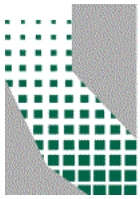

California Integrated Waste Management Board

April 2009

Contractor's Report

To The Board

Conversion Technologies Status Update Survey

California Environmental Protection Agency

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Governor

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Secretary, California Environmental Protection Agency

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Table of Contents

List of Tables

Acknowledgements

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- Jacques Franco, Contract Manager, CIWMB, Sacramento, California

Executive Summary

California communities and waste jurisdictions are exhibiting increased interest in alternatives to landfill disposal of municipal solid waste (MSW). Limited landfill space and increasing disposal costs are prevalent in some jurisdictions and regions in California. Siting new landfills is difficult and expensive and the public is generally not supportive of new or expanded facilities.

In addition, public policy goals and regulations encourage reduced landfill disposal through existing and future diversion requirements, improved long-term environmental performance, and the desire for lower greenhouse gas emissions from waste management systems. Some alternatives, e.g. conversion technologies (CT's), offer the opportunity to produce energy (some of it renewable) while reducing landfill disposal.

Several California jurisdictions are considering or actively investigating landfill alternatives and conversion technologies, including the City and County of Los Angeles, the City and County of Santa Barbara, Salinas Valley Solid Waste Authority, Orange County, and the cities of Tulare, Sacramento, San Jose, San Diego, and Santa Cruz. Outside of California, recent or current investigations to landfill alternatives include the solid waste agencies of Connecticut and Delaware, New York City, Taughton, Massachusetts, Toronto, Ontario, Canada, and others. The Waste Board has been investigating conversion technologies since at least 2001, holding workshops and forums, and funding research (CIWMB, 2001; CIWMB, 2001b; Williams, Jenkins et al., 2003; Hackett, Williams et al., 2004; Williams, 2007; Rapport, Zhang et al., 2008).

Earlier Waste Board-funded work at UC Davis produced an extensive conversion technologies database (Williams et al., 2003) and later work by UC Riverside and Davis evaluated many of the technologies in the database (Hackett et al., 2004).

Many, and probably most, near-term viable conversion technologies and associated project developers are identified in the several public reports that resulted from local jurisdiction investigations of landfill alternatives. However, the purpose of this survey is to update conversion technologies project and vendor information, and this report documents the survey results.

The survey was sent to 83 companies/technologies. Initially ten companies responded. Follow-up e-mails and phone calls brought the total response to 23 (a 28 percent response rate). Most of the responses were from smaller firms and start-ups. The survey did not reveal any commercial conversion technology operations using MSW that were not already known to the authors or the Waste Board, but did demonstrate that there are a number of smaller conversion technology developers or start-ups with an interest in the California solid waste market

Survey Overview

The goal of the survey was to better understand which marketed conversion technologies and developers are operating commercially viable facilities. The California Integrated Waste Management Board (CIWMB) is particularly interested in facilities that have the ability to process Municipal Solid Waste (MSW); produce electricity, biofuels, or other products; and reduce material flow to the landfill. This information, along with reports and information developed by the several California communities currently investigating conversion technologies, may assist other jurisdictions and individuals seeking information about these systems.

The companies with established MSW conversion technologies, in large part, did not respond (e.g., most of the firms and technologies included in various "short-lists" of potentially viable systems from recent local waste jurisdiction investigations in the U.S.). Survey responses were mostly from smaller firms and start-ups, and most provided information on status and future plans. Since the majority of these are in pilot start-up, operational data, e.g., credible emissions data was not readily available.

Overall, survey respondents seem optimistic about the ability to commercialize conversion technologies for MSW in California and elsewhere (perhaps not unexpected for firms hoping to develop and commercialize a process or technology). The following summarizes the findings based on the 23 survey responses.

- Primarily smaller, start-up companies responded to the survey;
- Five respondents claim to have commercialized MSW conversion technology facilities (none in the U.S.);
- Fifteen facilities claimed to be MSW-capable are in the large pilot, commercial demonstration, or commercialized phases;
- Four facilities are planning to incorporate MSW in the future;
- Over half of responding companies are developing thermal technologies, half of these focusing on gasification;
- Approximately half of the responding companies are developing more than one conversion process;
- Verification and further detail is needed to determine actual status of many facilities.

There was mixed reaction to displaying detailed survey response information on the CIWMB website, but posting basic information, such as technology type and operational status, should not be an issue. Having information posted on the website was not an incentive to providing information.

Methods

The survey was based on past experience with technology surveys, with an emphasis on understanding current status of the facility and the technology. While some large- and mid-sized California communities are investigating or evaluating proposals for conversion technology facilities (see Appendix C), smaller communities may be seeking information about the status and abilities of conversion technologies.

The survey questions explore system status, scale, whether MSW is a current feedstock, and attempt to gain an understanding of basic mass and energy balance of the system (the survey is included in Appendix A). The survey was abbreviated in an effort to improve response rate and did not try to quantify exact inputs and outputs or gather sensitive information. The survey instrument was vetted with Waste Board staff and several industry experts.

The conversion technologies database developed in 2003 (Williams et al., 2003) was reviewed, as well as several of the publicly available consultant reports on landfill alternatives (e.g., URS, 2005a; URS, 2005b; ARI, 2008) and a list was created based on companies currently promoting conversion technologies (emphasizing those not detailed in various RFP 'short lists.')

The survey was distributed through the Internet (website access and response). A list of the companies invited to respond to the survey is in Appendix B.

Results

Initially ten out of 83 companies responded. Follow-up e-mails and phone calls brought the total response to 23 (a 28 percent response rate) [Table 1].

Despite follow-up attempts, we could not contact 25 of the companies on the list (30 percent) due to out-of-date information or name and contact information changes. The remaining 35 did not respond to repeated e-mail requests for information.

None of the responding conversion technology companies are currently processing MSW in California.

Conducting the survey online facilitated development and follow-up. The online tool that was used limited question design and format to some degree, but work-arounds were constructed.[1] Other online survey instruments should be investigated for future surveys or consider personal interviews with viable companies to collect the pertinent information. Overall, this method worked well and almost all respondents were able to use the tool effectively. Two telephone interviews were conducted with those who had trouble with the survey format. The time taken to complete the survey was longer than estimated because many of the respondents added details about their technology, processes, and status.

[1] The online utility "Questionpro" was used. (www.questionpro.com)

Table 1: Summary of Survey Responses

Company Name	Location	Technology	Status	Claim MSW as a Feedstock?
Agricultural Waste Solutions, Inc.	California	gasification/pyrolysis	commercial scale demo	no
Arrow Ecology	Israel	anaerobic digestion	commercial scale demo/commercial (Australia)	yes
Balboa Pacific Corp.	California	pyrolysis	large pilot	yes
BlueFire Ethanol, Inc.	California	fermentation (acid hydrolysis)	permitting/ construction	yes
CCI US Corporation	Canada	anaerobic digestion (BTA)	commercial (Europe, Canada)	yes
Coaltec Energy USA, Inc.	Illinois	gasification	large pilot	planned
CSG Technologies, LLC	California	autoclaving	laboratory	planned
ECOCORP	Virginia	anaerobic digestion	commercial (Spain)	yes
Emerald Power Corporation	New York	pyrolysis	commercial scale demo	yes
Entech Renewable Energy Solutions	Australia	gasification	commercial	yes
GEM America, Inc.	New Jersey	pyrolysis /thermal cracking	large pilot	yes
Genahol LLC	Ohio	gasification/pyrolysis/anaerobic digestion/fermentation	permitting/construction	yes
Grand Teton Enterprises	California	gasification	permitting/construction; commercial scale demo	yes
Green Planet Fuel & Energy (Omnifuel)	Canada	gasification/pyrolysis	laboratory	yes
InEnTec Energy Solutions	Washington	gasification/plasma arc	large pilot/small pilot	planned
MWT Inc.	Georgia	pyrolysis	laboratory/small pilot	yes
PRM Energy Systems, Inc.	Arkansas	gasification	commercial	no
Pyromex AG	Switzerland	gasification/pyrolysis	laboratory	yes
Ren Waste	Israel	gasification/pyrolysis/ anaerobic & aerobic digestion/fermentation	laboratory	yes
Sanimax	Canada	pyrolysis/biodiesel	laboratory/commercial (biodiesel)	no
Sharp Energy	California	anaerobic digestion	commercial	no
Taylor Biomass Energy LLC	New York	gasification	planned	planned
Westinghouse Plasma Corp - Alter NRG	Pennsylvania	gasification/plasma arc	commercial (Japan)	yes

Technologies

Responses were received in all three conversion technologies pathways: thermochemical, biochemical and physicochemical (Table 2). Respondents had the opportunity to choose one or more technology and also describe their technology in more detail if required. Most provided a more detailed description of their process.

Table 2: Technology Distribution in Survey Results

Technology	Responses
Thermochemical	**21**
Combustion	0
Gasification	12
Pyrolysis	8
Autoclaving	1
Biochemical	**10**
Anaerobic Digestion	6
AD/Composting	1
Fermentation	3
Physicochemical	**1**
Biodiesel	1
Total	**32**

The conversion pathways among the 23 responses includes 21 thermochemical (12 gasification and 8 pyrolysis), ten biochemical (six anaerobic digestion), and one physicochemical (biodiesel) process.

Some of the survey respondents listed multiple technologies and pathways or have more than one technology in development. Others identify their process as a hybrid, using more than one technology in the process. Therefore, although there are only 23 respondents, there are 32 technologies represented.

Development Status

The survey asked respondents to indicate development status of their system based on categories specified in the survey, i.e. laboratory, in permitting or construction, small pilot, large pilot, commercial scale demonstration, or fully commercialized. Scale, or material processing capacity, is a factor used to distinguish among most of the categories (Table 3).

The respondents did not always agree with the survey definitions for facility status, and some defined their status differently depending on feedstock and number of facilities. The data presented are analyzed according to the categories as defined in the survey. Individual companies may have multiple facilities in different phases of development. Some of the respondents indicated "other" in the questionnaire. The responses are categorized in Table 3 according to our reading of all survey responses.

Table 3. Status of Responders Facilities/Processes

Development Status	Definition	Number
Laboratory	Currently operating in lab or workshop setting Up to 2 tons/day	6
Permitting/Construction	Completed permitting requirements Plan to complete permitting process within one year	3
Small pilot	At least one operating facility 2-10 tons/day Ability to use waste stream feedstock	2
Large pilot	At least one operating facility Proof of scalability More than 10 tons/day Ability to use waste stream feedstock	4
Commercial scale Demonstration	One facility operating for at least one year 7,500 tons/year min. Feedstock includes at least 25 percent from the waste stream	4
Commercialized	Two or more facilities operating for at least one year 7,500 tons/year min. each site Feedstock from waste stream (at least 50 percent)	5

Six responders indicate they are still in the laboratory or initial development phase. Five of respondents claim to have commercialized facilities that convert MSW, and two respondents operate commercial facilities using agricultural residue (a manure digester and a gasifier company).

The responding companies cover a wide range of facility/process development as well as types of feedstocks. Over half of the responsive companies (15) claim to be either using MSW in their facility development or planning to in the future. Four companies are not planning to incorporate MSW into their operations. All of the facilities in the permitting/construction phase can process MSW, two of which are located in California (Blue Fire Ethanol, Inc. and Grand Teton Enterprises). Of the commercialized respondents that consume municipal wastes, two are gasification systems, three are anaerobic digestion facilities, and one is a biodiesel process (using waste oils). None of the respondents have commercialized facilities processing MSW in California, and there are no commercial gasification or anaerobic digestion systems in the United States processing MSW (there are some food processors that digest their residues and some waste water treatment facilities co-digest waste oils and food residues, e.g., the facility at the Inland

Empire Utilities Agency, Chino, CA). Most of the responding companies claim an interest in or are planning to use MSW-derived feedstocks.

Process Inputs and Outputs

The survey included questions about current and planned feedstocks for the process as well as other inputs (e.g., energy, water). The range of feedstocks in the responses included post-MRF residue, as well as other MSW components. Regional food processing residues were listed as feedstocks as well (i.e., rice hulls, distillery residue, olive waste, and other food processing wastes). Most of the facilities that were processing or planning to incorporate greenwaste were also using foodwaste, commercial organics, biosolids, and separated paper and wood. Many of the thermochemical processes planning to use MSW are also considering waste tires. Four responses indicate electricity or natural gas is used as energy inputs and several include coal or petcoke as co-feed material.

Marketable outputs (products) listed in the responses include electricity (13 responses), heat or steam (eight responses), and ethanol (two responses). All except one facility producing electricity also listed heat as an output.[2]

Some respondents noted that outputs depended on feedstock combinations. These facilities, especially in the agricultural waste/green waste feedstocks, are interested in developing a variety of feedstocks in different combinations,

The survey did not explore if and where the outputs were currently being marketed. Follow-up information could include how markets are receiving these products and how they can tie into current systems.

Emissions

Detailed emissions information was not requested in the survey. Historically, respondents are not willing to share this information in a survey and responses are generally not considered independent and credible. The survey only asked if the company would be willing to provide emissions and discharge data if contacted later. Some technology providers did not respond to questions referring to emissions.

Seventeen respondents indicated they would be willing to share emissions/discharge data.[3] Thirteen are willing to share information about solid and water discharges, while only 11 are willing to share air emissions data. Fourteen respondents indicated that their emissions/discharge data was collected by a neutral third party.

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[2] Note that while electricity is relatively easy to market with access to the electricity grid, heat or steam is more difficult. A nearby load for heat and steam is generally required for it to be economic.

[3] The question regarding emissions information was to get a sense of willingness to share this data. Respondents were not asked for actual emissions/discharge data in the survey or in follow-up communications because time and budget did not allow for technology evaluation.

Expansion and Permitting

All respondents indicated they have plans to expand their operations.[4] This was true both of commercialized facilities and those still in the laboratory phase.

There were 17 responses to the permitting questions. Nine of the respondents viewed permitting requirements in California as an impediment to expanding operations, or would certainly make facility development more difficult. A few either were investigating or in the permitting process, while others (primarily anaerobic digestion systems) do not see permitting as an obstacle to bringing operations to California. The respondent currently in the permitting process in California indicated that permitting is not an issue.

One of the facilities in California indicated that it already have air permits for a pilot facility and did not see expanding facilities and permit modifications as an issue.

Conclusion

This survey was designed to update information on current status of conversion technologies using MSW as feedstock. Along with information from recent consultant reports evaluating conversion technologies and current RFPs, the Waste Board should have relatively current knowledge on status of many conversion technology suppliers. Appendix C contains a list of technology or process suppliers that have at least one operating commercial facility (using MSW components) somewhere in the world, or are in the permitting/construction stage, or considered a quasi-commercial scale demo for purposes or RFP reference facility.

The survey was distributed to 83 companies and there were 23 responses. Conducting the survey online streamlined development and follow-up. Almost all respondents were able to use this tool effectively. The format allowed for streamlining the responses and assisted with analysis. Unfortunately, it did not result in high response rates even after follow-up.

Most of the responses were from smaller firms and start-ups. The survey did not reveal any commercial conversion technologies sites consuming MSW that were not already known to the authors or the Board.

Though the survey was designed to understand development status, it is not an independent or in-depth evaluation of the technology providers. It does not evaluate the likelihood of technologies coming to California in the near future. There are many variables (regulations, costs, emissions, economies of scale, to name a few) that cannot be determined from this type of survey. As technologies become more widely established, the evaluation can be conducted on actual facilities and their applicability to the feedstocks and collection and separation methods currently available in California.

[4] We were not able to verify expansion plans.

Appendix A: The Survey

Questions marked with a * are required

BIO-ENERGY/MSW PROVIDER SURVEY

Thank you for participating in the bio-energy provider survey. It should only take about 15 minutes to complete. The focus of this survey is on conversion technologies and services with the ability to process a significant portion of the feedstock from the waste stream. The University of California, Davis is maintaining a current inventory of bio-energy technologies and companies. We are particularly interested in technologies and actual operating facilities or projects using materials from the urban sector, such as MSW or post-MRF residuals. The technology list and information from the surveys can be used as a clearinghouse for communities interested in landfill alternatives and bio-energy production from urban residuals. For example, the information provided by you may be made available on the California Integrated Waste Management Board (CIWMB) conversion technologies web page. Please be as specific as possible. We are providing space for you to include information on one or two of your facilities. If you operate more than two facilities, and want to provide further information, please let us know.
Contact us at **mswsurvey@ucdavis.edu** with any questions or comments.

Respond by: May 30, 2008

Name of Company *
Years in Business *
Contact Person *
Address *
Address
Phone *
email *
website *
Do you offer the technology as a license holder or vendor? If so, please describe.

2. Technologies

Please indicate the technology types you are currently using.
You may choose more than one.

Thermal

Combustion
Gasification
Pyrolysis
Plasma Arc
Other

Biochemical

Anaerobic Digestion
Aerobic Digestion/Composting
Fermentation (for example, ethanol)
Other

Physicochemical

Biodiesel
Other
Please describe your technology/process. *

3. Feedstocks

Which feedstocks can your process handle?
Please check all that apply.
Currently in Use Planned Use
MSW (unsorted)
Post-MRF MSW (black bin waste)
Greenwaste - residential
Foodwaste - residential
Source-separated Organics -
Commercial
Fats, Oil, Grease (FOG)
Separated Paper

Separated Wood
Separated Plastics
Waste Tires
Biosolids
Please describe any other feedstocks that you are currently using or planning to use.
Please describe any pre-processing that is required to use the feedstocks.

4. Facility Status

Please list status of operating facilities.
If yes, include in the box provided the date of closure and/or the date of planned operation.
Yes No
Past Operation, now closed
Currently Operating
Planned Facility
If you operated a facility that is now closed, please list the start-up and closure years and why it is no longer operating.

5. Stage of Development

Using the definitions below, indicate the current status of each of your facilities.

Laboratory

Currently operating in laboratory or workshop setting
Up to 2 tons/day

Permitting/Construction Phase

Completed permitting requirements
Plan to complete permitting process within one year

Small Pilot

At least one operating facility
2-10 tons/day
Ability to use waste stream feedstock

Large Pilot

At least one operating facility
Proof of scalability (over 10 tons/day)
Ability to use waste stream feedstock

Commercial scale demonstration

One facility operating for at least one year
7,500 tons/year minimum
Feedstock from the waste stream (25%+)

Commercialized

Two or more facilities operating for at least one year
7,500 tons/year minimum at each site
Feedstock from waste stream (50%+)
Please list the current status of your technology or process. *
Laboratory
Permitting/Construction
Small Pilot
Large Pilot
Commercial Scale Demonstration
Commercialized
Other

6. Inputs: Material and Energy

List the capacity actual input flow rates of your facility, either a single number or a range.
Per Day (or) Per Year
MSW - unsorted (tons)
Post-MRF MSW/black box
(tons)
Separated Plastic (tons)
Separated Wood (tons)
Separated Paper (tons)
Foodwaste - residential (tons)
Greenwaste - residential (tons)
Source Separated Organics -
Commercial (tons)
Waste Tires (tons)

Biosolids (tons)
Petcoke (tons)
Coal (tons)
Natural Gas MMBtu)
Electricity (kWh)
Water (gallons)
Please describe any other inputs and tonnages.

7. Outputs (marketable): Net Fuel/Energy and other materials

Please indicate your primary outputs.
Per Day (or) Per Year
Heat (MMBtu)
Electricity (kWh)
Ethanol (gallons)
Other alcohols (gallons)
Biodiesel or renewable diesel (gallons)
Compost or compostable material (short tons)
Water (gallons)
Steam (pounds)
Please describe any other outputs and tonnages.

8. Emissions/Discharges Data

Would you be willing to provide emissions/discharge data for the following?
Yes No
Air Emissions
Water Discharge
Solid Residues
Are the data from a credible third party independent organization?

9. Additional Information

Yes No
Do you have expansion plans?
Is permitting an impediment to operation in CA?
If the answer to Question 9 is Yes, please explain how permitting is/was a problem for your facility.
Facility Name *
Facility Location *
Time in Operation *
Contact Person *
Address *
Address
Phone *
email *
website *
Amount of MSW or other Waste Stream Material Processed - on average per year (enter 0 if none) *
Number of Hours of Continuous Operation Last Year (enter 0 if none) *
Please provide any additional information about your technology and facility.
Can we contact you directly for more specific information about your facility operations? If so, what is the best time to reach
you?
Do you have more than one facility?
Yes
No
The following set of questions is for a second facility. If you only operate one facility, you can skip this set of questions.

Appendix B: Survey Distribution

SUPPLIER	TECHNOLOGY	WEB ADDRESS
AAT Biogas	anaerobic digestion	www.aat-biogas.at
Abengoa	gasification	www.abengoabioenergy.com
AdaptiveNRG	plasma arc	www.adaptivenrg.com
Adherent Technologies, Inc	pyrolysis	www.adherent-tech.com/
Agricultural Waste Solutions	gasification	www.agwastesolutions.com/Solution.htm
Alico (BRI)	gasification	www.alicoinc.com
Allan environmental solutions	anaerobic digestion	www.allan-environmental.com
Arrow Ecology	anaerobic digestion	www.arrowecology.com
Balboa Pacific	pyrolysis	www.balboa-pacific.com/
BioEnergy Solutions	anaerobic digestion	www.allbioenergy.com
BioEngineering resources (BRI)	gasification/fermentation	www.brienergy.com
BioFine/KAME	hydrolysis	www.iags.org
Bigadan	anaerobic digestion	www.bigadan.com
BioRenewable Projects	anaerobic digestion	www.biorenewableprojects.com
BlueFire Ehtanol	fermentation	www.bluefireethanol.com
Canada Composting	anaerobic digestion	www.canadacomposting.com/
Changing World Technologies	thermal	www.changngworldtech.com
Chemrec	gasification - black liquor	www.chemrec.se
Choren Industries	gasification	www.choren.com
Citec	anaerobic digestion	www.citec.fi
Cleansave Waste Corp	autoclave	
Coaltec Energy	gasification	www.coaltecenergy.com
Community Power Corporation	gasification	www.gocpc.com
Compact Power	gasification	www.compactpower.co.uk
Costich Company	gasification	www.costich.tripod.com
Crimson Renewable Energy	biodiesel, biogas	www.crimsonrenewable.com/
Dynamotive Energy Systems	pyrolysis	
East Bay MUD	anaerobic digestion	www.ebmud.com
EarthPower organics	Anaerobic digestion	www.earthpower.com.au
Ebara	gasification	www.ebara.co.jp/en/
EcoCorp, Inc.	anaerobic digestion	www.ecocorp.com
Emerald Power Corp/Enerkem	gasification/catalytic	enerkem.com
EnerTech Environmental	gasification	www.enertech.com
Entech Solutions	gasification	www.entech.net.au/ws2
EnviroArcTechnologies	gasification	www.enviroarc.com
Environmental Power Corp	Anaerobic digestion	www.environmentalpower.com
Environmental Waste Int'l	microwave - tires	www.ewmc.com
GEM America	gasification/thermal cracking	www.gemamericainc.com
Genahol, Inc.	hydrolysis (and others)	www.genahol.com
Genencor	fermentation	www.genencor.com
Geoplasma LLC	plasma arc	www.geoplasma.com

GP Fuels, Inc.	gasification	www.downstreamsystems.com
Grand Teton Enterprises	anaerobic digestion	www.grandtetonenterprises.co
Herhof Gmbh	anaerobic digestion	www.herhof.com
Hotrot Composting	aerobic digestion	www.hotrotsystems.com
Hydrolve	thermal drying	www.hydrolve.com
ILS Partners/pyromx	gasification	www.ils-partners.com
Integrated Environmental Technologies	plasma	www.inentec.com
International Environmental Solutions	pyrolysis	www.wastetopower.com
Interstate Waste Technologies (IWT)	gasification	www.iwtonline.com
Iogen	fermentation	www.logen.ca
Molecular Waste Technologies	microwave	www.molecularwastetech.com
New Bio	anaerobic digestion	www.newbio.com
Ntech Environmental	gasification	www.ntech-environmental.com
OrgaWorld	anaerobic digestion	www.orgaworld.com
Organic Waste Systems N.V. (OWS)	anaerobic digestion	www.ows.be
Pacific Ethanol	fermentation	www.pacificethanol.net
Plasco Energy Group	gasification	www.plasco.com
Precision Energy Services, Inc.	gasification	www.pes-world.com
Presco	anaerobic digestion	www.preseco.eu
Primenergy	gasification	www.primenergy.com
PRM Energy Systems, Inc.	gasification	www.prmenergy.com
Pyromex	pyrolysis-hydrolysis	www.pyromex.com
Range Fuels	gasification	www.rangefuels.com
Recycled Refuse Int'l	pyrolysis	www.rcrinternational.com
RenWaste	anaerobic digestion	www.renwaste.com
Sanimax	biodiesel	www.sanimax.com
Sharp Energy, Inc.	anaerobic digestion	
Silvagas	gasification	www.silvasgas.com
Solena Group	plasma gasification	www.solenagroup.com
Taylor Recycling	gasification/pyrolysis	www.taylorrecycling.com
Thermogenics, Inc.	gasification	www.thermogenics.com
Thermoselect	pyrolysis	www.thermoselect.com
US Plasma	plasma gasification	www.usplasma.com
Valorga S.A.S. (Valorga)	anaerobic digestion	www.valorgainternational.fr
Vagron	anaerobic digestion	www.vagron.nl
Viresco Energy/Ce-Cer-UCR	hydro gasification	www.virescoenergy.com/
Waste Recovery -Seattle	advanced thermal	www.wrsi.info
Westinghouse Plasma/GeoPlasma	plasma gasification	www.westinghouse-plasma.com
WET systems	gasification	www.wsimgt.com
Whitten Group/Entech Renewable Energy	thermal/gasification	www.entech.net.au
World Waste Technologies Inc.	autoclave steam	www.worldwasteintl.com
Wright Environmental Management Inc	aerobic digestion, thermal	www.wrightenvironmental.com
Zeros Technology Holding	thermal oxidation	www.zerosinc.com

Appendix C: MSW Conversion Technology Suppliers

A list of technology or process suppliers that have at least one operating commercial facility (using MSW components) somewhere in the world, or are in the permitting/construction stage, or considered a quasi commercial scale demo for purposes, or currently being reviewed by a jurisdiction.

Table AC 1: Thermochemical Technologies

Company Name	Technology	Location	URL	Under Review (or short-listed) by:	Source (see below)*
Adaptive NRG / AdaptiveArc	Gasification (Plasma)	Mexico	http://www.adaptivearc.com/	Santa Barbara	10, 15
AlterNrg (Westinghouse plasma technology)	Gasification (Plasma)	Japan	http://www.alternrg.ca/	Santa Barbara	10
Changing World Technologies	Hydrothermal processing	Missouri	http://www.changingworldtech.com/	County of LA	6,14
Genahol, LLC	Gasification (syngas to ethanol)	Ohio	http://www.genahol.com/		3
Ebara	Gasification	Japan/Switzerland	http://www.ebara.ch/	City of LA	6,7
Entech Renewable Energy Solutions	Gasification	Australia	http://www.entech.net.au/ws2/	Santa Barbara	3,10, 12
Full Circle Energy	Gasification	City of Tulare	www.fullcircleenergy.com	City of Tulare	16
International Environmental Solutions (IES)	Pyrolysis	California	http://www.wastetopower.com/	County of LA, Santa Barbara	2,10,14
Interstate Waste Technologies (Thermoselect)	Pyrolysis/Gasification	Japan	http://iwtonline.com/	City of LA, County of LA, Santa Barbara, Salinas Valley	2,6,7,10,14
Ntech Environmental	Gasification	Poland/Korea?	http://www.ntech-environmental.com/	County of LA	14
Plasco Energy/World Waste Technologies	Gasification (plasma assist)	Canada	http://www.plascoenergygroup.com	City of LA, Salinas Valley, Santa Barbara	7, 9, 10
Urbaser, SA	Gasification (also AD)	Spain	http://www.urbaser.es/en	City of LA, Salinas Valley	7, 9
Wastegen / Techtrade	Pyrolysis (rotary kiln)	UK (facility in Germany)	http://www.wastegen.com/wastegenuk.htm		11, 13

* source list for these tables is at end of Appendix C

Table AC 2: Biochemical Technologies

Company Name	Technology	Location	URL	Under Review (or short-listed) by:	Source (see below)
BlueFire Ethanol	Fermentation (acid hydrolysis)	California	http://www.bluefireethanol.com/		1
BRI Energy	Hybrid process (gasification followed by fermentation)	Florida (and Arkansas)	http://www.brienergy.com/		1, 2
AAT	Anaerobic Digestion	Germany	http://www.aat-biogas.at/en/abu/index.php		4,5
Arrow Bio	Anaerobic Digestion	Israel, Australia	http://www.arrowbio.com/	City of LA, County of LA, Santa Barbara	4,6,7,10,14
Bekon	Anaerobic Digestion	Germany	http://www.bekon-energy.de/		17
BTA	Anaerobic Digestion	Germany (CCI for North America)	http://bta-international.de/home.html?lang=3		4,6
Citec (Waasa)	Anaerobic Digestion	Finland			6,8
Ecocorp	Anaerobic Digestion	US (foreign reference)	http://www.ecocorp.com/	Santa Barbara	3,10
Entec	Anaerobic Digestion	Austria	http://www.entec-biogas.com/en/company/profile.php		4,5
Haase	Anaerobic Digestion	Germany	http://www.haase-energietechnik.de/en/Home/		4,5
Iska	Anaerobic Digestion	Germany	http://www.iska-gmbh.de/		6
Kompogas	Anaerobic Digestion	Switzerland	http://www.kompogas.ch/index.php?id=13&L=1		6
Linde KCA/BRV	Anaerobic Digestion				4,6
Organic Waste Systems (DRANCO)	Anaerobic Digestion	Belgium	http://www.ows.be/		6
Orgaworld (Biocel)	Anaerobic Digestion	The Netherlands	http://www.orgaworld.nl/indexgb.html		4,5
Preseco	Anaerobic Digestion	Finland	http://www.preseco.fi/index.php?5		4,5
Ros Roca (Biostab)	Anaerobic Digestion	Spain	http://www.rosroca.com/en		
Valorga - Urbaser	Anaerobic Digestion	France	http://www.valorgainternational.fr/en/	City of LA, Salinas Valley	6,7,9
Wehrle Werk AG (Biopercolat)	Anaerobic Digestion	Germany	http://www.wehrle-umwelt.com/		6
Herhof Stabilat	Aerobic Drying (in vessel)	Germany	http://www.herhof.com/en/index.html		10

Source List for Technology Suppliers in Appendix C

1	(Williams, 2007) .
2	(Hackett et al., 2004)
3	(Novick and Williams, 2009)
4	(Rapport et al., 2008)
5	(Nichols, 2004) .
6	(Williams et al., 2003)
7	(Zermano, 2009)
8	(Kelleher, 2005)
9	(Mathews, 2009)

10	(Johnston, 2009)
11	(Diaz, 2008)
12	(HDR, 2008)
13	(URS, 2005b)
14	(Skye, 2009)
15	(Kolassa, 2009)
16	(Nelson, 2009)
17	(Franco, 2008)

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