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Critical & Clean Power:

7 Reasons Why PureCell® Fuel Cell Systems
Are the Right Choice

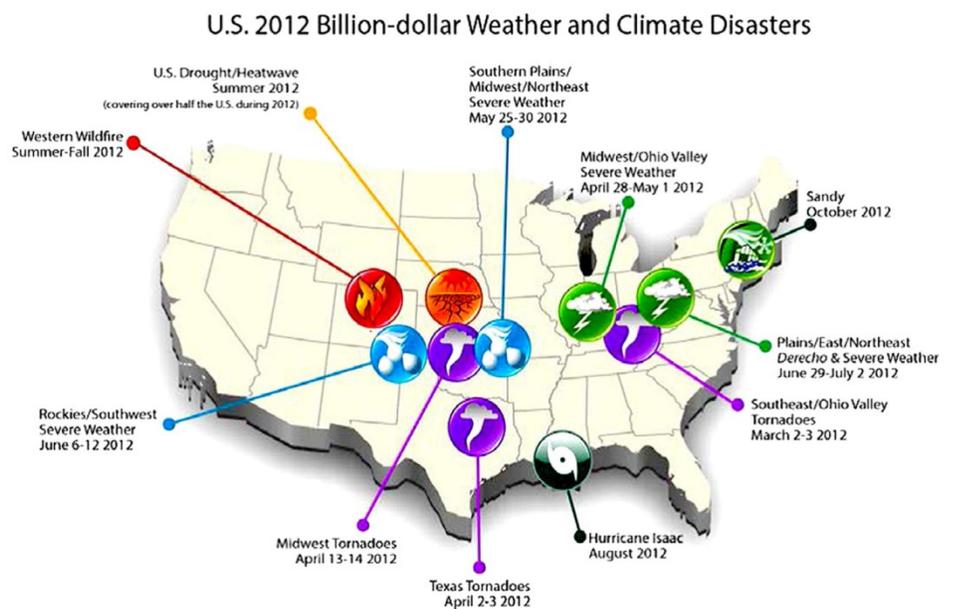
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Vulnerability of Our Electric Grid

The U.S. electric grid – that vast and complex power network so integral to daily life in the 21st century – is increasingly under pressure from high energy demand, aging infrastructure, and, most noticeably, Mother Nature. Natural disasters over the past decade, in the form of severe weather events like Hurricane Katrina in 2005, Hurricane Ike in 2008, Hurricane Irene in 2011, and Superstorm Sandy in 2012 (and many lesser known but equally devastating weather events) have taken their toll. Power outages often are the result of these storms, and the societal and economic consequences can be extraordinary.

Severe weather, in fact, is the leading cause of power outages in the United States, and costs our economy billions of dollars a year in lost output and wages, spoiled inventory, delayed production, inconvenience, and damage to the grid infrastructure, according to a 2013 report from the Department of Energy.¹ That’s not to mention the very real and personal losses within our homes, businesses, and communities—of life itself for some, and of access to critical power needs for heating, refrigeration and cooling for many.

The DOE findings² reveal the extraordinary impact of power outages. Between 2003 and 2012, there were approximately 679 power outages due to weather events. Over this period, almost 34 million Americans were affected, and the American economy lost an inflation-adjusted average of \$18 to 33 billion annually. Other recent reports estimate even greater economic losses due to weather-related outages: \$25 to 70 billion annually by Campbell (2012)³ and approximately \$80 billion per year, not including power quality events, according to the Lawrence Berkeley National Laboratory (LBNL).⁴



¹ “Economic Benefits of Increasing Electric Grid Resilience to Weather Outages.” The White House Council of Economic Advisors and the Department of Energy (DOE), August 2013.

² Ibid.

³ Campbell, Richard J. “Weather-Related Power Outages and Electric System Resiliency.” Congressional Research Service (CRS) Report for Congress, 7-5700, www.crs.gov , R42696. Aug. 28, 2012.

⁴ LaCammare, K.H. and Eto, J.H. “Understanding the Cost of Power Interruptions to U.S. Electricity Consumers.” Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley: University of California, Berkeley, 2004.

Weather statistics for 2011 and 2012 portend that the grid is indeed vulnerable, and add credence to the expectation that the number of power outages will rise, as climate change increases the frequency and intensity of hurricanes, blizzards, floods and other extreme weather events. Last year, the United States experienced 11 “billion-dollar storms” – the second-most for any year on record, behind only 2011 (DOE 2013).

Achieving Energy Security

As utility outages become more prevalent, cities, states, businesses, and industrial facilities across America are realizing that backup power must be part of any resiliency plan. Smart leaders are taking action, proactively integrating both primary and backup systems into their critical power operations.

What is the best solution?

CEOs, CFOs and facility managers who ask more questions, like the ones below, will achieve dramatically better and much more positive results when they consider their options for critical power.

- What if we could have a system that not only provides reliable backup power during electrical outages, but high-quality, continuous power to meet our daily energy and thermal needs?
- What if this system that provides both continuous and critical backup power could also be clean, thereby reducing our organization’s carbon footprint and demonstrating our commitment to reducing greenhouse gas emissions?
- What if this system, providing continuous power + critical backup power + clean power, could improve our bottom line, saving us thousands of dollars every year on our overall energy costs?

The Choice Is Yours:

Diesel Generators versus PureCell® Fuel Cell Systems

There are two viable options for critical backup power: diesel generators or fuel cells.

There is only one viable option for continuous, critical and clean backup power: fuel cells.

Backup Diesel Generators	PureCell® Fuel Cell Systems
High incidence of failed starts.	Reliability. Continuous operation means system is up and running when an emergency occurs.
Critical assets are typically idle.	Productivity. Critical assets used continuously for energy savings.
Diesel storage requires space; regular logistics planning and trucking; environmental risk.	On-Demand Fuel. Highly reliable natural gas supply; no diesel tanks or refueling required.
High GHG footprint. Emissions concern, even for required periodic testing.	Clean Power. Low GHG footprint. Typically exempt from air permitting due to ultra-low emissions.
Loud operation; often requires expensive enclosure.	Quiet Operation. Very low noise emissions during full power operation.
Requires costly, periodic testing (weekly/monthly) by code	Continuous Operation. Eliminates need for periodic testing.
Electricity only.	Comfort. Electricity and heat available during grid outage.

A Decision Maker's Guide

When diesel generators are compared to PureCell® fuel cell systems, there are inherent differences that any decision maker should know about. Here are seven reasons why PureCell® fuel cell systems are a better choice and the best solution for providing continuous, critical and clean power.

1. PureCell® fuel cell systems offer world-class reliability well beyond that of traditional diesel generators.

For many years, diesel backup generators have been a traditional choice for supplying electricity in the case of a grid failure. The problem is that they can be unreliable in an emergency, due to infrequent use and poor maintenance. Arshad Mansoor, senior vice president for Research and Development at the Electric Power Research Institute, an industry-funded research group, estimates the failure rate for backup generators is as high as 15%. Human error, either from poor planning or inadequate testing, plays a major role, he says.

Think about it. With a standby backup generator sitting idle, you don't know if it's in good working order until you try to start it. You may have tested it last month, but is it in good shape now when you need it the most? Unfortunately, in recent severe weather outages, the answer to that question all too often has been "no."

During Superstorm Sandy, there were multiple cases of backup generators that did not function properly. At New York University's Langone Medical Center, more than 300 patients had to be evacuated when flood water shorted out fuel pumps located in the basement, rendering both of the hospital's rooftop generators useless. Shortly after the Langone evacuation, Manhattan's Bellevue Hospital Center followed suit, evacuating 725 patients due to generator failure. In both cases, without power for elevators, many patients had to be carried down stairways. During the Northeast blackout in 2003, half of New York City's 58 hospitals suffered backup generator failures (NY Times, Aug. 16, 2003), and the lack of backup power allowed 145 million gallons of raw sewage to be released from a Manhattan pumping station (Times Union, Sept. 29, 2003).

"It's not an issue with the actual quality of the generators," said Dan Zimmerle, assistant research professor at Colorado State University. "It's maintenance related. For instance, if you don't burn diesel fuel sitting in the tank, it will start to degrade and clog the fuel filters. Things that don't get used tend to fail."

With a PureCell® fuel cell system running continuously and offering you an industry-leading 10-year cell stack life, you will never be in doubt about the reliability of your system. You will know at any given time whether or not your system is operationally ready to provide emergency backup power. You are eliminating unknowns and uncertainty, and you will be ready in an emergency. Data from the NYS Energy and Research Development Administration confirm that combined heat and power (CHP) systems that run every day and save money continuously are more reliable in an emergency than backup generators that only run during emergencies.⁵

⁵ Hampson, A., Bourgeois, T., Dillingham, G., Panzarella, I. "Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities," ORNL/TM-2013/100. Prepared by ICF International for Oak Ridge National Laboratory, Oak Ridge, Tennessee, March 2013.

PureCell® Fuel Cell Systems Met Sandy's Challenge

Superstorm Sandy ravaged the east coast of the United States and Canada at the end of October 2012, causing widespread economic destruction and created power outages lasting between hours and weeks for millions of people. PureCell® fuel cell systems in New York and Connecticut met the challenge, transitioning to grid-independent mode and providing Doosan FC customers with the electricity and the thermal energy they expected. The fuel cells at Price Chopper in Colonie, NY, and Middletown, CT, operated without the grid for 5 and 6 days, respectively. This allowed the supermarket to keep food available, lights on, most registers open, and the hot water system functioning. At Stop & Shop, Torrington, CT, the fuel cell system provided the grocery store with power and heat/cooling while the grid power was intermittent.

2. PureCell® fuel cell systems are productive in day-to-day operations, as opposed to diesel generators that sit “idle” until called upon in an emergency.

Backup generators have only one purpose: to power critical loads when the grid fails. They are expensive pieces of equipment that are designed for use only in an emergency.

Conversely, PureCell® fuel cell systems are complete CHP energy solutions. They run continuously – with or without the grid – delivering clean power and thermal energy every day of the year. PureCell® fuel cells operate at an overall CHP efficiency of 90%, a level of efficiency that surpasses the generating efficiency of central station utility power plants. The PureCell® Model 400 footprint (~ 30 ft long, 8 ft wide and 10 ft high) is modular and compact, making it ideal for a retrofit or facilities upgrade. Moreover, the systems can be combined to create multi-MW capability for a customer, and the byproduct heat can be used to generate chilled water for refrigeration and space cooling.

By using readily available, low-cost natural gas and opting for continuous prime power, as well as reliable critical power, PureCell® fuel cell customers negate the need for nonproductive backup diesel generators. As a direct result, they are able to use facility improvement dollars most effectively to reduce electricity bills, improve energy efficiency, and reduce carbon emissions.

A Doosan Fuel Cell America customer at the Octagon multi-family building on Manhattan's Roosevelt Island understands the efficiency benefits of its PureCell® system very well, and is thrilled with the results. The system, which provides heat and electricity for each of the 500 apartments in the building, has reduced Octagon's energy bills by approximately \$300,000 each year.

3. PureCell® fuel cell systems use highly reliable natural gas, a much cleaner and more easily accessed fuel source than diesel.

Diesel fuel for backup generators takes up valuable space at an end user's location, and requires regular logistics planning for trucking in the fuel. There is also an environmental risk of diesel fuel spills.

Moreover, storage tanks hold a finite amount of fuel, perhaps only enough for a few hours or days, and then they must be refilled. In the case of an emergency or a prolonged power outage, refueling requirements can be a serious problem, as Bellevue Hospital Center in Manhattan found out during Superstorm Sandy. National Guard troops carried fuel up 13 flights of stairs for hours in order to keep rooftop generators running. Even so, the generators eventually failed and forced patient evacuations.

PureCell® fuel cell systems, on the other hand, operate on natural gas—a highly reliable, readily available permanent source of fuel on demand.

Does natural gas provide energy security in the event of electric grid failures? The U.S. Department of Defense (DoD) wanted to know just that, as it considers the use of natural gas energy production on military installations. In a recent study for DoD, Massachusetts Institute of Technology Lincoln Laboratory assessed the reliability of the natural gas supply system during power outages, and found that there is minimal risk of interrupted deliveries for a moderate outage of two weeks to three months.⁶ The report is reassuring, saying that “if natural gas is available as a resource at a particular site, it will provide energy security because of its separate distribution pathway.” The report also references how the natural gas supply secured many end users in New York after Superstorm Sandy.⁷

4. PureCell® fuel cell systems provide clean power with ultralow emissions, as opposed to the negative environmental consequences of diesel-fired backup generators.

Air pollution and its associated health and environmental risks are a real and present danger to our planet. Today, most of us agree that greenhouse gas (GHG) emissions are major pollutants and a leading cause of climate change around the world, affecting air quality, weather patterns, sea level, ecosystems and agriculture.

PureCell® fuel cell systems offer both clean and critical power. They have a low GHG footprint and typically are exempt from air permitting regulations due to their ultralow emissions. They use natural gas, which is an inherently cleaner burning fuel that is ubiquitous in the US and can be produced domestically.⁸

Backup diesel generators, unlike PureCell® fuel cell systems, have a high GHG footprint. With diesel as the fuel source, there is no getting around it. Additionally, emissions from diesel exhaust contain high levels of well-known air pollutants that are known to negatively impact human health, the environment and global climate. These emissions include particulate matter (soot), nitrogen oxides (NO_x), which contribute to the production of ground-level ozone (smog), and sulfur dioxides (SO_x), which cause acid rain.

⁶ Judson, N. “Interdependence of the Electricity Generation System and the Natural Gas System and the Implications for Energy Security,” Technical Report 1173. Lincoln Laboratory, Massachusetts Institute of Technology, May 2013.

⁷ Revkin, A. “How Natural Gas Kept Some Spots Bright and Warm as Sandy Blasted New York City.” The New York Times, Nov. 5, 2012, New York: The New York Times Company.

⁸ <http://www.epa.gov/cleandiesel/technologies/fuels.htm>

The National Ambient Air Quality Standards (NAAQS) adopted by the U.S. Environmental Protection Agency (EPA) offer us protection against unsafe levels of air pollutants. States such as California, New York, and Texas have adopted even more rigorous regulations to reduce diesel exhaust emissions, and many other states also are beginning to adopt more stringent particulate matter and NO_x standards. Consider this assessment from the South Coast Air Quality Management District (SCAQMD): Emissions of nitrogen oxides (NO_x) from diesel-fired emergency engines are 200 to 600 times greater, per unit of electricity produced, than new or controlled existing central power plants fired on natural gas. Diesel-fired engines also produce significantly greater amounts of fine particulates and toxics emissions compared to natural gas fired equipment. Engines operated on fuels other than diesel, such as natural gas, ethanol, propane, or with dual fuels (diesel only for initial start-up and then primarily natural gas), are much cleaner and produce significantly less air pollution for the same amount of energy produced.⁹

In California, an emergency backup generator is only allowed to operate for 200 hours every year and only in the event of an emergency power failure or for routine testing and maintenance.¹⁰ At the Santa Rosa jail, the backup diesel generators are not permitted by air quality regulations to operate when utility power is available.¹¹ New York is following suit, with a proposed amendment to its environmental conservation law that will restrict the operation of diesel-powered electrical generation systems in areas of the state that already have severely compromised air quality. The amendment states “diesel generators are so dirty that the promotion of their use to meet the peak electric demands during summer, when air pollution is at its worse, is very unwise public policy.”¹²

5. PureCell® fuel cell systems are quiet and can be installed almost anywhere.

Fuel cells have few moving parts, a feature that allows them to operate with very low noise levels. Because of this, PureCell® systems can be installed almost anywhere (e.g., inside or outside, close to people, buildings and footpaths), often with no additional noise containment.

Contrast this to backup diesel generators, which are inherently noisy due to the high pressures and combustion process taking place inside the engine. As a result, diesel generators often are subject to site restrictions and must be installed outside to counteract the noise pollution, or they must be housed in specially designed enclosures for sound suppression.

9 South Coast Air Quality Management District (SCAQMD) is the air pollution control agency for all of Orange County and the urban portions of Los Angeles, Riverside and San Bernardino counties, the smoggiest region of the U.S. http://www.aqmd.gov/permit/fact_sheet_emergency_backup_gen.htm

10 Ibid.

11 Alegria, E., Brown, T., Minear, E., Lasseter, R.H. “CERTS Microgrid Demonstration with Large-Scale Energy Storage and Renewable Generation.” Submitted to IEEE Transactions on Smart Grids, 2013.

12 http://assembly.state.ny.us/leg/?default_fld=&bn=A00625&Summary=Y&Actions=Y&Text=Y&Votes=Y

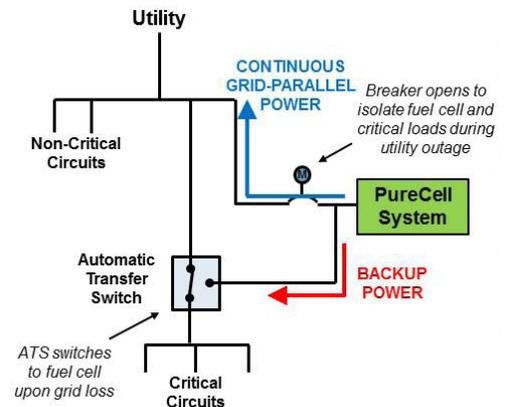
6. PureCell® fuel cell systems do not require costly, nonvalueadded periodic testing.

The continuous operation of PureCell® fuel cell systems eliminates the need for periodic testing to ensure emergency readiness and compliance with air pollution standards. In contrast, backup diesel generators require periodic testing that can be costly and complicated. For example, in Quincy, Washington, six well-known companies (Microsoft, Dell, Yahoo, Intuit, Sabey, and Vantage) operate large data centers and use large banks of diesel generators to provide critical backup power when the grid goes down. With so many diesel generators clustered in Quincy, Microsoft is coordinating testing schedules with the other data centers to keep emissions as low as possible. In addition, in a 2012 ruling, Microsoft’s permit for additional new diesel generators, although upheld, was amended to include a provision that Microsoft must inform administrators in the nearby elementary school when it tests the generators.¹³

Interestingly, in September 2012, Microsoft, citing diesel generators as “inefficient and costly to operate,” announced plans to explore “alternative backup energy options that would allow us to provide emergency power without the need for diesel generators, which in some cases will mean transitioning to cleaner-burning natural gas and in other cases, eliminating the need for back-up generation altogether.”¹⁴ Fuel cells and CHP projects are among the sustainable solutions mentioned by Microsoft.

7. PureCell® fuel cell systems provide electricity and comfort during a grid outage; backup generators only provide electricity.

PureCell® fuel cell systems are a highly efficient CHP distributed energy solution. In the case of a power outage, the fuel cell will keep critical facilities running without any interruption of service. Envision it. Your system is already up and running 24/7, functioning properly, and providing power and thermal energy (for heat, refrigeration, cooling) to meet your critical loads. Right now, it’s in grid-connect mode operating in parallel with the grid. Then, all of a sudden, the power goes out, and unperceivably, your system switches to grid-independent mode and continues to provide you with the power and energy you need. You will have not only lights, but heat, refrigeration and cooling for your critical loads.



Doosan FC has many satisfied customers who have experienced the benefits of their PureCell® fuel cell CHP systems during an emergency (refer to the Reliability section earlier in this paper for more details). The most recent examples are Price Chopper and Stop & Shop, two supermarket chains that were able to stay open during the aftermath of Superstorm Sandy.

¹³ Microsoft Columbia Data Center Expansion Project, Air Quality Program, Department of Ecology, State of Washington, December 2010.
¹⁴ <http://www.globalfoundationservices.com/posts/2012/september/12/microsofts-energy-and-efficiency-evolution-to-power-the-cloud.aspx>

PureCell® Fuel Cell Systems Advantage

The highly efficient PureCell® Model 400 system is a stationary phosphoric acid fuel cell (PAFC) power system intended for distributed generation and CHP applications. The Model 400 system is capable of producing ultra-clean, reliable electric power (400 kW continuously for 10 years), in addition to over 1.5 MMBtu/h of thermal energy for space heating, hot water applications, and cooling.

PureCell® systems' distinct advantages over backup diesel generators for critical power applications have already been discussed in this paper. Beyond those advantages, PureCell® fuel cell systems have an industry-leading 10-year cell stack life that assures our customers of high availability and low service cost.

Read on to see how several Doosan FC customers are realizing the PureCell® fuel cell advantage.

Saint Francis Hospital

Hospitals are an especially strong fit for fuel cells due to the nature of their 24/7 energy-intensive operations. At Saint Francis Hospital and Medical Center in Hartford, CT, two 400-kW PureCell® systems are satisfying 10% of the main campus’ electricity needs and 40% at its Mount Sinai campus—and the thermal energy from the fuel cells is being harnessed to serve heating loads at both locations.

“With fuel cells on each campus, it allows for a reliable power source on site . . . in addition, the high efficiency of the power plants is a way to save energy while promoting a healthy environment,” said Robert J. Falaguerra, vice president, Facilities, Support Services and Construction at Saint Francis.

Saint Francis Hospital	Emissions Reduction	Equivalent “Green” Benefit
CO ₂ Emissions	537 MT †	Planting 124 acres of trees
NO _x Emissions	1.26 MT	Taking 72 cars off the road
Water Saved *	1.4 MG †	Saving enough water to fill ~2.2 Olympic pools



* The PureCell® system operates in water balance, so there is no consumption or discharge of water during its operation.

† MT = million tons; MG = million gallons

Beacon Capital Office Building/ Fox News Headquarters, NYC

Beacon Capital Partners installed a PureCell® fuel cell system at its flagship Manhattan property. The building’s major tenant, Fox News, is benefiting from the installation, which is providing 20% of the building’s electricity and 50% of the building’s hot water for heating and bathroom sinks and showers. In times of emergency and for public use, the fuel cell system also is configured to provide backup power to a first-floor café and an arcade for shelter, as well as to an outdoor Fox News ticker for news updates and public service announcements.

Al Scaramelli, senior VP at Beacon, said “We weren’t interested in a token project. We wanted to do something that was significant in terms of sustainability and efficiency. The PureCell® Model 400 system at 1211 Avenue of the Americas in New York City accomplishes both, offering a strong example of how major urban office buildings can economically reduce carbon emissions through leading-edge technology. It was a win-win for us.”

Beacon Office Building	Emissions Reduction	Equivalent “Green” Benefit
CO ₂ Emissions	600 MT	Planting 138 acres of trees
NO _x Emissions	1.31 MT	Taking 75 cars off the road
Water Saved	1.4 MG	Saving enough water to fill 2.2 Olympic pools



Price Chopper, Colonie, NY

Price Chopper’s 69,000-ft² concept store and pharmacy in Colonie, NY, is meeting approximately 60% of its energy needs with a PureCell® Model 400 fuel cell system. Fuel cell heat recovery is providing the store with heat and hot water year-round, as well as helping to cool the store’s refrigerated cases in the summer. The system proved its grid-independent capability during Superstorm Sandy in 2012, when the PureCell® system kept food safe and the store open for 5 days while the grid was intermittently available.

Neil Golub, president and CEO, Price Chopper, said “We set out to design and build a store that would be world-class and would demonstrate our leadership and concern for the environment and energy efficiency. We are doing everything possible to make this store an example of how businesses should operate.” Price Chopper’s commitment was recognized by the U.S. EPA with the Colonie store receiving the highest Green-Chill gold-level certification ever achieved by a supermarket retailer.

Price Chopper Supermarket	Emissions Reduction	Equivalent “Green” Benefit
CO ₂ Emissions	518 MT	Planting 120 acres of trees
NO _x Emissions	1.02MT	Taking 67 cars off the road
Water Saved	1.2 MG	Saving enough water to fill 1.9 Olympic pools



Conclusions

PureCell® Model 400 fuel cell systems are complete energy solutions. They operate with and without the grid, providing not only critical and clean backup power when the grid fails, but continuous power to meet our customers' electric and thermal energy needs every day of the year.

PureCell® fuel cell systems offer distinct advantages over traditional diesel-fired backup generators:

1. **Reliability.** Our fleet has proven reliability, with over 11 million hours of operational experience at installations in 19 countries on six continents. Our fuel cells run continuously and, thus, are always operationally ready to handle an emergency.
2. **Productivity.** Our fuel cells are critical assets that are productive in day-to-day operations, offering our customers superior efficiency (up to 90%) that saves both energy and dollars.
3. **On-Demand Natural Gas.** Our fuel cells operate on natural gas, a highly reliable, readily available permanent source of fuel on demand.
4. **Clean Power.** Our fuel cells provide clean power with ultralow emissions. They have a low GHG footprint and give you an advantage toward achieving your energy responsibility goals.
5. **Quiet Operation.** Our fuel cells are quiet. No special enclosures for sound suppression are required, so they offer our customers great siting flexibility, inside or outside.
6. **Continuous Operation.** Our fuel cells run continuously and do not require costly, non-value-added testing for emergency readiness and compliance with air quality standards.
7. **Comfort.** Our fuel cells provide electricity and comfort when the grid fails. Because of the CHP application, our customers not only will have lights, but heat available to them to generate hot water, space heating, or cooling.

About Doosan Fuel Cell

Doosan Fuel Cell America, Inc. (Doosan FC) is a subsidiary of Doosan Corporation, a South Korea-based industrial company founded in 1896 with current operations in 38 countries. Doosan FC, headquartered in South Windsor, Conn., designs, engineers and manufactures stationary fuel cells for commercial and industrial applications. Formed in July 2014 following Doosan Corporation's acquisition of ClearEdge Power (formerly UTC Power), Doosan FC is the U.S. arm of the Doosan Fuel Cell Business Group and focuses on 400-kilowatt phosphoric acid fuel cells capable of supplying combined heat and power to building and utility systems. With its growing team, and focus on innovation and technology leadership, Doosan FC's stated vision is to be the global leader in the fuel cell industry.

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