



Bioenergy Technology for the Eastern Sierras Fuel Reduction Activities



Long-Term Solutions w/Emphasis on Bioenergy



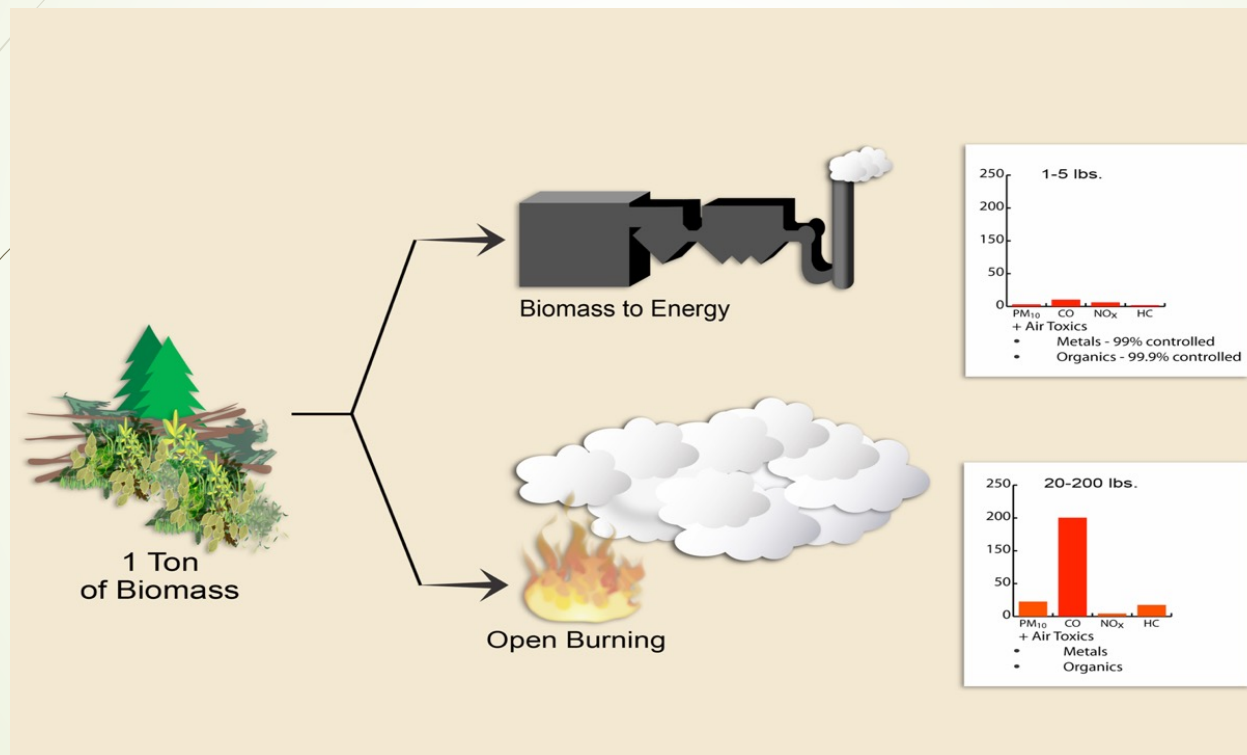


Key Considerations Regarding Bioenergy Facility

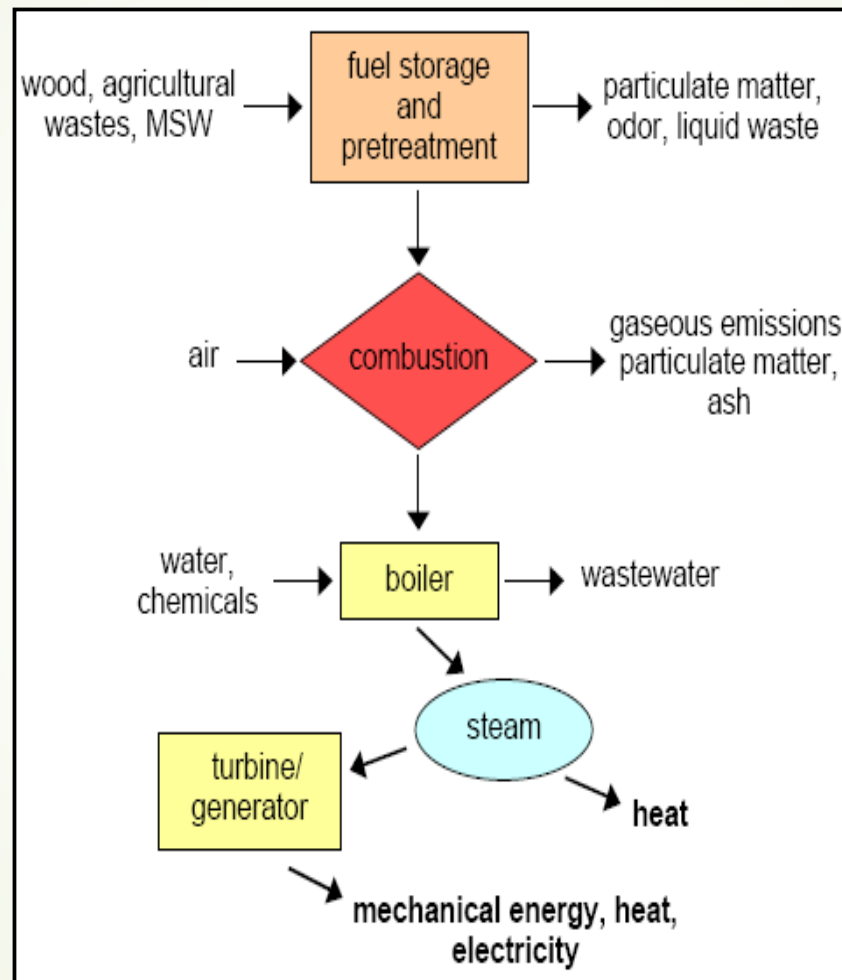
	Timber Harvest Residuals (BDT/Yr)	Forest Fuels Reduction (BDT/Yr)	Forest Products Manufacturing Residuals (BDT/Yr)	Urban Wood (BDT/Yr)	Powerline Corridor Maintenance (BDT/Yr)	Totals (BDT/Yr)
Potentially Available	1,961	28,000	360	1,864	350	32,535
Practically Available	1,765	25,800	360	1,678	245	29,848

Feedstock Type	Low Range (\$/BDT)	High Range (\$/BDT)	Average Delivered Price to Mammoth Lakes (\$/BDT)
Timber Harvest Residuals	\$50.00	\$55.00	\$52.50
Forest Fuels Reduction	\$46.00	\$56.00	\$51.00
Forest Products Manufacturing Residuals	\$10.00	\$20.00	\$15.00
Urban Wood	\$10.00	\$20.00	\$15.00
Powerline Corridor Maintenance	\$5.00	\$10.00	\$7.50

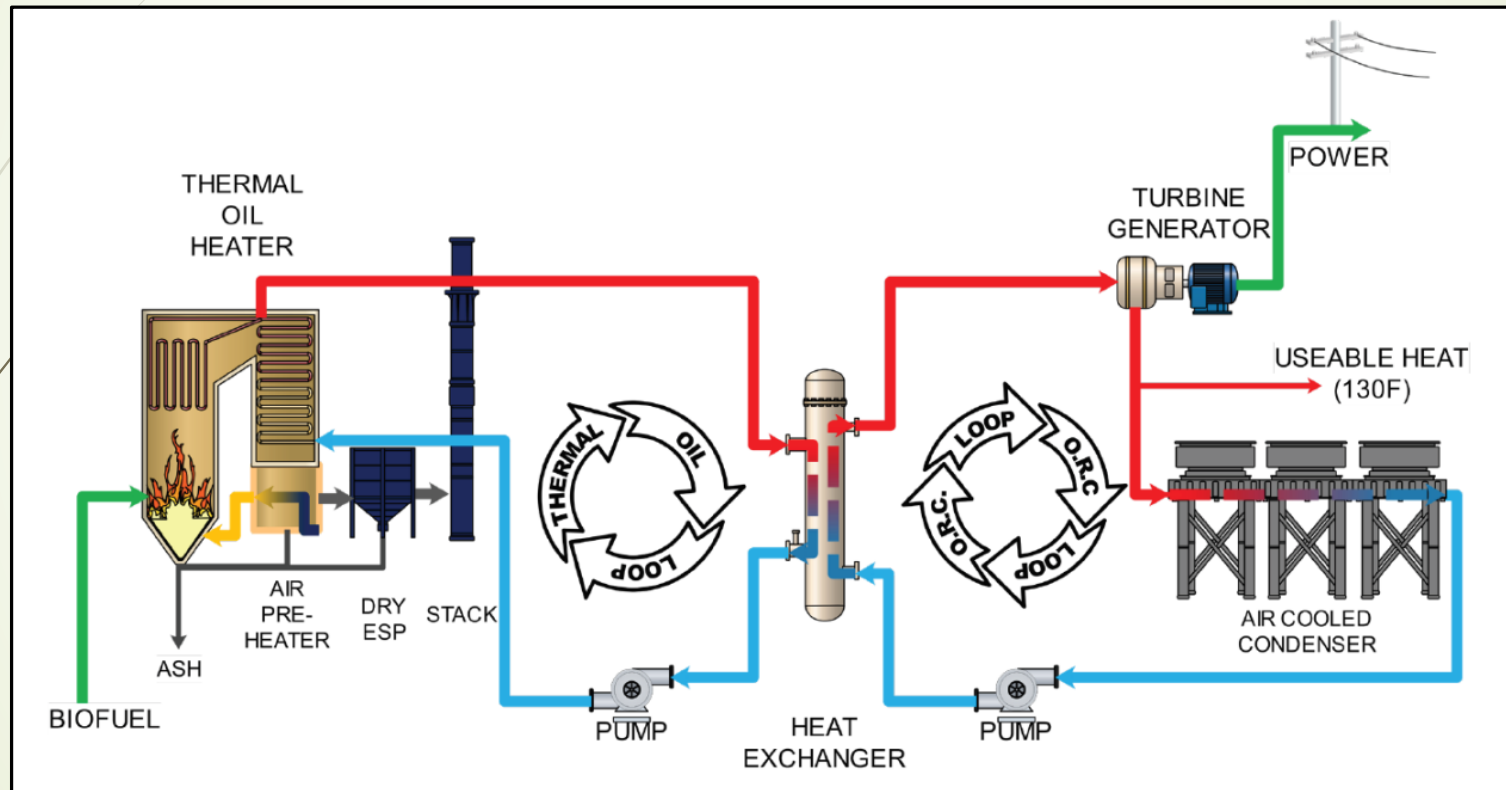
Woody Biomass Energy Production - Reduces Overall Emissions from Open Burning



Direct Combustion

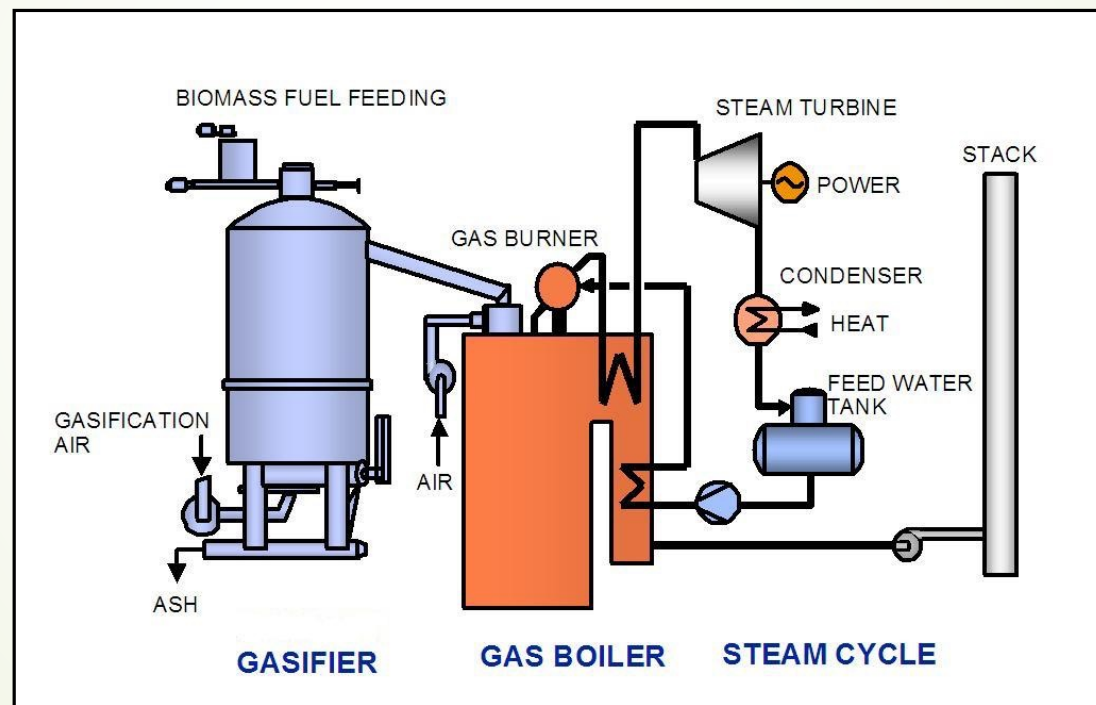


Direct Combustion w/ORC

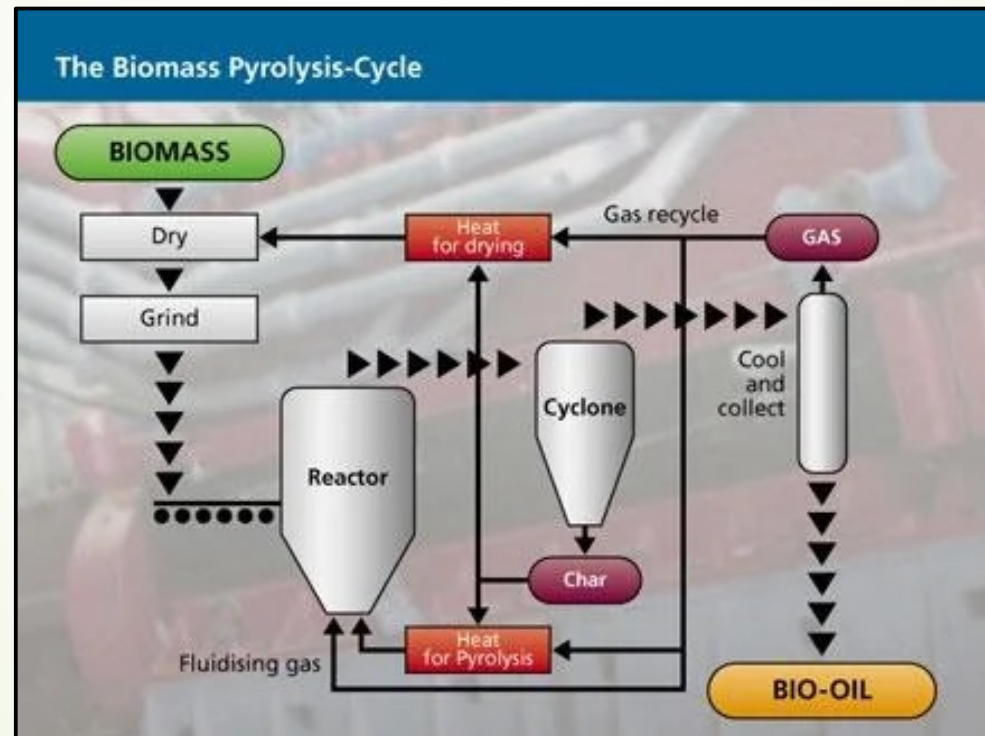


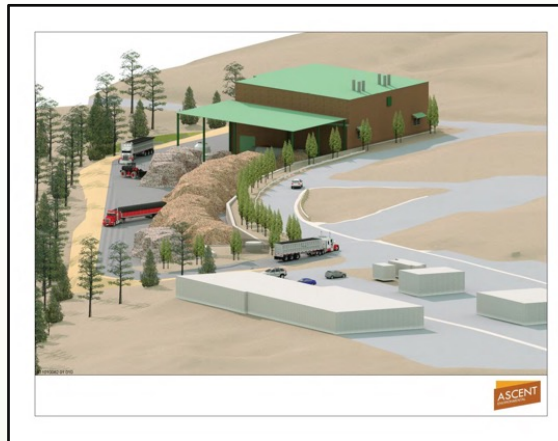
Gasification

Gasification converts biomass to a combustible gas (a.k.a. syngas)



Pyrolysis



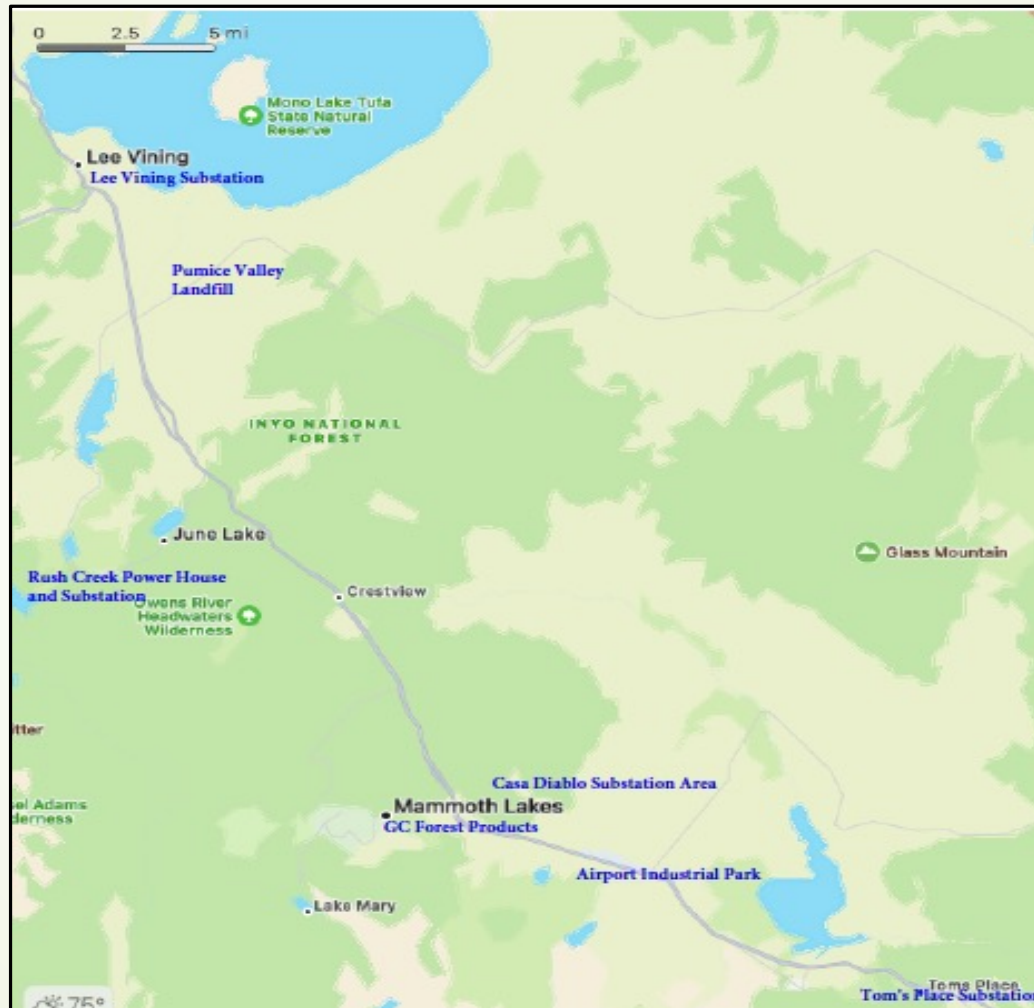




Facility Siting Review & Selection

- Lee Vining Substation
- Pumice Valley Landfill and Transfer Station
- Rush Creek Powerhouse June Lake
- GC Forest Products, Mammoth Lakes Industrial Park
- Casa Diablo Substation
- Airport Industrial Park
- Tom's Place

Site Locations



Casa Diablo Site



ORMAT ORC





Bioenergy Market Adjusting Tariff **BioMAT**

Category 3: Byproducts of Sustainable Forest Mgmt.

- Biomass from forest byproducts derived from fire threat reduction, infrastructure clearance projects or sustainable forest management activities.

Current price (11/2021):\$0.1997/kWh
This is the maximum price

Project Participation and Project Development

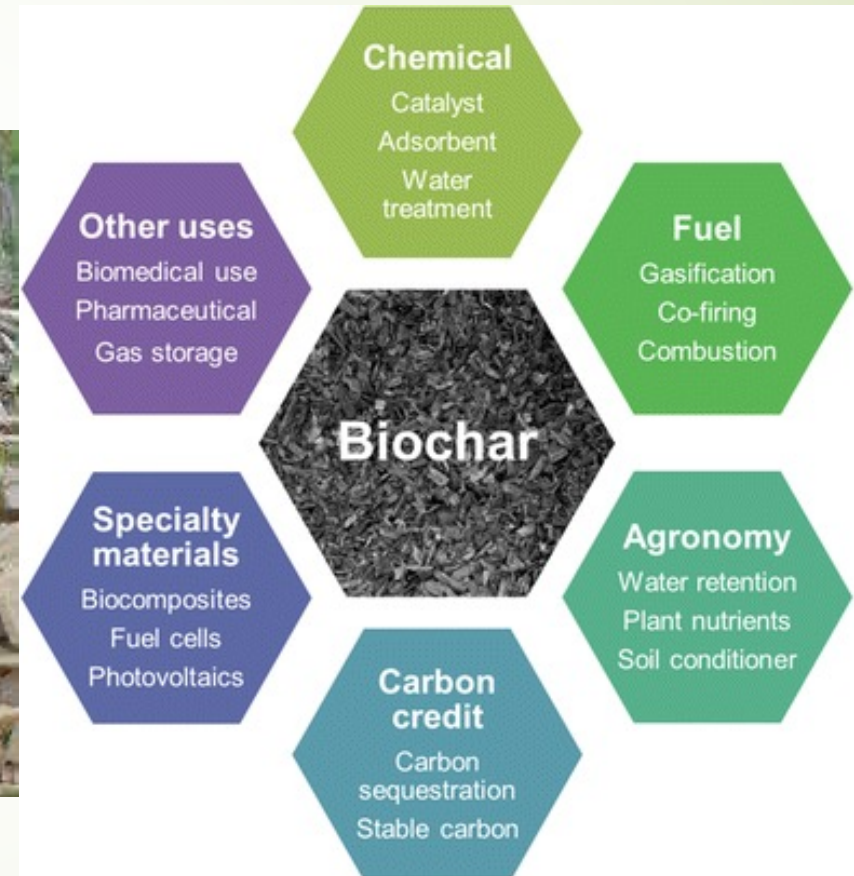
Requirements to prepare for the BioMAT auction include:

- System sizing based on sustainable feedstock availability;
- Technology and vendor selection;
- Site Control;
- Negotiate Memorandum of Understanding (MOU) for project development roles and responsibilities; and
- IOU System Impact Study for interconnection.

Additional pre-development work includes:

- Feasibility Study;
- Review site zoning and apply for a Conditional Use Permit (CUP) if necessary;
- Contract feedstock (if necessary); and
- Detailed financial model and plan to acquire financing.

Biochar



Mid-Term Biomass Storage

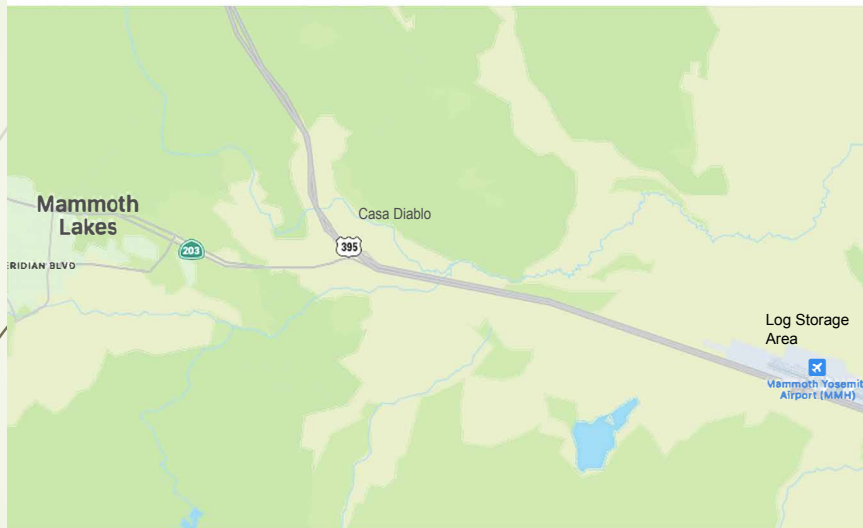


Table 1. Biomass Utilization Technology Companies

Company	Website & Contact Information	Technology Product(s)	Technology Maturity ¹	Experience with Woody Biomass/Project Locations
Earthcare	www.earthcare.com Mike McGolden mikemcgolden@gmail.com	Earthcare uses gasification to produce heat, steam, and electricity as well as biochar.	TRL: 7 - 8	Technology being considered by Town of Mammoth Lakes to use forest biomass and possibly other organic wastes.
EQTEC	www.Eqtec.com Jeffery Vander Linden jvanderlinden@eqtec.com	Gasification of biomass to create hydrogen, biochar, Renewable Natural Gas(RNG), Heat and Electricity.	TRL: 8	50,000 ton/year plant in Spain operating 7,500-8,000 hours per year since 2010. Produces 5.9 Mw electricity and heat. Plant in North Fork CA producing 2 Mw electricity and heat using forest wood. Operational in 2002. Numerous plants in Europe.



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Bio-Gas Energy (gasification)	www.biogas-energy.com Brian Gannon bgannon@biogas-energy.com	<i>Electricity Only</i> Small modular gasification systems plumbed together. Vendor reports 1.8 MWh of electricity generated per BDT of wood.	TRL: 9 Using commercially available 70 kW gasification system (with IC engine)	Yes, with urban, agricultural, and forest wood. 1.75 MW facility in development
Brad Thompson Company	www.bradtco.com Paul Sicurezza pauls@bradtco.com 360-635-7005	<i>Gasification</i> ; Bubbling Fluized Bed/close-coupled or Reciprocating Grate Stocker. Either can be set up to produce bio-char.	Electricity (8-9) Liquid/Gaseous fuels (7)	Urban wood, Ag wood, and Forest wood. Have ongoing and proposed projects using agriculture waste.
Char Technologies	www.Chartechnologies.com Andrew Friedenthal afriedenthal@chartechnologies.com	High Temperature Pyrolysis & WGS/Methanation to produce Renewable Natural Gas (RNG) and Biochar	TRL of 8-9. Will have TRL 9 project in Europe by end of summer	Experience with urban wood, Agriculture wood, and forest wood. At Kirkland Lake, 72K tons per year of wood waste into RNG; at St. Felicien, 36K tons per year of wood waste into Syngas & Biochar; at Obispo Hitachi Zosen Inova, 18K tons per year of digestate into Green Hydrogen & Biochar.

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Air Burners	www.airburners.com Michael Schmitt 772-220-7303 Office 772-631-8140 Cell	Biomass burner which uses a small diesel fueled engine to safely burn biomass leaving only carbon ash and biochar. Reduces particulate matter emissions by 80 to 90% over open pile burning.	TRL: 9	Will burn most any type of biomass including forest and agriculture biomass. No chipping or grinding required. Will take whole logs as long as they fit in firebox.
Aries Clean Energy	www.ariescleanenergy.com Joseph Renergy Gary Darling	<i>Electricity only</i> Gasification process with Organic Rankine Cycle engine/genset used to make electricity. Did not state how many BDT needed per MW (assume rule of thumb – 1.5 BDT per MW hour for ORC generators)	TRL: 7 to 9 Aries has existing commercial unit but continues to conduct engineering work to improve overall systems.	Yes, with urban, agricultural, and forest wood. Operating projects in TN and FL. Projects in various stages of development in CA.

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Company	Website & Contact Information	Technology Product(s)	Technology Maturity ¹	Experience with Woody Biomass/Project Locations
Sierra Energy	www.sierraenergy.com Michael Kleist mkleist@sierraenergy.com	<i>Electricity</i> Current modular design of 1 MW units. Conversion is about 1 BDT per MW. <i>Biofuels</i> Can produce diesel as liquid fuel, and hydrogen as gaseous fuel. Sierra Energy reportedly can produce hydrogen as gaseous fuel, creating about 50 kg of hydrogen per BDT.	TRL: 5 to 7. Demonstration plant constructed and undergoing commissioning, producing both electricity and biofuels	Yes, with urban, agricultural, and forest wood. 25 tons a day demonstration facility currently located in Central CA. Construction and demonstration funded in part by CA Energy Commission, and U.S. Department of Defense
Wellons	www.wellons.com Rob Broberg Rob.Broberg@wellons.com	<i>Electricity and Process Steam</i> Direct burn with a product yield of 1,000-1200 kwh per bone dry ton of biomass. System efficiency of about 50% for straight condensing system. Much higher efficiency if waste heat is recovered and utilized.	TRL for electricity: 9	Yes, with urban, agricultural, and forest wood. 350 energy systems around the world operational. Currently one system under construction and eight systems proposed each with a high probability of success.



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Company	Website & Contact Information	Technology Product(s)	Technology Maturity ⁷	Experience with Woody Biomass/Project Locations
West Biofuels	www.westbiofuels.com Matt Summers matt.summers@westbiofuels.com	<i>Electricity</i> Direct combustion process with Organic Rankine Cycle engine/genset used to make electricity 500 kw to 5 MW 750 kWh per BDT <i>Biofuels</i> Significant R&D has been conducted with Bioenergy 2020+, University of Vienna, UC San Diego, and UC Davis on hydrogen, renewable natural gas, renewable diesel, and mixed alcohol synthesis	TRL for electricity: 7 to 8. Demonstration unit at West Biofuels research and development facility in Woodland, CA TRL for biofuels: 5 to 7. Pilot demonstrations in Woodland and Austria	Yes, with urban, agricultural, and forest wood. Currently developing 3 MW electricity project in Northern CA using forest sourced wood. Partially funded by the CA Energy Commission (\$5MM). Also developing 3 MW facility using rice hulls in Northern CA. For biofuels, just completed a CA Energy Commission (CEC) funded (\$1MM) R&D mixed alcohol synthesis project, CEC funded (\$1MM) RNG R&D project, and are actively working on a bio-oil to jet fuel project with NREL (\$3M CEC funded)

Technology Developers

- Aries Clean Energy – Electricity via direct combustion and ORC
- Engemann – Electricity via direct combustion steam cycle (or ORC)
- Eqtec – Electricity via gasification and ORC
- West Biofuels – Electricity via gasification or direct combustion and ORC
- Earthcare – Gasification to produce heat, steam, electricity, and biochar

Project Essentials

Technologies	Direct Combustion or Gasification
Site	Casa Diablo - ORMAT
ORC	Must be able to use ORMAT manufactured ORC
BioMAT	Key to economic feasibility
Mid-Term Storage	Airport or? Even with ORMAT as site, still need large area to store logs and chip material for transport to ORMAT facility
USFS Stewardship Contract	Essential to attract developers
Facility size	2.5 MW for export via BioMAT PPA



Technology Developer Information



Company	Aires	Engemann	EQTEC	West Biofuels (Gasification)	West Biofuels (Direct Combustion)	Earthcare
Tech Products	Direct Combustion electricity via ORC	Direct Combustion electricity via steam cycle	Gasification to create hydrogen, RNG, heat or electricity	Gasification electricity via ORC	Electricity-Direct Burn- Thermal Oil heater drives ORC	Gasification to produce heat, steam, electricity, biochar
Tech Maturity	7,8,9	9	8	7,8	8,9	7,8
Conversion Rate	1 to 1.25BDT/MW					
Experience Woody Biomass	Yes, multiple operational facilities	Yes, numerous operational facilities	Yes, multiple operational facilities	Yes, multiple	Yes, multiple	Not yet. TOML is considering
Permitted Facility in CA	in development CA	in development CA 5 MW Nor Cal	North Fork, CA -2 MW	in development, 3 MW	in development, 3 MW	No
Production Cost	Feedstock dependent, tipping fee?	Not provided	Not provided	\$.12 kWh, offsets by BIOMAT	\$.12 kWh, offsets by BIOMAT	Not provided, tipping fee likely required
Capital Cost (assuming 2.5 MW)	\$15-17.5 M	\$20-\$25 M (5MW plant)	\$17.5-\$20 M	\$12.5-15 M	\$12.5-15 M	\$15.5M
Op & Maintenance Costs (annual)	\$570-\$665 K annually	Not provided	Not provided	\$500-\$750K	\$375-\$750k	\$820 gasifier O&M + \$250K annual biomass & ORC
Marketable Byproducts (assume low biochar market rate of \$250 /ton with @9K of feedstock)	Biochar (10% feedstock) \$725K yearly	Biochar (5% feedstock) \$363K yearly	Biochar (10% feedstock) \$725K yearly	Biochar (15% feedstock) \$1.1M yearly	Biochar (10% feedstock) \$725K yearly	1.25 MW and 5,000 tons of biochar annually \$1.25MM yearly
Operating Requirements (per shift)	1 operator/shift, 1 yard operator/ shift + mgmt. + admin staff	1-2 operators (w/ automated remote support)	2-3 staff per day, 2 staff per night shift	2 operators/shift, 1 yard operator + mgmt. + admin	2 operators/shift, 1 yard operator + mgmt. + admin	1-2 operators
System Efficiency	80%	?	Not provided	70-80%		Not provided
Parasitic Load	10%	?	Not provided	10%	10-12%	Not provided
Site Requirements (station) acres	1	Not provided	1-2	.5-1	.5-1	1-2
Site Requirements (feedstock) acres	2	Not provided	2-5	3	3	2-3
Environmental Considerations	Emissions control by BACT. Some wastewater. Minimal water supply needed. No solid waste generated.	Not provided, likely air quality impacts from direct combustions & Water requirements for steam turbine	Not provided, if electricity produced via gasification, emissions = significant impact	System uses gasification syngas in oil heater, and an emergency flare. No water needed and no wastewater discharge. No solid waste.	Direct combustion emissions controlled by Selective eNon-Catalytic Reduction (for NOx). PM control via multi clone sandbag house. Can meet ODEQ air emissions criteria.	Not provided, if electricity produced via pyrolysis, emissions = significant impact
Design Services	Yes	Yes	Yes	Yes	Yes	Yes
Design /Build	Yes	Yes	Yes	Yes	Yes	Yes
Design/Build/Operate	Yes	Yes	Yes	No	No	Yes

Bioenergy Pre-Development Tasks

	Pre-Development	
1	Select potential bioenergy developer and working with developer conduct the following activities	
2	Develop site control - Working the site's landowner/manager, to secure site. If federal land, conduct the necessary steps to garner a long-term lease and NEPA review	
3	Develop feedstock procurement plan and implement - Agreements/contracts with feedstock suppliers	
4	Conduct electrical grid interconnection process - Using the utility's Rule 21 interconnection process	
5	Prepare and submit application for interconnect and System Impact Study (SIS - conducted by the utility)	
6	Develop enough information to be able to apply for a BioMAT Power Purchase Agreement (PPA)	
7	Conduct BioMAT Program Participation Request to receive BioMAT PPA	
8	NEPA review for project if sited on federal land, CEQA review if sited on non-federal land	
9	Secure air quality permit from Great Basin Air Pollution Control District	
	Construct bioenergy facility	

