valley terrain (according to simple topographic map assessment), lower capacity factor potential of 13 – 13.5 mph wind resources, and current land use.*

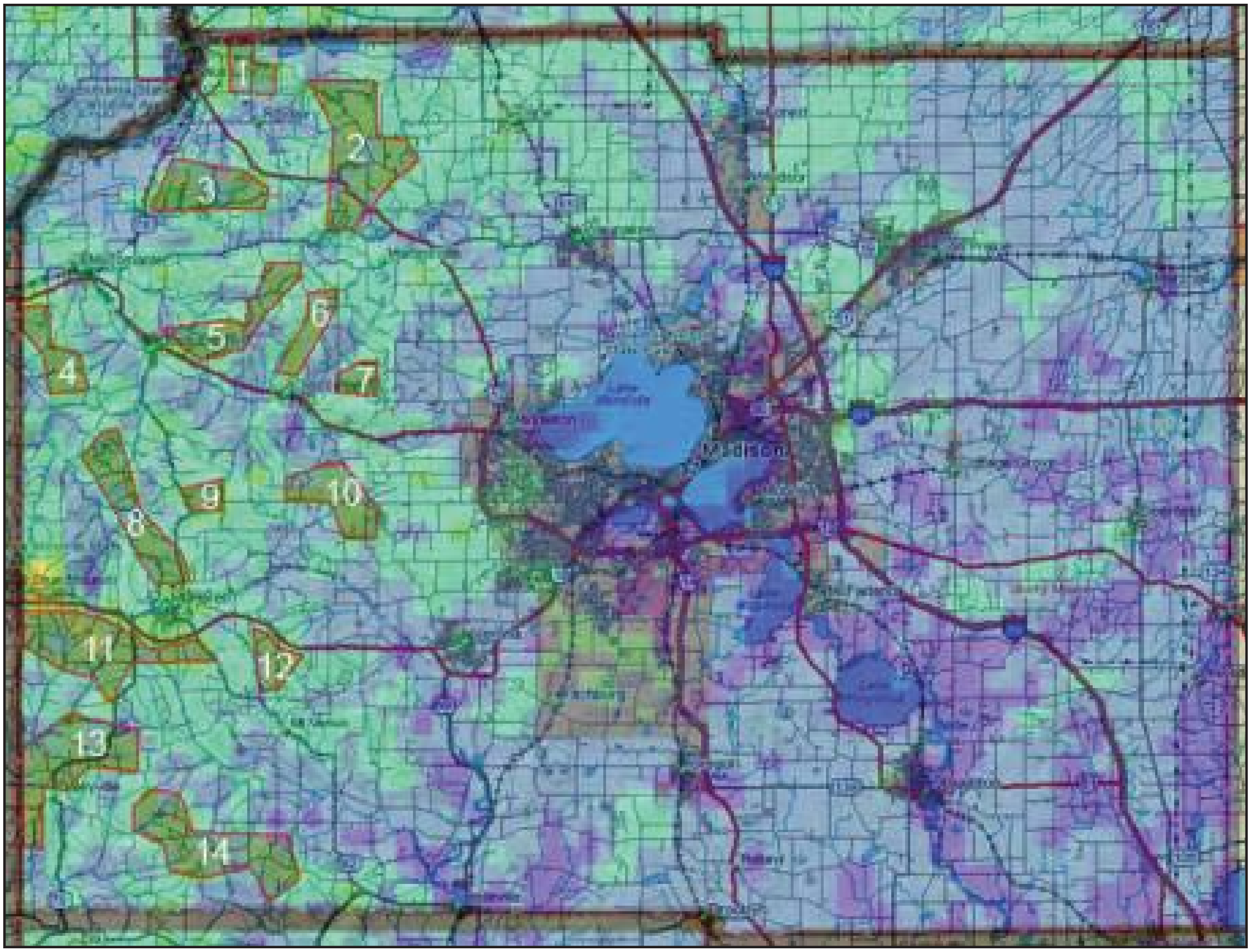

Figure B-1. Dane County Developable Wind Resource Areas

Photovoltaic Systems (PV)

Potential: Covering 880 acres (0.12 percent of Dane County) with PV panels rated at 100 MWdc (direct current output) could reduce afternoon demand by about 50 MW and generate 117,000 MWh/year. (Assumptions: 114 kW_{dc}/acre of unshaded fixed PV systems, generating 1170 kWh per year per kWdc of panel, and 50 percent of panel capacity is available during peak demand periods).

Systems could be placed on many locations, vacant land (e.g., highway sound barriers, and brown field sites), on the roofs of commercial buildings, and on the roofs of homes.

Table 28 shows the space requirements and costs for installing PV systems with capacities of 100 MW_{dc} (or about 75 MW when converted to alternating current for use on the electric utility network) in different types of installations. During Dane County's afternoon summer peak, each of these systems should have an average capacity of about 50 MW. These figures assume that the PV panels are crystalline PV, fix mounted and in the full sun. Approximately 120 square feet of PV panel area are required per kW_{dc} of rooftop panel capacity.

Table 28. Area needs and installed costs for PV systems with capacities of 100 MW.

Site	Area needs	Installed cost
Residential Roof tops	64,000 homes 190 ft^2 each	$600 million @ $6/watt
Vacant Land	880 acres	$600 million @ $6/watt
Commercial Building Roofs	560 buildings 21,500 ft^2 each	$550 million @ $5.50/watt

If all of Dane County's vacant land (13,250 acres) were used to site fix-mounted PV systems, 1,500 MWdc of PV could be installed (assuming 114 kWdc of PV could be sited per acre). The on peak demand is roughly 750 MW (assuming a 50 percent on peak capacity factor), the total installed cost is $7.6 billion (assuming a cost of $5/Watt), the site owner's cost share $3.8 billion (assuming a 50 percent of costs covered by incentives).

In Dane County, PV has a higher on peak capacity factor than wind, and a substantial technical potential. However PV systems have a high first cost and power generation is intermittent and non-dispatchable.

PV Coincidence with System Peak

PV is a poor technology for meeting early evening demand peaks. For example, when WP&L's 2003 demand peaked on a hot August day, peaks occurred at 50 percent of the substations between 6 p.m. and 7 p.m. At this time of the day, a PV system will typically be generating power at a very small faction (under 10 percent) of its rated peak capacity.

The other demand peaks at WP&L substations (45 percent of the sample) occurred in the late afternoon between 2 p.m. and 6 p.m. (with 25 percent between 3 p.m. and 4 p.m.). During this period, a PV system will produce at about 55 to 65 percent of its maximum output (of that same day).

During MGE's peak period, as defined by time of day rates, from 10 a.m. until 9 p.m. PV production averages at about 50 to 60 percent of the system's maximum output (of that same day). WP&L offers more than one energy peak period definition. If the peak period definition of 8 a.m. to 8 p.m. is used, PV production averages about 55 to 65 percent of the system's maximum output (of that same day).

Forecasting PV output is easier than wind energy production. PV systems with residential demand control programs may be an interesting partnership.

PV System Economics

Several factors are combining to rapidly improve PV system economics. PV systems costs are declining. Based on data collected by Focus on Energy on PV systems installed over the last two years in Wisconsin, prices have dropped by over 20 percent. Electric rates, purchased power costs, etc. are increasing at 4 to 10 percent per year.

The largest incentive is currently offered by the Focus on Energy Renewable Energy program. However, Focus on Energy does not have the budget needed to support an installation effort on this scale. Federal tax incentives are available for commercially non-utility owned systems including:

- A first cost 10 percent tax credit (max $25,000 per year carried over three years maximum) and
- Accelerated depreciation over 5.5 years.

Green power providers and other organizations are beginning to purchase the green tags from solar electric power systems at premium prices. These prices range from $0.02 per kWh to $0.15 per kWh for contract periods of up to ten years.

A state sales tax (5.5 percent) waiver on renewable energy equipment and installation has some likelihood of being enacted in the next 12 to 18 months.

With these developments, simple payback periods for commercially owned systems range from 15 to 25 years and returns on investment are in the 8 to 10 percent range.

Biomass

Anaerobic Digesters on Dairy Farms – Biogas. It is estimated that one MW of baseload generation could be produced from dairy cow waste on the 10 farms in Dane County with 500 or more head of dairy cows. The assumption of generation potential is five cows/kW (four kWh/cow/day). Animal waste from other cattle, hogs and pigs was not considered economically viable for energy recovery at this time.

Biomass Gasification for Introduction into a Boiler. Because crops are grown for gasification, the potential is determined by the cropland put into such production. Therefore, with enough land dedicated to this use, there is a large technical potential. No analysis has been done to date.

Biomass Direct Firing in a Boiler. Because crops are grown for firing for energy generation, the potential is determined by the amount of cropland put into such production. Therefore, with enough land dedicated to this use, there is a large technical potential. No analysis has been done to date.

Landfill Gas. This option is available, but has limited opportunity to be expanded. See potential sites previously described.

Wastewater Treatment Plant (WWTP) – Biogas. This option is available, but has limited opportunity to be expanded. See potential sites previously described.

4 *A Wisconsin investor owned utility is seriously considering purchasing the green tags from PV systems located in their service territory at a price of $0.10 to $0.20 for ten years. This incentive would be made available to a limited number systems.*

5 *Assuming a fixed unshaded system sited in MGE territory with an installed cost of $7/watt, the owner has a 20 percent federal tax rate, is able to use all Focus on Energy and Federal incentives, and sells all green tags at two cents per kWh, and a six percent annual electricity price escalation rate.*

6 ***Data:** All cattle and calves: Dane County is ranked 4th with 123,000 head as of 1/1/2003; All hogs and pigs: Dane County is ranked 5th with 30,500 head as of 1/1/2002; Grade A dairy herds: 420 herds as of 4/1/2003; Total Milk Production: Dane Co. is ranked 3rd with 930,600,000 lbs. per year. **Milk cows:** Total farms = 434, Total Head = 46,838, Farms by inventory (only data on larger farms) 200 to 499 head = 38 farms, 11,412 head; 500 or more = 10 farms; 7,886 head. **Other cattle**:Total farms = 964, Total head = 73,495. Farms by inventory (only data on larger farms) 200 to 499 head = 69 farms, 19,955 head; 500 or more = 16 farms, 12,123 head. In the 2002 Census of Agriculture, other cattle included heifers, steers, bulls 500 lbs and over, and all calves under 500 lbs. **Hogs and pigs:** Total farms = 83; Total head = 28,243, Farm by inventory (only data on larger farms) 500 to 999 head = seven farms; 5,825 head; 1,000 or more = 10 farms, 15,222 head. **Poultry:** Some poultry operations, but they appear to be fairly small operations.*

Natural Gas

Pressure into Power. High-pressure pipeline natural gas is reduced to lower pressure for distribution at Madison's natural gas city gate. Some of the energy of this pressure reduction can be recovered with a gas expansion engine coupled to a generator. This technology has been adopted at several locations in Europe. Assuming 1000 psi inlet pressure reduced to 100 psi outlet pressure, it is estimated that 750 kW can be generated at the Madison natural gas city gate.

Natural Gas - Generators

There is a significant potential for natural gas distributed generation. Multiple technologies are available and in commercial use in the United States:

- Microturbines (30 kW to 1700 kW), installed cost $1200 to $2000/kW7
- Gas reciprocating engines (30 kW to 6 MW), installed cost $500 to $1400/kW
- Gas turbines (3 MW to 30 MW), installed cost $600 to $1,500/kW

In addition, each technology has the potential for

- Use as emergency/interruption back up power source, peak generator, and baseload generator
- Cogeneration (hot water, steam, high temperature direct heat) and trigeneration (cooling)
- Operation by the site owner, the utility or both

Of the distributed generation options, natural gas fired generation is likely to have the largest near term potential in an urban setting to meet Dane county's growing demand. Natural fired generation has the following characteristics

- Several technology options
- Mature technology
- Reliable technology
- Reasonable cost
- Flexible technology – ability to operate as backup, peaker or baseload, and controlled by the site owner and/or the utility
- Board range of system sizes available
- Ability to cogenerate heat (and cooling (trigeneration))
- Relatively clean burning thus easier to site
- Natural gas is readily available through urbanized portions of Dane County

Gas-fired distributed generation technologies can be installed for electric power only generation, but there is little incentive to do so since they utilize a fuel that is both expensive and volatile in price. Because these technologies use natural gas, they do not insulate the customer from gas price increases and are generally more expensive to operate than larger utility scale combustion turbines using natural gas. While some customers may choose to install gas reciprocating engines or turbines to assure a reliable backup power supply, most would probably not install these technologies on the basis of economics (unless customers were also able to utilize the heat output for their process or heating needs or unless they had access to an otherwise wasted source of biogas). Without special circumstances (such as reliability, cogeneration or biogas supply), these technologies are not likely to be installed by customers.

Large scale power plants utilize so much heat that it is difficult to find customers with heat loads large enough to implement cogeneration. Gas reciprocating engines and small turbines can be matched to smaller heat loads. Micro-turbines are even more flexible, and can be sited in relatively small operations to provide both electricity and heat.

Micro Turbines

Single or groups of micro turbines could be located at small to medium sized commercial, institutional and industrial sites across Dane County. Economics would be improved by cogenerating hot water or steam. Potential sites include restaurants, clinics, hotels, laundries, health clubs, medical facilities, convenience stores, etc. The potential for micro turbine installations in Dane County is shown in Table 29.

Gas Reciprocating Engines and Gas Turbines

Potential sites for gas reciprocating engines and gas turbines are new and existing large health care facilities, medium to large industrial buildings, office and industrial parks and refrigerated warehousing.

Table 29. Estimates of potential installed microturbine (MT) capacity for select sites.

Site	Total sites in Dane County (source)	% Suitable to MT	Capacity Per Site	Total Capacity
Restaurants	610 (Isthmus Newspaper dining guide Madison area only)	10%	30 kW	1.83 MW
Hotels	61 (Wisconsin State Journal, metropolitan Madison)	20%	40 kW	480 kW
Nursing Homes	22 (Wisconsin State Journal)	25%	40 kW	220 kW
Health Clubs	40 (estimated from online listing)	25%	40 kW	400 kW
Commercial Office buildings	145 (Madison-area only, Wisconsin State Journal)	15%	40 kW	870 kW
Convenience stores	99 (Madison – area, phone book)	15%	30 kW	445 kW
Large grocery stores	28 (Madison-area, estimated from phone book)	20%	40 kW	224 kW

Stirling Engines

Stirling engines were invented almost 200 years ago but have yet to be proven in the market. A Stirling engine is an external combustion engine. In the moderate to long term the technology may play a role in Dane County's energy mix. Stirling engines can use many fuels and high temperature heat sources, have very low emissions, have high fuel efficiency, can operate from low pressure gas lines, and are quiet with low vibrations. They are predicted to have low maintenance costs and lower power generation costs.

STM Power of Ann Arbor Michigan is perhaps the closest to developing a commercially available Stirling engine. They are reportedly close to bringing a 55 kW unit to the market. The STM engine can operate using a wide variety of fuels (natural gas to biogas to diesel) or from waste heat streams with temperatures over 1440°F (i.e., waste heat off of kilns, and furnaces). The heat can be from a separate external fuel combustor that supplies heat to the Stirling engine. Solar energy concentrators could be used as the heat source. The STM sterling engine has about a 30 percent electrical efficiency (producing electricity alone) and about 80 percent efficiency as a cogenerator (producing electricity as well as low-temperature heat).

High temperature waste heat streams are not commonly available in Dane County. However Stirling engines are able to use lower temperature heat sources but they become larger and most costly per kW of engine capacity. When using an external combustor, Stirling engines may compete with internal combustion, turbine and microturbine generators.

Strategies To PROMOTE distributed Generation

Four basic strategies could be used to promote distributed generation.

- Systems could be sited, installed, owned, operated and maintained by the utility. These costs would need to be justified before the PSCW.
- The policy environment could be changed to encourage (or require) building owners to own, install and operate distributed generation systems.
- Electric tariffs could be changed to encourage building owners to own, install and operate distributed generation systems.
- Some combination of the above noted options

Sample policy changes could include:

- Requiring/encouraging natural gas distributed generation in specified commercial, industrial and institutional buildings and business and industrial parks
- Requiring/encouraging natural gas "combined heat and power" systems (CHP) in specified commercial, industrial and institutional buildings and business and industrial parks, particularly those with heat consumers.

Offer benefits to developers that include distributed generation systems such as:

- Higher allowable building density or additional floors
- Permitting expedition, exemptions or relaxation of some requirements, for projects that meet some of their own energy needs.
- Feebates (charging higher fees for buildings without distributed generation and pass the funds on as rebates to buildings that include such measures).
- Improved access to (and or reduced fees) for city and county financing (e.g., tax incremental financing (TIF))

Policies must also insure that developments are not allowed to place restrictions that forbid distributed generation systems other than for reasons of health and safety, and

Require that existing buildings with diesel back up generators be converted to natural gas fired generators for meeting peak and back up power needs.

Changes to Utility Tariffs

Like existing rate change requests, any utility rate change associated with distributed generation would need to be approved by the PSCW, perhaps as an experimental rate that is targeted at select areas of the county/state with transmission capacity constraints. Experimental rates could be capped.

Possible rate options to support the development of natural gas fired distributed generation include:

- Institute real time pricing
- Offer customer owned generator maintenance programs for generators that offset peak needs

Possible rate options to support the development of natural gas fired and renewable distributed generation include:

- Decrease standby rates for customers with on-site generation
- Offer uniform higher buy-back rates for distributed generators. Rates could vary depending on generation technology (e.g., depending on its peak capacity factor and air emissions) but otherwise be uniform for systems that either operate as independent power producers or as inside-the-fence customer-owned load management tools.

Possible rate options to support the development of renewable distributed generation include:

- Change net energy billing by increasing the net energy billing cap to the site's peak annual demand; or the average annual consumption at the site; or some level, such as one MW.
- Allow conjunctive net energy billing where a customer owned net metering system at one site could net meter against other meters located at other sites (e.g., a wind turbine owned by a school district net metering against the schools)
- Credit monthly and annual net energy production at the site's retail rate, not avoided cost.
- Modify green rates. A utility could own these systems or purchase renewable energy credits (a.k.a., green tags) from the system owners.
- Require that a percentage of green power is generated during the peak hours in areas of transmission constraint.
- Include a share of solar electricity systems, sited in areas of transmission constraints.

8 *Their webpage states that it will be available in the third quarter of 2004.*