SECTION 5

GETTING THERE
(the Blueprint)

"The best way to predict the future is to invent it."
Alan Kay
(conceived idea for the laptop computer)

INTRODUCTION

This Resource Management Blueprint puts forth a vision of what could be created in the City of Los Angeles by 2025, and the means of getting there. This section lays out the "blueprint", the design of the structure capable of getting us ultimately to a sustainable, zero waste city.

It is important to remember that this is a process and a long one at that. This blueprint will require ongoing work, refinement, and course corrections along the way. This is not, as they say, "set in concrete", but a living plan that requires nourishment, vision, and most of all persistence to stay the course.

There are definite recommendations for plans and facilities in this "blueprint". However, it is also important that we eliminate the concept of waste and begin to think in continuously renewable cycles of resources and products. Certainly this won't happen overnight, but it could happen within a decade, or two.

This blueprint builds on work completed over the past 15 years or more by our local officials and the Bureau of Sanitation and its consultants, including policies, programs and facilities developed in the original AB 939 Source Reduction and Recycling Element and its updates, and more recent work on policies and facilities needs. In addition, the blueprint borrows from the best programs and plans from other jurisdictions in California, across the U.S., in Europe and other countries around the world.

Of all the mega-cities in the world, Los Angeles with its 62% diversion rate is among the leaders. From the public sector side, we can boast of a fully-implemented residential curbside recycling program for both traditional recyclables and greenwaste, pilot programs launched for the multi-family and commercial sectors, rebate programs to encourage haulers to deliver MSW and C&D to processing facilities, a 10% franchise fee on all hauler gross receipts to fund ongoing diversion projects and programs, and S.A.F.E. centers for drop-off of Household Hazardous Waste (HHW) and e-Waste.

In addition, as discussed in Section 3, even with all the public sector programs, the private sector commercial material and C&D debris recycling efforts provide the bulk of city-wide diversion. This has been achieved through programs of source-separation as well as mixed material processing.

This being said, it is still critical to note that although the City's diversion rate has continued to climb resulting in the current reduction, reuse, recycling, and composting of over a million tons of material a year, since 1990, the City of Los Angeles has landfilled about the same quantity of waste each year - 3.5 million tons. This represents roughly one ton of waste disposed per year for every man, woman and child in the City.

In other words, all the tonnage reductions achieved by our AB 939 programs to date have been neutralized by increases in per capita generation and the overall growth in population and commerce in the City. Thus, in pure terms related to the minimization of waste disposed at landfills, we are right where we started 15 years ago.

Clearly, our efforts to date, although commendable, are not enough. This blueprint lays out the new paradigm that will take us over the next decades to a true zero waste society.

OVERVIEW

The focus of this blueprint is on the portion of the City of Los Angeles' total wastestream still going to landfill disposal. Roughly 40% of this disposal is collected by City forces from the single family homes and institutions, and 60% is collected by private haulers predominantly from multi-family complexes, commercial businesses, and industry.

To reach our ultimate target of "Zero Waste", meaning only a small amount of stable, inert material is placed in landfills, the City must develop or support the programs and facilities to process and divert the vast bulk of our wastestream. In addition, the City must enact the policies to support that new diversion infrastructure, and the education programs to both train the population in proper practices and educate today's youth so they are equipped to carry on this plan over the next 20 years and beyond – and hopefully "raise the bar" even further.

The focus of this section is on the main MSW stream, not "special wastes" such as tires, eWaste, biosolids, and HHW. Although proper management of these materials is important, programs and infrastructure are essentially in place to handle and recycle them, and more controls and mandated recycling is continuing to occur from the Federal level on down in these areas.

In order for us to free ourselves from a disposal-based system, this plan attacks the big ticket item – our trash, and treats it as a resource to be collected, reused, processed, recycled, converted and otherwise returned to the manufacturing sector and society as products, fuels, or renewable energy.

To a great extent, this will be accomplished by intensified processing of both source-separated and mixed wastestreams coupled with conversion technology (CT).

TECHNOLOGY

This section summarizes the physical system, the facilities, that will be needed to achieve the zero waste objective within 20 years.

COMPONENTS OF THE SYSTEM

The new blueprint is a combination of existing systems, structures and programs that will be intensified in the future; and new CT facilities. More discussion will follow in the section describing the actual system for each wastestream. The following are the most significant existing programs and facilities that will be continued and intensified.

Residential Sector

Single Family

- 3-can curbside recycling program (adding food to the greenwaste can)
- Backyard composting
- Mulching lawn mowers

Multi-Family

- Source separation pilot programs escalating to full scale
- Mixed waste processing at MRFs

Self-Haul

- Diversion of loads to chip & grind, MRFs, or C&D processing facilities

Commercial Sector

- Wet/dry routing
- Source separation
- Mixed material processing at MRFs
- Supermarket food waste recycling
- Restaurant, bar and hotel glass and foodwaste recycling
- Special event recycling
- LAX and Port of LA source separation and recycling

C&D Sector

- Deconstruction
- Source separation at the job site
- Mixed material processing at C&D facilities

A note is needed here on the concept of Inert Residual Repositories as a new form of landfill. Progressively over the next 20 years, the implementation of enhanced source separation programs and the development of mixed waste MRFs, autoclave systems and CT facilities will change the character of the waste material requiring landfill disposal. Increasingly, the organics will be removed, resulting in a more stable, inert residue that is benign in the environment and suitable for landfilling. Our goal is to achieve diversion levels such that this residue is roughly 10% or less of the tonnage being generated.

CONVERSION TECHNOLOGIES (CT)

Conversion Technologies are the new element in the 20-year plan for the City of Los Angeles. It is their ability to take the residual organic material remaining after our best efforts at reduction, reuse, recycling, MRF processing, and other traditional diversion programs, and convert most of it to beneficial and renewable, green energy, fuels, chemicals, compost and other feedstocks for manufacturing.

Because CT is relatively unknown in the U.S., an overview discussion is included here. At present, there are no commercial plants in N. America, with the exception of MSW composting, although two autoclave systems are nearing completion of construction in Anaheim, CA and Minneapolis, MN. However, several jurisdictions are evaluating CT projects including: the City of Los Angeles; the County of Los Angeles (Local Task Force); County of Riverside; the Sacramento Municipal Utility District (SMUD); Middletown, NY; Grove City, OH; and others.

This section is based on the current knowledge of the conversion technology industry, and recent requests for qualifications and proposals from cities and counties in California, including Los Angeles. These provide insight into real world responses by CT companies for potential projects in Southern California.

For a much more detailed evaluation of the technologies themselves, their performance, cost, environmental characteristics, etc., the reader is referred to the recent report by CIWMB staff “Conversion Technologies Report to Legislature” and the supporting documents “The Evaluation of Conversion Technology Processes and Products” prepared by UC Riverside[26], and “Life Cycle and Market Impact Assessment of Non-combustion Waste Conversion Technologies” prepared by RTI International[27].

An RFQ competition conducted by URS Consultants on behalf of the City of Los Angeles (to be completed in the summer of 2005) will provide detailed analysis of the various companies and their technologies. This will lead to the development of an RFP for the first CT plant in the City of Los Angeles.

In this section, conversion technologies that could make ***an appreciable*** impact in the future on the amount of waste destined for landfills in the City of Los Angeles are discussed. Even though there may be feasible and important *niche* type technologies, dealing with small quantities of waste or specific types of wastes, these were not evaluated because they will have little impact on systemic decision making.

Therefore, the followed assumptions guided the review of alternative technologies:

- Technologies should deal with the bulk of the mixed, post-MRF MSW wastestream, not specialty items alone such as tires or plastic.
- The technologies should be capable of handling large quantities of material in a continuous process (500 TPD per facility, or more)
- Technologies should be targeted only to waste still going to disposal rather than source-separated materials being successfully handled with traditional recycling/composting programs (i.e. commingled single-stream material). This is in keeping with recently proposed CT guidelines from the CIWMB.
- Technologies that involve modified landfill operations (balefills, landfill bioreactors) are not covered by this assessment.
- The focus is on technologies that are beyond the R&D phase and approaching commercialization or already in operation at full scale.

Waste-to-Energy (a special note)

With over 100 plants burning approximately 15% of the nation's trash and generating 2,750 megawatts of electricity, WTE is clearly in a different mode than the other technologies. In some parts of the U.S., most notably New England and Florida, WTE plays a *dominant* role, and in many other states (31 in total), a *significant* role in waste disposal. However, in California, there are only three WTE plants (Commerce, SERRF, and Stanislaus County), and no new facilities are planned. It is unlikely that WTE will play a key role in Los Angeles in the future because:

- In air-sensitive Southern California, incineration of MSW is difficult to justify to the public or the SCAQMD, for that matter
- Previous WTE projects, most notably LANCER and Irwindale failed to get off the drawing boards
- Decades old negative impressions of environmental impacts and public health issues continue in this part of the U.S.
- With deregulation of the power industry, the lucrative energy contracts awarded by utilities in the 1980's are no longer available.

That being said, recent and continual upgrading of WTE technology, particularly in air emissions control, have mitigated some of the previous environmental problems. For example, recent data from the Integrated Waste Services Association (representing the WTE industry) shows that the use of activated carbon as MACT (Maximum Achievable Control Technology) has achieved reduction in Mercury emission of over 90% and of dioxin and furans of over 99%.

These advances plus the proven performance of the plants over decades of operation would indicate that WTE should not be ruled out summarily for future application.

Table 5.1 provides a partial list of CT vendors active as of 2003, based on a listing by Santa Barbara County with recent additions by the authors. **Appendix D** provides a summary listing of conversion technology vendors, their plant locations, feedstocks, and capacities. Data was gathered on each technology with a focus on the status of commercialization; i.e. the development of full-scale facilities.

The Major CTs

Although several of the technologies could contribute in the future depending on further developments in technology and economics, based on worldwide performance and operating history, five technologies currently offer the most promise for the City of Los Angeles:

- Gasification/Pyrolysis
- Anaerobic Digestion
- MSW Composting
- Autoclaving
- Fermentation

Although most of the existing CT plants in Europe and Japan are of smaller capacity, each is essentially of "modular" design meaning they can easily be expanded by adding modules (typically in the 200 TPD range each). Thus, these plants have the capability to handle large volumes of MSW (500-3,000 TPD per plant), including the residue from MRF/transfer stations.

The recent Request for Proposals (RFP) competition in Santa Barbara County produced 49 companies active in the alternative technology industry, 14 proposals, and ultimately a shortlist of seven firms. Based on the proposals, the County developed the following description of a generic project:

- Approximately 80% (160,000 tons per year) of all MSW tons processed would be diverted from the landfill.
- Approximately 35% (70,000 tons per year) are recyclables captured by an up-front MRF and sent to traditional recycling markets.
- Approximately 45% (90,000 tons per year) are organic materials converted to "green" energy which is a locally sustainable resource.
- The resulting landfill diversion creates long-term disposal scenarios that would otherwise be unavailable (e.g. the projected 15-year life/capacity of Tajiguas Landfill would be transformed to 50+ years).
- The cost of conversion (an average of approximately $25/ton) is competitive with existing ($35/ton) and future (circa $80/ton) disposal/landfill costs.
- A conversion facility would require only a fraction of the land necessary for a landfill.

TABLE 5.1
LIST OF CONVERSION TECHNOLOGY VENDORS (*)

GASIFICATION / PYROLYSIS	American Plasma Corp.
	BAV Umwelttechnik
	BRI
	Brightstar Environmental, Inc.
	CR&R (Renewable Resources Alliance, LLC)
	Doug Blackburn
	Compact Power Ltd
	Costich Company
	Down Stream Systems, Inc.
	Eco Electric Power Company
	Energy Products of Idaho (EPI)
	Future Energy Resources Corp.
	Global Energy Solutions
	International Combustion Systems, Inc.
	International Environmental Solutions
	Interstate Waste Technologies
	JF Ventures Ltd
	Lurgi Energie und Entsorgung GmbH
	MEI Power corp.
	Precision Energy Services
	UA Plasma
	Recovered Energy, Inc.
	RGR Ambiente Srl
	Scientific Utilization, Inc.
	Startech
	The Biosphere Process
	Thermogenics, Inc.
BIO-REFINING or FERMENTATION	Arkenol, Inc.
	BC International Corp.
	BRI
	Filter Tech. Corp.
	Genahol, Inc.
	Masada Oxynol LLC
ANAEROBIC COMPOSTING	Arrow Bio, LLC
	BioConverter Park, LLC
	BioMil AB
	Organic Waste Systems (DRANCO)
	Canada Compost, Inc. (BTA)
	CITEC Group
	EcoCorp (Linde-KCA/BRV)
	Farmatic Biotech Energy AG
	Kompogas
	Onsite Power Systems
	Schwarting Unwelttechnik GmbH
	Waste Recovery Systems, Inc.(Steinmuller/Valorga)
MSW COMPOSTING	Bedminster
	Engineered Compost Systems (ECS)
	Herhof Umwelttechnik GmbH
	IPS (US Filter)
OTHER	Comprehensive Resource Recovery & Reuse (CR3)
	ReCulture Engineering
	World Waste International (WWI)
(*) based on Santa Barbara Co., "Alternatives to Disposal	Final Report September 22, 2003"

- While approximately 20% of all tons processed by a conversion facility must be landfilled, this waste would be converted into an inert state, which would significantly reduce operational costs associated with handling putrescible material and potential long-term environmental risks and associated liabilities at the landfill
- A conversion facility could not only power its own process, but produce “green” electricity thereby contributing toward the achievement of California’s renewable portfolio requirements and supporting local sustainability.

Each of the five major CT processes is described below. **Appendix D** provides information on some of the major CT vendors and their facilities with facility pictures for visual reference.

Based on results from the URS study for the City of Los Angeles and experience related to MSW composting and autoclaving, the commercial status of each of the CTs is estimated as follows:

Technology	% Commercialized
Gasification/Pyrolysis	100
Anaerobic Digestion	100
MSW Composting	100
Autoclaving	80
Fermentation	40

As shown, anaerobic digestion, gasification/pyrolysis and MSW composting have all achieved full commercialization, with autoclaving at 80% with two plants in construction in the U.S., and fermentation at 40% commercialized; the latter having no plants in operation yet.

Gasification/Pyrolysis

This technology involves the thermal conversion of organic material to synthetic gas or syngas (high percentage of methane), a small volume of ash, and water. The core of the technology is the thermal conversion unit with the product gas used to generate steam or electricity. See **Figure 5.1** for a schematic diagram of the process.

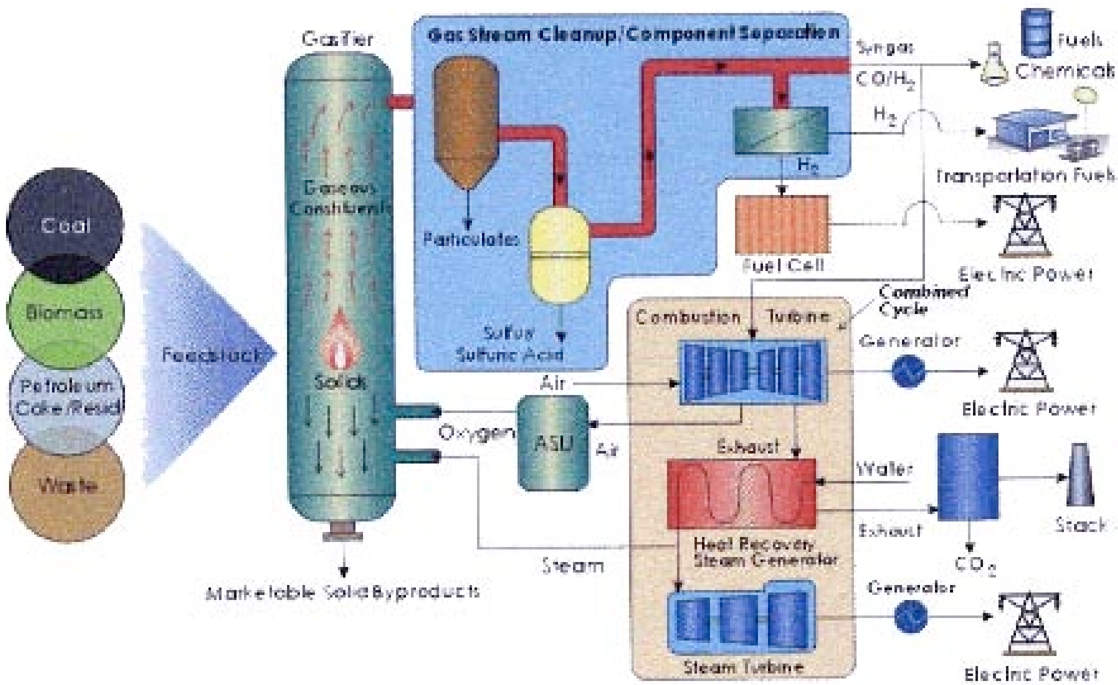
There are dozens of companies worldwide marketing gasification or pyrolysis technology. The greatest concentration of such plants in the world is in Japan where lack of landfill space and high disposal costs has driven them to seek more advanced solutions. According to CIWMB research, over 50 plants in Japan have installed capacity of more than 2.5 million TPY, equivalent to roughly 100% of the biomass going to landfill from the City of Los Angeles.

The focus of this technology to date in the U.S. has been on the conversion of select streams of material such as wood waste, chipped tires, or coal. However, there are several companies that include MSW as a target feedstock.

FIGURE 5.1

Gasification

Use of heat, pressure and steam to convert organic material directly to a synthetic gas (CO + H), oils, and char.



Typical Feedstocks:	**Coal**
	Coke
	Wood
	MSW

Principal Product: **Energy**

Source: CIWMB

In particular, gasification generates low air emissions, and achieves high rates of conversion leaving an ash residue of only 10-15% by weight of the incoming material, or less. The process generally requires a Refuse-Derived-Fuel (RDF) feedstock (vs. mixed MSW), and a landfill for disposal of ash.

Results of data gathering as part of the CIWMB study[26], showed that the current gasification plants in Japan and Europe are capable of meeting all the air emission standards that a plant in Los Angeles would be required to meet. These results would be examined in detail in the Environmental Impact Report (EIR) that would be prepared as part of the CEQA and Conditional Use Permit process for a CT facility in Los Angeles.

A key concern regarding the commercialization of the technology is the high capital and operating costs for the complex systems. This, coupled with the relatively low price of energy, means that the net tipping fee is likely to range from $40-$50 per ton.

Another issue is the public acceptability of a thermal process, regardless of how low the air emissions. The environmental community has come out in general against gasification because it is seen as another form of incineration, although clearly, it is not since it is "non-combustion". Regardless of current fact, fears of toxic air emissions persist and will likely only be allayed once and for all when a first plant is built in Los Angeles and the emissions rigorously tested. As previously mentioned, the Japanese and European plants are continuously monitored and have already passed similar and more stringent tests.

In addition, air emissions testing has just been completed at the International Environmental Solutions (IES) 50 TPD pyrolysis plant near Riverside, CA. Initial results indicate emissions below stringent South Coast Air Quality Management District (SCAQMD) limits.

Interestingly, gasification can be used as the front end of a bio-refinery to produce gas for conversion to ethanol. Thermogenics of Albuquerque, NM; Biomass Systems of San Leandro, CA; and BRI Energy are currently working on such systems that tout very high and efficient conversion to ethanol.

Plasma Arc Gasification is a variation of the gasification technology that is well established in the metals industry, and is being adapted to handle MSW. Initial applications have been for hard-to-handle material such as hazardous and radioactive waste. The in-vessel process involves the high-temperature "melting" of waste into gases and vitrified residue. The former can be used for power generation; the latter for aggregate, bricks and tile. Small demonstration plants have been constructed for testing various waste applications. Some gasification technologies are evaluating plasma arc as the front end of their systems.

Anaerobic Digestion

Anaerobic Digestion is the bacterial breakdown of organic material in the absence of oxygen. The process produces methane gas, which can be used for heat and/or power generation; and a solid residual that is typically composted into a soil amendment. See **Figure 5.2** for a schematic diagram of the process.

Anaerobic Digestion is one of the fastest growing CTs in the world. The greatest concentration of facilities is in Western Europe where a combination of market drivers is stimulating development of new plants in Belgium, Germany, Holland, Spain, Italy, France and other locations. According to the CIWMB report to the legislature, over 80 AD plants have a total installed capacity of 2.8 million TPY, equivalent to over 100% of the total biomass going to landfill from the City of Los Angeles.

Anaerobic Digestion is also being used extensively in the dairy industry to process cow manure and generate electricity for farms. Although small in size (most are for individual farms or collectives) the number and success of these projects is noteworthy and proves performance and cost effectiveness, at least in that agricultural arena. With a substantial horse population in the San Fernando Valley, this option has potential here in Los Angeles.

The application of importance here is the digestion of the organic fraction of MSW. There are scores of such plants operating throughout Europe, but as yet only one in N. America, and that only a demonstration plant in Toronto.

There are several potent and successful European firms with dozens of operating plants between them, who are actively pursuing projects in the European Union countries. They include, among others:

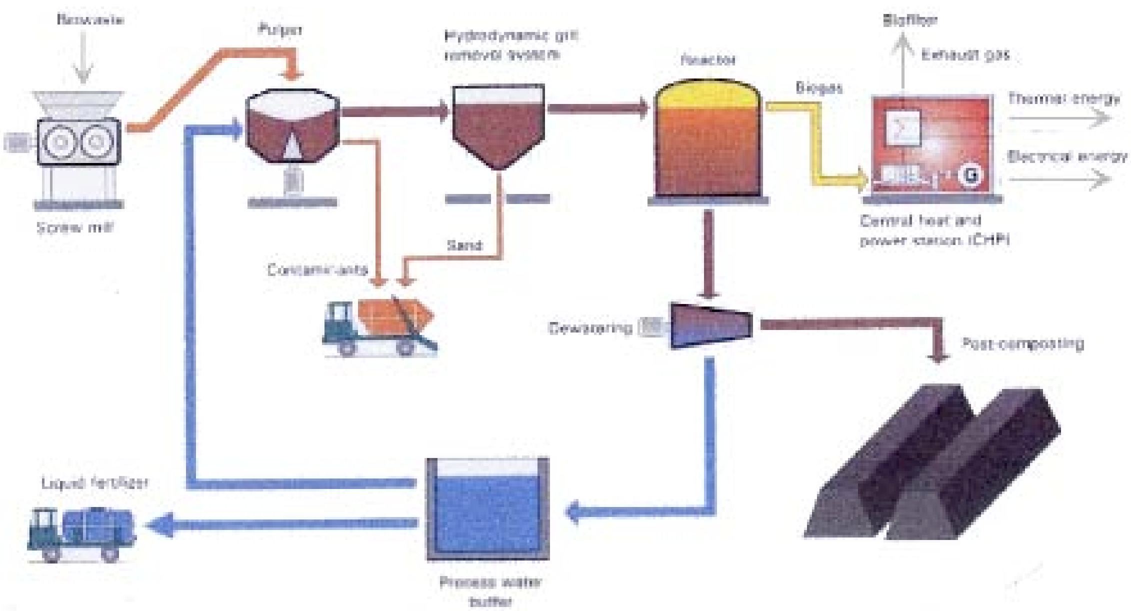
- OWS – Organic Waste Systems (Belgium)
- BTA (Germany)
- Steinmuller/Valorga (Germany and France)
- Linde (Sweden)
- Kompogas (Switzerland)
- Arrow Bio (Israel)

There are also three N. American companies with projects in development related to MSW; Onsite Power Systems; BioConverter Park, LLC; and Halton Recycling, Inc.

FIGURE 5.2

Anaerobic Digestion

The bacteria breakdown of organic material in the absence of oxygen to produce methane.



Typical Feedstocks: **Biosolids**
Livestock Manure
Greenwaste
MSW

Principal Products: **Energy**

Source: CIWMB

Onsite Power Systems is in the process of developing a large demonstration plant at UC Davis with the intent of translating that design and operating experience into the development of a 200 TPD greenwaste digestion facility for Cal State Channel Islands University. BioConverter has recently signed development contracts with the City of Lancaster for a 200 TPD greenwaste project, and the City of Los Angeles for a 2,700 TPD greenwaste facility. The latter included a guaranteed power purchase agreement from the City of Los Angeles DWP at $0.049/kWh.

The Sacramento Municipal Utility District (SMUD) is working with BLT Enterprises, Inc. and the City of Sacramento to install a 250 TPD OWS anaerobic digestion facility processing greenwaste, foodwaste, and low grade paper at BLT's Sacramento Recycling and Transfer Station. If developed, the plant will generate 1.25 MW of renewable electricity for SMUD's RPS program, or alternatively could pipe the biogas directly to SMUD's nearby generating station.

Canada Composting, Inc. (CCI) of Ontario constructed a full-scale, commercial anaerobic digestion plant processing MSW feedstock in Newmarket, Ontario. The 650 TPD plant utilizing the German BTA process, was the first of its kind in North America. Feedstock included foodwaste, greenwaste, and mixed residential trash. A patented hydro-pulper was used to separate organics from inorganics. The latter was sorted for recycling, and the former fed into the two-stage digestors. The high quality, low sulfur gas produced was engine ready, requiring no clean up. Residuals from the digestors were sold in bulk for soil amendment on golf courses and farms. The methane gas generated in the digestors was to be used in a co-gen plant to generate electricity to run the plant and export to the grid. With a reasonable capital cost of $25 million, tipping fee of approximately $38 per ton, this technology seemed poised for success. Unfortunately, a series of setbacks kept the plant from achieving full promise, and the plant was shuttered in 2003. It has since been re-designed and re-opened by Halton Recycling of Newmarket, Ontario. In addition, a second, smaller CCI plant is still in operation by the City of Toronto.

Key projects to monitor:

- **Halton Recycling, Inc., Newmarket, Ontario:** 100 TPD MSW and source separated organics
- **Onsite Power Systems, Camarillo, CA:** 200 TPD greenwaste to power
- **BLT / OWS Anaerobic Digestion, Sacramento, CA:** 250 TPD greenwaste, foodwaste and wastepaper to gas or power

MSW Composting

The fourth promising CT is the only one commercialized in the U.S., namely the in-vessel composting of MSW. The technology features controlled oxygen, moisture, and temperature environments to accelerate the decomposition of organics. Each in-vessel stage is generally followed by a curing stage, which is either an aerated-static pile, or traditional windrow. There are four firms currently pursuing projects in the U.S.

Bedminster has now developed 10 projects worldwide, six in the U.S., all handling mixed MSW and biosolids. Although their flagship Cobb County, GA plant experienced operational problems, it is now operating properly. New plants have come on line in the past few years, including the 700 TPD (designed to handle over 1,000 TPD) facility in Edmonton, Alberta. The company is now licensing the technology to others for project development.

The Bedminster system is designed to handle MSW and biosolids together, usually a 2:1 mix. It is not designed to run on MSW alone.

Conporec is a French-Canadian company with a front-end technology similar to Bedminster. Their one operating North American plant is located north of Montreal in Tracy, Quebec, and processes 35,000 TPY of mixed MSW (everything except Blue Box recyclables). They have also been awarded a 38,000 TPY facility in Delaware County, Delaware to process a mix of MSW and biosolids.

Herhof is a European technology with roughly 50 installations there. Historically, the Herhof system has focused on source-separated organics as a feedstock for production of compost. A more recent thrust has been the processing of MSW for the production of Stabilite, their patented Refuse-Derived-Fuel (RDF) that is sold to WTE and conventional power plants. The company is proposing a modified system to process MSW and produce compost and Stabilite. Their one North American facility, in Peele, Ontario (outside Toronto) processes 16,000 TPY of mixed MSW for sale as compost.

ECS (Engineered Compost Systems) operates a 50 TPD MSW composting facility at West Yellowstone, MT, and is constructing another 50 TPD MSW composting plant for Mariposa County, CA. The latter system will feature an upfront MRF followed by eight composting vessels for primary composting and an aerated static pile (ASP) system for extended curing.

See **Figure 5.3** for a schematic diagram of a typical MSW composting operation.

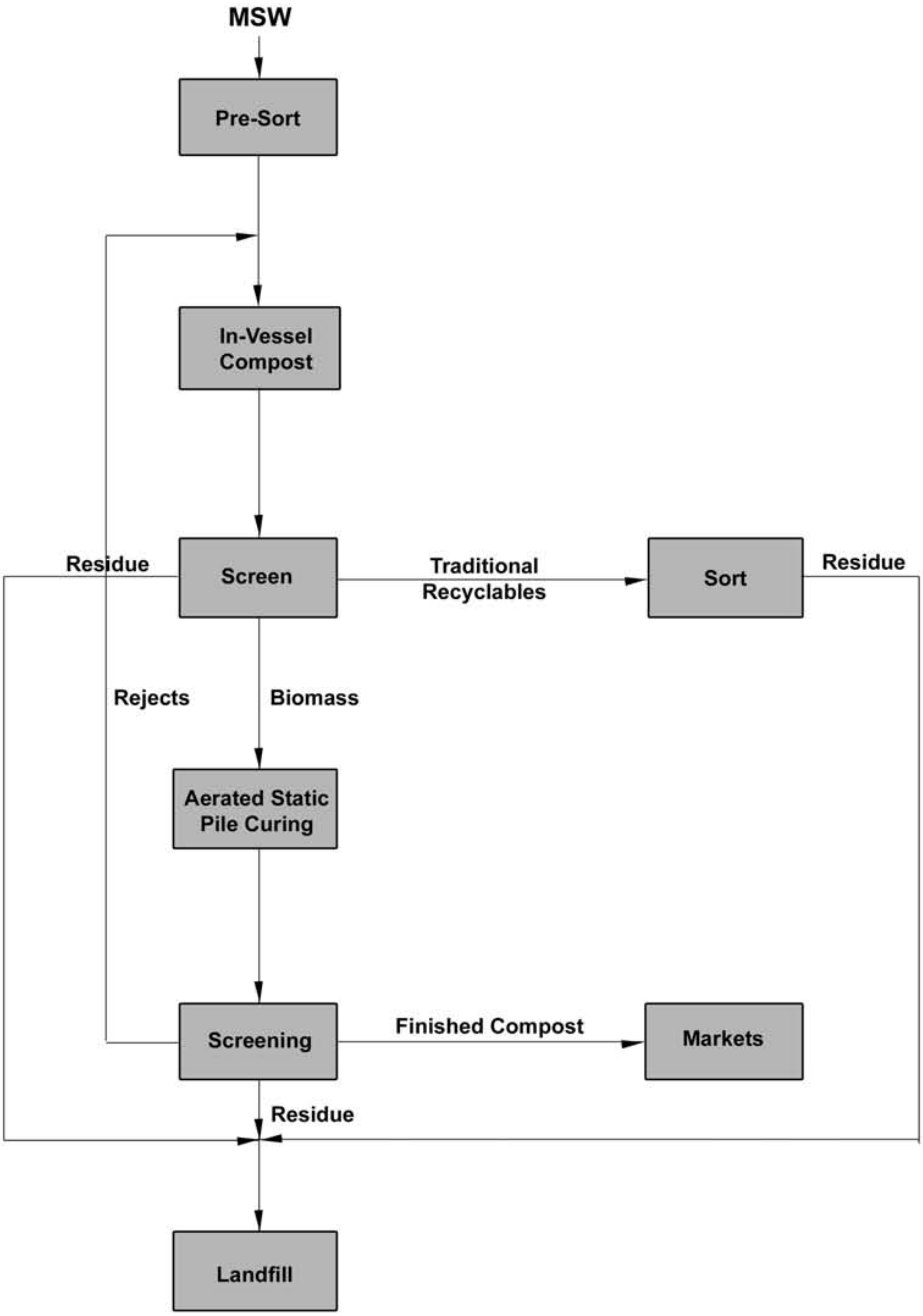
Key projects to monitor:

- **Bedminster, Edmonton, Alberta**: 700 TPD, largest MSW composting plant in North America
- **Bedminster, Cobb County, GA**: 300 TPD, operating flagship plant
- **Herhof, Peele, Ontario**: 16,000 TPY MSW plant, operational
- **Conporec, Tracy, Quebec**: 35,000 TPY MSW, operational
- **ECS, Mariposa County, CA**: 15,000 TPY MSW

The outstanding questions regarding MSW composting are the quality and marketability of the final product, and the overall cost. It is realistic to assume that MSW composting facilities will come with tipping fees in the $50 per ton range or more. This net cost is strongly impacted by the cost of residue disposal and the value and marketability of the finished compost.

FIGURE 5.3

MSW COMPOSTING



Autoclaving

Autoclaving of medical waste for sterilization before disposal has long been practiced throughout the U.S. However, this plan highlights a much broader, larger, and innovative process in which mixed residential and commercial MSW or post-MRF residue is "pressure cooked" with steam in large, rotating super drums up to 25 ft in diameter and 100 ft long. This facilitates subsequent separation of organic material (paper, cardboard, foodwaste, etc.) from inorganic (glass, metal, plastic, textiles, etc.).

As shown in **Figure 5.4,** the process involves the following steps:

- Autoclaving of "as received" or "post MRF" MSW (no shredding or pre-processing is necessary except removal of bulky items)
- Screening
- Sorting of traditional recyclables (and textiles if markets exist)
- Paper fiber cleaning (the two proprietary processes on the market vary in the degree of cleaning and following processes. WWI performs only preliminary cleaning, while CR3 performs a comprehensive cleaning followed by digestion of the reject organics).
- Anaerobic digestion (optional)
- Power generation (optional)
- Wastewater treatment and discharge to sewer

Autoclaving can be viewed as a "pre-processing" step for other CT applications or as a CT process in its own right. Overall diversion of 70-90% can be achieved depending on the quality of the MSW feedstock.

Two firms are in active project development:

- Comprehensive, Resources Recovery and Reuse (CR3) (Reno, NV)
- World Waste International (San Diego, CA)

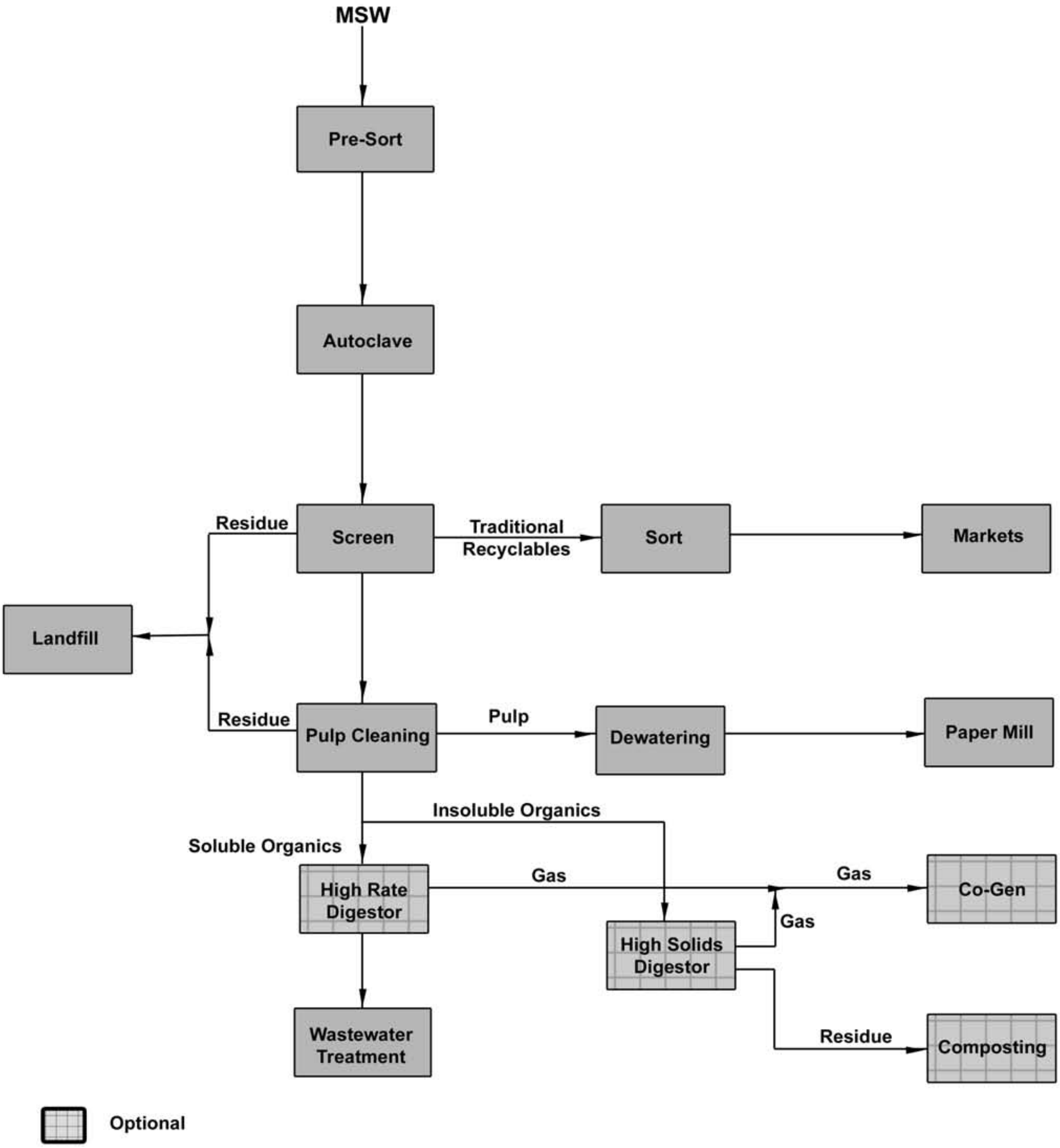
The importance of the ability of this technology to produce a high-quality organic feedstock for CT plants, all of which focus on the organic component of MSW, should not be overlooked. In fact, some of the greatest challenges facing these technologies are feedstock preparation (i.e. the problems with the first CCI plant in New Market, Ontario).

The first commercial CR3 has completed construction and is in the start-up phase in Minneapolis, MN. The plant will utilize two 8-ft diameter autoclaves to process up to 300 TPD of MSW into refuse derived fuel (RDF) for a nearby WTE plant.

The first commercial WWI plant is in construction at the CVT transfer station in Anaheim, CA. This plant features two approx. 12-ft diameter autoclaves that will process up to 500 TPD of mixed commercial and "post MRF" residue that is now disposed at the Brea Olinda Landfill. The recovered paper fiber will be dewatered to "wet lap" quality and sold to a local paper mill for manufacturing into new paper products, predominantly corrugated medium. This facility is due to start operations in the third quarter of 2005.

FIGURE 5.4

AUTOCLAVING



Fermentation or Bio-refining

Fermentation is the process of converting sugar to fuel-grade ethanol through Hydrolysis and Fermentation. Ethanol is a renewable, clean-burning fuel that results in a net-zero increase in greenhouse gases when MSW is used as the feedstock. This technology is widespread throughout the world, processing primarily corn and sugarcane into ethanol. For example, Brazil's vehicles run mainly on ethanol, not fossil fuels. Archer-Daniel- Midland (ADM), a Fortune 500 company, currently produces approximately 60% of the ethanol in the U.S. (all from corn). According to the Renewable Fuels Association, scores of ethanol plants in the U.S. produce nearly four billion gallons of ethanol per year, primarily in the Midwest, as demand for the fuel has grown rapidly in recent years.

In California ethanol is now being used as a replacement for MTBE (gasoline oxygenate). This has created a huge demand for ethanol (700 million gallons per year), which is currently being met by tank car shipments via rail from the Midwest.

Although virtually all our ethanol is currently made from corn or sugarcane, it can theoretically be manufactured from any organic material, including the organic fraction of MSW. Coincidentally, this fraction is predominantly the one still going to landfill disposal in Los Angeles. One example of bio-refining of a "waste" material is the Parallel Products plant in Rancho Cucamonga that produces about 6 million gallons per year of ethanol from waste soft drink beverages (Coca Cola, etc).

The essence of this technology, for application in this blueprint, is the breakdown of the organic fraction of MSW (paper, food waste, greenwaste) to sugar (glucose), followed by the bacteriological fermentation and distillation of the glucose to bio-fuels or bio-chemicals. The two dominant products are ethanol (clean burning fuel and gasoline additive), and acetic acid, although a wide range of end products is possible, including hydrogen for fuel cell cars. One benefit of this technology is the strength of the product markets, which are global in nature and non-traditional for MSW-derived materials.

Based on the initial report by URS Consultants for the City of Los Angeles, fermentation technology is not as advanced in a commercial sense as are either gasification or anaerobic digestion. In fact, there are no commercial cellulosic ethanol plants in the world at present. However, in five to 10 years, it is quite likely that this technology could be a major participant, and the lure of an almost unlimited ethanol market is irresistible. Thus the R&D work and the drive to commercialize a first project continues with some urgency.

From an environmental perspective, these plants are seen as low impact projects with most of the processes occurring in fully enclosed tanks and under biological conditions. This is particularly true of the enzymatic hydrolysis process which is all biological. However, even in the acid hydrolysis process, the acid is recaptured and the by-products (such as lignin and gypsum) made into saleable commodities.

There are several companies active in the field in the U.S. of which five (**Arkenol, BC International**, **Masada, Genahol, and BRI**) seem to be ahead as far as development of commercial plants using waste organics (agricultural or forest residues, processed MSW). Key projects in various stages of development in the U.S. include:

- **Masada, Middletown, NY –** 2,000 TPD MSW and biosolids-to-ethanol
- **Genahol, Canton, OH –** conversion of waste beverages and organic MSW to ethanol
- **BRI, Dallesport, WA –** gasification of 300 TPD of MSW and conversion of the syngas to ethanol
- **Iogen, Ottawa, Canada –** enzymatic hydrolysis of wheat straw to ethanol
- **Arkenol, Japan –** concentrated acid cellulose to ethanol

See **Figure 5.5** for a schematic diagram of the process.

These plants are complex, biological refineries costing in the $100 to $150 million range. Critical factors affecting development are the ability to obtain a guaranteed, long-term feedstock; obtain all permits; and secure financing. Although the technical aspect of these projects (i.e. will it work the way it's supposed to) has been guaranteed by engineering firms, each has experienced problems with financing. Without a reference plant, lending institutions are hesitant to participate. The capital-intensive nature of this technology continues to be an impediment; however, this could change overnight with a first project success.

Technologies Still in Development

Some technologies are simply not far enough along on the development curve. Typically these technologies have not passed the pilot plant stage, or are designed only to handle specialized wastestreams and feedstocks that are not MSW related. A short description of two of these follows:

- ***Fixation* –** the conversion of MSW to inert products. After shredding, the MSW is treated with a catalyst, which under high pressure sets into an inert solid, trapping all chemical constituents in a chemical bond. This material is then extruded into products such as building blocks, posts, and railroad ties. A demonstration plant was built and tested at the Advance Disposal Transfer Station in Hesperia, CA. Issues of reliability and performance remain, as well as questions regarding the marketability and environmental stability of the final products.

- ***Kinetic Disintegration* –** First American Scientific Corp. developed a pilot plant that used sound waves to powderize various waste materials. The process is most effective on select types of waste with markets for the pulverized product, such as: tires, drywall, glass, plastics, insulation, and biosolids. It is not geared to processing MSW, but may be of value as the front end of new technologies that work best on small particle material.

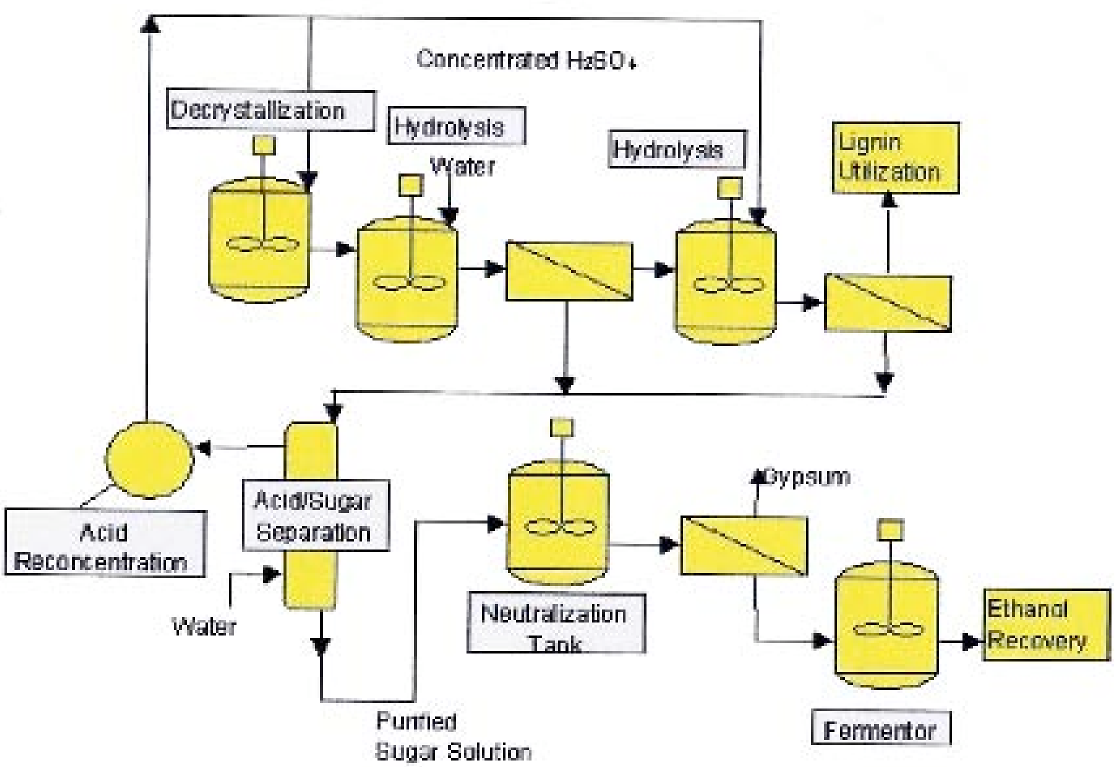
FIGURE 5.5

Fermentation

The conversion of cellulosic material to ethanol.

Concentrated Acid
Dilute Acid
Enzymatic

Concentrated Acid Hydrolysis



Typical Feedstocks: **Corn**
Sugarcane
Brewery Waste

Principal Products: **Ethanol Fuel**
Lignin

Source: CIWMB

CT Summary

Table 5.2 summarizes the pros and cons of the five highlighted CTs.

With the exception of the composting technologies, there is only one reference CT plant processing MSW in North America, and it is a small one in Toronto, Ontario (a BTA anaerobic digestion plant). However, it is likely that several more CTs will come on line in the next five years, including the two autoclave plants now completing construction.

Once the first plants are in the ground and operating successfully, any of these technologies could expand rapidly; just as they have in Europe and Japan.

The lack of successful implementation to date in N. America vs. the booming market for these technologies in Europe is easy to understand when one looks at the key factors that support such development:

- High waste disposal tipping fees (either landfill or WTE)
- Existing successful organics source-separation programs
- Landfill bans or taxes on organic waste disposal
- High green, renewable energy demand/value
- Societal acceptance (primarily compost products)
- Public and political support for higher cost solutions for environmental benefit
- Existing local reference plants
- Acceptance and support in the recycling community for new technologies

All of these factors are positive in Europe, whereas some are negative here in N. America and particularly in California. Of special interest in California is the last bullet in the above list. Alternative technologies, by and large, have had a very difficult path to acceptance by traditional recyclers and the even the California Integrated Waste Management Board. This negative reception stems from the following factors:

- Alternative technologies were seen as threats to existing “source separation” recycling programs (the black box that would do it all for you, eliminating the need for separation at the source).
- Gasification/Pyrolysis was viewed as nothing more than disguised WTE plants
- Conversion of organics to fuels and energy was considered a “low-end” use.
- There have been virtually no commercial size reference plants in N. America except for MSW composting, which has had a checkered past.
- Even with all the energy problems and huge societal cost of the recent energy crisis and reliance on imported oil, alternative fuels and green energy have not captured the public or political consciousness.

Nonetheless, as previously stated, several projects are moving forward, and a few successes could open the gates for a flurry of activity.

TABLE 5.2
ALTERNATIVE TECHNOLOGIES
SUMMARY EVALUATIONS

Alternatives	Description	Pros	Cons
Gasification/Pyrolysis	Thermal conversion of organic material to syngas (high percentage of methane), a small volume of ash, and water. The core of the technology is the thermal conversion unit, primarily various kinds of fluidized-bed, or fixed-bed, with the product gas used to generate steam or electricity.	• Capable of handling up to 1,500 TPD of MSW per plant • Generates very low air emissions and achieves high rates of burnout leaving little ash residue. • Gasification can be used as the front end of a bio-refinery to produce gas for conversion to ethanol.	• No commercial plants that gasify MSW are operating in the U.S. • High capital and operating costs means that the net tipping fee would likely be over $50 per ton. • Negative public acceptability of a thermal process
Fermentation	Breakdown of the organic fraction of MSW (paper, food waste, and greenwaste) to sugar (glucose), followed by the bacteriological fermentation and distillation of the glucose to bio-fuels or bio-chemicals. The two dominant products are ethanol (clean burning fuel and gasoline additive), and acetic acid.	• Capable of handling up to 1,500 TPD of processed MSW per plant • Ethanol is a renewable, clean-burning fuel that results in a net-zero increase in greenhouse gases. Huge California market as MTBE replacement • Many large plants in operation with corn and sugarcane feedstock	• Capital intensive • Lending institutions are hesitant to participate since there are no reference plants. • Cost of operation may be high • Difficult initial hydrolysis step
MSW Composting	In-vessel composting of MSW for production of soil amendment. Features controlled oxygen, moisture, and temperature environments to accelerate the decomposition of organics. Each in-vessel stage is generally followed by a curing stage, which is either an aerated-static pile or traditional windrow.	• Capable of handling up to 750 TPD of MSW per plant • Over 50 operational plants in Japan. • Four firms currently pursuing projects within the U.S. • Designed to handle raw MSW and biosolids. Does not need pre-processing of the MSW.	• Tipping fee of approximately $50 per ton is strongly impacted by the cost of residue disposal, and the value of the final compost • Marketability of the final product still a question. Some plants assign the compost a negative value in the early years.
Anaerobic Digestion	Anaerobic decomposition of organics, primarily biosolids and other distinct MSW wastestreams, including greenwaste, foodwaste and the other organic fractions.	• Capable of handling up to 500 TPD of processed MSW per plant. • Produces methane for heat and power generation, and liquid fertilizer and dry compost • Low environmental impacts • Over 50 operational plants in Europe • Accepts a diversity of organic feedstocks	• Only N. American reference plant is small demonstration facility in Toronto using the BTA technology • Requires good front end separation and feedstock preparation • Requires composting of digester residue, which can equal up to one-third or more of the incoming tonnage
Autoclaving	The steam "pressure cooking" of MSW in large rotating drums to facilitate recovery of recyclables and paper pulp, and the optional generation of gas for energy or fuel production.	• 2 plants in construction in the U.S. • Capable of handling up to 1,500 TPD or more of mixed MSW in 250 TPD modules • Recovers high levels of paper pulp • Can generate renewable energy • Can accept a diversity of feedstocks • Pulp and paper industry testing of recovered paper fiber is positive	• No reference plants-but two in construction in U.S. • Project costs yet to be confirmed at commercial sites. • No long term experience with use of pulp product in mills