



*Capture the energy ⚡ Release the potential*



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**Energy** It is the lifeblood of the modern world, powering our cities and driving an increasingly demanding global economy. Keeping up with demand —while also being conscious of carbon emissions and other environmental concerns — means seeking out new energy resources that are both efficient and sustainable.

**Biomass**— biological material derived from living, or recently living organisms, such as wood or agricultural residues — contains stored energy from the sun that can be liberated through combustion. Our ancestors have been doing it for ages in the form of campfires. But there's a cleaner, more efficient and cost effective way to tap into that energy source ... gasification.

# Gasification

**Gasification:** The right choice for releasing biomass energy



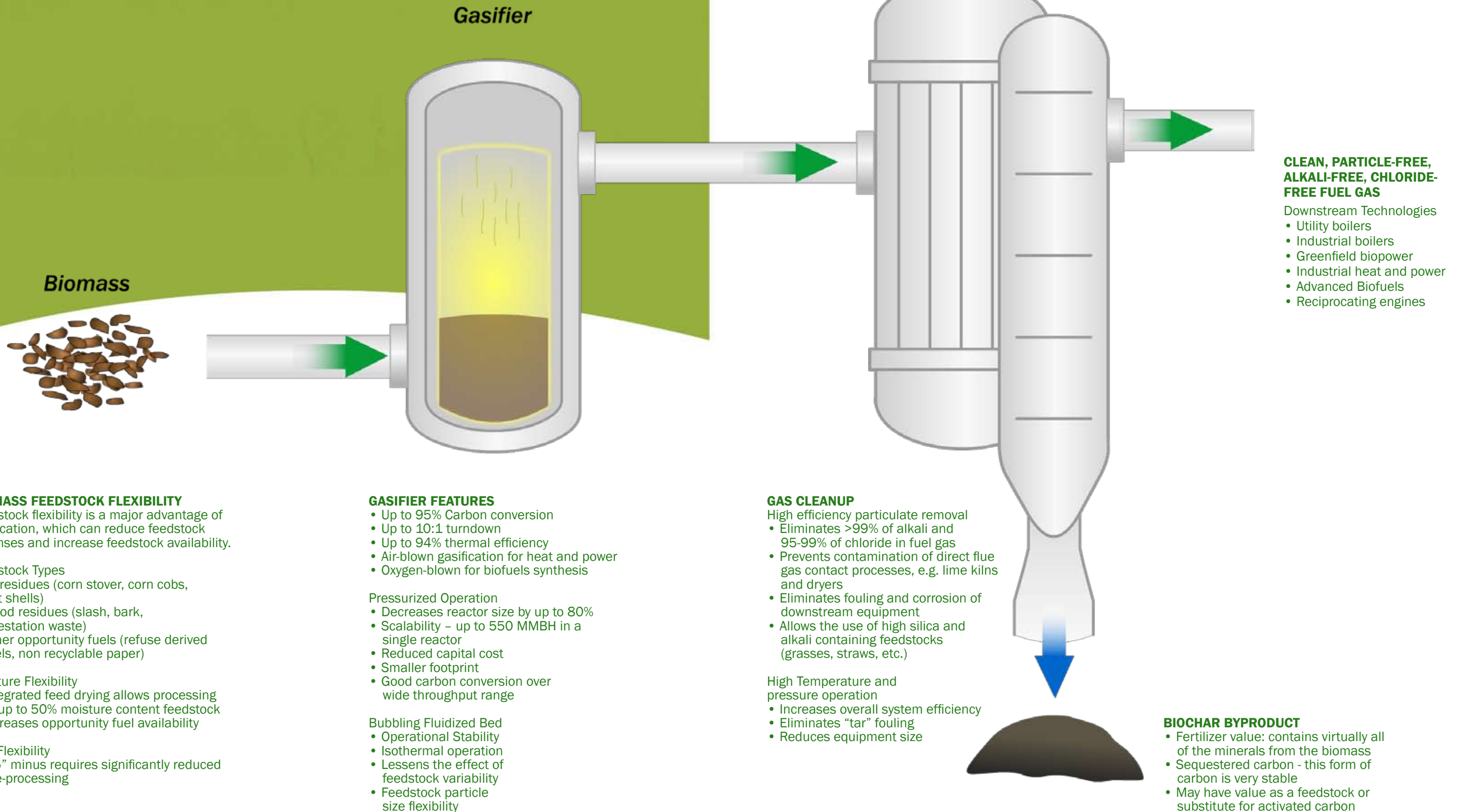
Frontline BioEnergy sits at the intersection of two undeniable global trends — the increasing demand for cost-effective energy, and the need for energy resources that are sustainable and environmentally friendly. Our gasification technology allows for the efficient, cost-effective use of sustainable biomass for renewable power, heat, and biofuels.

Frontline BioEnergy's proprietary technology centers on a biomass gasification system that converts solid fuel particles into a combustible gas. This renewable, gaseous fuel is cleaned and conditioned in our system and can be used in a variety of applications. Gasification allows for the production of a more energy efficient, cleaner burning, and environmentally friendly fuel source compared to non-gasified biomass, natural gas or coal.



# PMFreeGas™

**PMFreeGas™** The Frontline Gasification System: How It Works



# Advantages

## Advantages of PMFree Gas™ over direct combustion biomass energy systems

### Cost Advantage

- Lower CAPEX/kw than combustion due to higher efficiency
- Lower fuel expense per MWh produced power
- Lower O&M and repair expense due to production of clean-burning fuel gas
- Less downtime due to repairs
- Less expensive emissions compliance since a smaller gas volume is being treated

### Reliability Advantage

- Gasification with ash removal removes problematic alkali and chloride from the gas
- Alkali and chloride are responsible for major boiler maintenance: fouling, slagging, corrosion
- Feedstock flexibility of gasifier system enhances process reliability
- Gasifier and solids system reliability is decoupled from electric generating reliability with instant natural gas backup system

### Efficiency Advantage

- Gasification allows repowering without significant de-rate of generating asset – maintains ability to operate near peak efficiency point without turbine rebuild
- More efficient combustion for steam-based power cycles: 10% excess air for fuel gas combustion v. 50%-100% excess air for solids combustion
- High (up to 94%) hot gas efficiency (HGE) for direct gasification conversion; main losses from incomplete carbon conversion, which can be recovered off-site

### Emmissions Advantage

- Emissions control managed on the fuel side, not the combustion side: smaller gas volume to treat
- Gasification with ash removal removes particulate matter (PM) emissions prior to combustion
- Frontline gasification technologies have excellent chloride removal, down to MACT compliant levels
- Gas fuel allows the use of low-NOx burner technology

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