Environmental Benefits of "ZEROS" CO_2-Free Electricity

The domestic (and global) utility industry is undergoing a major transformation. Affordability, reliability, multiple fuel sources, reduction of greenhouse gas emissions, and cyber-security are key areas of change. Given recent natural disasters of heretofore unseen damage, resiliency has been added to that list.

Increased deployment of utility-scale energy generation, digitization, electrification of transportation, wide-scale distributed energy resources, and reduction of environmental impacts are mega-trends reshaping the industry. The result is a power grid that is becoming increasingly clean, sustainable, secure, more intelligent, mobile and distributed. The transformation is already altering the old notion of the traditional utility from a regulated entity to one that is an ENERGY INNOVATIONS PROVIDER. This is the opportunity presented by The Zero-emission Energy Recycling Oxidation System (ZEROS).

ZEROS is the ultimate "green" technology.

- **ZEROS profitably produces base-load electricity from all classes of coal, other fossil fuels, biofuels, and organic/hydrocarbon wastes.**
- **ZEROS emits *NO* greenhouse gases or other (direct or fugitive) air or water emissions and generates valuable CO_2 credits.**

What kinds of emissions do coal-fired power plants generate?

According to USDOE (Environment Baseline, Volume 1: Greenhouse Gas Emissions from the U.S. Power Sector, June 2016) "the power sector has historically been, and continues to be, the largest source of GHG emissions in the United States . . . CO_2 from coal combustion accounted for over 75 percent of U.S. power sector GHG emissions."

In the U.S. in 2014, electricity generated from coal produced 1,570.4 million metric tons CO_2 equivalent (MMT CO_{2e}). In comparison electricity generated from biomass produced 25.9 MMT CO_{2e}, and electricity from waste produced 9.4 MMT CO_{2e}.

According to the International Energy Agency (Workshop on IEA High Efficiency, Low Emissions Coal Technology Roadmap, November 2011), the best available technology for coal-fired power plants produces air emissions of 960.6 kg CO_2 / MWh, 0.16 – 0.42 kg NO_x / MWh, 0.6 – 0.8 kg SO_2 / MWh, and 0.16 – 0.42 kg particulate matter (PM) / MWh of electricity generated.

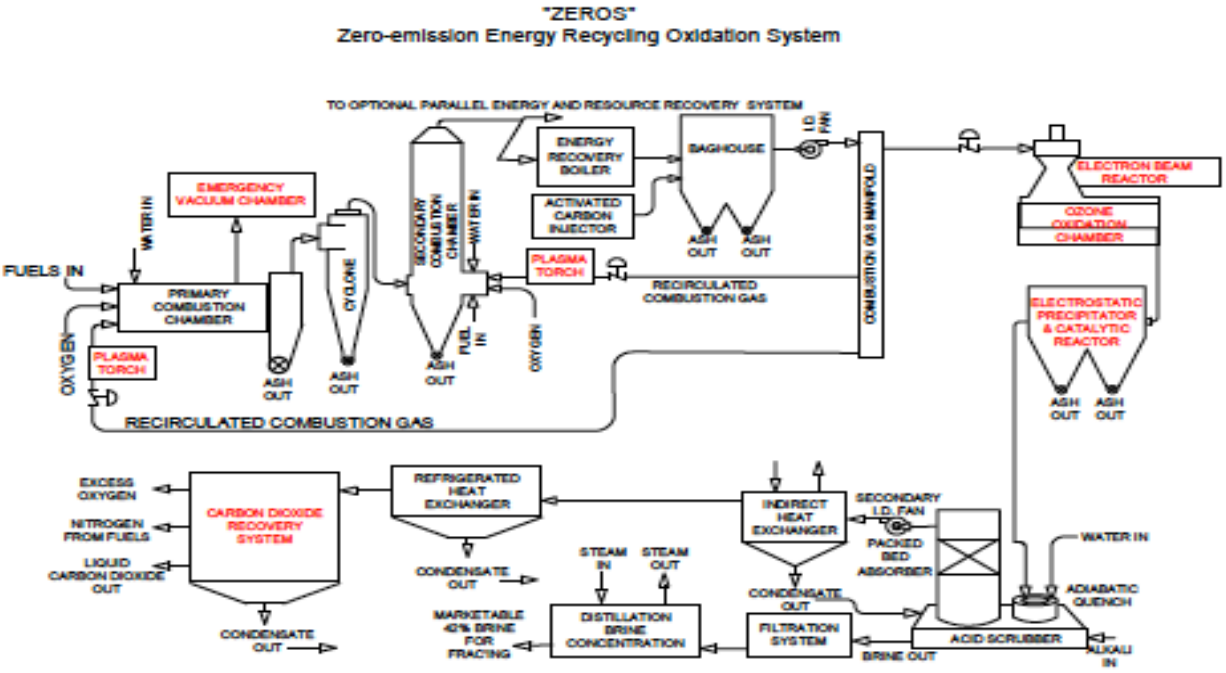
Why is ZEROS so "GREEN?"

- **ZEROS can be powered by any grade of coal or lignite, as well as almost any hydrocarbon or organic waste material.**
- **ZEROS generates base-load electricity with *NO* CO_2 or other air or water emissions.**
- **ZEROS can produce for sale large amounts of pure CO_2, distilled water (from waste water), argon, nitrogen, and oxygen gases, ash, and oxides of nitrogen, sulfur, mercury, and other potential contaminants.**
- **ZEROS also destroys asbestos, dioxins, and other toxic wastes and generates commercially valuable carbon dioxide and clean energy credits.**
- **ZEROS produces more electricity per unit of fuel than traditional coal-fired power plants.**

How is a ZEROS power plant different from a typical coal-fired power plant?

- **Virtually all coal-fired power plants (as well as biomass and waste-to-energy plants) use ambient air to "gasify" and "incinerate" their fuel. Ambient air contains almost 80 percent nitrogen gas (N_2), which greatly decreases the efficiency of fuel combustion, is oxidized to NO_x (which is emitted to the air), and makes sequestration of CO_2 very difficult and costly.**
  - **Coal-fired power plants emit most of the carbon they consume as carbon dioxide. In addition, they emit substantial amounts of NO_x and SO_2, and they are the largest source of anthropogenic mercury emissions in the USA.**
  - **Coal-fired power plants are typically designed to use a very specific type and grade of fuel; they are unable to operate efficiently with other types of fuel.**

- **In contrast, ZEROS uses pure oxygen (O_2) to oxidize its fuel. This "oxy-fuel" process greatly increases the efficiency of combustion, virtually eliminates the production of NO_x, and permits efficient sequestration of CO_2, as well as contaminants such as SO_2 and particulate matter.**
  - **ZEROS power plants emit *NO* carbon dioxide, particulates, mercury, NOx, or SO_2. As a result, ZEROS plants can be operated without impacting air quality. In fact, ZEROS facilities generate valuable CO_2 credits.**
  - **The ZEROS oxy-fuel process and equipment are capable of using a wide variety of fuel types and qualities, increasing the system's resilience and sustainability in the event of changing fuel availability and costs.**



How does ZEROS do it?

- **ZEROS uses pure oxygen ("Oxy-fuel" combustion) rather than ambient air in a two-stage process to oxidize its fuel. The oxygen used by ZEROS can be generated on site or purchased. If produced on site with an oxygen separation unit, the facility can also produce pure argon, nitrogen, and oxygen for sale.**
- **Fuel (coal, lignite, and/or hydrocarbon/organic waste) is injected into and gasified in a first stage oxidizer (a sealed rotary kiln), using a small amount of pure oxygen to produce a synthesis gas.**
- **Ash within the synthesis gas is separated with a cyclone for sale. Ash remaining within the rotary kiln is separated with an "ash drag" for sale.**
- **The synthesis gas then passes to the second stage oxidizer where additional pure oxygen and water are added to produce a gas consisting primarily of CO_2, and high-temperature steam.**
- **Because virtually no nitrogen gas enters either oxidation chamber, no NO_x and much less flue gas are produced than in a typical power plant, making condensation and separation of H_2O, CO_2, particulates and other contaminants (for disposal and/or sale) much easier. In fact, ZEROS has *NO* smoke stack, and generates *NO* direct or fugitive air emissions.**
- **The gas leaving the second stage oxidizer passes through an energy recovery boiler that produces high temperature steam. This steam is used to flash-distill waste water for sale, then drive a steam turbine to generate electricity. Steam can also be sold directly to nearby industries.**
- **The gas that exits the energy recovery boiler passes into a bag house where activated carbon is added to capture remaining organic contaminants for sale.**
- **Part of the gas leaving the baghouse, consisting primarily of CO_2 and water vapor, is recirculated to the first and second stage oxidizers to control the rates of oxidation within them.**
- **The remaining gas leaving the baghouse is scrubbed of heavy metals (Pb, Hg, etc.) and trace amounts of acid gases (HCl, HNO_3, H_2SO_4, etc.) by using an electron beam reactor, an electrostatic precipitator, and an acid scrubber to remove them from the gas phase for sale or disposal.**
- **Because all particulates, acid gases, and other pollutants are scrubbed from the flue gas and captured for sale, no air or water pollutants are released into the environment.**
- **The remaining scrubbed gas, consisting almost entirely of CO_2 and water vapor is then cooled to condense and remove the water (for sale as distilled water). The CO_2 that remains can be sold as gas (via CO_2 pipelines), liquid carbonics, dry ice, or supercritical CO_2 via existing markets and transportation systems.**
- ***NO* solids, liquids, or gases are emitted to the atmosphere or to waste waters.**

One more time, what does ZEROS do?

- **ZEROS generates base-load electricity using coal, lignite, municipal/industrial solid and liquid waste, and/or other hydrocarbons as fuel.**

- **ZEROS produces electricity, CO_2, nitrogen, argon, and distilled water for sale.**
- **ZEROS generates commercially valuable CO_2 credits.**
- **ZEROS produces *NO* greenhouse gases, air emissions, or water emissions.**
- **ZEROS facilities are very profitable.**

Pro-Forma Financial Summary of the ZEST-TX, LLC Project

Capital Cost	**$650, 619,306**
Power Production (MWh/yr)	**1,036,800**
Wholesale Power Price (/MWh)	**$120.00**
Power Sales (/ yr)	**$124,416,000**
By-Product Revenue (CO2, Nitrogen, Argon, Ash) (/ yr)	**$89,940,000**
Total Annual Sales (/ yr)	**$214,356,000**
Equity	**$649,619,306**
Financing (Loan to Value, %)	**100.00**
Interest Rate (%)	**4.00**
Term (years)	**20**
DSCR Initial	**2,578.73**
DSCR Average	**2,902.82**
Tax Rate - Ten Year MACRS (%)	**18**
Benefit / Cost Ratio	**2.54**
Discount Rate (%)	**6.00**
Per Year After-Tax Return on Capital (%)	**22.50**
Per Year After-Tax Equity IRR (%)	**22.50**

ZEROS is a patented "oxy-fuel" system that addresses the major trends and changes in the utility industry It is clean (has no air or water emissions), climate-friendly (emits no CO2), sustainable and resilient (has fuel flexibility), and distributable (can be scaled to large- or small-scale fuel sources and energy demands). It can stand alone or be integrated into existing power plants, is affordable and profitable, and can be built to be cyber-secure.

The utility industry is the backbone of America's economy. Transportation, water, emergency services, manufacturing and national security are only a few of the industry's downstream dependencies. There are new factors and circumstances that can affect this backbone, the electrical grid. ZEROS addresses these factors and circumstances and is a positive DISRUPTOR for the benefit of the critical American grid system.