



Transforming Waste Liabilities into Energy Assets

Pyrolysis

*An Elegant Solution for Converting Waste to Energy
Advanced Recycling and Energy Conversion*



GREEN WASTE ENERGY INC.

Agenda

- The State of Recycling – China has changed things
- Green Waste Energy / Prestige Thermal Energy
- The Process - AREC
- Discussion

Some Basic Points

- Waste is a problem that needs a solution
- AREC compliments recycling, it does not replace it
- Temperatures are all in Celsius

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Americans Are Good at Recycling?

- FALSE!
- About 25 percent of what ends up in the blue bins is contaminated, according to the National Waste & Recycling Association.
- People throw wire hangers, pizza boxes, ketchup bottles and yogurt containers into the bin which was sent to China, where low-paid workers sorted through it and cleaned it up.
- In San Francisco, lauded for its environmentalism, waste-management companies struggle to keep recycling uncontaminated.

Recycling

- Blaine County, ID - mixed-paper recycling was about 90 percent clean, but its paper broker said the mixed paper needed to be 99 percent clean for anyone to buy it.
- Items made of different types of plastic nearly always end up in the trash, because recyclers can't separate the plastics from one another.
- What are your rules for recycling plastic?

Recycling Rules

- County Dependent
- Which plastic containers are recyclable and which aren't?
- Is Styrofoam recyclable – Yes but no.
- Can pizza boxes be recycled? – Remove the food.
- Should plastic bottle caps be left on? – It depends.
- Can I recycle my plastic bag? – 7 different categories on the web site.
- In all cases, Contamination of recyclable material with trash is a problem.
- Bottom Line – Recycling is complex and problematic.⁸

Landfills

- ~99% of Landfill Emissions are Carbon Dioxide (CO₂) and Methane (CH₄)
- Methane is also a GHG and has ~30 times more Impact than CO₂
- EPA 2017 Estimate that Landfills are the 3rd largest Source of human related Methane Emissions

Diverting Organics From Landfills

- US EPA Estimates that more Food reaches Landfills & Incinerators than any other single Material is our Wastestream
- Estimate that 49.9% could be Composted
- CA has Mandated Organic Diversion
- Composting is Complex & Takes >22 days
 - Control O₂, Moisture, Temp, pH & C:N Ratio
- Composting can Emit VOCs
- Compost is not Necessarily Pathogen Free

A Solution

Convert the calorific waste into clean energy without fuss or incineration

Advanced Recycling and Energy Conversion (AREC)

Separate Streams of Organic and Inorganic Waste

Green Waste Energy

- Approximately \$3.5 M initial private investment
- Technology from Prestige Thermal Energy of South Africa
- Patented in USA to Green Waste Energy
- 3 Pilot Sites in SA
- Two US projects in development
- Close to Funding of a major Project in Western Europe

Prestige Thermal Energy

- Thermal Equipment Manufacturer: induction furnaces, die casting, etc founded in 1955
- ISO 9001 & 14001 Accredited
- World's largest concentration of gasifiers & pyrolyzers
- Synthetic fuels produced in So Africa for years
- Exports to: USA, UK, Germany, Turkey, Egypt, Australia, Russia and South America
- Manufacture key components of C6 Technology: autoclave, pyrolyzer, dryer & thermal oxidizer
- Johannesburg, South Africa

Pyrolysis

- ... is a thermochemical decomposition of material at elevated temperatures in the absence of oxygen (or any halogen). It involves the simultaneous change of chemical composition and physical phase and is irreversible.

What Kinds of Waste Can C6 Process?

Process any type of waste that has a calorific value:

- Hydrocarbons such as oil;
- Complex sugars such as vegetable waste;
- Organic chemicals such as animal fat;
- Plastic bags, bandages, diapers, pizza boxes, misc plastic, etc.

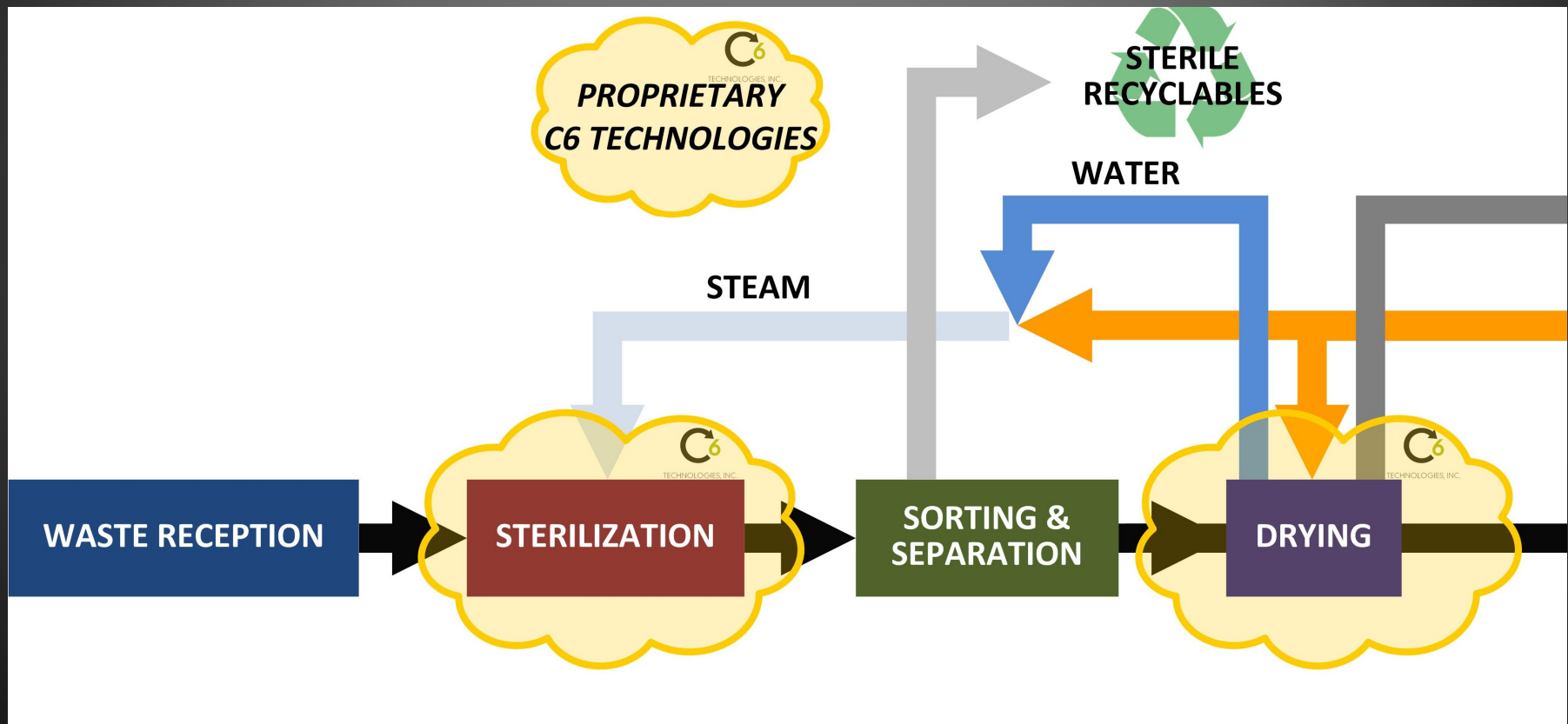
What can't pyrolysis process:

- Plaster board
- Metal
- Glass
- Inert materials w/o a Btu value

The C6 Process

1. Reception
2. Sterilization
3. Drying
4. Conversion
5. Cleaning
6. Generation
7. Emissions
8. Residue Disposal

Phase I - Preparation



Sterilization

Use Autoclaves to decontaminate waste

- Destroy most pathogens and microbial life forms via steam @ 160 C for ~50 minutes.
- Able to process bio-hazardous waste such as hospital waste, slaughterhouse waste, sewage, etc.
- Internal agitation reduces waste to homogenous size; eliminates need to open garbage bags or touch waste.
- Removes labels and glaze; further enhances resale value of recyclables.
- Sterilization not required for biomass, tires, C&D, etc.

Autoclave Operation

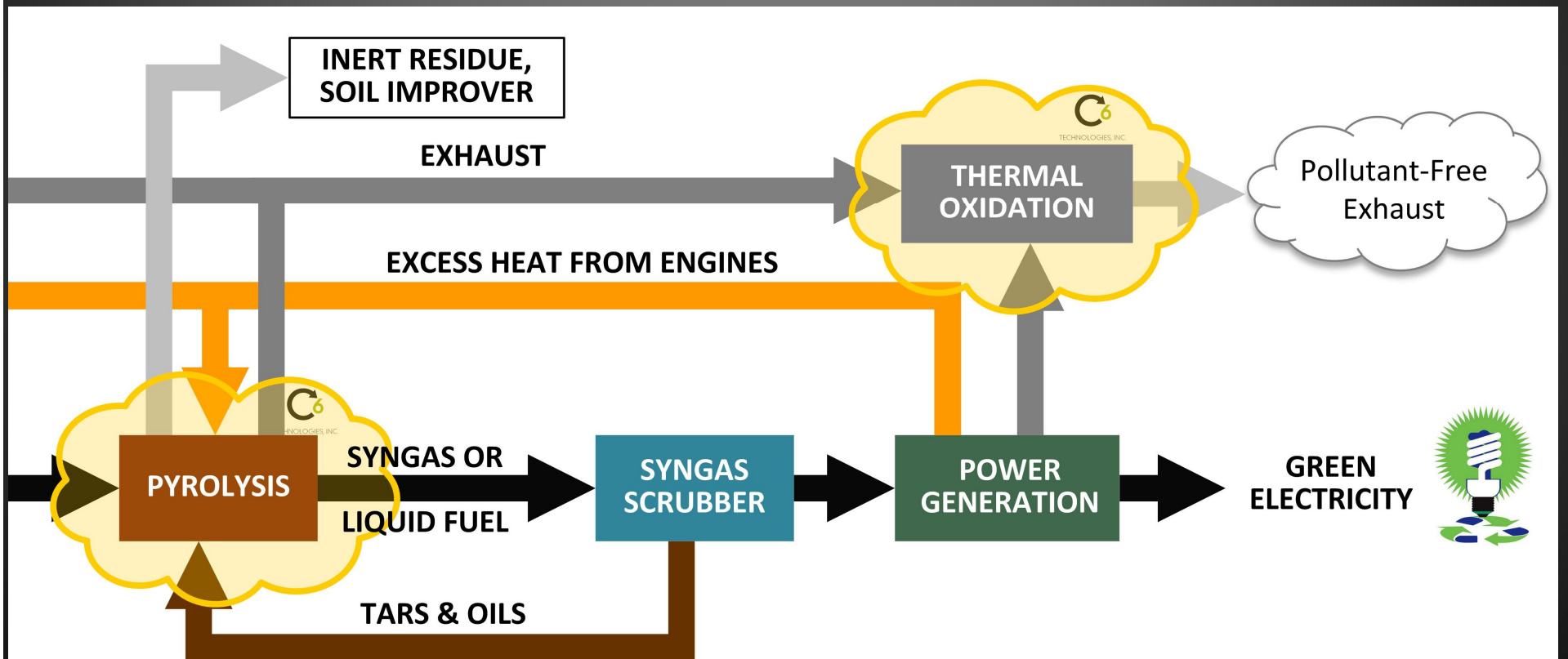
- Pressurized saturated steam (160°C and 75 psi) “pressure-cooks” the waste for up to 50 minutes, giving a very high pathogen and virus kill rate.
- Outer pressure vessel is static; inner drum with reverse / forward rotation for material homogenization; continuous reverse for material discharge.



Drying

- Extract excess moisture and convert the fiber into solid form.
- Dryers use excess heat from engines to keep feedstock drying costs low.
- Dry cellulose feedstock increases pyrolyzer efficiency.

Phase II - Generation



Pyrolysis

- Pyrolysis is an advanced form of gasification.
- Feedstock is decomposed at elevated temperatures in an oxygen-starved environment to produce a synthetic gas or “syngas”.
- Dissimilar to burning, which requires oxygen.
- Organic compounds break down into lower molecular weight compounds, changing physical form.
- Capable of treating many different hydrocarbon-based and organic wastes.

Pyrolyzer

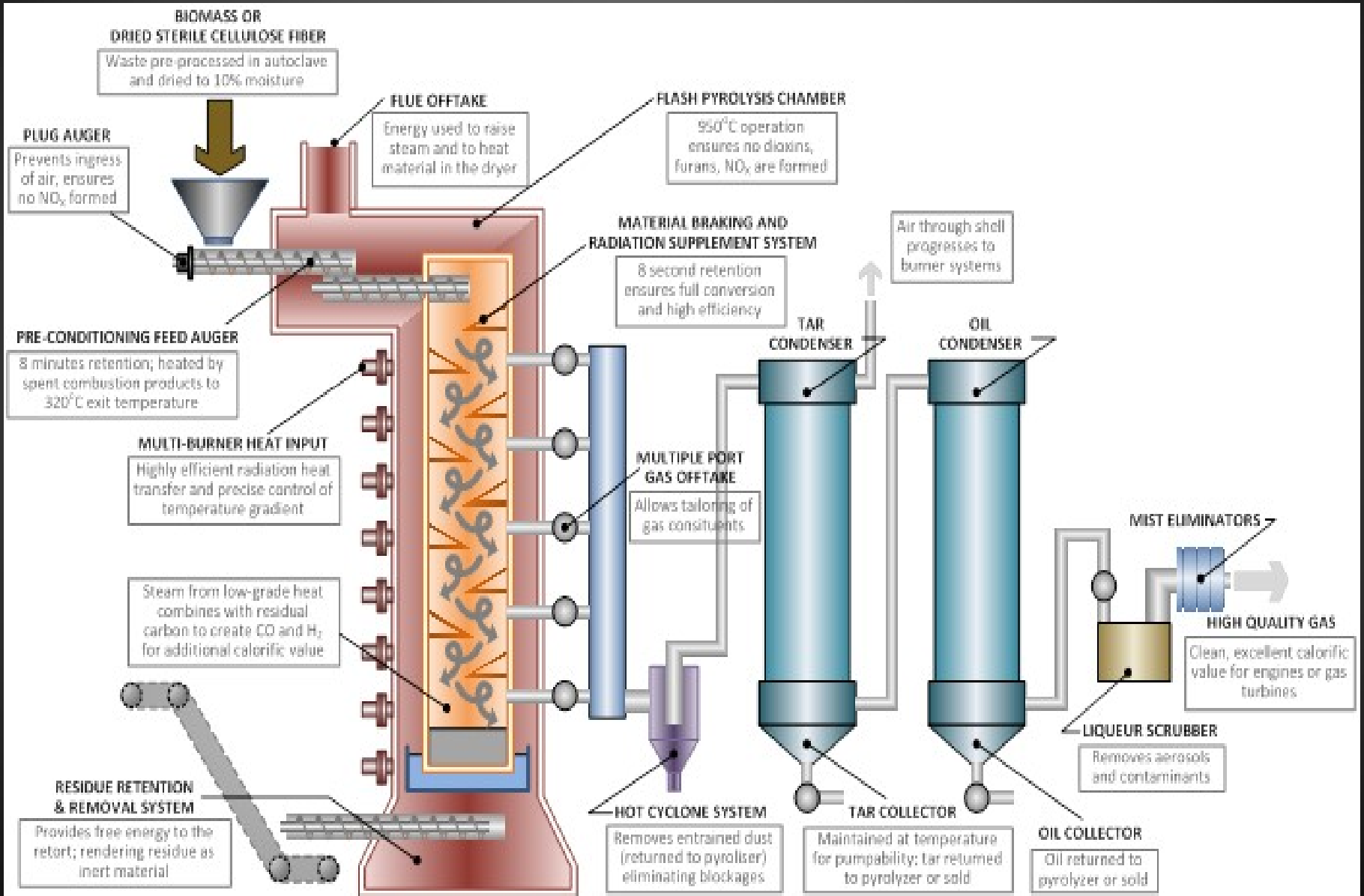
Consists of two stages:

Pre-pyrolyzer pre-heats material to 300°C; inner drum is rotated within a heated outer vessel. Outer vessel temperature and speed of rotation allows precise control of exit temperature.

Pyrolyzer unit also consists of a totally sealed inner unit surrounded by a heated outer vessel. After initial startup using external fuel, the pyrolyzer is heated using part of the syngas that it generates to a temperature of 950°C.



C6 Proprietary Technologies - Pyrolyzer



Syngas Scrubber

- A gas clean-up system is employed to render the syngas “engine friendly” and serves to reduce overall plant emissions.
- Tars, olefins and “fines” are cycled back through the pyrolyzer to ensure they are further decomposed into syngas.

Power Generation

- Syngas is suitable for use in gas engines such as Jenbacher to generate electricity or fuel in steam turbine applications.
- Syngas burns more efficiently and cleanly than the waste from which it was made.
- Excess engine exhaust heat & pyrolyzer heat can be used to make steam to drive steam turbines to increase electricity output.
- Engine block heat is available.

Phase III – Cleanup & Disposal

- Emissions – make it a non-issue
- Disposal – make it an asset instead of a liability

Emissions Treatment via Thermal Oxidation

- All emissions come to a Thermal Oxidizer: pyrolyzer, dryer and engine exhaust
- Passed over 850°C ceramic bed.
- EU standard for emissions: 800°C for 2 sec's
- Pollutants are oxidized, reduced to only 16 ppm, well below all global emissions standards.

C6 Emissions Data

Contaminant	European Waste Incineration Directive Limits	Typical Result
• CO	50 mg/m ³	17.7 mg/m ³
• SOX	50 mg/m ³	negligible
• NOX	200 mg/m ³	26.4 mg/m ³
• Dioxins & Furans	0.1 ng/m ³	negligible
• Particulates	10 mg/m ³	0.1 mg/m ³
• TOCs	10 mg/m ³	negligible

Inert Residue - Marketable Outputs

The inorganic feedstock materials form an inert, non-hazardous residue that is approximately 10-15% of feedstock volume, depending on the feedstock composition. The residue is of grey granular form.

The inert residue has several applications including:

- Road Aggregate: rocks or sand;
- Brick-Making: Low cement type stock bricks;
- Combined with resin to make particle board substitute;
- In the worst case, the residue is a non-hazardous landfill;

Pyrolysis of biomass produces a potassium-rich organic output that can be used as a beneficial soil additive.

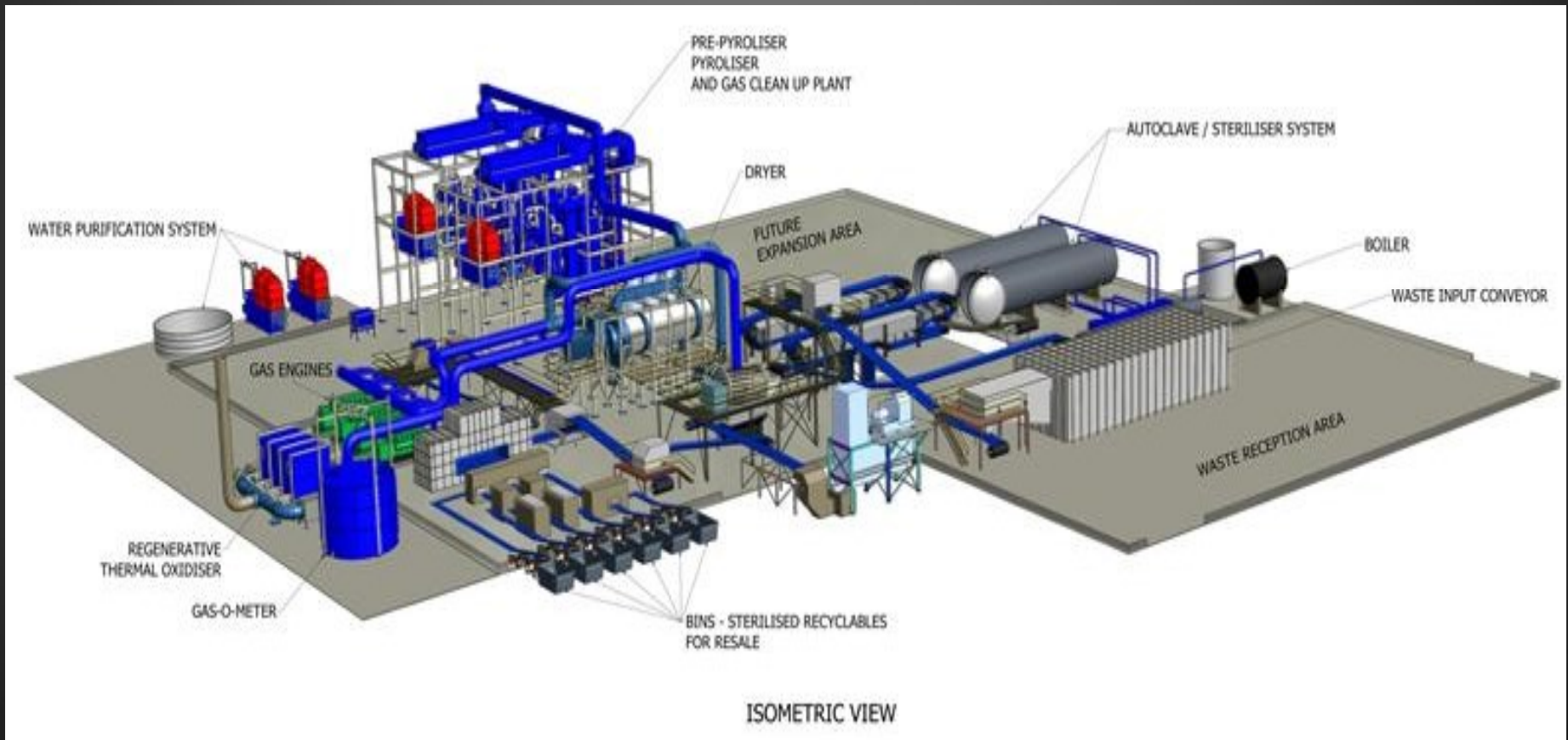
Projected Power Output

- 500 tpd = ~ 10 MW
- 1,000 tpd = ~ 25 MW

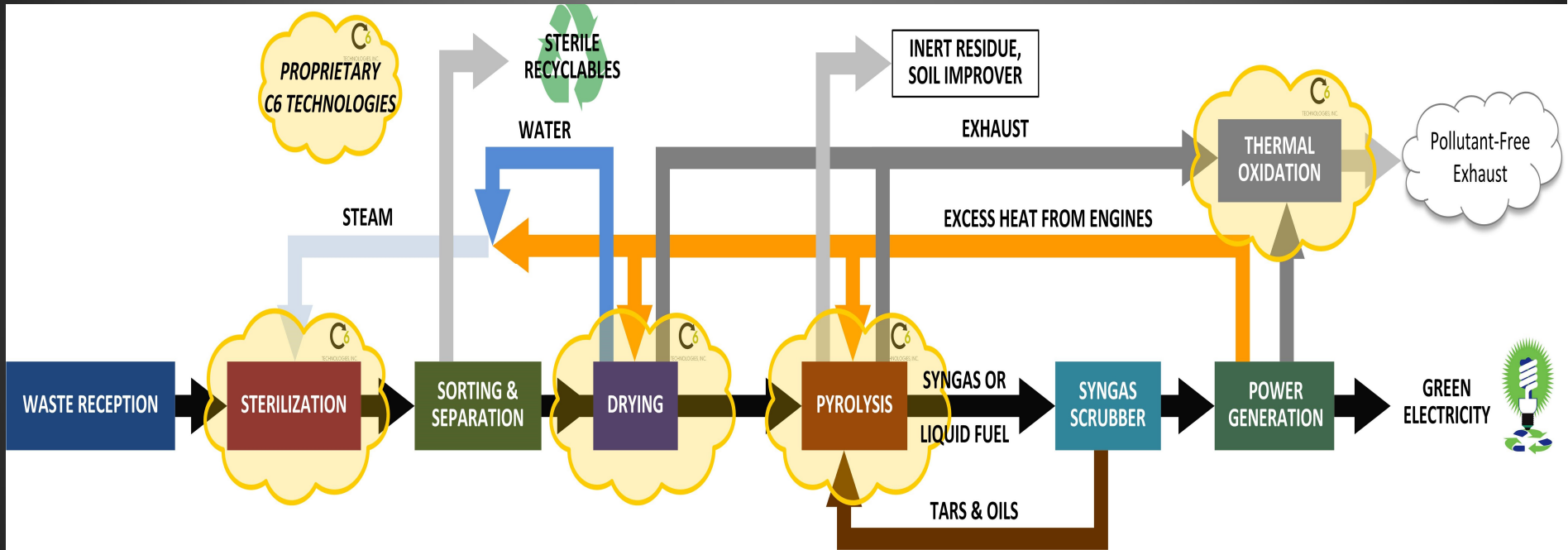
net of internal use

< 15% rejects & <30% moisture

Plant Physical Layout



450 tpd: 4-5 Acres. 1000 tpd: 7-10 Acres



Discussion

Advanced Recycling & Energy Conversion Fits Well
into the UCRRA Future

Stay tuned

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