ZEROS (Zero-emission Energy Recycling Oxidation System)

A Case Study

What Is ZEROS?

- Innovative “Oxy-Fuel” technology - uses pure oxygen to gasify then oxidize a variety of organic/hydrocarbon fuels.
- Produces heat to drive steam turbine/ electricity generator
- Produces “synthesis gas” and modified, carbon-recycling Fischer-Tropsch reaction to produce diesel or jet fuel

What Is ZEROS?

- Produces pure oxygen needed for oxidation using a standard air separation unit
- Electricity and steam produced by system used to cool, condense and sequester all carbon dioxide, water, and acid gases produced by oxidation
- Fuels can include municipal solid waste, industrial waste, wood waste, scrap tires, sewage sludge, animal manure, agricultural and forestry biomass

Can Use Various Fuels

- Municipal Solid Waste
  - 250 million tons of Municipal Solid Waste generated each year in the US
  - 11,000 MW/h and 6.2 billion gallons of synthetic diesel could be produced by 340 ZEROS plants
- Biomass
  - DOE estimates that biomass could supply 30% of our petroleum needs.
- Coal and Lignite

History

- Invented in 1990s by Mr. Steve Clark of Oilwell Control Services
- Initial application – remediating oil-contaminated soil with zero air or water emissions
- Other applications – remediating contamination by oxidizing diverse hazardous organic wastes in several states
- Four transportable ZEROS waste remediation facilities developed and used in USA during 1990s

History

- Ceased operation in 2000 due to health issues
- Began developing ZEROS waste-to-energy applications after 2003
- Ten patents issued to Mr. Clark from 1996-2011
- Several ZEROS waste-to-energy projects now under development in USA, but no ZEROS plants in operation in 2011

Major Components

- Air separation unit (to produce oxygen, nitrogen, and argon)
- Primary combustion chamber (rotary kiln) for gasification
- Secondary combustion chamber for complete oxidation
- Heat exchanger, steam turbine, electrical generator

Major Components

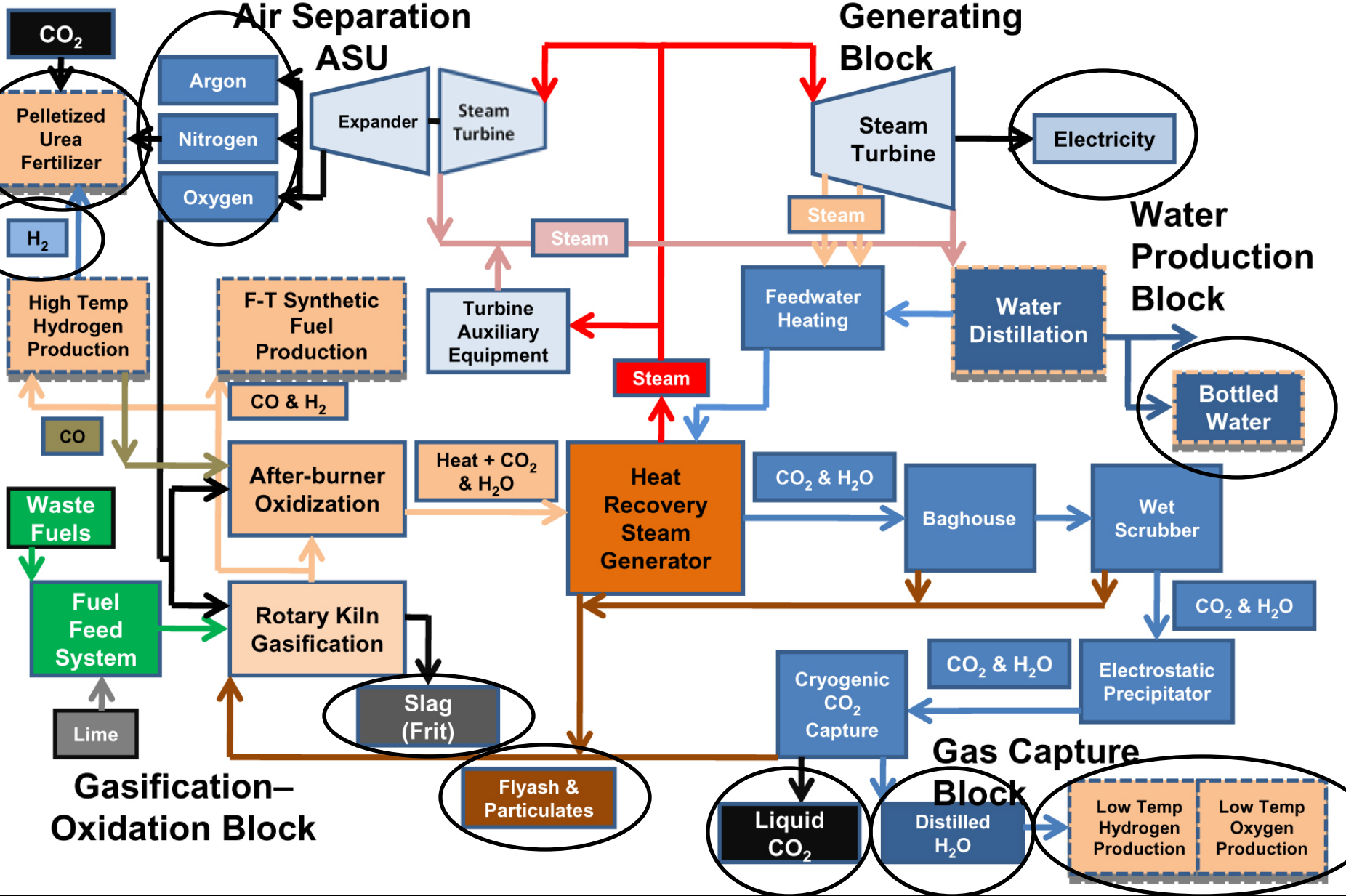
- Steam reformer to generate hydrogen gas
- Modified carbon-recycling Fischer-Tropsch reaction vessel to produce sulfur-free liquid diesel or jet fuel
- Flue gas purification system
- Carbon dioxide sequestration system (cools, compresses, condenses)
- And more….

Waste Remediation Configuration

ZEROS Can Produce Several Commercial Products

- Electricity
- Pure liquid or solid carbon dioxide
- Pure nitrogen, argon, oxygen, and hydrogen gases
- Diesel or jet fuel
- Distilled water
- Small amounts of ash and salts
- Urea fertilizer

Product Options



Environmental Benefits Typical Plant

- Oxidizes large amounts (>1000 tons/day) of waste
- Zero air and water emissions
- Sequestration 100% of carbon dioxide produced (greenhouse gas)
- Generates 50 MW/h gross renewable electricity
- Produces 35 million gal/yr of sulfur-free synthetic diesel or jet fuel
- Can distill 5 million gal/day of waste water

Operational Benefits

- Fuel can be supplied by existing waste management collection systems
- Easily located at existing landfills or transfer stations
- Can vary fuel input mix hourly, daily, or seasonally
- Can vary output of electricity and synthetic transportation fuel hourly, daily, or seasonally

Economic Benefits

- ZEROSECONOMICS©
- Killeen-Fort Hood ZEROS project (typical)
- Base Analysis (40 year life)
- Income from:

Electricity	Metals
Synthetic diesel	Hydrogen gas
Demineralized water	Argon gas
Carbon dioxide	Nitrogen gas
Tipping fee	Ash

Robust Scenario (includes financing, federal taxes, incentives; $millions)

	Nominal	Real
Capital investment	$268	$265
Revenues	8,125	1,071
Operating costs	-1,975	-221
Property tax abatement	15	7
Interest	+933	-59
Net annual taxes	-2,387	-237
Net salvage value	60	0.4
Net present value	$4,505	$297

Economic Indicators (Robust Scenario)

- Benefit-Cost Ratio 2.12
- Return on Investment 18.6%
- Breakeven Analysis
  - Capital investment +190%
  - Operating costs + 283%
  - Revenues - 60%
  - Project life 7 years

Economic Conclusions

- Based on available data, ZEROS technology has substantial potential for being profitable
- Sensitivity analyses suggest some “wiggle room” in the profitability and operation of ZEROS technology
- Profitability is sensitive to several key data-input values.
- Data from operating plants, should increase robustness of the results
- An economic/financial model, ZEROSECONOMICS©, is available to evaluate different applications of ZEROS technology

Impediments to Project Implementation

- Lack of operating unit for demonstration (risk aversion)
- Multi-year agreements for fuel supply (municipal or industrial wastes, coal, lignite, etc.)
- Multi-year agreements for product purchase (electricity, diesel or jet fuel, carbon dioxide, etc.)
- Government regulations
  - Unintended consequences of implementing zero-emission technologies (sets new standard for emission technologies)
  - Fear of need to modify landfill permits

Learn More About ZEROS

- <zerosinc.com>
- Jones, C. Allan and Steve L. Clark. ZEROS, the Zero-emission Energy Recycling Oxidation System, a Description for Non-Engineers. Texas Water Resources Institute Technical Report No. 398. April 2011.
- Rister, M. Edward, Ronald D. Lacewell, and Allen W. Sturdivant. Economic and Financial Implications of the ZEROS Technology. Texas Water Resources Institute Technical Report No. 402. July 2011.

Thank you!