

TECOGEN INC.
Form 10-K
March 29, 2019

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, DC 20549
FORM 10-K

ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934
For the fiscal year ended December 31, 2018

or
 TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934

Commission file number 001-36103

TECOGEN INC.

(Exact name of Registrant as specified in its charter)

Delaware

04-3536131

(State or Other Jurisdiction of Incorporation or Organization) (IRS Employer Identification No.)

45 First Avenue

Waltham, Massachusetts 02451

(Address of Principal Executive Offices) (Zip Code)

Registrant's Telephone Number, Including Area Code: (781) 466-6400

Securities registered pursuant to Section 12(b) of the Exchange Act:

Title of each class	Name of each exchange on which registered
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Common Stock, \$.001 par value	NASDAQ Capital Market
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Securities registered pursuant to Section 12(g) of the Exchange Act:

None

Indicate by check mark if the registrant is a well-known seasoned issuer, as defined in Rule 405 of the Securities Act. Yes No

Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 or Section 15(d) of the Act. Yes No

Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days. Yes No

Indicate by check mark whether the registrant has submitted electronically every Interactive Data File required to be submitted pursuant to Rule 405 of Regulation S-T (§232.405 of this chapter) during the preceding 12 months (or for such shorter period that the registrant was required to submit such files). Yes No

Indicate by check mark if disclosure of delinquent filers pursuant to Item 405 of Regulation S-K is not contained herein, and will not be contained, to the best of the registrant's knowledge, in definitive proxy or information statements incorporated by reference in Part III of this Form 10-K or an amendment to this Form 10-K.

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, a smaller reporting company or an emerging growth company. See the definitions of "large accelerated filer", "accelerated filer", "smaller reporting company" and "emerging growth company" in Rule 12b-2 of the Exchange Act. Large accelerated filer Accelerated filer Non-accelerated filer Smaller reporting company

Emerging growth company

If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act.

Indicate by check mark whether the registrant is a shell company (as defined in Rule 12b-2 of the Act). Yes No

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As of June 30, 2018, the last day of the registrant's most recently completed second fiscal quarter, the aggregate market value of the voting and non-voting common equity held by non-affiliates was: \$65,946,973. Solely for purposes of this disclosure, shares of common stock held by executive officers and directors of the registrant as of such date have been excluded because such persons may be deemed to be affiliates. This determination of executive officers and directors as affiliates is not necessarily a conclusive determination for any other purposes.

As of March 28, 2019, 24,829,746 shares of common stock, \$.001 par value per share, of the registrant were issued and outstanding.

DOCUMENTS INCORPORATED BY REFERENCE

Certain information required for Part III of this Annual Report on Form 10-K is incorporated by reference from the Tecogen Inc. definitive proxy statement for its 2019 Annual Meeting of Stockholders, which shall be filed with the Securities and Exchange Commission pursuant to Regulation 14A of the Securities Exchange Act of 1934, as amended, within 120 days following the registrant's fiscal year ended December 31, 2018.

CAUTIONARY NOTE CONCERNING FORWARD-LOOKING STATEMENTS

THIS ANNUAL REPORT ON FORM 10-K CONTAINS FORWARD-LOOKING STATEMENTS WITHIN THE MEANING OF THE PRIVATE SECURITIES LITIGATION REFORM ACT OF 1995 AND OTHER FEDERAL SECURITIES LAWS. THESE FORWARD-LOOKING STATEMENTS ARE BASED ON OUR PRESENT INTENT, BELIEFS OR EXPECTATIONS, AND ARE NOT GUARANTEED TO OCCUR AND MAY NOT OCCUR. ACTUAL RESULTS MAY DIFFER MATERIALLY FROM THOSE CONTAINED IN OR IMPLIED BY OUR FORWARD-LOOKING STATEMENTS AS A RESULT OF VARIOUS FACTORS.

WE GENERALLY IDENTIFY FORWARD-LOOKING STATEMENTS BY TERMINOLOGY SUCH AS “MAY,” “WILL,” “SHOULD,” “EXPECTS,” “PLANS,” “ANTICIPATES,” “COULD,” “INTENDS,” “TARGET,” “PROJECTS,” “CONTEMPLATES,” “BELIEVES,” “ESTIMATES,” “PREDICTS,” “POTENTIAL” OR “CONTINUE” OR THE NEGATIVE OF THESE TERMS OR OTHER SIMILAR WORDS. THESE STATEMENTS ARE ONLY PREDICTIONS. THE OUTCOME OF THE EVENTS DESCRIBED IN THESE FORWARD-LOOKING STATEMENTS IS SUBJECT TO KNOWN AND UNKNOWN RISKS, UNCERTAINTIES AND OTHER FACTORS THAT MAY CAUSE US, OUR CUSTOMERS’ OR OUR INDUSTRY’S ACTUAL RESULTS, LEVELS OF ACTIVITY, PERFORMANCE OR ACHIEVEMENTS EXPRESSED OR IMPLIED BY THESE FORWARD-LOOKING STATEMENTS TO DIFFER. THIS REPORT ALSO CONTAINS MARKET DATA RELATED TO OUR BUSINESS AND INDUSTRY. THIS MARKET DATA INCLUDES PROJECTIONS THAT ARE BASED ON A NUMBER OF ASSUMPTIONS. IF THESE ASSUMPTIONS TURN OUT TO BE INCORRECT, ACTUAL RESULTS MAY DIFFER FROM THE PROJECTIONS BASED ON THESE ASSUMPTIONS. AS A RESULT, OUR MARKETS MAY NOT GROW AT THE RATES PROJECTED BY THIS DATA, OR AT ALL. THE FAILURE OF THESE MARKETS TO GROW AT THESE PROJECTED RATES MAY HAVE A MATERIAL ADVERSE EFFECT ON OUR BUSINESS, RESULTS OF OPERATIONS, FINANCIAL CONDITION AND THE MARKET PRICE OF OUR COMMON STOCK. SEE “ITEM 1A. RISK FACTORS,” “ITEM 7. MANAGEMENT’S DISCUSSION AND ANALYSIS OF FINANCIAL CONDITION AND RESULTS OF OPERATIONS” AND “ITEM 1. BUSINESS,” AS WELL AS OTHER SECTIONS IN THIS REPORT, THAT DISCUSS SOME OF THE FACTORS THAT COULD CONTRIBUTE TO THESE DIFFERENCES. THE FORWARD-LOOKING STATEMENTS MADE IN THIS ANNUAL REPORT ON FORM 10-K RELATE ONLY TO EVENTS AS OF THE DATE OF WHICH THE STATEMENTS ARE MADE. EXCEPT AS REQUIRED BY LAW, WE UNDERTAKE NO OBLIGATION TO UPDATE OR RELEASE ANY FORWARD-LOOKING STATEMENTS AS A RESULT OF NEW INFORMATION, FUTURE EVENTS OR OTHERWISE.

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Item 1. Business

The Company

Tecogen Inc. ("Tecogen,") was incorporated in the State of Delaware on September 15, 2000. Tecogen designs, manufactures, markets, and maintains high efficiency, ultra-clean cogeneration products including natural gas engine-driven combined heat and power, air conditioning systems, and water heaters for residential, commercial, recreational and industrial use. Tecogen is known for cost efficient, environmentally friendly and reliable products for distributed power generation that, through patented technology, nearly eliminate criteria pollutants and significantly reduce a customer's carbon footprint.

Tecogen has two wholly-owned subsidiaries, namely, American DG Energy, Inc. ("ADGE"), a Delaware corporation formed in July 2001 and acquired by Tecogen in May 2017 pursuant to the Merger described below, and TTcogen LLC, a Delaware limited liability company that became a wholly-owned subsidiary of Tecogen in March 2018 when Tecogen acquired the remaining membership interests in TTcogen that Tecogen did not previously own. ADGE also owns 51% of American DG New York, LLC ("ADGNY"), a joint venture. Both ADGE and ADGNY distribute, own, and operate clean, on-site energy systems that produce electricity, hot water, heat and cooling. ADGE's business model is to own the equipment that it installs at customers' facilities and to sell the energy produced by these systems to the customer on a long-term contractual basis. Tecogen is also developing ultra-low emissions technologies using its patented Ultera® technology for the automotive market. See "Our Products - Ultera Low-Emissions Technology" below for a more in depth discussion of the Ultera emissions opportunity. Tecogen, together with its wholly-owned consolidated subsidiaries, is hereinafter referred to as the "Company," "Tecogen," "we," "our," or "us."

The Company's operations are comprised of two business segments. Our Products and Services segment designs, manufactures and sells industrial and commercial cogeneration systems as described above. Our Energy Production segment sells energy in the form of electricity, heat, hot water and cooling to our customers under long-term sales agreements.

On May 18, 2017, holders of approximately 71% of the ADGE's outstanding common stock approved the proposed acquisition of ADGE (the "Merger") and holders of approximately 55% of the outstanding stock of Tecogen approved the issuance of Tecogen shares in the Merger. Consequently, on that day Tecogen completed its acquisition, by means of a stock-for-stock merger, of 100% of the outstanding common shares of ADGE. As a result, ADGE became a wholly-owned subsidiary of Tecogen. See Note 4 - Acquisition of American DG Energy, Inc. of the Notes to the Consolidated Financial Statements for further information and Item 3. Legal Proceedings for information regarding litigation related to the Merger.

In May 2016, Tecogen entered into a joint venture agreement, (the "JV Agreement") with Tedom a.s., a European combined heat and power product manufacturer incorporated in the Czech Republic ("Tedom") and Tedom's subsidiary, Tedom USA, Inc., a Delaware corporation. Pursuant to the JV Agreement, the parties formed TTcogen LLC, a Delaware limited liability company ("TTcogen"). TTcogen offered Tedom's line of Combined Heat and Power ("CHP") products to the United States via Tecogen's nationwide sales and service network. On March 27, 2018, the Company acquired Tedom's 50% interest in TTcogen LLC, and will continue to market, sell, and service the Tedom 35kW CHP equipment on an exclusive basis in certain territories.

On October 28, 2017, all the shareholders of the joint venture company organized by the Company and a group of European strategic investors, Ultra Emissions Technologies, Ltd. ("Ultratek"), including the Company, unanimously voted to terminate the joint venture. Ultratek was organized to develop and commercialize Tecogen's patented technology, Ultera®, for the automotive market. Upon termination of the joint venture, Ultratek was dissolved and the exclusive license for the use of Ultera that was granted to Ultratek automatically reverted back to the Company. The Company received its full \$2,000,000 investment in Ultratek upon the completion of the dissolution process. Upon dissolution, the Company purchased all of the remaining assets of Ultratek, including new intellectual property that Ultratek developed and other assets, for a total purchase price of \$400,000. The Company continues to develop the Ultera technology.

On May 4, 2018, the Company, and its wholly-owned subsidiaries, ADGE and TTcogen LLC (collectively, the "Borrowers"), entered into a Credit Agreement with Webster Business Credit Corporation (the "Lender") that matures in May 2021 and provides Borrowers a line of credit of up to \$10 million on a revolving and secured basis, with availability based on certain accounts receivables, raw materials, and finished goods.

On December 14, 2018, the Company and ADGE entered into agreements relating to the sale of two energy purchase agreements and related energy production systems for \$2 million and on March 5, 2019 entered into agreements relating to the sale of six energy purchase agreements and related energy production systems for \$5 million. In connection with the sale, the Company entered into agreements to provide billing and asset management services and operations and maintenance services for agreed fees for the duration of the energy purchase agreements, pursuant to which the Company guarantees certain minimum collections and is entitled to receive fifty percent of the excess of collections over agreed minimum thresholds.

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Business Overview

Tecogen designs, manufactures, markets, and maintains high efficiency, ultra-clean cogeneration products including natural gas engine-driven combined heat and power, air conditioning systems, and water heaters for residential, commercial, recreational and industrial use. The company is known for cost efficient, environmentally friendly and reliable products for distributed power generation that, through patented technology, nearly eliminate criteria pollutants and significantly reduce a customer's carbon footprint.

Tecogen's natural gas-powered cogeneration systems (also known as combined heat and power or "CHP") are efficient because they drive electric generators or compressors, which reduce the amount of electricity purchased from the utility while recovering the engine's waste heat for water heating, space heating, and/or air conditioning at the customer's building.

Tecogen manufactures three types of CHP products:

- Cogeneration units that supply electricity and hot water;
- Chillers that provide air-conditioning and hot water marketed under the TECOCHILE® brand name; and
- High-efficiency water heaters marketed under the Ilio® brand name.

All of these are standardized, modular, CHP products that reduce energy costs, carbon emissions, and dependence on the electric grid. Tecogen's products allow customers to produce power on-site in parallel with the electric grid or stand alone when no utility grid is available via inverter-based black-start capability. Because our CHP systems also produce clean, usable heat energy, they provide economic advantages to customers who can benefit from the use of hot water, chilled water, air conditioning and heating.

Following the acquisition of ADGE in May 2017, the Company also sells energy in the form of electricity, heat, hot water and cooling to customers under long-term energy sales agreements (with a standard term of 10 to 15 years). The typical sales model is to install and own energy systems in customers' buildings and sell the energy produced by those systems back to the customers at a cost set by a negotiated formula in customer contracts. We call this our "On-Site Utility" business, or our Energy Production segment.

Traditional customers for our cogeneration and chiller systems include hospitals and nursing homes, schools and universities, health clubs and spas, hotels and motels, office and retail buildings, food and beverage processors, multi-unit residential buildings, laundries, ice rinks, swimming pools, factories, municipal buildings, indoor agriculture, and military installations; however, the economic feasibility of using our systems is not limited to these customer types. Market drivers include the price of natural gas, local electricity rates, environmental regulations, and governmental energy policies, as well as customers' desire to become more environmentally responsible.

Through our factory service centers in California, Connecticut, Florida, Massachusetts, Michigan, New Jersey, and New York our specialized technical staff maintains our products via long-term service contracts. To date the Company has shipped over 3,000 units, some of which have been operating for almost 35 years.

Our CHP technology uses low-cost, mass-produced engines, which we modify to run on natural gas. In the case of our mainstay cogeneration and chiller products, the engines have proven to be cost-effective and reliable. In 2009, in response to the changing regulatory requirements for stationary engines, our research team developed an economically feasible process for removing air pollutants from the engine exhaust. This technology's U.S. and foreign patents were granted beginning in October 2013 with other domestic and foreign patents granted or applications pending. Branded Ultera®, the ultra-clean emissions technology repositions our engine driven products in the marketplace, making them comparable environmentally with other technologies such as fuel cells, but at a much lower cost and greater efficiency. Because of this breakthrough design for emission control, multiple Tecogen natural gas-fueled CHP modules fitted with the patented Ultera control technology have been permitted to the current regulatory limits in the Los Angeles area. In 2018, a group of natural gas engine-generators upfitted with the Ultera system were successfully permitted in the same Los Angeles region to unrestricted operation, the first natural gas engines to do so without operating time limits or other exemption. These engines were permitted to levels matching the California Air Resources Board ("CARB") stringent 2007 emissions requirements, the same emissions standard used to certify fuel cells, and the same emissions levels as a state-of-the-art central power plant. We now offer our Ultera emissions control technology as an option on all our products or as a stand-alone application for the retrofitting of other

rich-burn spark-ignited reciprocating internal combustion engines such as the aforementioned engine-generators. Tecogen products are designed as compact modular units that are intended to be installed in multiples when utilized in larger CHP plants. The majority of our CHP modules are installed in multi-unit sites with applications ranging up to 12 units. This approach has significant advantages over utilizing single larger units, allowing building placement in constrained urban settings and redundancy to mitigate service outages. Redundancy is particularly relevant in regions where the electric utility has formulated tariff structures that include high “peak demand” charges. Such tariffs are common in many areas of the country, and are applied by such utilities as Southern California Edison, Pacific Gas and Electric, Consolidated Edison of New York, and National Grid of Massachusetts. Because these tariffs are assessed based on customers’ peak monthly demand

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charge over a very short interval, typically only 15 minutes, a brief service outage for a system comprised of a single unit can create a high demand charge, and therefore be highly detrimental to the monthly savings of the system. For multiple unit sites, the likelihood of a full system outage that would result in a high demand charge is dramatically reduced, so consequently, these customers have a greater probability of capturing peak demand savings.

Our CHP products are sold directly to customers by our in-house marketing team, and by established sales agents and representatives.

ADGE installs, owns, operates and maintains complete distributed generation, or DG systems (or energy systems), and other complementary systems at customer sites, and sells electricity, hot water, heat and cooling energy under long-term contracts at prices guaranteed to the customer to be below conventional utility rates. As of December 31, 2018 we had 81 operational energy systems, representing an aggregate of approximately 5,035 kilowatts, or kW, 39.0 million British thermal units, or MMBtu's, of heat and hot water and 4,660 tons of cooling (kW is a measure of electricity generated, MMBtu is a measure of heat generated and a ton is a measure of cooling generated).

The Company's operations are comprised of two business segments. Our Products and Services segment designs, manufactures and sells industrial and commercial cogeneration systems as described above. Our Energy Production segment sells energy in the form of electricity, heat, hot water and cooling to our customers under long-term sales agreements.

Products and Services

Our Products and Services segment represented 82.2% and 88.5% of our consolidated revenues for the years ended December 31, 2018 and 2017, respectively. See Note 16. "Segments" of the Notes to the Consolidated Financial Statements. Our products and services are described below.

Our Products

We manufacture natural gas engine-driven cogeneration systems, heat pumps, and chillers, all of which are CHP products that deliver more than one form of energy. Our cogeneration products are all standard, modular units that come pre-packaged from the Company's factory for ease of installation at a customer's site. The package incorporates the engine, generator, heat-recovery equipment, system controls, electrical switchgear, emission controls, and a data controller for remote monitoring and data transmission; minimizing the cost and complexity of installing the equipment at a site. This packaged, modular system simplifies CHP technology for small to mid-sized customers who typically are less experienced with the implementation and benefits of a CHP system.

Traditionally all of our cogeneration systems and most of our chillers have utilized the same engine, the TecoDrive 7400 model. This is an engine modified by us to use natural gas fuel. In 2017, we introduced a new, slightly larger engine into certain products with advanced features, including improved efficiency and an advanced ignition system. The CHP products utilizing the new engine are the InVerde e+® and the TecoPower models CM-60 and CM-75. The new engine and the older TecoDrive model share custom features that enhance durability and efficiency, many of which date from our extensive research done previously with engine manufacturers and the gas industry, including the Gas Research Institute. For the Ilios water heater, we introduced a technologically advanced Ford engine that is enhanced for industrial applications.

Our commercial product lines include:

- the InVerde e+® and TecoPower cogeneration units;
- TECOCHILL® air-conditioning and refrigeration chillers;
- Ilios® high-efficiency water heaters; and
- Ultera® emissions control technology.

InVerde Cogeneration Units

Our premier cogeneration product has been the InVerde, a 100-kW CHP system that not only provides electricity and hot water, but also satisfies the growing customer demand for operation during a utility outage, commonly referred to as "black-start" capability. Our exclusively licensed microgrid technology (see "Intellectual Property" below) enables our InVerde CHP products to provide backup power in the event of power outages that may be experienced by local, regional, or national grids. In 2017 we introduced an extensively redesigned version of the unit, the InVerde e+, which includes a state of the art power conversion system, more effective acoustic treatment, and the larger, more efficient

engine. The InVerde e+ includes variations with power ratings from 75kW to 125kW.

The InVerde e+ incorporates an inverter, which converts direct current, or DC, electricity to alternating current, or AC. With an inverter, the engine and generator can run at variable speeds, which maximizes efficiency at varying loads. The inverter then converts the generator's variable output to the constant-frequency power required by customers in 50 or 60 Hertz.

This inverter technology was developed originally for solar and wind power generation. The Company believes that the InVerde is the first commercial engine-based CHP system to use an inverter. Electric utilities accept inverter technology as

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“safe” by virtue of its certification to the Underwriters Laboratory interconnection standard 1741. Our InVerde has earned this certification which qualifies our product for a much simpler permitting process nationwide and is mandatory in some areas such as New York City and California, a feature we consider to be a competitive advantage. The inverter also improves the CHP system’s efficiency at partial load, when less heat and power are needed by the customer.

In 2018 the InVerde e+ was certified to the more technically advanced UL 1741SA. The “SA” or “smart inverter” certification is for those incorporating more advanced safety features and operating modes which can help support the grid on demand when strained. Upcoming SA requirements will require additional certification primarily involving standard communication protocols which will be available to the utility when enlisting grid support. We believe future utility programs which involve command and control of smart inverter assets on their grid will be an important change in how distributed generation is valued by utilities and may offer additional revenue to our customers.

The InVerde’s black-start feature addresses a crucial demand from commercial and institutional customers who are increasingly concerned about utility grid blackouts and brownouts, natural disasters, security threats, and antiquated utility infrastructure. Multiple InVerde units can operate collectively as a stand-alone microgrid, which is a group of interconnected loads served by one or more power sources. The InVerde is equipped with software that allows a cluster of units to seamlessly share the microgrid load without complex controls; a proprietary cost advantage for multiple modules at a single location.

The InVerde CHP system was developed in 2007 and began shipping in 2008. Our largest InVerde installation utilizes 12 units, which supply 1.2 MW of on-site power and about 8.5 million Btu/hr of heat (700,000 Btu/hr per unit).

TECOGEN Cogeneration Units

The TECOGEN cogeneration system is the original model introduced in the 1980s; available in sizes of 60 kW and 75 kW and capable of producing up to 500,000 Btu/hr of hot water. This technology is based on a conventional single-speed generator. It is meant only for grid-connected operation and is not universally accepted by utilities for interconnection, in contrast to the InVerde. Although this cogeneration product has the longest legacy and largest installed population, much of its production volume has been supplanted by the InVerde and its broader array of product features. In 2017 the Company introduced an upgraded version of the 60kW and 75kW models under the new name TecoPower. The key features of the TecoPower models are the larger engine with improved efficiency, advanced ignition system, more effective acoustic aftertreatment, and the ability to operate even at the very low gas supply pressures in New York City with a pressure booster.

TECOCHILL Chillers

Our TECOCHILL natural gas engine-driven chillers are available in capacities ranging from 25 to 400 tons, with the smaller units air-cooled and the larger ones water-cooled. Using technology first developed in 1987, the engine drives a compressor that makes chilled water, while the engine’s free waste heat can be recovered to satisfy the building’s needs for heat or hot water. This process is sometimes referred to as “mechanical” cogeneration, as it generates no electrical power, and the equipment does not have to be connected to the utility grid.

A gas-fueled chiller provides enough air conditioning to avoid most of the utility’s seasonal peak charges for electric usage and capacity. In summer when electric rates are at their highest, natural gas is “off-peak” and quite affordable, allowing TECOCHILL® customers to avoid typically higher summer-time “peak-usage” electric rates. Gas-fueled chillers also free up the building’s existing electrical capacity to use for other loads and can operate on minimal electric load in case of electric grid blackout; a key feature for customers concerned about load demand on backup power generators.

Ilios High-Efficiency Water Heaters

Tecogen has developed several heat pumps under the Ilios brand name including a High Efficiency (“HE”) Air-Source Water Heater, HE Water-Sourced Water Heater, and HE Air-Sourced “Split System” Water Heater. Our water heater products operate like an electric heat pump but use a natural gas engine instead of an electric motor to power the system. The Ilios® high-efficiency water heater uses a heat pump, which captures warmth from outdoor air even if it is moderately cool outside. Heat pumps work somewhat like a refrigerator, but in reverse. Refrigerators extract heat from inside the refrigerator and move it outside the refrigerator while heat pumps extract heat from outside and move

it indoors.

The gas engine's waste heat is recovered and used in the process, unlike its electric counterpart, which runs on power that has already lost its waste heat. This means that the heat being captured from outdoors is supplemented by the engine's waste heat, which increases the efficiency of the process. The net effect is that an Ilio® heat pump's efficiency far surpasses that of conventional boilers for water heating. Gas engine heat pumps can deliver efficiencies in excess of 200%.

Similarly, if used for space heating, the engine-powered heat pump is more efficient than an electric heat pump, again because heat is recovered and used for other building processes. The product's higher efficiency translates directly to lower fuel consumption and, for heavy use customers, significantly lowers operating costs when compared with conventional equipment.

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In 2013, a water-sourced model of the heat pump was added to our product line. This heat pump captures heat from a water source such as a geothermal well or from a pre-existing chilled water loop in the facility; the latter configuration provides simultaneous heating and cooling benefits, doubling the effect.

Following on the success of the water-sourced model, in early 2015 a 'split system' Ilios® model was introduced. The new split system offers increased flexibility because its air-source evaporator package can be installed remotely. The engine driven heat pump, which is contained in a small acoustic enclosure, can be located within a building's mechanical space while the quiet air-source evaporator package can be installed on a roof, or in any outdoor space. The outdoor evaporator component is connected to the indoor heat pump via refrigerant lines, therefore eliminating all freeze protection issues in colder climates. All of the water being heated remains inside the conditioned space, eliminating the need for a costly isolation heat exchanger and additional pumps, which simplifies installation and increases efficiency because it can operate at a lower delivery temperature.

The heat pump water heater serves as a boiler, producing hot water for drinking and washing, space heating, swimming pools, or other building loads. Energy cost savings to the customer depend on the climate. Heat pumps in general, whether gas or electric, perform best in moderate weather conditions although the performance of the Ilios® water-source heat pump is not impacted by weather or climate conditions. In a typical building, the Ilios® heat pump would be added on to an existing heating or water heating system, and would operate as many hours as possible. The conventional boiler would be left in place, but would serve mainly as a backup when the heat pump's engine is down for maintenance or when the heat pump cannot meet the building's peak heating load. In areas where low electric rates make CHP less economical, the Ilios® heat pump could be a financially attractive alternative because its economics depend only on natural gas rates. In some areas with high electric rates, the Ilios® option could have advantages over CHP; for example where it is hard to connect to the utility grid or where the building's need for electricity is too low for CHP to be economically sound.

Ultra Low-Emissions Technology

All of our CHP products are available with the patented Ultra® low-emissions technology as an equipment option. This breakthrough technology was developed in 2009 and 2010 as part of a research effort partially funded by the California Energy Commission and Southern California Gas Company. The objective was to bring our natural-gas engines into compliance with California's stringent air quality standards.

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The chart below compares emission levels of the Company's Ultera® technology to other technologies. As of December 31, 2018 our Ultera® CHP and fuel cell technologies are the only technologies that we know of which comply with California's air quality standards for CO and NOx, represented in the chart by the colored horizontal lines, shown as the world's strictest air quality standards on the lower right of the chart.

(5) (2) (4) (4) (3) (1)

- (1) California has the strictest air quality standards for engines in the world
- (2) Conventional Energy Source is U.S. powerplant and gas boiler. Average U.S. powerplant NOx emission rate of 0.9461 lb/MWh from (USEPA eGrid 2012), CO data not available. Gas boiler efficiency of 78% (www.eia.gov) with emissions of 20 ppm NOx @ 3% O₂ (California Regulation SCAQMD Rule 1146.2 and <50 ppmv CO @ 3% O₂ (California Regulation SCAQMD BACT).
- (3) Tecogen emissions based upon actual third party source test data.
- (4) Microturbine and Fuel Cell emissions from EPA CHP Partnership - Catalog of CHP Technologies- March 2015.
- (5) Stationary Engine BACT as defined by SCAQMD.

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Through development of a two-stage catalyst emission treatment system, the Company was able to meet or exceed the strict air quality regulations with a solution that is cost-effective, robust, and reliable. Inclusion of the patent-protected Ultera® low-emissions technology as an option keeps our CHP systems compliant with air quality regulations. The first commercial CHP units equipped with Ultera low-emissions technology shipped to a California utility in 2011.

We conducted three validation programs for this technology:

1. Third-party laboratory verification. The AVL California Technology Center, a long-standing research and technology partner with the international automotive industry, confirmed our results in their state-of-the-art dynamometer test cell, which was outfitted with sophisticated emissions measurement equipment.

2. Verifying longevity and reliability in the field. By equipping one of our 75 kW units, already operating at a customer location in Southern California with the Ultera® low-emissions technology and a device to continuously monitor emissions we verified longevity and reliability. The Ultera low-emissions system operated successfully for more than 25,000 hours, approximately 3.5 years, and consistently complied with California's stringent emission standards over the entire field testing period.

3. Additional independent tests. During the field test, two companies licensed in California to test emissions each verified our results at different times. The results from one of these tests, obtained in August 2011, enabled us to qualify for New Jersey's fast-track permitting. Virtually every state nationwide requires some kind of permit related to local air quality, but New Jersey allows an exemption for systems such as ours that demonstrate superior emissions performance. This certification was granted in November 2011, and since then we have sold Ultera® low-emissions systems to customers in this territory.

In 2012, a 75 kW CHP unit equipped with the Ultera® system became our first unit to obtain a conditional air permit (i.e., pending a third party source test to verify compliance) in Southern California since the strict regulations went into effect in 2009. A state-certified source test, administered in January 2013, verified that our emissions levels were well below the new permitting requirements, and the final permit was approved in August 2013.

Standby Generators

After successfully developing the Ultera technology for our own equipment, the Company's research & development team began exploring other possible emissions control applications in an effort to expand the market for the ultra-clean emissions system. Retrofit kits were developed in 2014 for other stationary engines and in 2015 the Ultera Retrofit Kit was applied successfully to natural gas stand-by generators from other manufacturers, including Generac and Caterpillar.

Historically, standby generators have not been subjected to the strict air quality emissions standards of traditional power generation. However, generators which run for more than 200 hours per year or run for non-emergency purposes (other than routine scheduled maintenance) in some territories are subject to compliance with the same stringent regulations applied to a typical electric utility. As demand response programs become more economically attractive and air quality regulations continue to become more stringent, there could be strong demand for retrofitting standby generators with our Ultera® emissions control technology, thus providing a cost-effective solution to keeping the installed base of standby generators operational and in compliance.

In 2017, a group of generators owned by a single customer in Southern California were supplied Ultera kits because of their particular requirement to exceed the 200-hour annual limit. These units are now operational and have been tested by the customer and shown to be compliant with the local pollution limits which we believe to be the strictest anywhere in the United States, and potentially the world. Our CHP products have been permitted to this same standard. However, CHP products are given a heat credit which effectively increases the allowable limit. In 2018 permitting was completed making these certification levels the lowest we have achieved. We believe no other engines have been certified to these levels since the latest regulations in the Los Angeles region became effective ten years ago.

Biogas

The Ultera® emissions control technology developed by our engineering team applies specifically to rich-burn, spark-ignited, internal combustion engines. While originally intended for natural gas-powered engines, we believe that our technology may be adapted for other fuel types as long as the engine meets the rich-burn criteria.

In 2015 the Ultra system was applied to a biogas powered engine operating at the Eastern Municipal Water District's (EMWD) Moreno Valley Region Water Reclamation Facility in Perris, California. The demonstration project was a result of an ongoing collaboration between Tecogen, the EMWD and various other partners, and successfully applied an Ultra Retrofit Kit to a 50-liter Caterpillar engine fueled by biogas extracted from an anaerobic digester. Biogas is a significant byproduct of wastewater treatment plants. Considered to be a renewable source of fuel, it is becoming an increasingly important resource for power generation. According to the American Biogas Council, nationwide

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there are over 1,100 engines fueled by wastewater-derived biogas, over 600 fueled by landfill-generated biogas, and over 100 running on biogas from agricultural waste. This represents a significant potential market for the Ultera Retrofit Kit application as these biogas engines become subject to the same air quality standards as traditional power generation sources.

Automotive Emissions Control

In October 2015, following revelations of wide-scale problems with vehicle emissions compliance and testing, Tecogen formed an Emissions Advisory Committee to examine the potential application of Ultera to the automotive gasoline market. According to the U.S. EPA, 50 percent of nitrogen oxides (NOx) and 60 percent of all carbon monoxide (CO) emissions in the United States come from vehicle exhaust. The Ultera® emission control system is designed to target both NOx and CO. After a thorough investigative process on the part of the Emissions Advisory Committee and various industry expert consultants, the group recommended that the Company pursue a funded initiative to develop the technology for gasoline vehicles.

In December 2015, the Company and a group of strategic investors formed a joint venture company, Ultra Emissions Technologies, Ltd. ("Ultratek"), to advance the Ultera near-zero emissions technology for adaptation to transportation applications powered by spark-ignited rich-burn engines in the automobile and truck categories. Tecogen granted Ultratek an exclusive license for the development of its patented, emissions-related, intellectual property for the vehicle market.

Initially Ultratek's focus was on preliminary research, testing, and verification that the Ultera technology can in fact be applied to gasoline engines while maintaining similar near-zero emission results as have been demonstrated in other use cases. Having completed multiple phases of testing at AVL's California Technology Center, the Ultratek team verified the viability of the Ultera technology for gasoline automotive use.

On October 24, 2017, the Company and the group of strategic investors agreed to dissolve Ultratek due to varying opinions regarding next steps toward potential commercialization. Upon dissolution, the remaining cash was disbursed in accordance with the joint venture agreement, first to the Company which was entitled to receive its cash investment of \$2,000,000, with the remainder, on a pro rata basis, to the strategic investors. Additionally, the license the Company originally granted to Ultratek reverted back to the Company, and the Company purchased all of the remaining Ultratek assets and intellectual property that Ultratek had created for a total purchase price of \$400,000.

On November 28, 2017 Tecogen formed Ultera Technologies, Inc., a Delaware corporation, as a wholly owned subsidiary, to continue the effort toward commercialization that was begun by Ultratek. Ultera Technologies Inc. was dissolved in 2018 and Tecogen will continue the research and development relating to prototypes for commercialization. If successfully developed, the market for automotive emissions control could be a source of future growth for the Company; although it could take years to realize that goal, and there is no guarantee that such efforts will be successful.

Fork-Truck Research

In October 2016, the Company was awarded a Propane Education & Research Council (PERC) research grant funding the Company's proposal to develop the Ultera ultra-clean emissions control technology for the propane powered fork truck market.

Electric fork trucks have been making significant in-roads in the fork truck industry, in part, because of their green image and indoor air quality benefit. The primary benefit of the Ultera-equipped ultra-clean propane fork truck will be fuel cell like emissions and a propane-green brand that offers a robust indoor air quality advantage without compromising vehicle performance. The project will assess the adaption of the Ultera near-zero emissions technology for the fork truck category and demonstrate the technical performance on popular propane fork truck models. In 2018, the PERC funded portion of the project concluded successfully and our manufacturer that participated in the project, providing technical and marketing support and supplying a test truck, reviewed the results and decided to move forward with the program. The manufacturer was named in 2018 as Mitsubishi Caterpillar Forklift America (MCFA), a major supplier in North and South America. The program is currently focused on testing modified engine control firmware being prepared by MCFA in Japan for optimizing the Ultera process on the test fork truck.

Management believes that approximately 70,000 propane powered fork trucks are sold annually in the United States. Successful completion of this project could open a new emissions control market to the Company.

Other Ultera Applications

According to a 2013 Massachusetts Institute of Technology study, the U.S. experiences 200,000 early deaths each year due to emissions from heavy industry, transportation, and commercial and residential heating. As climate change and air quality continue to develop as areas of focus for government regulators, emissions restrictions are expected to become increasingly stringent around the world. These tightening regulations could open up new markets and applications for the Ultera near-zero emissions control technology. These opportunities may include:

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commercial and industrial natural gas fueled engines from other manufacturers; and
natural gas and biogas powered vehicle fleets - such as municipal bus fleets

Product Service

We provide long-term maintenance contracts, parts sales, and turnkey installation through a network of ten well-established field service centers in California, the Midwest, the Northeast and now the Southeast. These centers are staffed by full-time Company technicians, working from local leased facilities. The facilities provide offices and warehouse space for inventory. We encourage our customers to provide internet connections to our units so that we may maintain remote communications with the installed equipment. For connected installations, the machines are contacted daily to download their status and provide regular operational reports (daily, monthly, and quarterly) to our service managers. This communication link is used to support the diagnostic efforts of our service staff, and to send messages to preprogrammed phones if a unit has experienced an unscheduled shutdown. In many cases, communications received by service technicians from connected devices allow for proactive maintenance, minimizing equipment downtime and improving operating efficiency for the customer.

The work of our service managers, supervisors, and technicians focuses on our products. Because we manufacture our own equipment, our service technicians bring hands-on experience and competence to their jobs. They are trained at our corporate headquarters and primary manufacturing facility in Waltham, Massachusetts.

Most of our service revenue is in the form of annual service contracts, which are typically of an all-inclusive “bumper-to-bumper” type, with billing amounts proportional to the equipment's achieved operating hours for the period. Customers are thus invoiced in level, predictable amounts without unforeseen add-ons for such items as unscheduled repairs or engine replacements. We strive to maintain these contracts for many years, and work to maintain the integrity and performance of our equipment.

Our products have a long history of reliable operation. Since 1995, we have had a remote monitoring system in place that connects to hundreds of units daily and reports their “availability,” which is the amount of time a unit is running or is ready to run. More than 80% of the units operate above 90% availability, with the average being 93.8%. Our factory service agreements have directly impacted these positive results and represent an important long-term annuity-like stream of revenue for the Company.

New equipment sold beginning in 2016 and select upgrades to the existing installed equipment fleet includes an industrial internet solution which enables Tecogen to collect, analyze, and manage valuable asset data continuously and in real-time. This provides the service team with improved insight into the functionality of our installed CHP fleet. Specifically, it enables the service department to perform remote monitoring and diagnostics and to view system results in real time via a computer, smart phone or tablet. Consequently, we can better utilize monitoring data ensuring customers are capturing maximum possible savings and efficiencies from their installation. Through constant monitoring and analysis of equipment data, Tecogen expects to enhance the performance of installed equipment by ensuring machinery consistently operates at peak performance and is available to deliver maximum potential value for customers. In 2018 we migrated our cloud based system from the General Electric's Company's Equipment Insight product to our system developed in-house which we have trade named CHP Insight®. CHP insight stores operating data on the cloud like the GE system but we have added improved user interface features specific to CHP operation as well as sophisticated data analysis tools. Management believes that similar monitoring solutions are available from other alternative sources.

Energy Production

Our Energy Production segment represented 17.8% and 11.5% of our consolidated revenues for the years ended December 31, 2018 and 2017, respectively. See Note 16. "Segments" of the Notes to the Consolidated Financial Statements. Our on-site utility business is described below.

On-Site Utility

Our wholly-owned subsidiary, ADGE, distributes, owns and operates clean, on-site energy systems that produce electricity, hot water, heat, and cooling. Our business model is to own the equipment that ADGE installs at customers' facilities and to sell the energy produced by these systems to customers on a long-term contractual basis. We call this business the “On-Site Utility” and offer natural gas powered cogeneration systems that are reliable and energy efficient.

ADGE utilizes energy equipment supplied by Tecogen and other cogeneration manufactures. Our cogeneration systems produce electricity from an internal combustion engine driving a generator, while the heat from the engine and exhaust is recovered and typically used to produce heat and hot water for use on-site. ADGE also distributes and operates water chiller systems for building cooling applications that operate in a similar manner, except that the engines in the water chiller systems drive a large air-conditioning compressor while recovering heat for hot water.