



FastOx[®] Gasification

A Zero Waste Solution

Southern California Conversion Technology Conference

Los Angeles County Public Works

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Rob White, Chief Strategist | RWhite@SierraEnergy.com

Current Waste Handling Practices

Options for processing waste are limited



Significant Amount of Waste Still Landfilled

Environmentally unsustainable

- ❑ U.S. generates 250 million tons of waste annually
 - ❑ 100 million tons landfilled (U.S. EPA)
 - ❑ 3.5 tons of CO₂e /ton of waste landfilled
- ❑ Methane from landfills is 84x more polluting than CO₂
- ❑ Unmitigated & closed landfills can pollute soil & water

Economically unsustainable

- ❑ Mixed-wastes hard to separate
- ❑ Rising cost of environmental compliance/regulation
- ❑ What to do with remaining waste post recycling/separation



Thermochemical Conversion Options

Recycle

Compost

Anaerobic
Digestion

Aerobic Digestion

Pyrolysis

Down Draft
Gasification

Up Draft
Gasification

Plasma
Gasification

Molten Baths

FastOx
Gasification

Fluidized Bed
Gasification

Microwave
Plasma

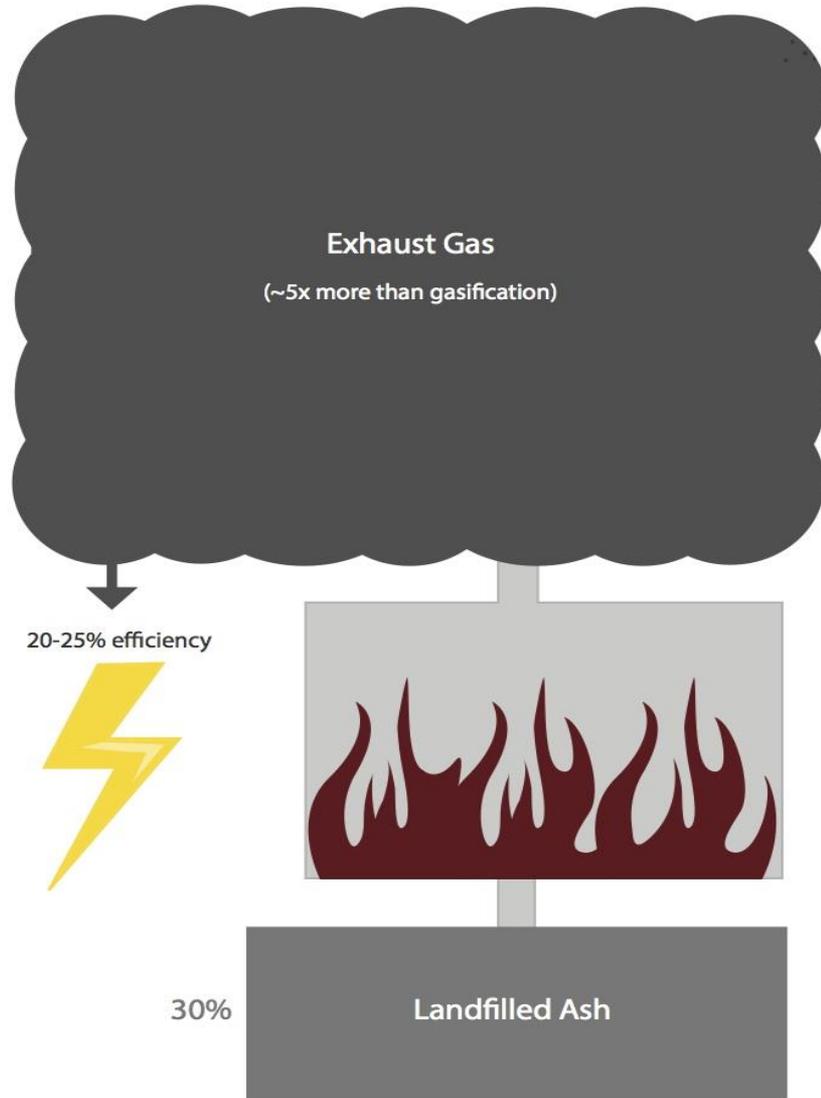
Free Radical
Gasifier

Thermal
Depolymerization

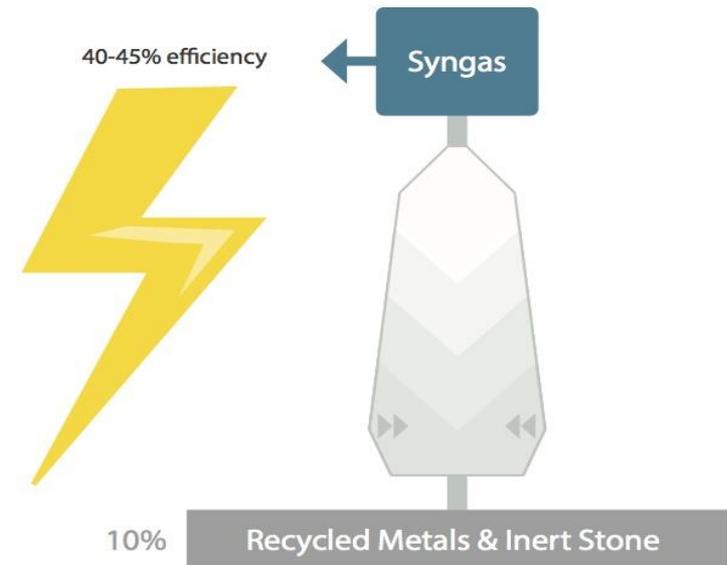
Methane Capture

Burn

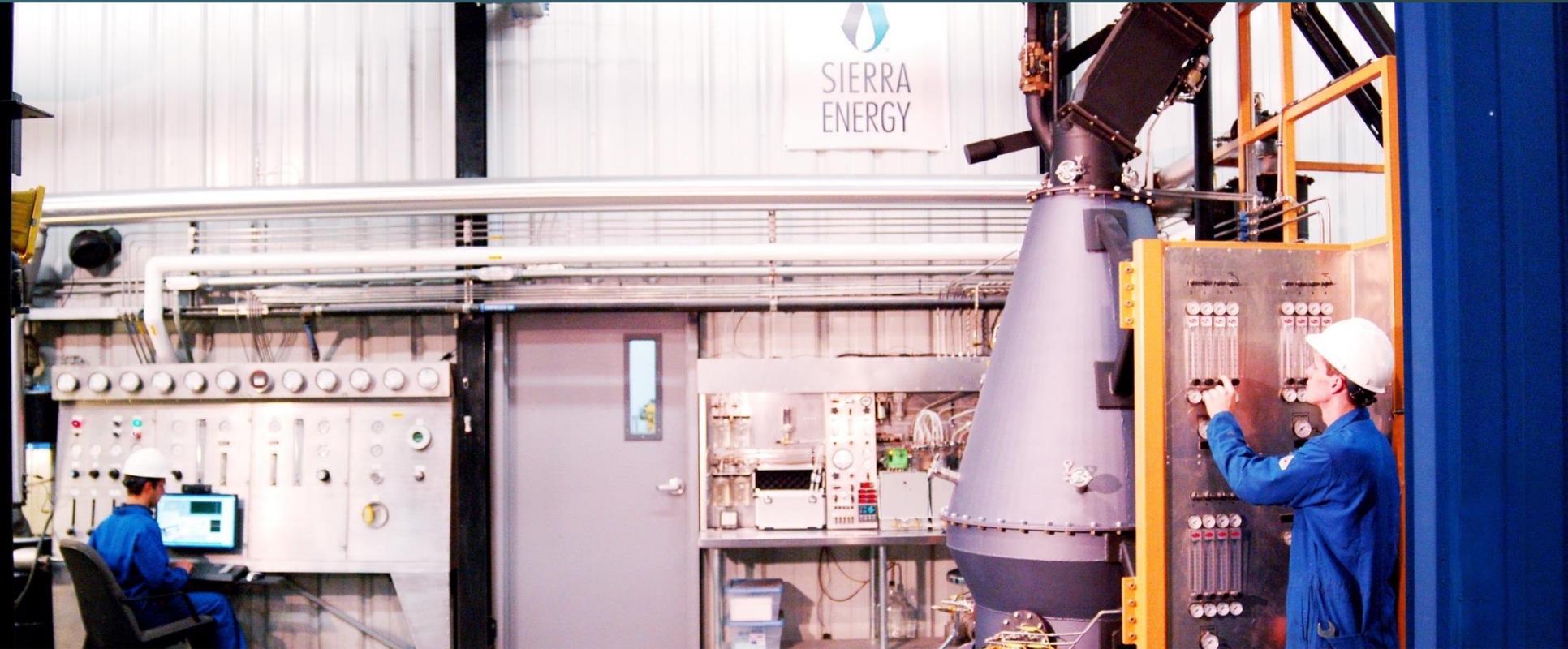
Gasification is Not Incineration



Reference: C-Tech Innovation Ltd,
"Thermal methods of municipal
waste treatment"



Full-scale Prototype



Renewable Energy Testing Center

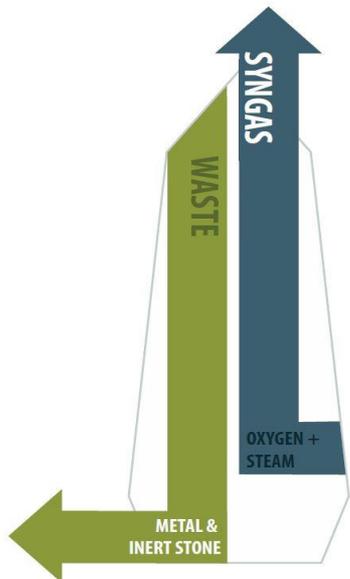
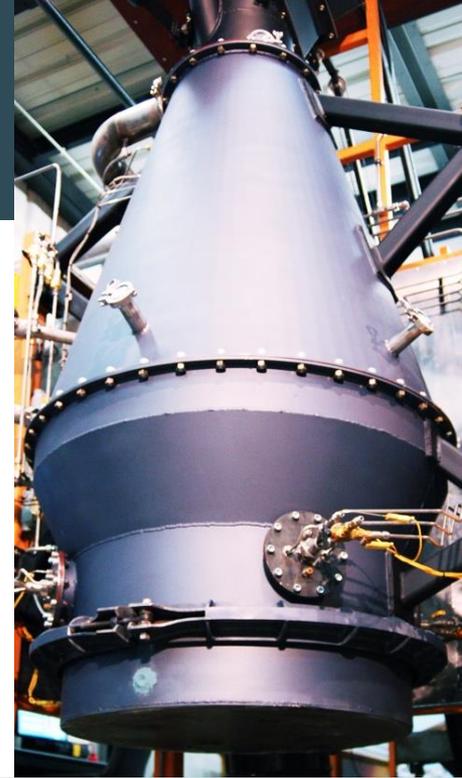
*McClellan Business Park,
Sacramento CA*

5-year successful testing & research demonstrated:

- ❑ Ran for combined 1,000 hours
- ❑ Reaches 4,000 degrees F – vaporizes/melts materials
- ❑ Can handle wide variety of waste feedstocks
- ❑ Resulting syngas is energy-dense – CO-H₂ blend
- ❑ Closed system results in zero emissions from gasifier

The FastOx[®] Gasifier

- ❑ Heating profile doesn't generate dioxins/furans
- ❑ NO_x & SO_x not created
- ❑ No ash for disposal
- ❑ Converts waste into useful new resources
- ❑ Low maintenance - no internal moving parts
- ❑ Scalable unit (based on technology background)

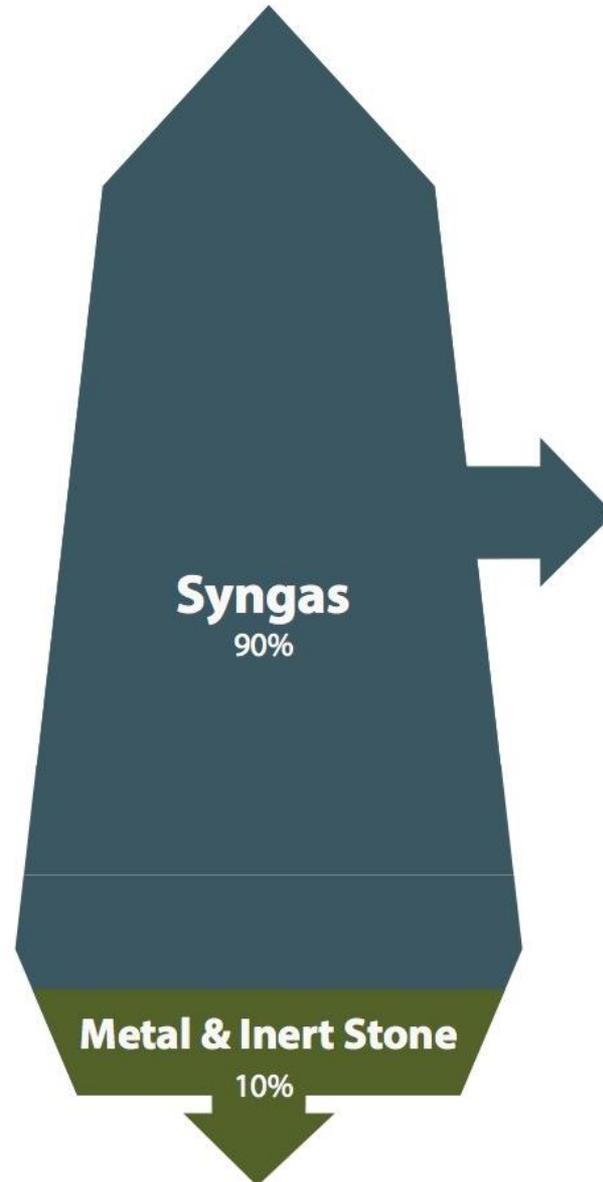


How It Works

- ❑ Waste is fed into the top
- ❑ Oxygen and steam injected at the bottom
- ❑ Organics vaporize - recovered as energy-dense syngas
- ❑ Inorganics melt - recovered as inert stone and metal

Waste Becomes High-value Products

Waste Becomes...



FastOx[®] Systems Have Minimal Footprint

Solar Power: 8 acres



Wind Power: 6 acres



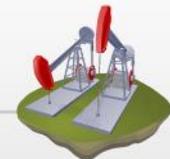
Coal Power: .7 acres



Nuclear Power: .7 acres



Natural Gas Power: .4 acres



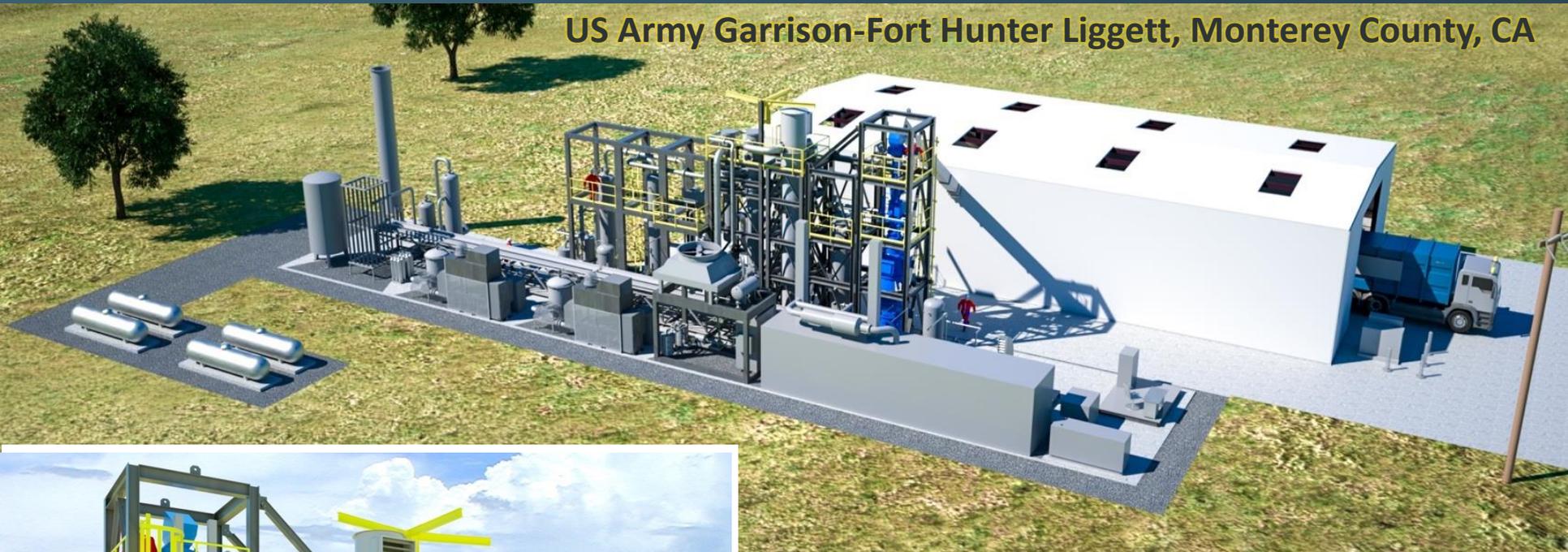
FastOx Gasification System: .25 acres



These values represent the land needed to produce enough electricity to power 1000 homes. *Source: SAIC/RW Beck*

Full-scale Commercial Demonstration Facility

US Army Garrison-Fort Hunter Liggett, Monterey County, CA



Pathfinder at Fort Hunter Liggett



Under construction - Commissioning fall 2016

- Process up to 15 tons/day
- Feedstock
 - ▣ Post-recycled waste from facility
 - ▣ Woody biomass
- Outputs
 - ▣ Electricity
 - ▣ FT Diesel
 - ▣ Hydrogen



Continued FastOx[®] System Development

- Sector leadership recognized by:

- ▣ White House
- ▣ Federal, state, municipal agencies
- ▣ Environmental organizations

- Current Agency Funding Proposals

- ▣ Increase size of FastOx System to 100 tons/day
- ▣ Greater efficiencies using High Performance Computing
- ▣ Demonstrate destruction of hazardous materials onsite
- ▣ Demonstrate increased biofuels production



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



Lawrence Livermore
National Laboratory



- Significant Recent Investment from Global Infrastructure Fund

- ▣ Continues R&D funding
- ▣ Ensures technology maturation

An Integrated Solution to Waste



50%



Recycled Materials

30%



Organic Waste

20%



Divert Remainder
From Landfill

Zero Waste Innovation Park (ZWIP)

Yolo Co. Central Landfill

- Preferred location, near:
 - ▣ Davis – 2 miles
 - ▣ UC Davis – 3 miles
 - ▣ Sacramento – 12 miles
 - ▣ SF Bay Area – 75 miles



ZWIP – A next gen waste R&D facility

Planned Facility

- Facility Scope
 - multi-phase – starting with 3+ acres, building to over 100+ acres
 - capital expenditure - \$200+ million
- Funding Sources
 - federal loan guarantees, muni-bonds, private investment



Active demonstration of net-zero waste processing

- R&D - demonstrate cooperative technologies that achieve zero waste
- New Resources - production of clean, renewable end products
- Impact Policy - minutes from the state capitol

ZWIP Collaborations

- Creating Partnerships at ZWIP to:
 - ▣ Develop high-tech mechanical sorting/processing technologies
 - ▣ Enhance/support anaerobic digestion & composting
 - ▣ Mitigate/eliminate risk and liability for waste landfilling
- **Academic Alliance** - developing formal academic partnerships

Lead Partner



- Developing Research Partnerships



Complete Waste and Energy Solution

	Existing Practices	Sustainable	Low Emissions	Baseload Power	Profitable w/o Subsidy	Low Maintenance
Waste Problem	Landfills				✓	✓
	Incineration			✓		
	Plasma Gasification	✓	✓	✓		
Energy Problem	Fossil Fuels			✓	✓	
	Wind & Solar	✓	✓			✓
	Geothermal	✓	✓	✓		
Complete Solution	FastOx Gasification	✓	✓	✓	✓	✓



Location

State

California

County

Fresno

City by County (population over 25,000)

Clovis

Population of County (2010)

920,623

Projected Waste Potential [MT/day]

1,841



International (Optional)

Country

Est. Population

City/Province

To find out how FastOx can meet your specific needs: SierraEnergy.com/calculator

Feedstocks

Total Input in Metric Tons [MT]

Calculated System Size of: 250 MT/day

250 [MT/day]

of Projected Waste Potential

Municipal Solid Waste

75%

\$ 49

[/MT]

Biomass

25%

\$ 2

[/MT]

End Product

Select End Product

Electricity

Sale Price (in USD)

\$ 0.11

[/kWh]

Local Utilities

Local Natural Gas Price

Jobs Created:

22

Local Natural Gas Cost [MMBTU]:

\$2.50

Local Electricity Cost [kWh]:

\$0.06

Annual Revenues

Primary Tipping Fee:

\$3,356,000

Secondary Tipping Fee:

\$46,000

Total Tipping Fee:

\$3,401,000

Sale of Electricity:

\$6,758,000

Sale of Recovered Materials:

\$564,000

Estimated Revenue:

\$10,723,000

Annual Expenses

Labor and Benefits:

\$1,172,000

System Maint:

\$625,000

Supplies and Materials:

\$260,000

Estimated Expenses:

\$2,057,000

Operating Income

Annual Revenue:

\$10,723,000

Annual Expenses:

-\$2,057,000

Projected Income

\$8,666,000

Capital Investment

Waste PreProcessing

\$3,319,000

Oxygen Production

\$4,710,000



Thank You!

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Sierra Energy | 221 First St, Davis, CA 95616 | (530) 759-9827 | info@sierraenergy.com

Inputs*

Waste into gasifier: 1,000 kg
Oxygen into gasifier: 233 kg
Steam into gasifier: 96 kg

Outputs*

Syngas

Net Calorific Value:

8.26 - 8.87 MJ/kg (dry syngas)

Composition:

70% Carbon Monoxide

30% Hydrogen*

Inert Stone

Molten metal and stone: 101 kg

End Products

Electricity: 1,083 kWhe (gross)

Diesel: 148 liters

Hydrogen: 78 kg

Competitive Design Advantages

Efficient

Cold gas efficiency: **66-79%**

Parasitic load: **16-20%**

Reliable

347 days of continual up-time

Low Emissions

+ Emissions less than natural gas

+ Lowest No_x and So_x emissions of any conversion technology

Cost Effective

Costs up to 40% less than competing technologies

*Values based on prototype testing at RETC, current value engineering, and industry specifications

Competitive Solution