SMALL MODULAR BIOMASS SYSTEMS REVIEW AND DEMONSTRATION

Sacramento Municipal Utility District Presentation

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SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.SM

SACRAMENTO STATE

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PROJECT OVERVIEW

- Review pertinent state-of-the-art and opportunities of emerging small modular biomass conversion systems (50 kw or less) using low moisture biomass fuels
- Assess costs, performance and market characteristics (e.g. supply curves) of applicable small modular biomass conversion systems;
- Determine potential sites for demonstration and deployment;
- Evaluate economic feasibility of promising small modular biomass conversion systems;
- Deploy and demonstrate the best candidate technology within the SMUD service territory.

STATE-OF-THE-ART REVIEW

- TSS Consultants identified 18 technology providers with pertinent equipment. A request of information was developed to facilitate the aggregation of information across three principle categories:
  - Technical specifications
  - Operational specifications
  - Company specifications

- RFI sent to technology providers, with 8 companies responding
  - All Power Labs, Berkeley, CA
  - Borealis Wood Power, Ontario, Canada
  - Holzvergaserwekstatt, Bunde, Germany
  - Superior Gasification, Lees Summit, MO
  - Tactical Woodgas, Nine Mile Falls, WA
  - Trillion, Singapore
  - Volter, Kempele, Finland
  - Vulcan Gasifier, Muskegon, MI

TECHNOLOGY SCORING CRITERIA

Scoring Criteria	Weight Factor	Score	Description
Factors Addressing Capital Cost and Payback Period (30%)			
Unit Size	5%	0	No gasifiers < 100kW
		1	Gasifier is outside of 15 – 85 kW
		2	Gasifier is outside to 30 – 70 kW
		3	Gasifier is in the range of 30 – 70 kW
Waste Heat Recovery	5%	0	No waste heat recovery information provided
		1	Waste heat recovery options provided, no heat value
		2	Waste heat recovery options provided, kWth/kWe ≤ 1
		3	Waste heat recovery options provided, kWth/kWe > 1
Biochar Production & Handling	5%	0	No biochar production or handling information provided
		1	Biochar >20% of feedstock
		2	Biochar < 20% of feedstock with manual removal
		3	Biochar < 20% of feedstock with automatic removal
Grid Interconnection	5%	0	No interconnection information provided
		1	Specified for off-grid use
		2	Custom interconnection equipment
		3	Standard interconnection equipment
Unit Price	10%	0	No price information provided
		1	Price exceeds $10/W
		2	Price is between $5/W and $10/W
		3	Price is below $5/W

TECHNOLOGY EVALUATION

Scoring Criteria	All Power Labs	Borealis Wood Power	Holzvergas-erwekstatt	Superior Gasification	Tactical Woodgas	Trillion	Volter	Vulcan Gasifier
Factors Addressing Capital Cost and Payback Period (30%)								
Unit Size (5%)	2	3	2	3	1	3	3	2
Waste Heat Recovery (5%)	3	3	3	1	1	1	3	1
Biochar Production & Handling (5%)	3	3	0	1	0	0	3	0
Grid Interconnection (5%)	3	3	3	2	1	2	3	1
Unit Price (10%)	3	2	2	3	3	0	2	3
Weighted Subtotal	**0.85**	**0.8**	**0.6**	**0.65**	**0.45**	**0.3**	**0.8**	**0.5**
Rank	**1**	**2**	**5**	**4**	**7**	**8**	**2**	**6**
Factors Addressing System Operations (45%)								
Syngas Composition (5%)	3	3	0	2	0	3	3	0
Syngas Cleanup (10%)	2	1	2	2	2	1	2	1
Feedstock Specifications (10%)	3	3	2	1	1	2	3	1
Feedstock Consumption (5%)	3	3	3	3	2	1	3	3
Metering Bin (5%)	1	2	3	3	1	0	3	1
System Maintenance (10%)	3	2	2	2	1	1	3	2
Weighted Subtotal	**1.15**	**1**	**0.9**	**0.9**	**0.55**	**0.6**	**1.25**	**0.6**
Ranks	**2**	**3**	**4**	**4**	**8**	**6**	**1**	**6**
Factors Addressing Air Emissions and Resources (15%)								
Water Use (5%)	1	2	1	1	1	1	1	3
Air Emissions (10%)	2	2	1	0	1	0	2	0
Weighted Subtotal	**0.25**	**0.3**	**0.15**	**0.05**	**0.15**	**0.05**	**0.25**	**0.15**
Rank	**2**	**1**	**4**	**7**	**4**	**7**	**2**	**4**
Factors Addressing Proven History (10%)								
Existing Facilities (5%)	3	2	0	0	1	2	2	0
Client References (5%)	3	3	0	3	0	3	3	0
Weighted Subtotal	**0.3**	**0.25**	**0**	**0.15**	**0.05**	**0.25**	**0.25**	**0**
Rank	**1**	**2**	**7**	**5**	**6**	**2**	**2**	**7**
Total (Points)	**2.55**	**2.35**	**1.65**	**1.75**	**1.20**	**1.20**	**2.55**	**1.25**

EVALUATION OF THREE FINALISTS

- Three finalists selected for further evaluation of technical, economic, environmental, regulatory, and institutional considerations.
  - All Power Labs
  - Borealis Wood Power
  - Volter

- Technical
  - Specific gasification rate
  - Interconnect
  - Feedstock requirements
  - References

EVALUATION OF THREE FINALISTS (CONT'D)

- Economics
  - System dimensions
  - Continuous run time
  - Mechanical automation
- Environmental/Regulatory/Institutional
  - Air emissions
  - Wastewater discharge
  - Warranty information
- All Power Labs selected as finalist

The All Power Labs Power Pallet can generate up to 18 kilowatts

DEMONSTRATION SITE SELECTION

- Preliminary Site Identification
  - Feedstock availability – feedstock cost, including delivery and storage can be significant
  - Staff availability – Cost of labor, especially with low power output, can quickly consume revenue
  - Value added – Revenue from low power output, even with biochar, is low therefore sites identified should try and achieve additional value, such as educational value or sustainability marketing.

- TSS identified the following categories of sites
  - Transfer and Processing Facilities
  - Institutional/Educational
  - Government

SITE SELECTION EVALUATION CRITERIA

- TSS evaluated the preliminary sites through a series of technical components, in-person correspondence with business representatives, and site visits. Sites were ranked according to the following criteria:
  - Expressed interest
  - Feedstock availability
  - Space availability
  - Staff availability
  - Value added potential
  - Interconnection potential
  - Electric rate schedule
- Site evaluation criteria were given a scoring range of generally 1 to 3, with the exception of “Expressed Interest” which was given a “Go/No go” score.

SELECTION MATRIX

Site Name	Weighting Factor	American River College	City of Sacramento Maintenance Services	Consolidated Pallet	Consumnes College	Florin Perkins Landfill	Folsom Lake College
Expressed Interest	Go/No-Go	1	1	0	1	0	1
Feedstock Availability	10%	1	3	2	1	2	1
Space Availability	20%	3	1	1	3	3	1
Staff Availability	20%	2	3	3	2	3	2
Value Add Potential	30%	3	2	0	3	0	3
Interconnection Potential	10%						
Electrical Rate Schedule	10%						
Total Score	100%	2.00	1.70	1.00	2.00	1.40	1.60
Rank		3	7	17	4	14	8

Site Name	Weighting Factor	Kiefer Landfill	L&D Landfill	Lopez Ag Service	Republic Elder Creek Road	Sacramento City College	Sacramento County NARS
Expressed Interest	Go/No-Go	1	0	0	0	1	1
Feedstock Availability	10%	2	2	2	2	1	2
Space Availability	20%	3	3	2	1	1	3
Staff Availability	20%	3	3	3	3	2	3
Value Add Potential	30%	2	0	0	2	3	2
Interconnection Potential	10%						
Electrical Rate Schedule	10%						
Total Score	100%	2.00	1.40	1.20	1.60	1.60	2.00
Rank		5	15	16	9	10	6

Site Name	Weighting Factor	Sacramento County Regional Parks	Sacramento International Airport	Sacramento Parks and Recreation	Sacramento State University	Sierra Waste	SMUD
Expressed Interest	Go/No-Go	1	1	1	1	0	1
Feedstock Availability	10%	1	1	1	1	2	3
Space Availability	20%	1	3	1	3	1	3
Staff Availability	20%	3	3	3	3	3	3
Value Add Potential	30%	2	1	2	3	0	2
Interconnection Potential	10%						
Electrical Rate Schedule	10%						
Total Score	100%	1.50	1.60	1.50	2.20	1.00	2.10
Rank		12	11	13	1	18	2

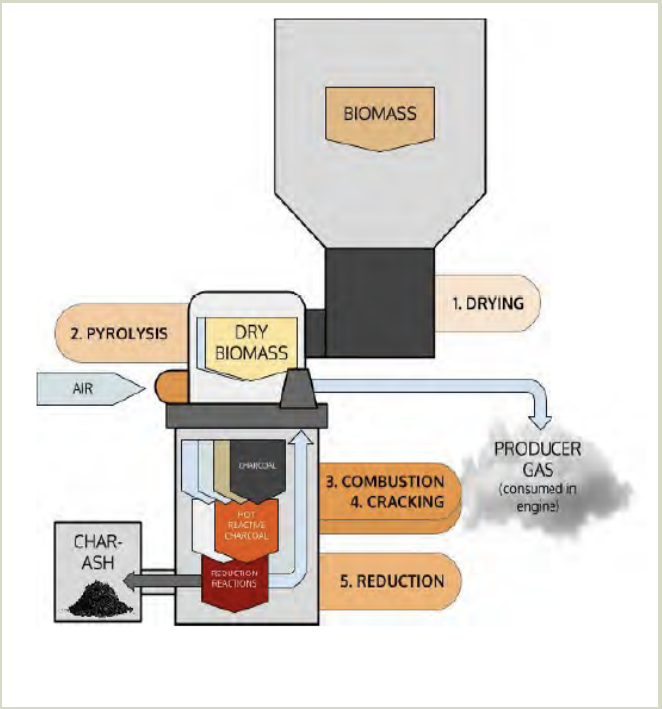
CANDIDATE SITE SELECTED

- California State University, Sacramento – Sustainable Technologies Optimization Research Center (STORC)

CSUS committed to build a structure to house the gasifier unit for testing and system refinement. This structure is to be in place late Summer 2017.

DEMONSTRATION OF SELECTED TECHNOLOGY

All Power Labs Power Pallet



DEMONSTRATION OF SELECTED TECHNOLOGY

DEMONSTRATION OF SELECTED TECHNOLOGY (CONT'D)

DEMONSTRATION OF SELECTED TECHNOLOGY - CHALLENGES

APL GASIFICATION SYSTEM PERFORMANCE DURING TESTING

Description	Units	Performance				
		Expected	Min.	Max.	Avg.	St. Dev.
Biomass Feed rate	lb/hr	46.8	19.8 (28.8)	89.5 (54.0)	43.4 (41.4)	16.1 (7.7)
Specific Gasification Rate	kg/m3 -hr	251	122.7 (179.2)	555.9 (335.5)	269.6 (256.9)	100.1 (47.7)
Biochar Rate	lb/hr	2.3	0.4 (0.5)	1.4 (1.4)	1.0 (1.0)	0.3 (0.3)
Biochar Production Rate	%	5	1.1 (1.5)	6.4 (4.9)	2.9 (2.8)	1.5 (1.1)
Air Emission (CO)*	ppm	70	0 (0)	766.0 (10.7)	26.0 (0.8)	102.7 (1.8)
Air Emission (NOx)**	ppm	3	0.5 (0.7)	334.1 (254.9)	84.0 (82.5)	62.7 (58.3)

Values in ( ) used a data set without the max and min recorded data.
*** Values in ( ) exclude runs 5 and 7 because of major excursions and run 6 because the catalytic converter was not on.**
**** Values in ( ) exclude run 6 because the catalytic convert was not on.**

CONTINUED DEMONSTRATION AND REFINEMENT OF TECHNOLOGY

- CSUS and SMUD are currently working on a Research and Development Collaboration Agreement:
  - Continue to operate the unit with undergraduate and graduate students as a hands-on learning tool
  - Continue emissions testing under various operating parameters
  - Integrate the gasifier system into a self sufficient renewable energy component for the STORC using students and staff to design and manufacture:
    - Wood chip grinder
    - Wood chip screener
    - Wood chip drying system
    - Automatic wood chip feeder

DEPLOYMENT OF SIMILAR SYSTEMS IN THE SMUD TERRITORY

- As previously mentioned 17 potential sites in SMUD territory were identified as candidate sites. There are likely many more.
- The continued testing, integration, and ancillary equipment development at CSUS will further assist in the deployment of these systems
- Currently the SMUD Biomass Program is developing "Smart Mechanisms" approach that SMUD can use to better capture the value of the environmental benefits of bioenergy projects, share costs with stakeholders, and allow for the economic use of woody biomass gasifiers in SMUD territory.