Biomass Gasification
Nexterra Systems Corp.

Presenter

Scott Layne, CEM
Regional VP, Sales

Technology: Gasification

Feedstocks: Woody waste

Output: Syngas, hot water, steam, electricity

Size Range: 2-10 mWe, 10 to 120 million BTU/hr

Commercial Status: Commercial since 2003

Projects Installed: 6 systems, 3 in construction

Target Market: Institutional, industrial, government, district energy, wastewater treatment

BIOMASS GASIFICATION

Domestic, Dispatchable Renewable Heat & Power

Presentation:

- Background & overview of technologies
- Business of biomass
- Example projects

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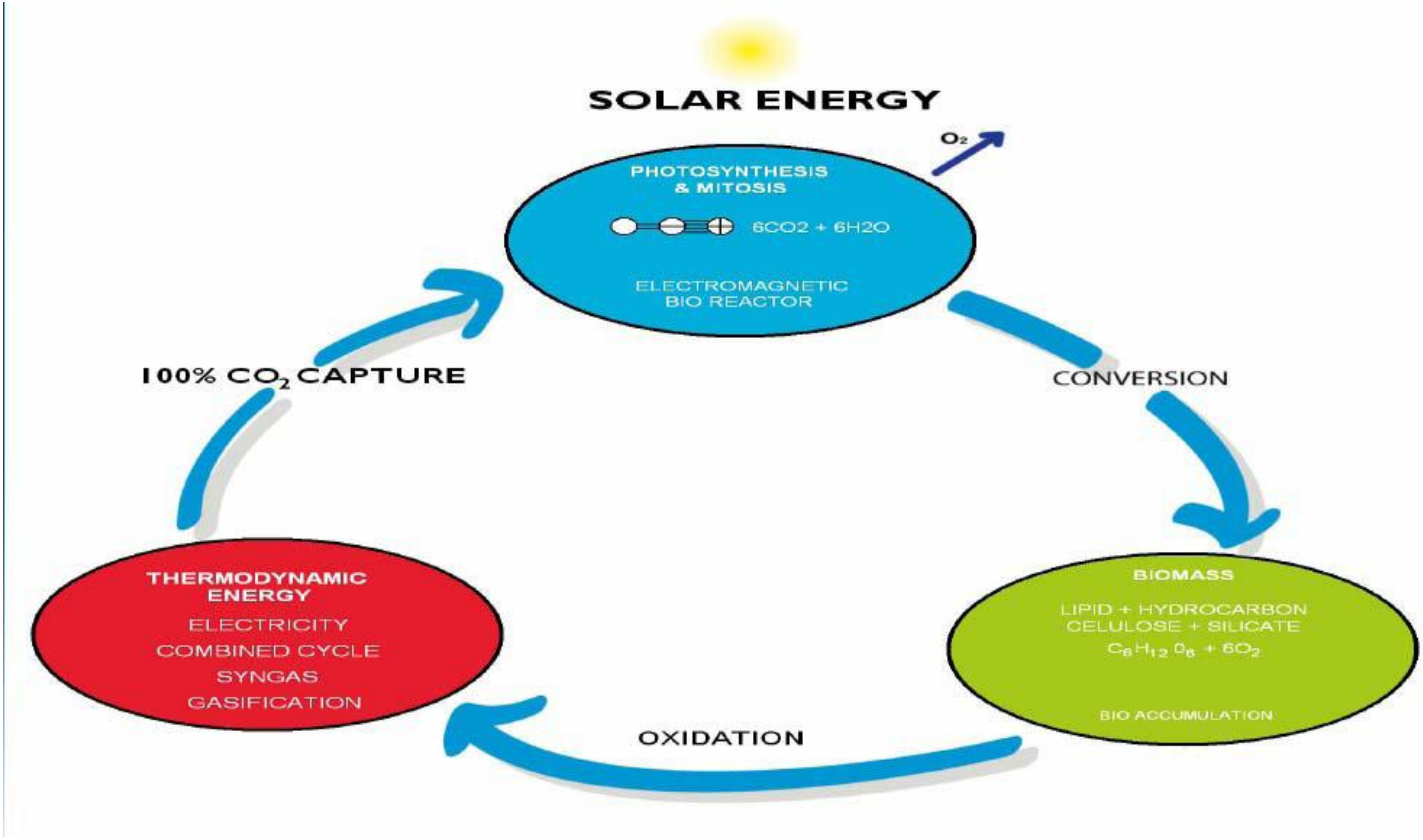
Gasification Background

Biomass – the ultimate Solar Technology?



What is Gasification?

- A process which converts carbon-containing fuels into gas. The gas produced can be referred to as producer gas, biogas, synthesis gas or syngas.
- Coal was gasified in the 1800's to produce 'town gas', later replaced by natural gas
- Gasifiers were used early in the 1900's to produce 'wood gas' to provide an alternative to gasoline for cars

Gasification is a thermo-chemical reaction with the following distinct stages:

- Drying
- Pyrolysis (thermal decomposition)
- Char combustion
- Ash removal

Gasification Technologies

- Fast Pyrolosis
- Slow Pyrolosis
- Anaerobic Digestion
- Dry Anaerobic Digestion
- High Temperature Decomposition (Plasma)

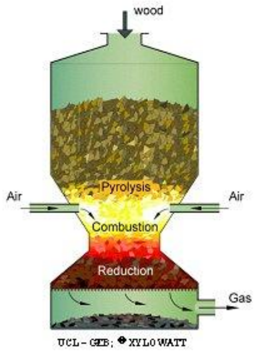
Gasifier Design - 3 main categories of gasifier

Updraft

- Air flows upwards through the fuel pile, counter-current to the fuel flow
- Ash discharges from the bottom of the vessel

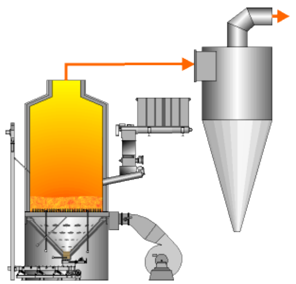
Downdraft

- Fuel and air flow co-currently down through the gasification vessel
- Ash discharges from the bottom of the vessel



Fluidized Bed

- Air fluidizes fuel bed
- Ash is entrained in the syngas and is separated from the syngas in a cyclone



Gasifier Design

Gasifier Type	Scale	Fuel Requirements		Efficiency	Gas Characteristics	Other Notes
		Moisture	Flexibility			
Downdraft Fixed Bed	5 kW_{th} to 2 MW_{th}	<20%	• Less tolerant of fuel switching • Requires uniform particle size • Large particles	Very good	• Very low tar • Moderate particulates	• Small Scale • Easy to control • Produces biochar at low temperatures. • Low throughput. • Higher maintenance costs
Updraft Fixed Bed	<10 MW_{th}	up to 55%	• More tolerant of fuel switching than downdraft	Excellent	• High tar • Low particulates • High methane	• Small- and Medium-Scale • Easy to control • Can handle high moisture content • Low throughput
Bubbling Fluidized Bed	<25 MW_{th}	<5 to 10%	• Very fuel flexible • Can tolerate high ash feedstocks • Requires small particle size	Good	• Moderate tar • Very high in particulates	• Medium Scale • Higher throughput • Reduced char • Ash does not melt • Simpler than circulating bed
Circulating Fluidized Bed	A few MW_{th} up to 100 MW_{th}	<5 to 10%	• Very fuel flexible • Can tolerates high ash feedstocks • Requires small particle size	Very Good	• Low tar • Very high in particulates	• Medium to Large Scale • Higher throughput • Reduced char • Ash does not melt • Excellent fuel flexibility • Smaller size than bubbling fluidized bed

Gasification vs. Combustion

Comparison – Biomass Combustion vs. Nexterra CHP

30 MW ABB/Zurn biomass plant, CA

2 MW Nexterra biomass CHP plant

	Old Paradigm	New Paradigm
Model	Centralized	Distributed
Efficiency (power only)	Low (20%)	High (25%)
Efficiency (CHP)	System dependent	High (60%+)
Scale (economic)	Large (>30 MW)	Small (2–10 MW)
Fuel Footprint	High (30 MW = 250,000 bdtpy)	Low (2 MW = 13,000 bdtpy)
Fuel Truck Traffic	High (30 MW = 36 trucks/day)	Low (2 MW = 2 trucks/day)
Steam Plant Operators	Yes	No
PM Emissions	High volume	Ultra Low – natural gas equivalent
Permitting/Public Risk	Higher	Lower
Construction Time	Long : 24 – 36 months	Short: 12 months
Grid Connection Costs	Higher	Minimal – inside the fence
Urban Friendly	No – scale, traffic, emissions	Yes – scale, traffic, emissions

Biomass Heat and Power – Smaller Is Better

Conventional Biomass
(Large Combustion)

Centralized, rural, industrial, low efficiency, higher emissions, capital intensive

Constrained by scale = fuel disruption, fuel risk, financing permitting, community acceptance

Next Gen Biomass
(Small Gasification)

Small plants, urban, institutional, high efficiency, ultra low emissions, community friendly

Constrained by technology response comparable to other renewables (e.g. solar, wind)

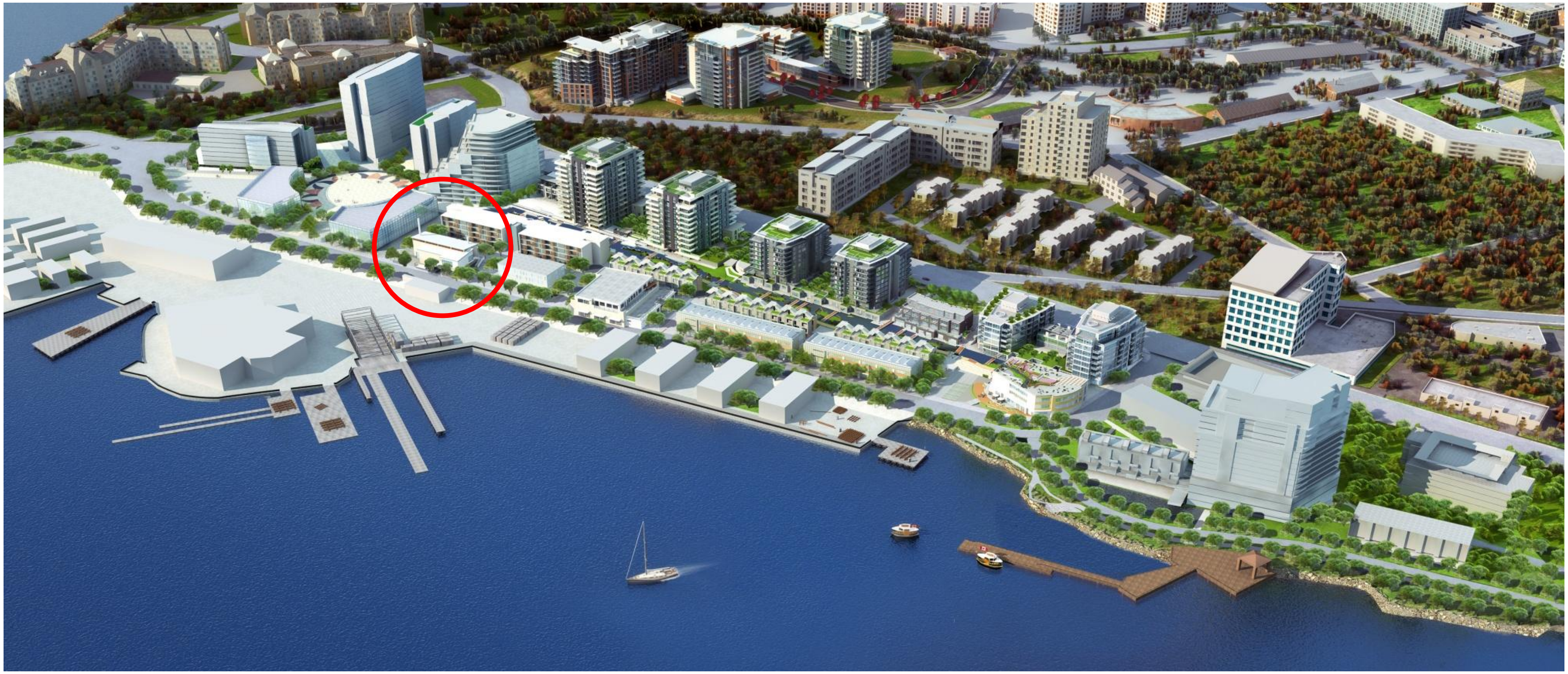
Summary Gasification vs. Combustion

Attribute	Comparison	Benefit
Air Emissions Lower PM, NOx, CO, VOC, TOC emissions	Lower	Easier permitting, more rapid public acceptance and cleaner air. Lower PM into the heat exchanger substantially reduces maintenance costs
Fuel Flexibility 5 – 60% MC and 3 inch minus vs. combustion systems that operate on either wet or dry fuel	Better	More fuel supply options, lower fuel cost, and reduced fuel procurement risk
Operational Performance Higher turndown ratio, faster response to changing load conditions, free-flowing ash and dormancy mode	Better	More adaptable to a wider range of operating conditions
Operating Costs Lower fuel cost, automated operation, low parasitic load, minimal operator intervention	Lower	Comparable although Nexterra has lower parasitic power load due to less equipment required for ash removal and soot blowing; lower fuel cost
Maintenance Costs Less boiler tube fouling, less equipment to maintain, longer refractory life due to clean FG	Lower	Lower maintenance costs, fewer unscheduled maintenance outages and lower lifecycle costs
Syngas Versatility Nexterra systems can direct fire syngas into existing boilers, engines and turbines which cannot be achieved by combustion systems	Unique	Can result in lower capital cost for some systems by retrofitting existing boiler equipment

Air Emissions from Nexterra Thermal Gasifiers vs. Wood-Fired Combustion

Emission Type		Comparison	Range	Benefit
PM Particulate Matter	PM @ Heat Recovery Unit Inlet	Lower	30 times lower	A. Reduce load on dust collection equipment B. Smaller dust collection unit required to achieve the same level of PM emissions C. Reduce fouling of heat exchangers, less soot blowing, lower operating costs D. Longer refractory life, lower maintenance
	PM @ Exhaust Stack	Lower using same APC	-	
NO_x Nitrogen Oxides	NO_x [Fuel Related]	Same	-	Nexterra Gasification System can incorporate SNCR technology in order to achieve lowest NO_x emission levels
	NO_x [Thermal]	Lower	10 - 20% lower	
	NO_x Abatement Capabilities -SNCR	Lower	40 - 50% lower	
CO Carbon Monoxide		Lower	10 times lower	Less CO released to the atmosphere
VOC Volatile Organic Compounds		Lower	10 times lower	Less VOCs released to the atmosphere
TOC Total Organic Carbon		Lower	10 times lower	Less TOCs released to the atmosphere
CO_2 Carbon Dioxide		Same	-	No Change
SO_x Sulfur Oxides [Fuel Related]		Same	-	No Change

Urban Friendly *Dockside Green -- Victoria, BC*

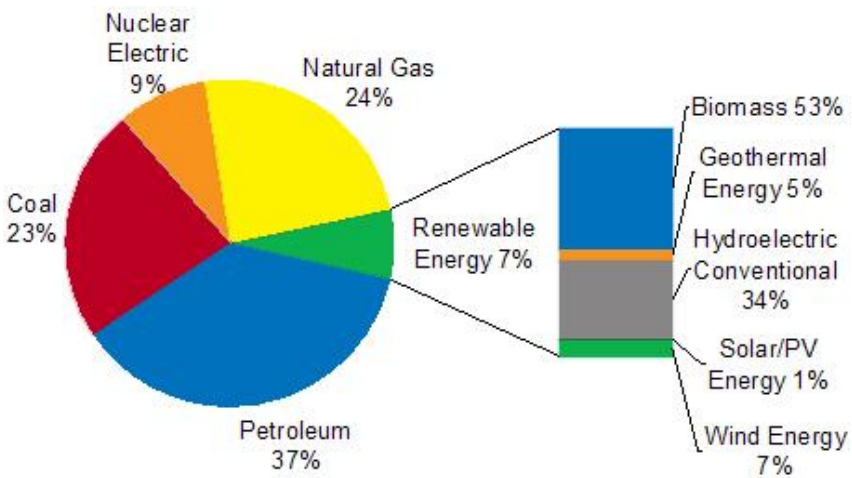


The Business of Biomass

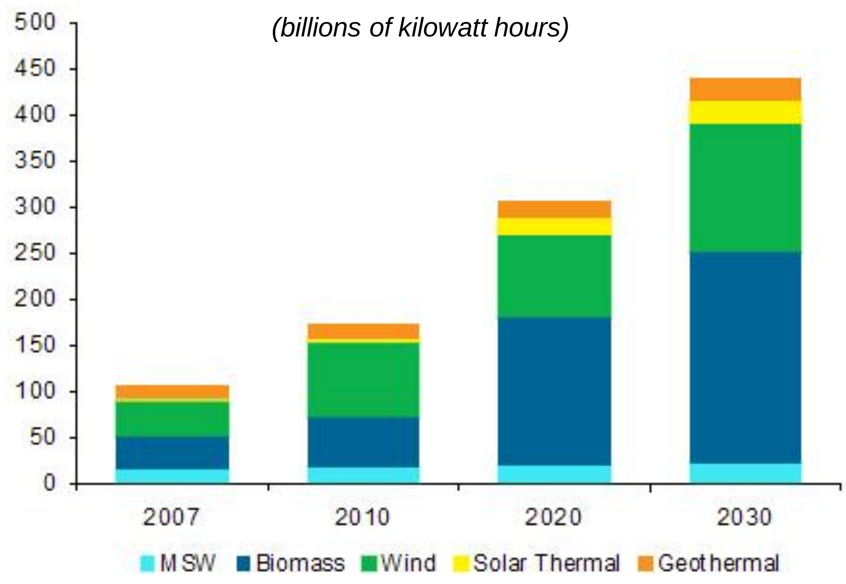
US Renewables – Biomass is Growing

- The EIA Annual Energy Outlook for 2010 projects that the demand for renewable energy will experience robust growth through 2030
- Biomass will account for a significant portion of incremental demand

Current U.S. Energy Supply[1]



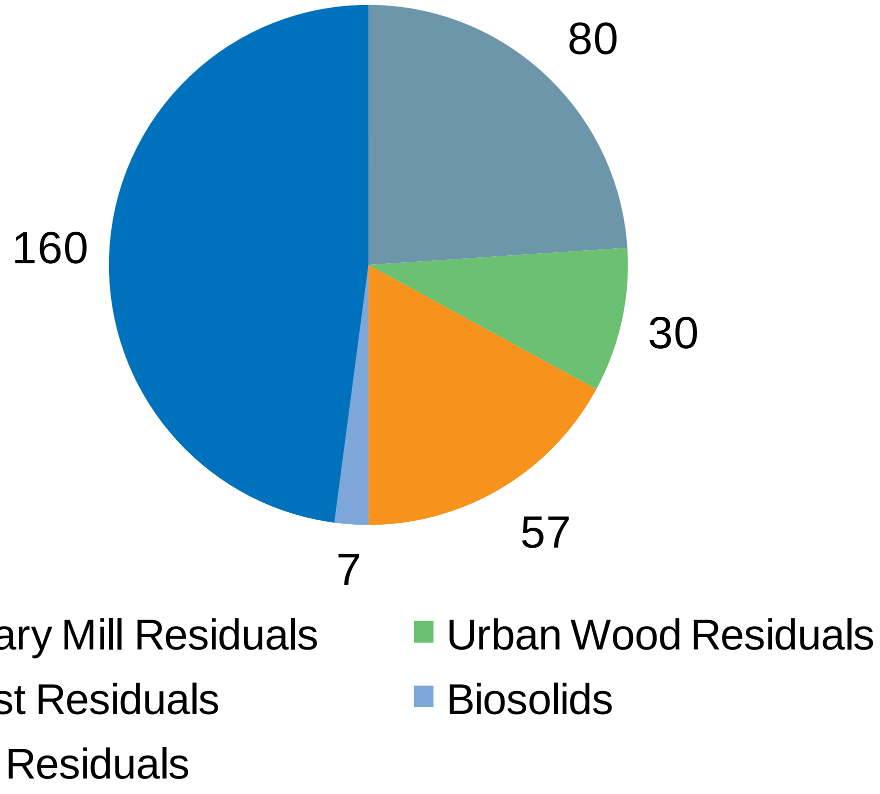
U.S. Renewables Forecast[1]



1 *EIA Annual Energy Outlook 2010.*

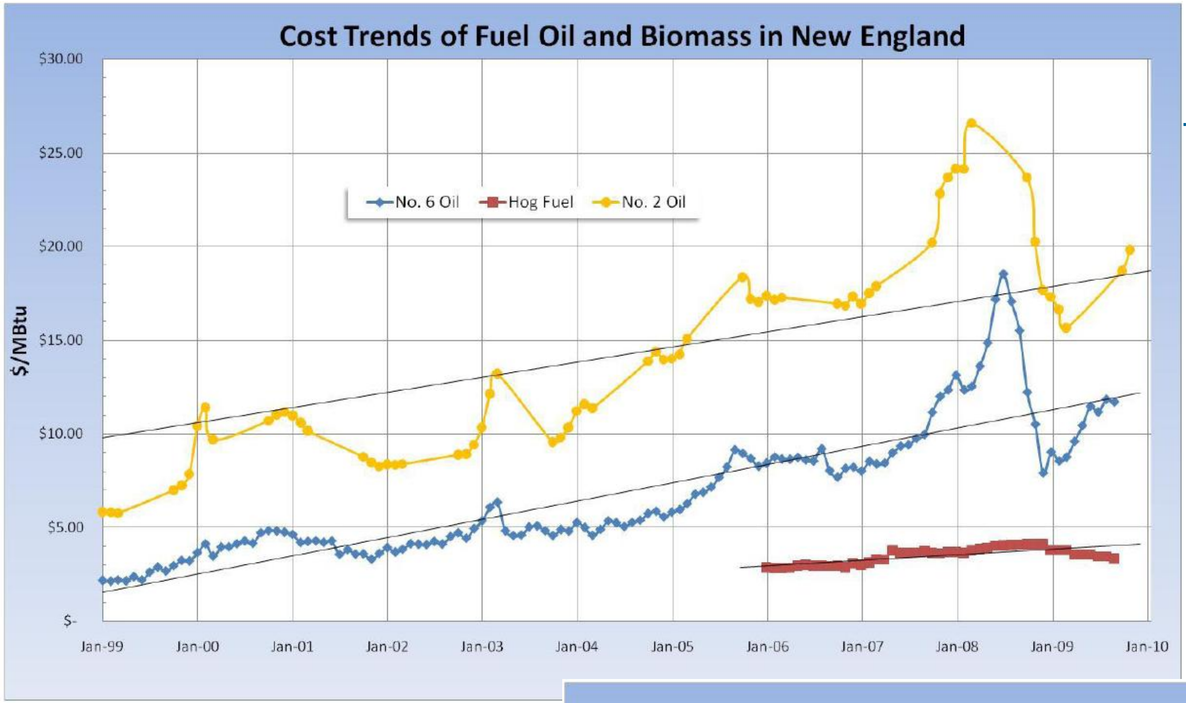
Widely Available Supply of NA Biomass

U.S. Volume of Biomass (millions of tons/year)



1 million bone dry tons of wood/yr = 150 MW
e.g. Urban Wood (MBDT/Y) = 4,500 MW

Source: National Renewable Energy Laboratory.

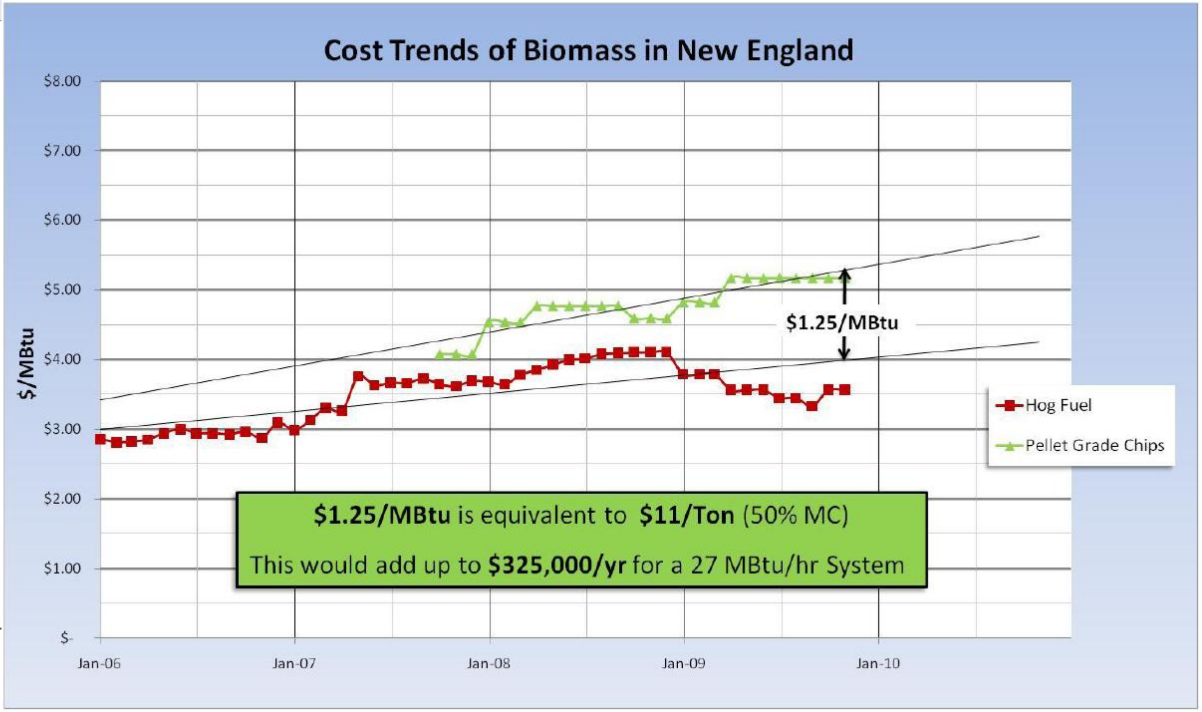


Wood Biomass Cost Advantage

25-50% of Fossil Fuels

Fuel Flexibility Advantage

25-50% lower



Opportunities and Challenges

OPPORTUNITIES

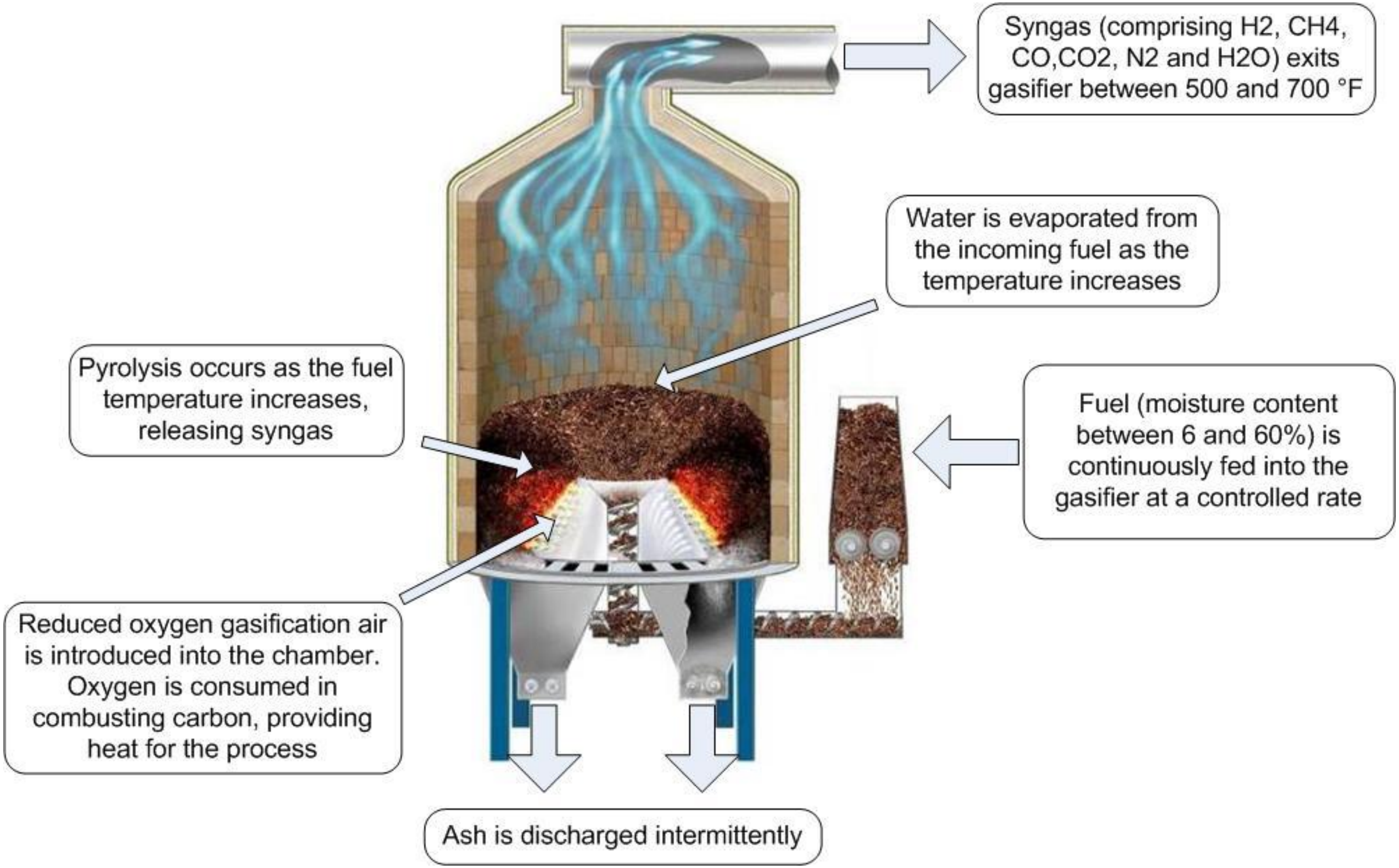
- Customers need alternatives to carbon based fossil fuels
- Organizations need energy security & fuel supply diversity
- GHG/sustainability goals place a premium on energy from renewable sources
- Carbon accounting is coming
- Government and other incentive programs (REC's, tax credits, etc.)
- Policy and regulatory consistency
- Biomass fuel supply markets are maturing

CHALLENGES

- Low fossil (natural gas) energy prices
- Biomass systems require operator training and acceptance
- Many projects are seasonal heating only versus continuous 7/24/365
- Customer perceptions about emissions, fuel supply, and scale
- Biomass energy projects are capital intensive
- 3rd party business models require innovation in procurement and contracting
- Mixed vendor performance history, "over sizing" and "over promising"

Overview of Nexterra Technology

Fixed-Bed Updraft Gasifier



Nexterra's Gasifier Technology – How it Works

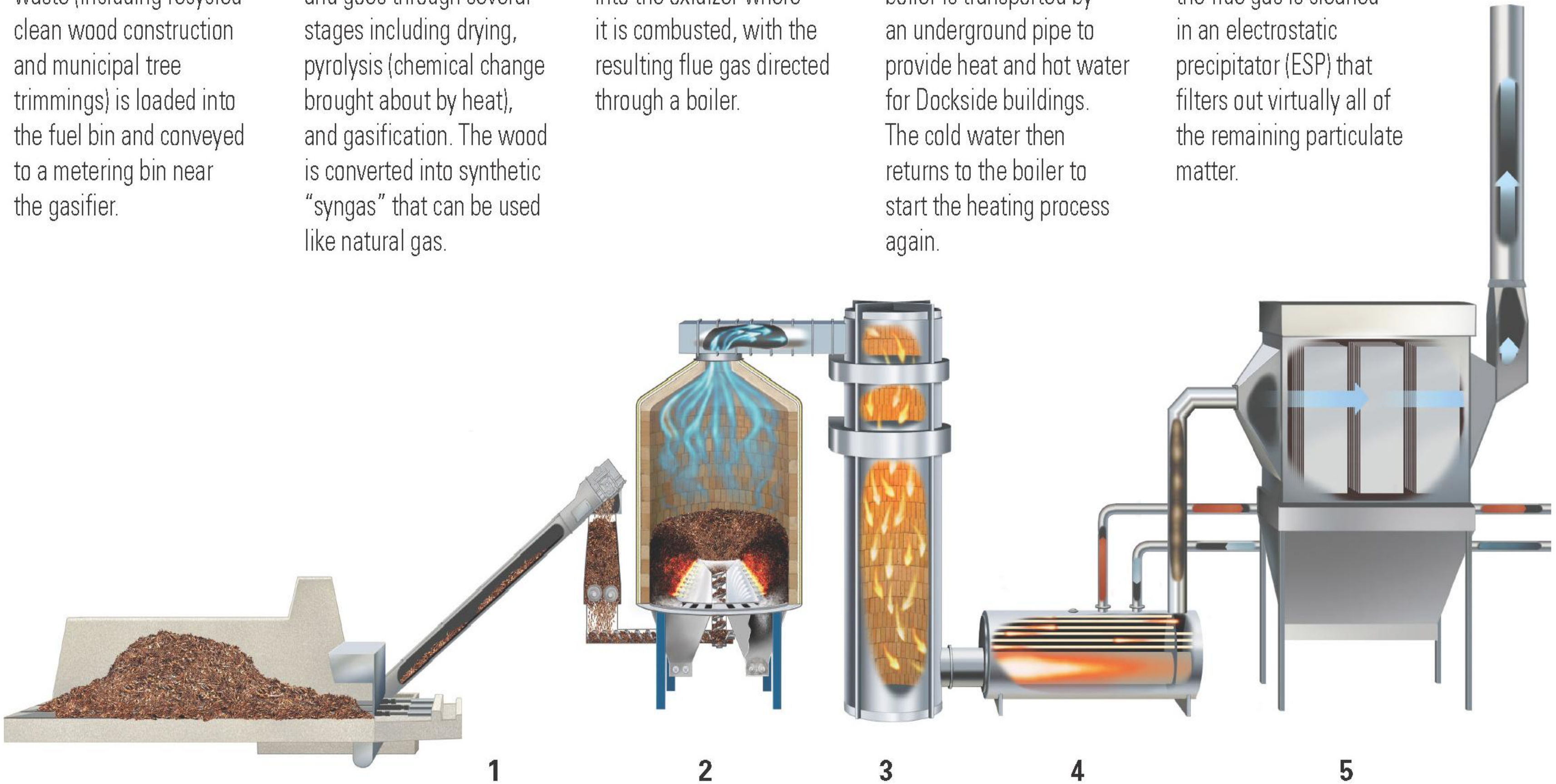
1. Fuel In-Feed
Locally sourced wood waste (including recycled clean wood construction and municipal tree trimmings) is loaded into the fuel bin and conveyed to a metering bin near the gasifier.

2. Gasifier
Fuel enters the gasifier and goes through several stages including drying, pyrolysis (chemical change brought about by heat), and gasification. The wood is converted into synthetic "syngas" that can be used like natural gas.

3. Oxidizer
The syngas is conveyed into the oxidizer where it is combusted, with the resulting flue gas directed through a boiler.

4. Boiler
Hot water from the boiler is transported by an underground pipe to provide heat and hot water for Dockside buildings. The cold water then returns to the boiler to start the heating process again.

5. ESP
After exiting the boiler, the flue gas is cleaned in an electrostatic precipitator (ESP) that filters out virtually all of the remaining particulate matter.



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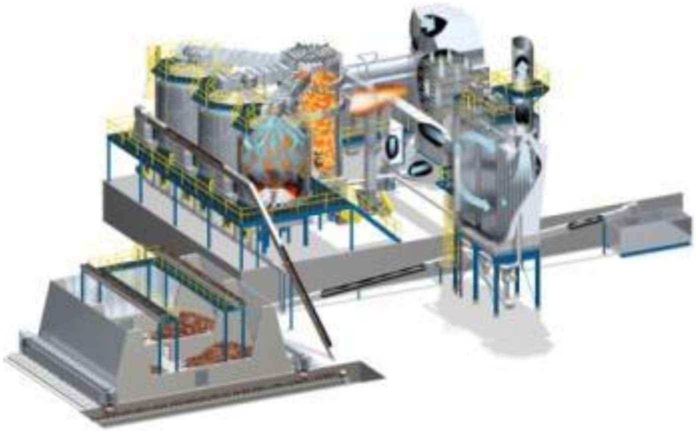
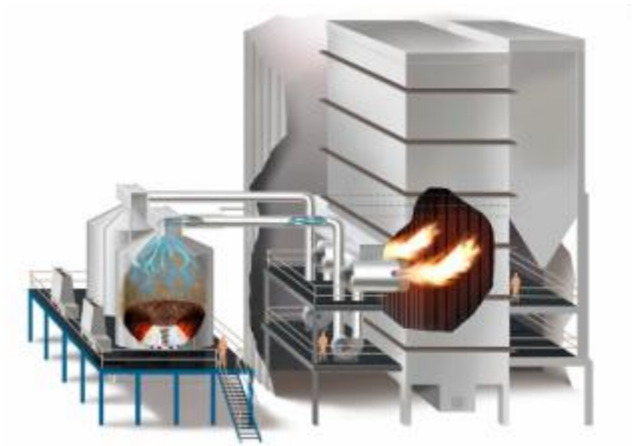
Standard Thermal System Configurations

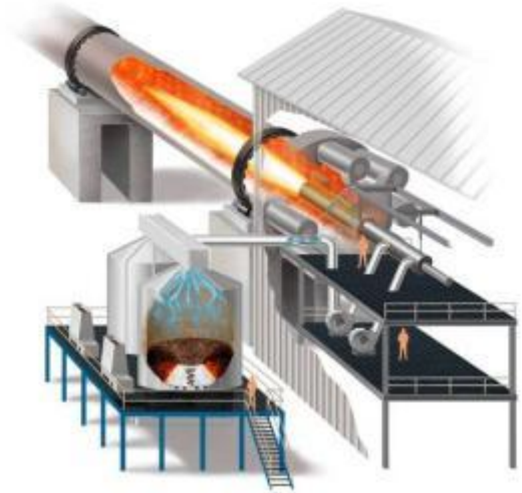


Greenfield - Gasification to steam or hot water
Standard configurations from 20 – 120 MMBtu/hr



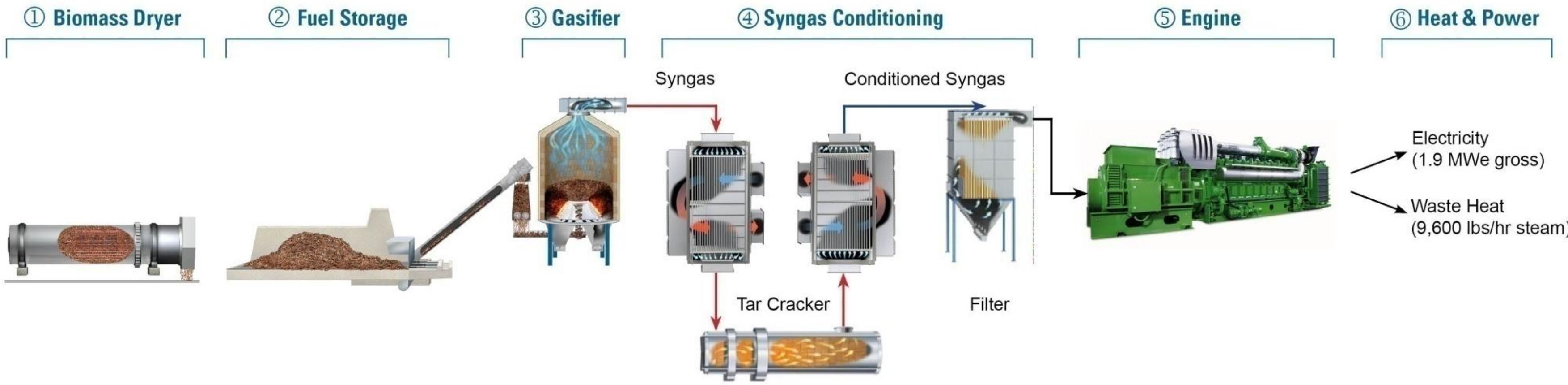
Retrofit - Gasification to direct-firing retrofitted boilers
Standard configurations from 20 – 120 MMBtu/hr

Greenfield - Gasification to steam power or steam CHP
Standard configurations from 2 – 10 MWe



Retrofit - Gasification to direct-firing retrofitted lime kilns
Standard configurations from 20 – 120 MMBtu/hr

Stationary Engine Biomass CHP System



<u>Nexterra Gasification and Conditioning plus GE Engine Technology</u>

- Game-changing technology for biomass power systems
- Combined Heat and Power Efficiency of 60%
- Economic at small-scale 2 – 10 MWe
- More efficient than conventional steam power generation
- Firm, base load green energy
- No steam engineers, closed loop--no water use
- Emissions comparable to natural gas

GE Energy

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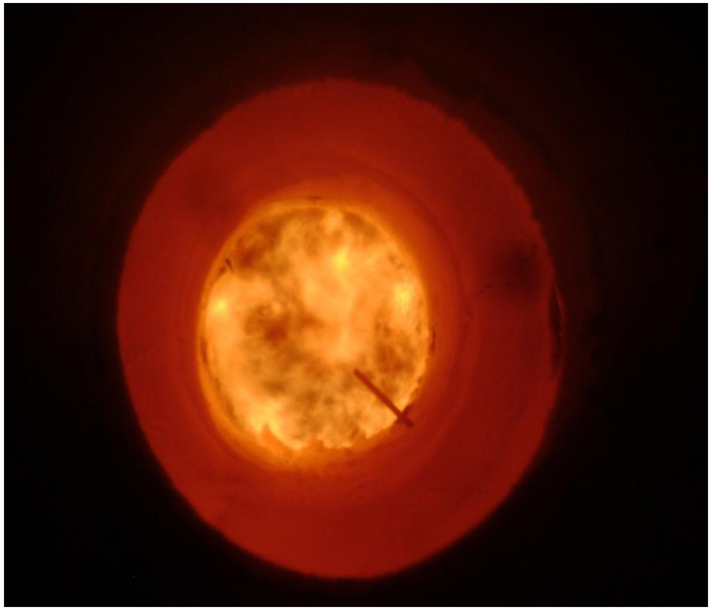
Management of Syngas Combustion

Combustion chamber

- Syngas combustion in the oxidizer indicates low char and particulate carryover
- Close control of syngas combustion parameters is possible



Exhaust stack

- Visually clean stack emissions
- Low particulate matter
- Emission controls to suit local permit requirements

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Gasification Technologies

.5 MW Gasifier

Plasma Gasifier

Plasma torch temperatures approach 5000 deg. C

Claim to support production liquid fuels and chemical feedstocks

Biomass Feedstocks

Possible Feedstocks for Gasification

- Woody Biomass – forest products & residuals, crop trees, urban wood waste
- Agricultural Waste – corn stover, oat/rice hulls, bagass, etc.
- Organic MSW – food waste, yard waste, FOG’s (fats, oils, greases)
- Animal Waste – poultry litter, livestock manure
- Biosolids – sludge from municipal wastewater treatment operations
- Algae, Kelp, Seaweed

  - Various alternative fuels for gasification are possible. Issues include:
    - Availability, reliability & cost – long term supply
    - Drying & handling the fuel
    - Emissions & operational characteristics
    - Project economics & risk

Typical Wood Fuel Sources

Urban Wood Waste

Examples: Pallets, Landscape trimmings, C&D

Uses: landfill, bioenergy

Costs: $0 - $40/bdt

Forest Residues

Examples: Bark, tree tops, thinnings

Uses: Bioenergy, Mulch

Costs: $20 – 40/bdt

White Wood

Examples: Chips, Sawdust

Uses: Pulp and Paper, Pellet mills, animal bedding, liquid fuels

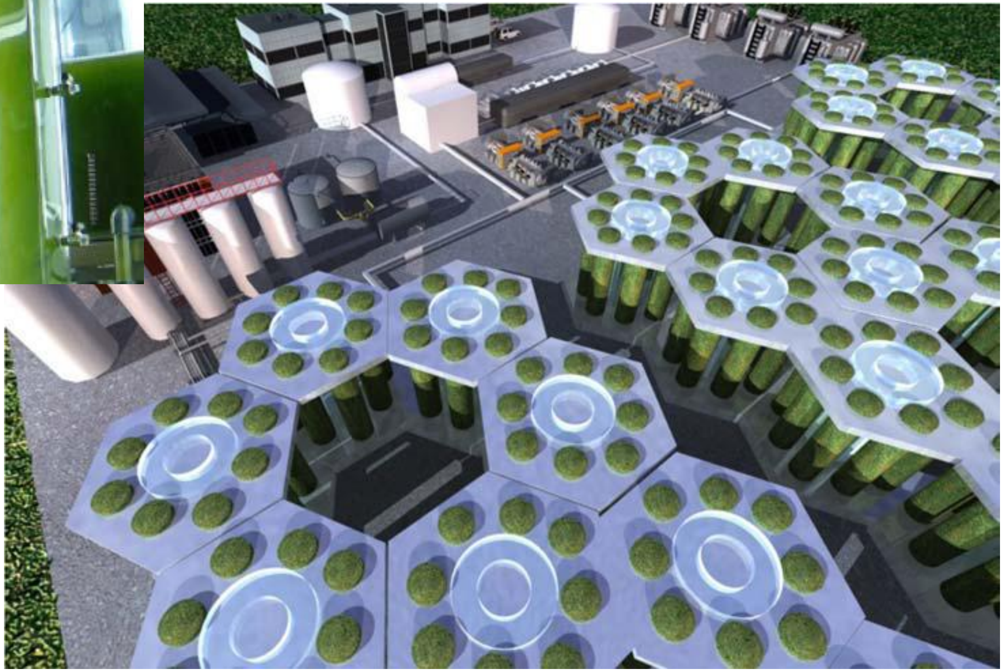
Costs: $60 - $80/bdt

Increasing Cost & Competition for Supply

Algae as a Fuel Source

Algae growth columns in lab setting.

Control of biomass composition to support production of chemical feedstock using Fischer-Tropsch process.



Concept of algae growth farm

Biosolids Gasification

- Gasification has been discussed in many forums as a strong candidate to resolve the issue of biosolids management (Furness, Hoggett, & Judd, 2007)

- Dried biosolids heating value and other performance characteristics are similar to woody biomass

- Trials were completed using 90,000lbs of biosolids at the Nexterra Product Development facility using a fixed bed updraft gasifier

- For the trial, no modifications were made to existing plant or layout

- Fuel was manually loaded into gasification feed system by Bobcat front end loader and presented no handling challenges

Sample Projects

TOLKO INDUSTRIES LTD.

Tolko – Heffley Creek Kamloops, BC

- Plywood Plant
- Annual Savings: $1.5 MM
- GHG Reduction: 12,000 tpy
- Operational since May 2006

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DOCKSIDE GREEN

Dockside Green – Victoria, BC

- District Heating & Hot Water – 8 MMBtu/hr
- Fueled with Urban Wood Waste
- LEED platinum development
- Started up May 2009

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Kruger

Kruger Products Tissue Mill – Vancouver, BC

- 40,000 lbs/hr gasification system
- Displaces 400,000 GJ/yr of natural gas
- Lowers GHGs by 20,000 tonnes/yr
- Operational December 2009

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Conclusions

Benefits of Biomass Gasification Projects

1. Lower operating cost or budget neutral
2. Fuel price stability
3. Energy security
4. Reduced GHGs
5. Sustainable fuels management solution
6. Economic development & local job preservation
7. Opportunity to renew & re-capitalize infrastructure
8. Innovative financial models & structures
9. Grants & incentives may be available
10. On-site renewable energy vs. buying REC's

Thank You

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