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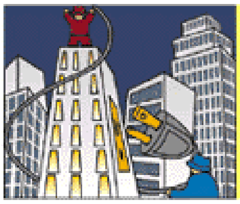


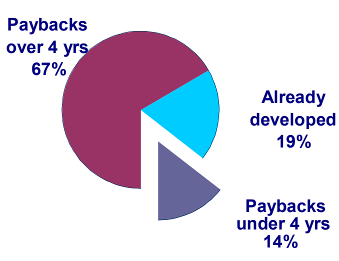
Distributed Generation MONITOR

In the last edition of the DG Monitor, we provided readers with a snapshot of the DG market, its technologies, and other hot topics. In this issue, we'll follow up with a look at DG's future. ***DG Monitor Staff***

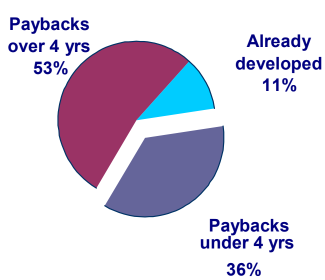
DG Market Growth Dependent on New CHP

With changes in the energy marketplace, concerns over grid reliability and security, and increased interest by some facilities in controlling their own power supplies, a diverse set of DG solutions is emerging. These solutions include: Reciprocating engines and combustion turbines, microturbines, renewables and fuel cells. These solutions can be used in a variety of applications from CHP and backup power, to niche applications such as premium power, peak shaving, and green power.

Much of recent growth in DG sales has been for backup applications. Over time, niche applications, including premium power, peak shaving and green power, may take hold. For now, though, U.S. Department of Energy (DOE) sponsored research by RDC suggests that much of the untapped potential for the DG market is in buildings using CHP.[1] Under current conditions, studies indicate that the market potential for building and industrial CHP applications is about 70 GW. Of this, about 22 GW worth of projects are economically achievable within a four year payback period.



Current CHP Potential 70 GW



Future Market Potential 120 (with improvements in DG Technology)

However, improvements in installed cost and efficiency of DG technologies increases the future market potential of CHP dramatically: it jumps from 70 GW to almost 120 GW, of which 60 GW worth of projects are economically achievable within a four year payback period. These improvements not only expand DG market potential, they also change the make up of the market by increasing turbine's share. Although turbines currently lag behind in the DG technology face off, environmental concerns and resulting emissions controls may help tip the balance in their favor.

As reported in the last issue of the *DG Monitor*, reciprocating engine sales have been strong in recent years, and with base case numbers, recips are expected to continue to dominate, accounting for 52% of market potential while micro and industrial turbines make up 44% of the market. In the future case, with improvements in DG technologies, recips are still strong with about 37% of the market, but micro and industrial turbines grow to 63% of the market potential. The study showed that turbines out-represent recips across all DG size ranges (from 0.3-50 MW) except for the 28-300 kW size range. To meet these expectations, DG technologies across the board must meet target improvements. Also, a number of other barriers to DG market penetration must be lowered. For example, the market must begin to value the *(continued on page 3)*

[1] "Meeting the DER Goal with Turbines." Presentation at the DOE Microturbine and Industrial Gas Turbine Peer Review Meeting. On the web: http://www.eren.doe.gov/der/pdfs/micro_indgas_conf_02/paul_lemar.pdf

IN THIS ISSUE

Resource Dynamics Corporation

To view earlier editions of the DG Monitor or to begin receiving the publication via email please visit: www.distributed-generation.com.

About the DG Monitor The DG Monitor is a bimonthly publication of the Resource Dynamics Corporation covering the many facets of the emerging Distributed Generation marketplace. Articles both report and interpret the most important items. In addition, the Monitor includes special series on DG technologies, applications, manufacturers, and other issues, providing the reader with a complete picture of these topics over several issues.

Comments or requests for additional information can be addressed to DGMonitor@rdcnet.com, through our website at www.distributed-generation.com, or by contacting Jean Connors at 703/356-1300 x 208.

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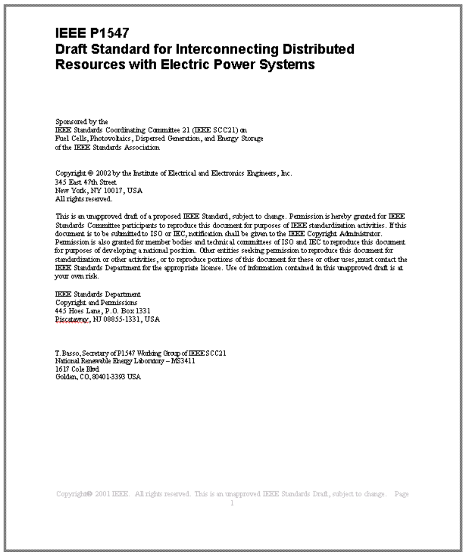
Update on IEEE P1547

The *IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems*, IEEE P1547 documents the mandatory, minimum functional technical requirements that are universally needed to help assure a technically sound interconnection. Included in the development of this standard are industry, utilities and general interest groups and individuals. Over the course of the development, the P1547 Working Group membership has greatly increased in numbers.

The current version of the standard is pre-ballot draft09. At a June 4-7, 2002 Working Group meeting in Vail, Colorado, this draft was presented by the writing group. Details of the standard were discussed to arrive at the consensus point where the group can move forward with an IEEE ballot on P1547 this summer. This consensus building will involve a final draft update by the writing group, incorporating comments and concerns expressed at the June meeting.



IEEE P1547
Draft Standard for Interconnecting Distributed Resources with Electric Power Systems

Sponsored by the
IEEE Standards Coordinating Committee 21 (IEEE SCC21) on
Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage
of the IEEE Standards Association

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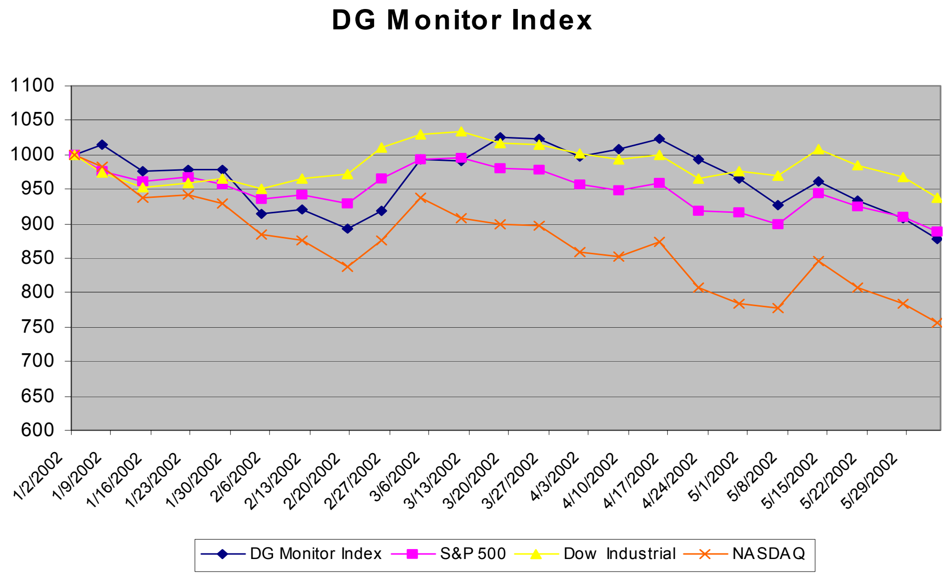
At the June meeting, the overall aspects of the P1547 standard were discussed, as were requirement and specifications, the upcoming ballot, and P1608 Draft Application Guide for IEEE Std. 1547 Standard for Interconnecting Distributed Resources With Electric Power Systems, P1589 Draft Standard For Conformance Test Procedures for Equipment Interconnecting Distributed Resources With Electric Power Systems, and Proposed P1614 Draft Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected With Electric Power Systems. N. Richard Friedman of the Resource Dynamics Corporation is chairing the IEEE P1608 Working Group.

For more information on this standard development process, contact N. Richard Friedman at (703)356-1300, ext 203.

*The DG Monitor Index*SM

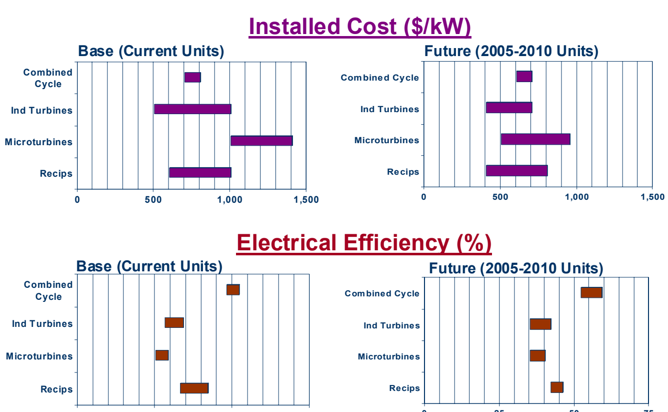
The DG Monitor IndexSM was developed to track the share price of companies involved in the DG marketplace. A group of 15 publicly-traded North America-based stocks was selected that reflect the diversity of the DG sector. The following companies are included in the index:

- Active Power
- American Power Conversion
- Astropower
- Ballard
- Capstone
- Caterpillar
- Cummins
- DTE
- Duke Energy Corp
- Emerson Electric
- PlugPower
- Spire
- United Technologies
- Williams
- Woodward

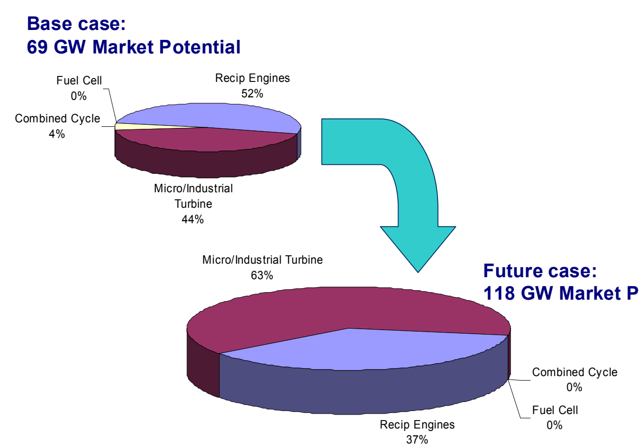


The index is based on the purchase of an equal dollar amount of each stock ($66 2/3) on January 2, 2002, and tracks the cumulative performance of the collection of stocks. Splits and dividends are included in the index. The chart above shows the 2002 performance relative to other stock indexes. So far this year, the index has dropped from 1,000 to 887, reflecting the poor performance of the U.S. stock market. The DG Monitor IndexSM has outperformed the NASDAQ, while underperforming the Dow Industrial. The Index will be included in each issue of the DG Monitor to give an indication of how the investment community feels about the strength of the DG sector. ■

(DG Market, continued from page 1) non-energy benefits of DG. Other barriers, such as the lack of standardized systems, supporting market infrastructures, and of application and integration knowledge must be addressed. In this issue, an update of the status *IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems*, IEEE P1547, which seeks to provide a uniform standard for interconnection of distributed



DG Cost and Performance to Improve Over Time



Improved Unit Cost and Performance Expands Market and Turbine Share

resources with electric power systems, is provided. Development of this standard is one of the many steps necessary for DG to reach its potential. Subsequent articles will drill-down into the results of recent studies, including a look into top applications, size ranges, and regions of the country. ■

DG APPLICATION SERIES: COMBINED HEAT AND POWER (CHP)

Combined heat and power (CHP) is defined as the simultaneous production of electrical power and another form of useful thermal energy from a single fuel-consuming process. CHP, also known as cogeneration, is a highly efficient process with overall efficiencies (electric + thermal) as high as or up to 90 plus percent. Distributed generation cogeneration applications can use reciprocating engines, combustion turbines, or fuel cells as the prime mover. Some large industrial sites also use steam turbines as part of CHP systems. This article will detail the heat recovery options for these prime movers.

Reciprocating Engines

Reciprocating engine CHP systems can be designed to produce steam, hot water (the most common type), or hot air. There are three types of heat recovery options that can produce steam with reciprocating engines. The standard heat recovery option uses liquid-to-water heat exchangers on the water jacket cooling fluid, the lubricating oil system, and sometimes on the aftercoolers and turbocharger. To make steam, an air-to-water heat exchanger is also used on the engine exhaust. With heat recovery from the three liquid-to-water exchangers, water is heated up to 160-180^{o} F. The pre-heated water enters the exhaust gas heat exchanger where it is heated up to 180-200 ^{o}F or is evaporated. The exhaust gas energy is about 50% of the total thermal energy produced. Medium size engines (1-5 MW) usually produce saturated steam of 350-400^{o}F, while large units can deliver superheated steam at 480-600^{o}F. The minimum exhaust gas temperature at the exit of the heat exchanger is 320-340^{o}F for fuels containing sulfur, like diesel oil, or 190-210^{o}F for sulfur-free fuels like natural gas.

Ebullient cooling systems are another way to make steam with reciprocating engines. These systems cool the engines by the circulation of a boiling coolant (usually water) through the engine jacket. The water is then fed through an air-to-water heat exchange using the engine's exhaust. These systems can produce low-pressure steam (usually no more than 250°F and a maximum of 15 psig). In an ebulliently cooled engine, the coolant (e.g. water) enters the engine as a pressurized liquid at its boiling point. The coolant absorbs heat from the engine and some changes phase (evaporates). Heat transfer from the engine to the coolant occurs at a constant temperature, leading to lower thermal stress to the engine. The coolant in the engine, which is a mixture of liquid and vapor, has a lower density than the coolant that enters the engine, so rises to the top of the engine. After exiting the engine, the coolant enters a steam separator, where steam is separated. The mixture can also be sent to an exhaust gas heat exchanger to produce higher quality steam.

A third way to make steam is to use a forced-circulation system. With these systems, the water in the engine jacket operates at higher than usual pressure and temperature, in the range of 250-270 ^{o}F. These systems can produce steam at slightly higher temperatures and pressures than standard systems.

Units designed to make hot water for industrial applications use a system similar to the first steam heat recovery option described above. Water is heated by three liquid-to-water exchangers to 160-180 ^{o}F, and then the water enters the exhaust gas heat exchanger where it is heated up to 180-200 ^{o}F.

Some reciprocating engine systems have cogeneration systems designed to provide heat for drying operations. Products like bricks, ceramics, and animal feed can be dried directly with the engine's exhaust. This is known as "dirty" drying, because of the pollutants in the engine's exhaust. There are also some reciprocating engine CHP systems that use indirect air heating. An air-to-air heat exchanger is used when products, process operations, or the facility environment are potentially compromised by using direct drying/heating systems. These are used for products like food and finish drying and curing systems.

Turbines

Combustion turbine-based CHP systems can be designed to produce steam, hot water, or hot air. Steam systems are the most common type, because of the high quality waste heat available and the high demand for steam in many industries.

Hot exhaust gas from the exhaust of a simple cycle combustion turbine can be used to make steam or hot water by adding a heat recovery steam generator (HRSG). Because of the high quality waste heat available in the exhaust gas, *(continued on page 5)*

(Application Series, continued from page 4)

high-pressure steam suitable for many industrial processes can be generated. The exhaust gas at 1,000-1,050^{o}F is cooled in the HRSG to about 300 ^{o}F to extract heat. A temperature of 300^{o}F is maintained at the outlet of the HRSG to avoid condensation of exhaust gases. At lower temperature levels, gases such as SO_x and NO_x would form acids and combine with water condensation to corrode the HRSG.

The basic heat-to-power ratio of a simple gas turbine cogeneration system is about two. Since a turbine's exhaust gas is also oxygen rich, it can support additional combustion through supplementary firing in the HRSG. Supplementary firing can increase the heat-to-power ratio to about four. An HRSG unit with supplementary firing contains additional burners to increase the heat output and requires additional fuel.

Turbine exhaust can also be used directly for industrial heating and drying operations. It can be used in specially-designed equipment like dryers, kilns, calciners, and ovens. Products like gypsum, plasters, cements, limestone, bricks, glass and mineral wool can be heated or dried using turbine exhaust. As with reciprocating engines, direct use of the exhaust is known as "dirty" drying/heating, because of the pollutants in the exhaust steam (although in some turbine applications like greenhouse heating the pollutant carbon monoxide is desirable, and thus the exhaust is not thought of as "dirty"). An air-to-air heat exchanger can used when products, process operations, or the facility environment are compromised by using direct drying/heating systems.

Fuel Cells

The phosphoric acid fuel cell can be used in two different types of industrial cogeneration applications: to produce hot water at around 140°F, or to produce hot water at around 140°F and low temperature steam at 250°F. Overall efficiency for both is around 87 percent. High temperature solid oxide and molten carbonate fuel cells are projected to produce higher temperature steam.

Cooling and Refrigeration

In some CHP applications, the waste heat is used for cooling or refrigeration. Two technologies that turn waste heat into refrigeration/cooling are described below.

Absorption Chillers. Absorption chillers involve a complex cycle of absorbing heat from the CHP system to create chilled water. The waste heat from the CHP system is used to boil a solution of refrigerant/absorbent, most systems using water and lithium bromide for the working solution. The absorption chiller then captures the refrigerant vapor from the boiling process, and uses the energy in this fluid to chill water after a series of condensing, evaporating, and absorbing steps are performed. This process is essentially that of a thermal compressor, which replaces the electrical compressor in a conventional electric chiller. In doing so, the electrical requirements are significantly reduced, requiring electricity only to drive the pumps that circulate the solution.

Desiccants. Desiccants are used in some heating, ventilating, and air conditioning (HVAC) systems to remove moisture and reduce the cooling load. Desiccant systems incorporate desiccant materials, which absorb moisture from the air. After a period of exposure to humid air, these materials become saturated, and require regeneration if they are to be reused. This regeneration is typically accomplished by exposing the desiccant material to heated air. Desiccant systems typically incorporate a desiccant wheel, which rotates between a stream of ventilating air (from which it removes humidity) and a stream of heated air (which regenerates the desiccant material). By rotating through these two streams of air, the desiccant wheel dehumidifies the ventilating air and rejects the moisture to the heated air stream. Desiccant systems become a part of a CHP system when they use the waste heat from the CHP system to provide regeneration. ■

* This article is based on information from a report Resource Dynamics Corporation is producing for the U.S. Department of Energy entitled: "Cooling, Heating and Power for Industry: A Market Assessment."

Choosing DG Conferences

Most *DG Monitor* readers are invited to multiple DG conferences each year. Conferences can offer an important look into the DG market, both present and future, and in addition provide a forum for discussion across industry sectors. However, there are a great many DG related conferences out there, and it is often difficult to know which will provide you with the information and the contacts you need.

Over the years, we here at RDC have attended, organized, and presented at a great many of the most popular and influential conferences. The list below, which is not comprehensive, show the major DG events. This list will be maintained on our web site (www.distributed-generation.com) and updated periodically. We will also continue to note upcoming conferences in the *Monitor's* Conference section.

Our readers also provide a great resource for Conference information and evaluation. Do you have a comment on a Conference you felt to be particularly helpful? Suggestions for fellow readers looking to learn more about DG? Write us and share your experiences. If the *DG Monitor* gets enough feedback we will summarize your responses in a subsequent article.

Conference	Typical Month	Sponsor	Specialty	Web Address
The Business Case for Cogeneration	June	Center for Business Intelligence	Cogeneration	www.cbinet.com
Distributed Generation Technology Seminar	Ongoing	Basler Electric	Free briefings on DG performance	www.basler.com
DER Workshops	Ongoing	U.S. Department of Energy	Government research projects	www.eren.doe.gov
DR Week (topic varies)	Varies	EPRI	Business strategies	www.epri.com
International Symposium on Distributed Generation: Power System and Market Aspects	October	Royal Institute of Technology, Sweden	European markets	www.distributed-generation.org
Power-Gen Asia	October	PennWell	Asian situation	www.pennwell.com
Annual Distributed Power Conference	November	California Alliance for Distributed Energy Resources and the Distributed Power Coalition of America	Long-standing DG conference sponsored by leading trade associations	www.distributed-generation.com/dpca
Power-Gen International	December	Pennwell	Technology and business strategy	www.pennwell.com
National Energy Service Conference	December	The Association of Energy Service Professionals International	DG installation	www.aesp.org
Distributed Power Conference	February	Intertech Conferences		www.intertechusa.com
Annual Distributed Generation & On-Site Power Conference	March	GESI	Long-standing DG conference	www.dist-gen.com
Distributed Resources Conference and Exhibition	March	EPRI	EPRI's premier DR conference	www.epri.com
On-Site Power Generation	May	Electrical Generating Systems Association	Manufacturing situation	www.egsa.org
Distributed Energy Conference	May	Western Energy Institute	Western U.S.	www.powerin.org
Power-Gen Europe*	June	PennWell	European situation	www.pennwell.com

* Covers larger power generation technologies as well as DG-sized units and projects.

CONFERENCES

IDEA 93rd Annual Conference & Expo (www.districtenergy.org), June 23-25, 2002, Baltimore, MD

IEEE Power Engineering Society Summer Meeting 2002 (www.ieee-spm2002.org), July 21-25, 2002, Chicago, IL

DG NOTES

June 6, 2002 - **Hess Microgen** started-up a 1MW onsite cogeneration system for California brick and tile manufacturers, Pacific Clay Products. The system, which consists of five 200 kW natural-gas fired cogeneration packages operating in parallel with the grid, will produce about 65% of Pacific Clay's electricity needs and provide cogeneration heat to offset existing gas-driven product dryers.

June 5, 2002 - **RealEnergy, Inc.** has 32 onsite energy systems, producing twenty MW of electricity, either operating or under construction in CA. RealEnergy has installed systems for large building owners and real estate portfolio managers and will install systems in three sites for the State of California Department of General Services.

June 4, 2002 - **H Power Corp**. installed a 4.5-kW cogeneration propane fueled fuel cell system in Yellowstone National Park, Wyoming. The installation, which will provide electricity to ticket kiosks and an office and byproduct heat, was made through Fall River Rural Electric Cooperative. Also in May, **H Power** and marketing partner Energy Co-Opportunity, Inc. installed RCUs (4.5-kW PEM fuel cell system powered by propane, designed to provide both electricity and heat for use in homes and small businesses) at Rappahannock Electric Cooperative in Bowling Green, Virginia; Delta-Montrose Electric Association in Montrose, Colorado; Enerstar Power Corporation in Paris, Illinois; and Platte-Clay Electric Cooperative in Kearney, Missouri.

May 22, 2002 - **Global Thermoelectric Inc.** and **Advanced Energy Systems Ltd.** will cooperate in the commercial development of integrated power electronics and control technologies for SOFC systems.

May 21, 2002 - **Ballard Power Systems** introduced its Ecostar(TM) Power Converter, rated at 110 KVA and specifically designed to operate with, and convert power from, a microturbine power source.

May 14, 2002 - **MWH Energy Solutions, Inc**. signed an agreement to distribute **FuelCell Energy's** Direct FuelCell® (DFC) power plants in municipal, utility support, commercial and industrial applications. Initial focus will be on wastewater treatment facilities throughout the U.S. **FuelCell** also expanded their agreement with **Caterpillar** to develop and distribute DFCs for industrial and commercial use, and to incorporate its fuel cell module into Caterpillar generators in the 250-kW to 3-MW size range. The companies will explore the development of a hybrid power system combining Caterpillar's turbine engine technology with FuelCell's products.

May 2, 2002- **Ocean Power Corp** signed an agreement establishing the conditions for sale of 10,000 3-kW Home Power Units with a private real estate management company. The Unit utilizes a Stirling engine and is designed to generate electricity, hot water and HVAC on-site for multi-family apartment complexes.

May, 2002 - Governor John Engler unveiled NextEnergy - an economic development plan to make Michigan a world leader in the research, development, commercialization and manufacture of alternative energy technologies such as hydrogen fuel cells.

RDC DG NEWS

Presentations

"Overview of IEEE P1608." - N. Richard Friedman, at IEEE SCC 21, P1547 WG, Vail, Colorado, June 6, 2002.

Reports

U.S. Department of Energy/National Renewal Energy Laboratories - Distributed Energy Resources Interconnection Systems: Technology Review and Research Needs, June 2002.