Distributed Generation and Your Energy Future

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ABSTRACT

Distributed generation (DG) is electric or shaft power generation at or near the site of use as opposed to central power station generation. Combined heat and power (CHP) takes advantage of this site location to recover the normally wasted thermal energy from power generation and utilizes it beneficially to increase the total system efficiency. This article explores the rapidly developing world of DG and associated CHP. First the article shows why DG is necessary in the US power future and that DG is going to happen. Then, the article briefly looks at the different technologies that might be employed and their relative advantages and disadvantages. The article then explores who should be the major designers and implementers of DG and CHP technologies, and develops a strong argument that in many cases this should be an Energy Service Company (ESCO). Finally, the reasons for selecting either an independent ESCO or a local utility affiliated ESCO are discussed, and in particular, opportunities for the local utility ESCO (the local grid) to be a major moving force in this effort are examined in depth.

INTRODUCTION

Distributed generation (DG) is electric or shaft power generation at or near the user's facility as opposed to the normal mode of centralized power generation and utilization of large transmission and distribution lines. Since DG is at or near the user's site, combined heat and power (CHP) becomes not only possible, but advantageous for many facilities. CHP is the simultaneous production of electric or shaft power, and the utilization of the thermal energy that is "left over" and normally wasted at the central station generating site. Since DG means the power is generated the user's site, CHP can be used to beneficially recover "waste" heat, and provide the facility with hot water, hot air, or steam, and also cooling through the use of absorption chillers.

Normal power generation using a steam Rankine cycle (steam turbine) is around 35% efficient for electric power production and delivery to the using site. DG with its associated CHP potential means the total system efficiency can be improved dramatically and sometimes even doubled. Thus, even though DG cannot usually beat the electrical generation efficiency of 35% - 40% (at the central station), it can save the user substantial amounts of money through recovery of the thermal energy for beneficial use at the site. In addition, there are many other potential benefits from DG/CHP, discussed below.

Thus, the user can choose the objective he/she desires and will likely find a technology in this list that meets that objective. Objectives might include power production that is environmentally friendly, is cost effective, is more reliable, or yields better power quality. Each of these candidate technologies will be briefly explored in the sections that follow.

WHY DG?

To explore why DG should be (and is becoming) more popular, the question of Why DG? needs to be addressed from the perspective of the user, the utility, and society in general. Each of these perspectives is examined below.

The user might desire more reliable power. This can occur with DG especially when it is connected to and backed-up by the grid. The user might desire better quality power which can result because there will be fewer momentary interruptions and possibly better voltage consistency.

Often, the user desires better economics (cheaper power), which is quite possible with DG when CHP is employed. Finally, there could be a competitive advantage during a utility power outage when the user has power and the competition does not.

The utility might desire less grid congestion and less future grid construction, both of which DG definitely yields. The utility may be able to hold on to a customer better if the customer has DG and CHP at their site. Certainly this is true if the utility constructs and runs the local power facility. Today's technology is capable of allowing the utility to remotely dispatch literally hundreds of DG units scattered in the grid, which could dramatically improve their ability to handle peak load and grid congestion problems.

Society in general likes DG/CHP which can provide strong environmental advantages (when the appropriate technology is utilized). For example, CHP means less total fuel will be consumed placing less strain on the environment. Also, DG means less grid construction, and "green technology"(wind, photovoltaics, etc.) can be used if desired. Since less total fuel is consumed, there will be reduced reliance on imported oil and gas, and an improved balance of payments for the United States.

BASIC PHILOSOPHIES

In the development to follow, some basic objectives are assumed. They are:

- Any expenditure of funds should be cost effective
- Any change should be good for all parties, or at least be of minimal harm to any party
- Existing partnerships that are working should be maintained if at all possible.

These assumptions should be clear as stated above; but more explanation will follow as the arguments are developed.

EXISTING AND FUTURE MARKETS FOR DG

Resource Dynamics Corporation has estimated that the installed base of DG units greater than 300 kW in size is at least 34 GW (34×10^9 watts). The Gas Research Institute (GRI) estimates that the installed DG capacity in the US of all sizes is 75 GW. Just over 90% of the installed units are under 2 MW (2×10^6 watts) and well over 90% of the installed units are reciprocating engines. The use of DG power plants for back-up purposes is growing steadily at 7% per year while other DG applications for baseload and peaking requirements are growing at 11 and 17% respectively. Resource Dynamics Corporation says there is the potential to double the installed DG capacity by adding as much as 72 GW by 2010. All these sources confirm that there is already a large base of DG units nationally, and that the growth will be significant. DG is happening and will continue to happen.

Without trying to stratify it with exact numbers, the potential market could be broken into three components. They are 1) large and medium, 2) small, and 3) smaller. Each of these categories is examined briefly below.

The large and medium market is often 25 MW and larger (sometimes hundreds of MW) and is a mature market because there have been plants operating for many years. Typically these are in the larger process industries such as petroleum refining, pulp and paper, and chemical plants. Steam production may be in the range of hundreds of thousands of pounds per hour. While there are many such operating plants today, this mature market probably still offers the largest immediate growth potential. There is much more that could be done.

The small market will range somewhere between 50 (or 100) kW and 25 MW. These might be plants that need significant steam and could easily add a topping or bottoming steam turbine to become DG-CHP. Important to their success is the need for thermal energy and electricity (or shaft power) and the relative sizes of those needs might dictate which technology is appropriate. This market is virtually untouched today and the management/maintenance talents in these facilities might easily support this DG/CHP technological addition to their needs. Some facilities of this size will not have the management backing and maintenance talent that it takes to make these DG/CHP systems operate successfully. Those facilities would likely seek "outsourcing" for the power plant. The growth possibility here is extremely large but will likely take a few years to realize its full potential.

The smaller market would include those small manufacturing plants or commercial facilities that need less than 50 (or 100) kW and don't have large thermal needs. These plants and facilities likely **do not** possess the management backing and desire or maintenance talent it takes to run them. The market potential here is tremendous in numbers of applications but small in numbers of total MW. Finally, there is a significant drop in economies of scale somewhere around 200 to 500 kW so the economics here won't be as exciting as the other two markets. Thus, the authors' opinion is that this market will not be as robust in the near to immediate future. Note that this could change overnight if a local ESCO such as the utility ESCO offered to design, install, run, and dispatch these units.

DG TECHNOLOGIES

There is a wide range of technologies possible for DG. They include:

- Reciprocating engines—diesel, natural gas, and dual fuel
- Gas turbines—microturbines, miniturbines, and large turbines
- Steam turbines
- Fuel Cells
- Photovoltaic Cells
- Wind turbines
- Storage devices (batteries or flywheels)

The following table briefly summarizes the pros and cons of these different DG/CHP technologies. If more detailed information is needed, the authors recommend *Guide to Energy Management* (Chapter 14), Fourth Edition, The Fairmont Press; *Energy Management Handbook* (Chapter 7), Fifth Edition, The Fairmont Press; or the *Combined Heating, Cooling and Power Handbook*, The Fairmont Press.

The table demonstrates that there is a wide range of technologies available. Some are environmentally friendly, some are not. Some are more economically feasible while others are extremely expensive. Some use mature technologies while others are still somewhat of a gamble. What is badly needed for this market to mature are more ESCOs that are broadly experienced in DG/CHP applications and that are good at all of the above technologies, including the non-traditional approaches. Their tool sack contains all of these technologies and they know when and

Table 1. Overview of DG Technology

Technology	*Pros*	*Cons*
Fuel Cell	1. Very low emissions 2. Exempt from air permitting in some areas 3. Comes in a complete "ready to connect" package	1. High initial investment 2. Only one manufacturer producing commercially available units today
Gas Turbine	1. Excellent service contracts 2. Steam generation capabilities 3. Mature technology	1. Requires air permit 2. The size and shape of = the generator package is relatively large
Micro turbine	1. Low initial investment 2. High redundancy with small units 3. Low maintenance cost 4. Relatively small size 5. Installation flexibility	1. Relatively new technology 2. Requires an air permit 3. Possible syncronization problems at large installations
Engine	1. Low initial investment 2. Mature technology 3. Relatively small size	1. High maintenance cost 2. Low redundancy in large sizes 3. Need air permit
Photovoltaics	1. Low O&M costs 2. Environmentally friendly	1. Very expensive initially 2. Very large footprint 3. Sun must shine 4. Battery storage usually needed
Wind	1. Low to medium O&M costs 2. Environmentally friendly	1. Large footprint 2. Wind must blow

how to apply each of these technologies. To our knowledge, today only a few ESCOs can claim this broad a talent base.

WHO?

Thus far we have demonstrated that there is a significant market projected for DG/CHP systems and that this market needs to be satisfied. We have also shown there is a wide range of technologies that is available. What is needed is someone to "make this happen." Rather obviously, there are about three groups that could make this happen. They are:

The users themselves
ESCOs (Energy Service Companies)
— Independent ESCOs (consultants)
— Utility affiliated ESCOs

This section examines each of these groups, and shows how they might contribute to the expanded need for DG/CHP. One consideration in evaluating the potential success of a DG/CHP project is the goal alignment of the participants, where the goals of the user or the facility are compared to the goals of the organization that is implementing the project. The closer these goals match up—or align—the more likely the DG/CHP project is to succeed.

The Group of Users Themselves

The users' goals are to have a DG/CHP project that provides an appropriate solution to their needs for electric or shaft power, and probably heat; works well for them both in the short term and the long term; and maximizes their economic benefit from this investment.
The user knows its process better than anyone else. This is a real advantage of doing DG/CHP projects in house and leads to the best economics if it works. Finally, the goal alignment for this group is the best of the three groups, as it is the user itself doing the job.

For this to work, the user must have a staff of technically qualified people who can analyze potential technologies, evaluate the options, select the best technology for their application, permit and install the equipment, and operate the DG/CHP system in a manner which produces the desired results. In addition, management and maintenance must both commit to the project. This often will not occur if they wish to devote their time and efforts to building better products, delivering better services, or expanding into new products or services. Another disadvantage is that a very large capital investment is normally required and many plants and facilities simply do not have the necessary capital. Finally, these projects would involve grid interconnections and environmental permitting. Many plants and facilities are very unfamiliar with these requirements.

However, if the facility or plant does have a committed and skilled management and staff that can select, permit, install, finance and operate the DG/CHP system, this approach will most likely provide them with the highest rate of return for this kind of project.

The ESCO Group

For facilities that cannot or do not want to initiate and implement their own DG/CHP projects, the involvement of an Energy Service Company—or ESCO—is probably their most appropriate alternative. ESCOs brings a very interesting set of talents to DG/CHP projects. The right ESCO knows how to connect to the grid, what permits are required, and how to obtain those permits. The right ESCO knows all of the technologies available and how to choose the best type and size to utilize for this application. The right ESCO is a financial expert that knows all of the financing options available and which might be best. Often, this means they have partnered with a financing source and have the money available with payback based on some mutually agreeable terms (interest bearing loan, shared savings, capital lease, true lease, etc.)

One of the disadvantages of using an ESCO is they are sometimes "in a hurry." When this happens, the project design is not as well done as it should be, and they may leave before the equipment is running properly. Commissioning becomes extremely important here. Another disadvantage is that some ESCOs choose the same technology (cookie cutting) for all projects. A certain type turbine made by a particular company is always chosen, when this may not always be the best solution. If the ESCO approach is to work, all technologies must be considered and the best one chosen. For this group, goal alignment is not the best as the user no longer is in charge and the relationship is likely to be of limited duration ("outsourcing" being a possible exception.)

However, if an "ideal" ESCO can be found and utilized, this approach offers a very satisfactory arrangement.

Independent ESCOs (Consultants)

The goals of the independent ESCO are typically to sell the customer a technology solution that the ESCO is familiar with; get the equipment installed and checked out quickly; maximize their profit on the project; and in the absence of a long term contract to provide maintenance or operating assistance, to get out as quickly as they can. Sometimes the independent ESCOs goals do not line up that closely with the customer's. The independent ESCO may try to sell the customer a particular piece of equipment that they are most familiar with, and may be one that gives them the largest profit. If there is not going to be any long term contract for the ESCO, then they want to get the project completed as quickly as possible, and then get out. This may leave the user with a DG/CHP system that is not thoroughly checked out and tested, and leaves the user to figure out how to operate the system and how to maintain it. The project ESCO team may then depart the facility, and return to their distant office which may be in a very different part of the country.

However, as long as the user is willing to pay the ESCO for continuing support, the ESCO is almost always willing to do that. Unless the user is willing to pay for a part time or full time person to remain at their facility they will have to deal with the ESCO by phone, FAX, FedEx or Email.

One of the other potential problems with an independent ESCO is the question of its permanence. Will it be around for the long term? Historically, making the comparison of current DG/CHP ESCOs to the solar water heating companies of the 1970s and 1980s, leads to the concern that some of the DG/CHP ESCOs may not be around for the long term. Very few of the companies that manufactured, sold, or installed solar water heating systems at that time are still around today. Many of these solar water heating companies were gone within a few years of the customers purchasing the systems. Most of these companies were actually gone long before the useful lives of the solar systems had been reached. Repair services, parts, and operating advice were often no longer available, so many solar water heating system users simply stopped using them, or removed the systems. Based on this history, selection of an ESCO that is likely to be around for the long term is an important consideration.

Utility Based ESCOs

Next, consider a utility-based ESCO. Utility affiliated ESCOs have goals similar to the independent ESCOs goals in many respects, but the big difference is that the utility is a permanent organization that is local, is there for the long term, and is interested in seeing the user succeed so that they will be an even better customer in the long run. Also, since the utility and the affiliated ESCO are local, they can send someone out periodically to check on the facility and the DG/CHP project to help answer questions and make sure the project is continuing to operate successfully. The utility is financially secure, stable, and in most instances is regarded by the community as an honest and trustworthy institution.

This ESCO now is an independent branch of the local utility. If they have the full set of tools (knowledge of all the technologies) then their advantages include all those listed above. In addition, there is much better goal alignment. They will be there as a partner as long as the wires are connected and that likely is almost forever. Thus, both parties want this to work. They are the grid, so the grid interconnection is not as much of a problem. The user and the utility have been partners for years. This would change the relationship - not destroy it. (The devil you know vs. the one you don't) Finally, this is what they do (almost).

One limitation of the utility-based ESCO is that they must change their mindset of "sell as much electricity as possible," and recognize that there is a lot of business and income to be captured from becoming an energy service organization. Someone is going to do these DG/CHP projects; the utility revenue base is most enhanced when they do it and when the project is successful. Their services could involve design, installation, start up, commissioning, and passing of the baton to the user or they might run it themselves (outsourcing).

Now, if the local utility company ESCO can take advantage of the opportunities they have, then they have a lot to offer to facilities and plants that are interested in working with them to put in DG and CHP systems. The old Pogo adage "We are surrounded by insurmountable opportunities" is always around in these situations. Another old saying would describe this DG/CHP opportunity for utility affiliated ESCOs as "the business that is there for them to lose." The utility affiliated ESCOs need to aggressively pursue these opportunities.

SOME LOCAL UTILITY ESCO SUCCESSES

A very good example of a local utility ESCO success story comes from the experiences shared by AmerenCILCO - a utility company in central Illinois. This company has experiences with both DG and CHP projects.

DG-only Projects

AmerenCILCO has extensive experience in using reciprocating engine generator sets as DG to meet peak load conditions on their system. The specifications of some of their DG projects are as follows:

- Hallock Substation, 18704 N. Krause Rd., Chillicothe, IL
  - 8 reciprocating diesel engine generator sets
  - Nominal capacity 1.6 MWe each, 12.8 MWe total
  - Owned by AmerenCILCO

- Kickapoo Substation, 1321 Hickox Dr., West Lincoln, IL
  - 8 reciprocating diesel engine generator sets
  - Nominal capacity 1.6 MWe each, 12.8 MWe total
  - Owned by Altorfer Inc.; power purchase agreement with AmerenCILCO, operating agreement provides for O&M

- Tazewell Substation, 18704 N. Krause Rd., Chillicothe, IL
  - 14 reciprocating diesel engine generator sets
  - Nominal capacity 1.825 MWe each, 25.55 MWe total
  - Owned by Altorfer Inc.; power purchase agreement with AmerenCILCO; operating agreement provides for O&M

Although these DG power module facilities are primarily used as peaking facilities, they are also used to maintain system integrity in the event of an unanticipated outage at another AmerenCILCO generating station. They are unmanned and remotely operated from the company's Energy Control Center. They have proven to be a reliable and low cost option for the company to meet its peaking requirements. The power module sites were constructed at a cost of approximately $400/kW and have an operating cost of $75/MWh using diesel fuel at $0.85/gallon.

DG/CHP Projects

AmerenCILCO also has some successful CHP projects. A summary of two such DG/CHP projects are given below.

INDIAN TRAILS COGENERATION PLANT

The Indian Trails Cogeneration Plant is owned and operated by AmerenCILCO. It is located on the property of MGP Ingredients of Illinois (MGP) in Pekin, Illinois and provides process steam to MGP and electricity to AmerenCILCO. The plant was constructed at a cost of $19,000,000 and went into full commercial operation in June 1995.

The plant consists of three ABB/Combustion Engineering natural gas-fired package steam boilers and one ABB STAL backpressure turbine-generator. Two of the boilers, Boilers 1 and 2, are high-pressure superheat boilers rated at 185,000 lb/hr of steam at 1250 psig and 900 degrees F. Boiler 3 is a low-pressure boiler rated at 175,000 lb/hr of steam at 175 psig and saturated temperature. Boilers 1 and 2 are normally in operation, with Boiler 3 on standby to insure maximum steam production reliability for MGP.

The high-pressure steam from Boilers 1 and 2 passes through the ABB backpressure turbine-generator, which is rated at 21 megawatts. The steam leaving the turbine is at 175 psig and is desuperheated to 410 degrees F to meet MGP's process steam requirements. The electricity produced goes to the AmerenCILCO grid to be used to meet utility system requirements.

The plant configuration provides significant operating efficiencies that benefit both MGP and AmerenCILCO. Indian Trails has an overall plant efficiency in excess of 80% and an electric heat rate of less than 5200 Btu/kWh. The construction of Indian Trails by AmerenCILCO created an energy partnership with a valued customer. It allowed MGP to concentrate its financial and personnel resources on its core business. In turn, AmerenCILCO used its core business of producing energy to become an integral part of MGP's business, making AmerenCILCO more than just another vendor selling a product.

MEDINA VALLEY COGEN PLANT

The Medina Valley Cogeneration Plant is owned and operated by AmerenCILCO. It is located on the property of Caterpillar and provides process steam and chilled water to Caterpillar, and electricity to AmerenCILCO. The plant was constructed at a cost of $64,000,000 and went into full commercial operation in September 2001.

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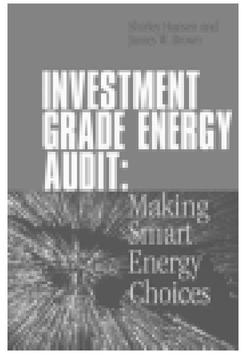

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The plant configuration provides significant operating efficiencies that benefit both Caterpillar and AmerenCILCO. Medina Valley has an overall plant efficiency in excess of 70% and an electric heat rate of less than 6400 Btu/kWh. The construction of Medina Valley by AmerenCILCO created an energy partnership with a valued customer whereby competitive electricity and steam prices were provided, as well as greater operational flexibility, improved quality control in manufacturing, and improved steam reliability. It also allowed Caterpillar to concentrate its financial and personnel resources on its core business. In turn, AmerenCILCO used its core business of producing energy to become an integral part of Caterpillars business, strengthening its ties with a major customer, as well as adding additional efficient generating capacity, and improving air quality (399 fewer tons pollutants/year).

CONCLUSIONS

DG and DG/CHP should, must, and will happen. The benefits to all parties when CHP is utilized are too much to ignore. Therefore, the question becomes who should do it, not should it be done.

If management is behind the project, the engineering and maintenance staff is capable, and financing is available, the project should be done in-house. Maximum economic benefits would result. However, the user must commit to this project.

If any of the above is not true, the best approach for the facility or plant is to seek the help of an ESCO. It is important that the ESCO chosen must be fully equipped with knowledge and experience in all of the technologies and be able to provide the financing package. Such ESCOs do exist today, but some of them need a better understanding of the different technologies required, as well as insuring that the DG/CHP project is successfully completed and turned over to a facility that can operate it and maintain it. Commissioning and baton passing must be part of the contract.

The authors believe there is a tremendous opportunity for local utility ESCOs to successfully participate in this movement to Distributed Generation, and particularly to the use of Combined Heat and Power. A utility affiliated ESCO - properly equipped as we have defined it - can do these projects, and can do them successfully. The local utility ESCO has entries with local facilities and plants that few other ESCOs have. If the utility can exploit this opportunity, they have the chance to help many facilities and to help themselves in the process. This is a true Win-Win opportunity for the utility affiliated ESCO. All utilities should be ready to fill this need or recognize that they will likely lose market share.

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