



Los Angeles County Conversion Technology Evaluation Report

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Phase II - Assessment

Converting Waste into Renewable Resources

October 2007

LOS ANGELES COUNTY CONVERSION TECHNOLOGY EVALUATION REPORT – PHASE II

October 2007

Prepared for

The County Of Los Angeles
Department Of Public Works

And

The Los Angeles County Solid Waste Management Committee/Integrated Waste Management Task Force's Alternative Technology Advisory Subcommittee

Prepared by

ARI

Alternative Resources, Inc.
1732 Main Street
Concord, MA 01742
(978) 371-2054

On the Cover: Representative images of the five conversion technologies evaluated in Phase II of the County's project.

Electronic copies of this Report are available online, along with additional conversion technology resources, at *www.SoCalConversion.org*

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ALTERNATIVE TECHNOLOGY ADVISORY SUBCOMMITTEE OF THE LOS ANGELES COUNTY INTEGRATED WASTE MANAGEMENT TASK FORCE

Paul Alva, Chair, County of Los Angeles Department of Public Works
Fernando Berton, California Integrated Waste Management Board
Dave Hauser, Browning Ferris Industries
Alex Helou, City of Los Angeles Bureau of Sanitation
Wayde Hunter, North Valley Coalition
Kay Martin, Bioenergy Producers Association
Mark McDannel, County Sanitation Districts of Los Angeles County
John McTaggart, Los Angeles County Integrated Waste Management Task Force
Mike Mohajer, Los Angeles County Integrated Waste Management Task Force
Michael Theroux, Theroux Environmental Consulting
Eugene Tseng, Eugene Tseng and Associates
Christine Urbach, County of Los Angeles Department of Public Health
Ed Wheless, County Sanitation Districts of Los Angeles County
Jeff Yann, Hacienda Heights Improvement Association
Miguel Zermeno, City of Los Angeles Bureau of Sanitation

KEY STAKEHOLDERS AND STAFF

Kevin Chen, Southern California Edison
Virginia Jauregui, County of Los Angeles Department of Public Works
Carl Pederson III, County of Los Angeles Department of Public Works
Coby Skye, County of Los Angeles Department of Public Works

ALTERNATIVE RESOURCES, INC. PROJECT TEAM, PROJECT CONSULTANT

Alternative Resources, Inc.
Clements Environmental Corporation
Facility Builders & Erectors
Holland & Knight LLP
UltraSystems Environmental

CONVERSION TECHNOLOGY
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1.0 OVERVIEW

Background

Conversion technologies refer to a wide array of biological, chemical, thermal (excluding incineration) and mechanical technologies capable of converting post-recycled residual solid waste into useful products and chemicals, green fuels such as hydrogen, natural gas, ethanol and biodiesel, and clean, renewable energy such as electricity. In addition to the production of locally-generated renewable energy and green fuels, the use of conversion technologies in Southern California could effectively enhance recycling and beneficial use of waste, reduce pollution such as greenhouse gas emissions, and reduce dependence on landfilling and imported and domestic fossil fuels.

Conversion technologies are successfully used to manage solid waste throughout Europe, Israel, Japan, and other countries in Asia, but are not yet in commercial operation in the United States. While there are and have been pilot demonstrations of conversion technologies in the United States, the absence of larger scale demonstration facilities and commercial facilities in this country is an obstacle to demonstrating the benefits these technologies can offer. In addition to lack of U.S. experience, specific development hurdles for conversion technologies in California may include: cost, especially when compared to the current, relatively inexpensive cost of landfill disposal; the lack of a clear permitting and regulatory pathway; a lack of diversion credit, renewable energy credit, or other incentives for the development of emerging technologies; and misconceptions regarding the performance of these technologies.

For nearly a decade, the County of Los Angeles has been a consistent supporter of conversion technologies for their ability to manage post-recycling residual waste materials in an environmentally preferable manner and their potential to assist jurisdictions in meeting the State's waste diversion mandate. For example, the County has supported legislation and worked with State and local governments and other key stakeholders to advance research and development of conversion technologies.

County Role

Pursuant to AB 939, counties have the added responsibility of preparing and administrating the Countywide Siting Element and the Countywide Integrated Waste Management Summary Plan. The Summary Plan describes the steps that will be taken by local agencies, acting independently and in concert, to achieve the 50 percent waste diversion mandate. The Countywide Siting Element, which was adopted by a majority of the cities in the County of Los Angeles encompassing a majority of the cities' population, the County Board of Supervisors, and the State, is the current long-term planning document which provides for the County's solid waste disposal needs for the residual waste remaining after undergoing all recycling and other waste diversion efforts. Currently, residents and businesses in Los Angeles County generate over 24 million tons of trash each year, of which approximately 12 million tons, equivalent to over 40,000 tons of trash each day, must be properly disposed.

Meeting the mandates of AB 939 is especially challenging in Los Angeles County. The County of Los Angeles includes 88 cities and 134 unincorporated communities with a combined population in excess of 10 million. The County of Los Angeles has the largest and most complex solid waste management system in the country, with over 140 permitted waste haulers, 28 large transfer stations/material recovery facilities, 11 municipal solid waste landfills, 11 inert waste landfills, 2 waste-to-energy facilities, 43 construction and demolition debris recycling facilities and 350 recyclers. Each year, Los Angeles County residents and businesses generate approximately 24 million tons of materials, with approximately 50% being diverted through source reduction and recycling away from disposal. However, 12 million tons of trash remains each year, equivalent to approximately 40,000 tons which must be safely and properly disposed on a daily basis. This presents a challenge in not only protecting the public health and safety and the environment through effective solid waste management on a daily basis but also continuing to expand waste reduction, resource recovery, and recycling programs and policies.

The Los Angeles County Board of Supervisors is the legislative and executive branch of County government. The Board of Supervisors have been steadfast advocates of alternatives to landfills, and provided the leadership needed to advance the development of these emerging technologies. The Board of Supervisors have designated the Department of Public Works as the lead County agency advising the Board of Supervisors on waste management issues and responsible for the County's compliance with AB 939 mandates. This includes the waste diversion mandate for the unincorporated areas as well as Countywide solid waste planning responsibilities, in concert with the cities and the Task Force.

As part of its continuing efforts to evaluate and promote the development of conversion technologies, the County incorporated into the land use permit for the Puente Hills Landfill a condition requiring the owner/operator of the landfill, the County Sanitation Districts of Los Angeles County, to provide up to $100,000 in funding each year for the remainder of the landfill's lifespan, in order to study conversion technologies, and requires the Sanitation Districts consider funding a pilot conversion technology facility, should a suitable technology be identified. The land use permit approved by the County Board of Supervisors also requested the Los Angeles County Solid Waste Management Committee/Integrated Waste Management Task Force (see description below) form the Alternative Technology Advisory Subcommittee (Subcommittee), a multi-stakeholder group whose mission is to thoroughly evaluate and promote the development of conversion technologies.

Continuing this model, the County adopted a land use permit for the Sunshine Canyon landfill, owned and operated by Browning-Ferris, Industries, which included a condition for providing $200,000 per year in funding for 10 years. This funding will continue the work of the Subcommittee, the Task Force and the Department of Public Works in implementing the recommendations of this Report and advancing the vision of the Board of Supervisors to some day make landfills obsolete.

To further this goal in the near term, the County of Los Angeles Department of Public Works is collaboratively working with the Task Force and the Subcommittee to facilitate development of a fully operational conversion technology demonstration facility in Southern California. The goal of the County's project is to demonstrate technical, environmental and economic benefits of conversion technologies through design, construction and operation of a facility in Southern California, in order to forge permitting and legislative pathways for conversion technologies and promote development of future projects. This demonstration project is the first implementation resulting from the combined efforts to evaluate the feasibility of conversion technologies in Southern California, including a broad evaluation in Phase I and a more detailed evaluation in Phase II. A brief description of the Phases is included below, with a more detailed explanation in Sections 2 and 3 of this Report.

Pursuant to Chapter 3.67 of the Los Angeles County Code and AB 939, the Task Force is responsible for coordinating the development of all major solid waste planning documents prepared for the County of Los Angeles and its 88 cities. Consistent with these responsibilities, and to ensure a coordinated and cost-effective and environmentally-sound solid waste management system in Los Angeles County, the Task Force also addresses issues impacting the system on a Countywide basis. The Task Force membership includes representatives of the League of California Cities-Los Angeles County Division, the County of Los Angeles Board of Supervisors, the City of Los Angeles, the waste management industry, environmental groups, the public, and a number of other governmental agencies.

In 2004, as requested by the County, the Task Force established the Alternative Technology Advisory Subcommittee to evaluate and promote the development of conversion technologies. The Subcommittee’s membership includes municipal officials, regulators, consultants, industry, environmental and community representatives, all experts in the field of conversion technologies and solid waste management.

Phase I – Initial Technology Evaluation

Beginning in 2004, the County contracted with URS Corporation to conduct a preliminary evaluation of a range of conversion technologies and technology suppliers, and initiated efforts to identify material recovery facilities (MRFs) and transfer stations (TSs) in Southern California that could potentially host a conversion technology facility. A scope beyond just Los Angeles County was considered important as stakeholders in the Subcommittee extended beyond Los Angeles County, and the implications of this effort will have many regional impacts.

In August 2005, the Task Force adopted the Subcommittee's *Conversion Technology Evaluation Report*. As more fully described in Section 2 of this report, Phase I resulted in identification of a preliminary short list of technology suppliers and MRF/TS sites, along with development of a long-term strategy for implementation of a conversion technology demonstration facility at one of these sites. The Department of Public Works and the Subcommittee intentionally pursued integrating a conversion technology facility at a MRF/TS site in order to further divert post-recycling residual waste from landfilling and take advantage of a number of beneficial synergies from co-locating a conversion facility at a MRF.

Phase II – Facilitation Efforts for Demonstration Facility

In July 2006, the County contracted with Alternative Resources, Inc. (ARI) to further advance its efforts to facilitate development of a conversion technology demonstration facility (Phase II). The ARI team included multi-disciplined expertise, including Clements Environmental Corporation, Facility Builders and Erectors, Holland & Knight, and UltraSystems Environmental. Key Phase II services provided by the ARI team included:

- an independent evaluation and verification of the qualifications of selected technology suppliers and the capabilities of their conversion technologies;
- an independent evaluation of candidate MRF/TS sites, to determine suitability for installation, integration and operation of one of the technologies;
- a review of permitting pathways;
- identification of funding opportunities and financing means;
- identification of potential County incentives (i.e., supporting benefits) to encourage facility development amongst potential project sponsors; and
- negotiation activities to assist these parties in developing project teams and a demonstration project.

This report describes progress to date on Phase II of the County's project to facilitate development of a conversion technology demonstration facility in Southern California, and represents a culmination of approximately one year of work conducted by the County and Subcommittee in conjunction with the ARI team.

Phase III – Long-Term Development of Conversion Technologies

As described previously, Los Angeles County residents and businesses generate approximately 24 million tons of materials, with approximately 50% being diverted through source reduction and recycling away from disposal. This results in over 12 million tons of trash left for disposal every year, a number that is expected to continue to grow, despite waste reduction and recycling programs, due to continued population and economic growth in the region. With the certainty that in-County landfill capacity will run out in the long term, and will be substantially diminished in the short term, the County of Los Angeles recognizes the imperative to develop technically, economically and environmentally feasible alternatives to landfills within Los Angeles County.

The goal of the County's demonstration project (Phase II) is to forge permitting and legislative pathways for conversion technologies and promote development of future projects. Building on the experiences gained after the successful development of one or more demonstration projects in Phase II, the next logical step is a focus on development of commercial scale facilities using proven technologies within Los Angeles County. To facilitate this goal, future, Phase III activities may include the following:

- Re-evaluating the marketplace of conversion technologies to consider new and emerging developments and continue to pursue development of the most technically and environmentally effective technologies, focusing on the identification of potential sites within Los Angeles County, including key potential sites identified in Phase II;

- Developing partnerships with local cities within Los Angeles County interested in the development of conversion technology facilities within or adjacent to their borders; and

- Facilitating development of commercial-scale conversion technology facilities designed to manage Los Angeles County's waste stream.

These activities can occur concurrently with the continued development of the Phase II demonstration projects.

Public Outreach

In January 2007, the County initiated efforts to develop and implement a public outreach and education plan for development of conversion technologies in Southern California. These public outreach efforts have been occurring integrally with the evaluations described in this report. This report is not intended to address the details of the public outreach plan. However, the findings presented herein are intended to be shared through the public outreach program, to facilitate the development of a conversion technology demonstration facility.

The County's Role as a Project Facilitator

The County is promoting the development of a conversion technology demonstration facility by serving as a project facilitator. In this role, the County is effectively using its resources to promote project development in a variety of ways. In the work completed in Phase I and Phase II, the County has utilized the expertise of Department of Public Works staff, the Subcommittee, and its consulting teams to disseminate a wide range of information regarding conversion technologies, potential host locations, and project development activities. Overall, the County is providing a framework to bring technology suppliers and MRF/TS site owners and operators together for development of a project.

As the County continues to support and promote conversion technologies and works to achieve development of a demonstration facility in Southern California, its role of facilitator is likely to evolve. Each technology supplier and MRF/TS site owner/operator may have different needs and priorities for facilitation of project development. As a facilitator, the County can consider discrete actions along with invested public and private partners, such as County Sanitation Districts Board of Directors and BFI, it can take and specific incentives it can offer to promote project development. There are a wide range of potential opportunities for County facilitation and support of a conversion technology demonstration facility. Some of these are essential support activities, such as providing for public waste supply agreements or for public "backing" of private waste supply agreements for the term of financing. Others are support activities that would facilitate project development, such as developing and sharing technology and site information, and promoting beneficial use of products. These potential opportunities for County support of a conversion technology demonstration facility are further addressed in this report.

2.0 SCOPE AND METHODOLOGY OF PHASE II STUDY

Phase II activities began in July 2006, and progressed steadily through the development of this report. The scope of Phase II work has consisted of implementation of key activities identified in the Phase I strategic action plan, including: verification and evaluation of technology supplier qualifications and technology capabilities; evaluation of candidate MRF/TS sites and verification of their ability and willingness to partner with a technology supplier; and other activities aimed at promoting and facilitating development of a conversion technology demonstration facility. The scope and methodology of the Phase II study is summarized below.

Selection of Participating Technology Suppliers

Technology suppliers were selected to participate in Phase II based on:

(1) The results of the Phase I evaluation and ranking;

(2) Consideration of new and relevant information regarding technology performance and development, including ancillary capabilities of technology suppliers (e.g., integrating combined heat and power or alternative fuels in project development activities); and

(3) The ability and willingness of the technology supplier to participate in Phase II, recognizing the substantial commitment to supply detailed information that would be required on their part. In addition to having the ability and willingness to partner with one of the candidate MRF/TS sites, the minimum commitment required of the technology suppliers included disclosure of technical, environmental and cost information for the technology, disclosure of technical and financial resources of the technology supplier, and identification of an operating reference facility.

Thirty-two technology suppliers were considered for participation in Phase II, including: the six technology suppliers previously short listed in Phase I; the eight technology suppliers that passed the screening criteria and were evaluated in Phase I, but at the time were not recommended for further evaluation; and eighteen additional technology suppliers that were not evaluated in the Phase I study, but had subsequently contacted Los Angeles County and expressed an interest in the County's conversion technology demonstration project. The eighteen additional technology suppliers were evaluated using the minimum criteria established for the Phase I screening and applied to the other technologies, with a more stringent requirement for diversion potential.

Ultimately, nine technology suppliers were selected for participation in Phase II, including the six that were recommended in Phase I and three additional technology suppliers that were evaluated in Phase I but not recommended at the time (Arrow Ecology and Engineering, Ebara Corporation, and International Environmental Solutions).

After selection of the participating technology suppliers, a Request for Information (RFI) was issued to the nine selected participants. During the RFI response period, four of the nine selected technology suppliers chose to withdraw from the process for a variety of reasons on their part. The Phase II process proceeded with a final list of five technology suppliers. The suppliers and proposed projects are listed alphabetically in Table 1.

Table 1. Technology Suppliers Participating in Phase II and Proposed Projects

Technology Supplier	Technology Type	Proposed Capacity	Major Products
Arrow Ecology and Engineering (Arrow)	Anaerobic Digestion	300 tpd	Biogas (Electricity) Digestate (Compost) Recyclables
Changing World Technologies (CWT)	Thermal Depolymerization	200 tpd	Renewable Diesel Carbon Fuel Metals
International Environmental Solutions (IES)	Pyrolysis	242.5 tpd @ 58.9% moisture 125 tpd@ 20% moisture	Syngas (Electricity)
Interstate Waste Technologies (IWT)	Pyrolysis / High Temperature Gasification	312 tpd (1 unit) 624 tpd (2 units) 935 tpd (3 units)	Syngas (Electricity) Mixed Metals Aggregate
NTech Environmental (NTech)	Low Temperature Gasification	413 tpd	Syngas (Electricity)

Methodology for Technology Evaluation

Information required for the technology evaluation and for evaluation of the resources and qualifications of the technology suppliers was gathered through a detailed Request for Information (RFI). The RFI described Los Angeles County's objectives for the demonstration project, and disclosed the technical, economic, and qualifications criteria that were established for the Phase II evaluation process. The RFI also identified the candidate MRF/TS sites, provided contact information for the MRF/TS site owner/operators along with key site information, and provided waste composition assumptions. The RFI was issued in October 2006, and responses were received in December 2006. A copy of the RFI is provided in Appendix B to the report. The evaluation criteria are identified in the report, as a preface to the review of resources and financial qualifications of the technology suppliers (Section 4) and the technology evaluations (Section 5).

In January 2007, after submittal and initial review of the RFI responses, interviews and working meetings were conducted with each of the technology suppliers in Los Angeles. This direct interaction with the technology suppliers provided the opportunity to confirm information and gather additional data and materials as needed. Throughout the review process, direct interaction and coordination with the technology suppliers continued, including visits to reference facilities from February through April 2007, to ensure the most accurate and complete information was available for review. Upon analysis of information obtained during the presentations and site visits, preliminary findings were summarized and a workshop was conducted with the Subcommittee to review and discuss the preliminary findings. Following the Subcommittee's review, the preliminary findings were shared with the technology suppliers in June 2007, to provide a final opportunity for data confirmation and input. Information in this report is current through June 2007.

Selection of Candidate Sites

The Phase I study recommended six MRF/TS facilities as preferred locations for development of a conversion technology demonstration facility. Early in the Phase II process (July 2006), the owner/operators of the six potential sites were contacted and site visits were conducted to determine interest in continued participation in the County's demonstration project. Four of the original six sites expressed a willingness and ability to participate. Two of the sites, both identified in Phase I as "second priority" sites, dropped out: the Central Los Angeles Recycling Center and Transfer Station (CLARTS), because it is a potential site for the City of Los Angeles conversion technology project, and the proposed facility in Santa Clarita, because of uncertainty regarding the approval of the entire industrial development that would have encompassed the MRF/TS. Late in the Phase II process, a new MRF was added to the project, specifically in consideration of their relationship with one of the selected technology suppliers (International Environmental Solutions). This additional MRF (Rainbow Disposal in Huntington Beach) was evaluated under this project exclusively in partnership with IES. The five MRF/TS sites evaluated in Phase II are identified in Table 2, listed in alphabetical order.

Table 2. MRF/TS Sites Evaluated in Phase II

MRF/TS Facility	Location
Community Recycling/Resource Recovery Inc.	Los Angeles County (Los Angeles)
Del Norte Regional Recycling and Transfer Station	Ventura County (Oxnard)
Perris MRF/Transfer Station	Riverside County (Perris)
Rainbow Disposal Company, Inc. MRF(1)	Orange County (Huntington Beach)
Robert A. Nelson Transfer Station and MRF	Riverside County (Unincorporated)

(1) The Rainbow Disposal MRF was evaluated under this project exclusively in partnership with IES.

Methodology for Site Evaluation

Criteria were established to evaluate the suitability of each facility to host a conversion technology demonstration facility. The criteria included the fundamental prerequisite of ability and willingness to partner with a technology supplier for development of a demonstration facility, along with primary criteria (e.g., space availability, feedstock quantity) and secondary criteria (e.g., ability to assist in marketing products, accessibility to major transportation routes). Information required for site evaluations was gathered through a series of site visits and meetings with each of the individual site owner/operators. The criteria that were established for the Phase II site evaluations (see Section 6 of the report) provide a template that may be useful by other entities that are similarly working on development activities for a conversion technology project.

Reference Facility Tours

Reference facility tours were an important component of the Phase II technology evaluations. The tours provided the opportunity to gather and confirm technology-specific information, and to gather valuable insight for development of a demonstration project in Southern California.

Each participating technology supplier was required to identify an operating reference facility that could be visited to observe the technology. Members of the Subcommittee, Department of Public Works staff, and representatives of the ARI team participated in the tours, which took place from February through April 2007. When possible, meetings were also held with regulators and local government officials to gather insight regarding the development and operational history of the facilities. Table 3 identifies the reference facilities that were visited. Additional information on the reference facilities and relevant findings from the tours and meetings are integrated with the technology evaluations in Section 5 of the report.

Table 3. Reference Facility Visits

Technology Supplier	Reference Facility Visited (Location)
Arrow Ecology	Hiriya, Israel
Changing World Technologies	Carthage, Missouri
International Environmental Solutions	Romoland, California
Interstate Waste Technologies	Chiba, Japan Kurashiki, Japan
NTech Environmental	York, England (pre-processing) Bydgoszcz, Poland (gasifier)

Project Economic Analysis

Planning-level cost and pricing estimates provided by the technology suppliers, including the estimated tipping fees, were independently reviewed and evaluated to determine:

- completeness and reasonableness of cost and pricing assumptions;
- consistency of estimated tipping fees with cost and pricing assumptions and technical data (e.g., annual waste throughput, quantity of products, quantity of residue); and~~,~~
- sensitivity of estimated tipping fees to outside influences.

The evaluation included economic modeling to independently estimate tipping fees.

The tipping fees estimated by the technology suppliers and confirmed by modeling as achievable fall in the range of approximately $50 to $70 per ton. In comparison, current waste disposal costs in the region vary considerably based on location, extent of MRF processing, and long-term disposal agreements. Current landfill gate fees for MSW range from approximately $30 to $40 per ton. Costs including transportation and additional processing (as indicated by gate rates at MRF/TSs) are somewhat higher, ranging from approximately $40 to $50 per ton.

The Puente Hills Landfill is the largest operating landfill in the United States at 13,200 tpd, and a dominant force in setting market prices in the Los Angeles County area. The Puente Hills Landfill will close in 2013, and the Sanitation Districts of Los Angeles County, will develop a system for long haul by rail from the Puente Hills MRF, adjacent to the Landfill, in order to compensate for a fraction of the disposal capacity no longer available upon closure of the landfill on October 27, 2013. This "waste-by-rail" system is estimated to be operational by 2011 and will direct waste to the Mesquite Landfill, several hundred miles from Los Angeles. The Sanitation Districts estimate the cost for rail haul from the Puente Hills MRF at approximately $75/ton, requiring a ramped increase before the Landfill closes in order to prevent a sudden spike in cost and provide for a levelized rate.

The Sanitation Districts projects this "levelized" gate fee (i.e., tipping fee) at Puente Hills for rail haul and disposal will be approximately $45 per ton in 2013, which corresponds with the potential initial operating year for a conversion technology facility ($50 to $70). Five years thereafter (i.e., by 2018) the gate fee for rail haul and disposal is expected to be approximately $70 per ton, and within ten years (i.e., by 2023) the gate fee is expected to be over $100 per ton. These prices are expected to reflect overall market conditions.

The estimated tipping fees for the conversion technologies compare favorably with projected costs for haul and disposal in the immediate future, and are estimated to be directly cost competitive with landfill disposal within 5-10 years. On a life cycle basis (e.g., over 20 years of operation), the conversion technologies could be less costly than rail haul and disposal. However, in the initial years of conversion technology operation (e.g., up to the first five years of operation in the scenario presented above) there may be a need to "bridge" the economic gap, if any, in order to make up the difference between those new facility costs and prevailing transfer and landfill disposal prices until such time as market waste disposal fees equal those for conversion technologies.

3.0 SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

Summary of Findings

As described in this report, the Los Angeles County Solid Waste Management Committee/Integrated Waste Management Task Force (Task Force), its Alternative Technology Advisory Subcommittee (Subcommittee), and the Los Angeles County Department of Public Works have been working to facilitate the design, construction and operation of a conversion technology demonstration facility(ies) in Southern California, to demonstrate the capabilities and benefits of conversion technologies, and to forge permitting and legislative pathways for future projects. This report describes Phase II of the County's project facilitation activities. Key activities of Phase II included: (1) verification and evaluation of technology supplier qualifications; (2) verification and evaluation of technology capabilities (including technical, environmental and economic factors); and (3) evaluation of candidate MRF/TS sites and verification of their ability and willingness to partner with a technology supplier. Phase II activities also included identification of: project funding opportunities and financing approaches; financing requirements; and County incentives needed or helpful to facilitate project development. Tables 4 and 5 identify, respectively, the technology suppliers and sites recommended to participate in the next step of the Phase II process. It should be noted that the listing is alphabetic, and the ordering does not signify any ranking or preference. Key findings are as follows:

1. **Technology Readiness and Reliability.** Four of the five technology suppliers have demonstrated the technical capabilities of their conversion technologies with MSW (Arrow, IES, IWT and NTech Environmental) and are "ready" for application as part of a conversion technology demonstration project in Southern California. It should be recognized, however, that each of these technology suppliers would be incorporating one or more new aspects into its design concept, such as the unique integration of pre-processing equipment and/or other facility components. Also, specific waste characteristics, waste receiving and separation requirements, State and local regulatory requirements, and specific product markets will need to be addressed in an application of these conversion technologies in Southern California.

   CWT has demonstrated its depolymerization technology with agricultural waste, but has not yet demonstrated its technology with MSW. Additional development work is necessary for application of CWT's technology to MSW (particularly for processing MRF residuals and post-recycled MSW). CWT was not recommended for further consideration for this project because its technology is not yet demonstrated for MSW, although, CWT's technology may be applicable to other waste streams. CWT's technology may be suitable for consideration in a future phase of Los Angeles County's project development activities (Phase III).

Table 4. Technology Suppliers Recommended for Next Step of Phase II
(Listed Alphabetically)

Technology Supplier	Technology Type
Arrow Ecology and Engineering (Arrow)	Anaerobic Digestion
International Environmental Solutions (IES)	Pyrolysis
Interstate Waste Technologies (IWT)	Pyrolysis / High Temperature Gasification
NTech Environmental (NTech)	Low Temperature Gasification

Table 5. MRF/TS Sites Recommended for Next Step of Phase II
(Listed Alphabetically)

MRF/TS Facility	Location
Del Norte Regional Recycling and Transfer Station	Ventura County (Oxnard)
Perris MRF/Transfer Station	Riverside County (Perris)
Rainbow Disposal Company, Inc. MRF(1)	Orange County (Huntington Beach)
Robert A. Nelson Transfer Station and MRF	Riverside County (Unincorporated)

(1) The Rainbow Disposal MRF was evaluated under this project exclusively in partnership with IES.

2. **MRF/TS Site Suitability.** Four sites were found to be technically and environmentally suitable for co-location of a conversion technology project: Del Norte Regional Recycling and Transfer Station (Oxnard); Robert A. Nelson Transfer Station and MRF (Unincorporated Riverside); Perris MRF/Transfer Station (Perris); and Rainbow Disposal Company, Inc. MRF (Huntington Beach). Community Recycling/Resource Recovery, Inc. MRF/TS in Los Angeles was limited by available space and is faced with an active LEA Cease & Desist Order that may pose a constriction for project development at this site. The Community Recycling site was not recommended for this project because of those constraints. However, Community Recycling has access to a larger site, which may be suitable for consideration in a future phase of Los Angeles County's project development activities (Phase III).

   With only one exception, the MRF/TS sites have continued to express a willingness and ability to partner with a technology supplier and participate in Los Angeles County's conversion technology demonstration project. The only exception is the Del Norte Regional Recycling and Transfer Station in Oxnard (Ventura County), which has not yet made a commitment to continue to participate in the County's project. As the only publicly-owned MRF/TS under consideration, the Del Norte site requires a more formal and lengthier process for making a project commitment. In addition, the City of Oxnard has received and is evaluating a project offer that could result in development of the land adjacent to the MRF/TS, which was identified for location of a conversion technology facility. The future of Oxnard's participation in the County's project is uncertain.

3. **Corporate and Team Resources.** The teams assembled include technology suppliers and experienced team members in key roles such as finance, design and construction, and operations, and are capable of developing a project.

4. **Financial Resources.** Although in most cases, technology suppliers have not been in business in the U.S. market long enough to have built extensive U.S. project inventories or financial track records, the inclusion of major experienced financial, engineering and construction and/or operations team members, and their teaming with MRF/TS owners, will enhance their overall financial resources and capability, providing sufficient resources for project development and operations. In particular, these teaming arrangements will strengthen the ability to provide design, construction, operations and performance guarantees, and the taking of risks associated with these types of guarantees.

5. **Diversion Potential.** The conversion technologies have the potential of achieving significant diversion of MRF residue and post-recycled MSW from landfill disposal, ranging from approximately 87 percent to 100 percent by weight of the waste received, provided reliable markets can be identified for secondary products.

6. **Conversion Capability, Marketable Products.** The technologies have the capability of recovering recyclables, converting waste into intermediate fuel products (e.g., biogas, syngas, steam, biodiesel), efficiently using the fuel products on-site for power generation, and producing secondary material products. On-site power generation is currently the proposed alternative due to strong market demands for electricity, particularly from renewable energy sources.

7. **Environmental Soundness.** The technologies are expected to be permittable in Southern California, meeting applicable environmental standards. Appropriate air pollution controls will be required. The fuel gas (e.g., biogas, syngas) can be collected and cleaned prior to use for power generation, as necessary for permitting. Phase II addressed three key pollutants: nitrogen oxides (NOx); dioxins; and greenhouse gas (GHG) emissions.

    - NOx is a criteria air pollutant of concern as established by the U.S. EPA. NOx was selected as a key indicator of environmental acceptability of conversion technologies because ground level ozone (smog) is one of the most significant pollution issues in Southern California, and NOx is the most significant pollutant generated by conversion technologies that contributes to smog. The U.S. EPA classifies the Los Angeles South Coast Air Basin as being a severe non-attainment area for ozone, a precursor to smog. Smog poses a threat to humans because it can irritate the respiratory system and lead to severe respiratory health problems. The conversion technologies evaluated would apply control technologies to reduce NOx emissions, and would have potential, controlled NOx emissions that are significantly lower than the Federal requirements for large municipal waste combustors (i.e., approximately 10 times less).

    - Dioxin was selected as a key indicator of environmental acceptability of conversion technologies, because it is a toxic air pollutant of great public concern. Potential dioxin emissions from conversion technologies are expected to be very small compared to Federal requirements for large municipal waste combustors (i.e., approximately 10 to >100 times less).

    - Greenhouse gases are those gases in the atmosphere that increase global warming. Conversion technology facilities have the potential to significantly contribute positively towards the State's Global Warming Solutions Act goals. These technologies achieve significant diversion from landfill disposal and convert organic waste material into renewable energy, fuels and other products, resulting in a net reduction in greenhouse gas emissions.

- The net generation of emissions can be reduced when considering the life-cycle impact of conversion technologies. By design, conversion technologies offset emissions from other sources, including the transportation of waste to remote disposal that is no longer necessary, as well as the combustion of fossil fuels offset by the generation of renewable energy in the form of electricity or green fuels. Co-location of conversion technology facilities with MRFs maximizes this transportation reduction of residual solid waste. When factoring in diversion of materials from disposal as well as offsets from transportation and energy production, conversion technologies are likely to reduce net emissions.

8. **Estimated Tipping Fees.** The tipping fees estimated by the technology suppliers, and reviewed in this study, fall in the range of $50 to $70 per ton, excluding IWT's single-unit, 312-tpd project, which is not considered economically viable. Sensitivity analyses (conducted to determine the impacts on tipping fees of certain contingencies) do not result in a significant change to the overall tipping fee range.

9. **Competitiveness of Estimated Tipping Fees.** As noted above, tipping fees needed to support a conversion technology project range from approximately $50 to $70 per ton. While these estimated tipping fees may be competitive with the future tipping fees associated with rail haul and landfill disposal, they are greater than current waste disposal costs in Los Angeles County. To support financing and successful project development and operation, there may be a need to "bridge" this economic gap, if any, until such time as market waste disposal fees equal those for conversion technologies.

   Many alternatives could be considered to help meet this need, including one or more of the following:

   - funding provided by the Sanitation Districts, consistent with the conditions of the Puente Hills Landfill C.U.P.;
   - funding provided by BFI, consistent with the conditions of the Sunshine Canyon C.U.P;
   - funding provided by the cities in Los Angeles County and the County itself;
   - development of public waste supply agreement (or private agreement with public “back stop”) with supporting tip fees;
   - increasing the amount of the project financing to provide surplus funds to “subsidize” initial tip fees being paid;

- instituting a ramped tipping fee (i.e., a structured annual increase that is kept in place until the prices charged cover the cost incurred, similar to the funding subsidy formulated by the CSD for the Waste by Rail Project);

- instituting a “green fee” to be paid by MRF/TS customers for waste processed at the conversion technology facility;

- eliminating the Solid Waste Management Fee (currently $0.86 per ton) for waste originating in Los Angeles County going to the conversion technology facility, to provide a reduced tip fee for waste delivered to the conversion technology facility;

- increasing the Solid Waste Management Fee (currently $0.86 per ton) imposed on each ton of solid waste being disposed to provide a dedicated funding source for promoting development of conversion facilities;

- providing tax incentives that may result in lower facility construction or operating costs; and

- successful acquisition of State and Federal grants to augment other funds as discussed above.

The level of support needed and alternatives to address needed support would require evaluation in the next step of this process, when firm, competitive offers from the project developers are made, and proposed tip fees and project-specific market conditions are known.

10. **Financing Approach.** Given the experience and corporate and team resources of the technology suppliers, and assuming waste supplies would be provided or assured by a public entity or credit-worthy private source with assignable public contracts at a sufficient tipping fee for the term of financing, the technology suppliers could structure financable projects applying customary U.S. solid waste market project financing techniques. However, specific means for providing or assuring the waste supply need to be developed, as does a means of providing a supporting tipping fee. Tax-exempt, private activity bonds would most likely be the least-costly means of private project financing. Support from the County and/or other public agencies may be needed to secure allocation of "volume cap" from the State for such financing.

    State and Federal funding opportunities are limited, but could be used to assist in project development and/or project financing. Securing such funding is competitive and requires project definition.

Recommended Next Steps – Competition for Selection of Project(s)

Although substantial evaluation work has been completed, resulting in selection of acceptable technologies and sites for one or more demonstration facilities for Southern California, formal project offers have not yet been presented. As a next step, it is recommended upon approval from the County Board of Supervisors that the Task Force, Subcommittee and Department of Public Works establish a competition to solicit formal, site-specific offers from the acceptable technology suppliers in partnership with the acceptable MRF/TS sites. Such a process would establish a defined mechanism by which one or more projects would be selected to receive County support to further facilitate project development activities.

The competition would not be a formal procurement process, and it would be open only to the technology suppliers and sites identified in this report as "recommended". The process would differ from a procurement in its formality and the extent of detail requested, both of which would be streamlined. However, the competition would still require clear project definition and commitments on the part of the development team making the offer, including a tipping fee and project guarantees, and it would need to meet standards set by the Task Force, the Subcommittee and the Department of Public Works. In return, the selected project(s) would be offered County support to facilitate development activities. Potential options for support are described below, and ultimately must be selected and approved by the County before being formally offered.

The advantage of the competition is that it would allow the marketplace to establish the most beneficial pairing of sites and technologies, a process most appropriate for a privately developed project, and it would encourage the development of site-specific projects that meet the objectives of the County, the Task Force and the Subcommittee. In this way, specific offers would be evaluated to enable selection of the best project(s) as offered by a team that includes a technology supplier and site, rather than selection of a preferred technology and site for which a partnership has not yet been established or may not be possible, and a project that is not yet defined. The competition would also strengthen the County's negotiation position as a project facilitator.

The competition would be initiated with issuance of a "letter of invitation" to the recommended technology suppliers and MRF/TS sites, outlining the standards and incentives and other elements of the competition. A time limit would be set for project offers to be made. Approximately 3 to 4 months is recommended, to allow time for the technology suppliers and MRF/TS owners and operators to explore partnership opportunities and develop site-specific project offers. Upon receipt of project offers, the Task Force, Subcommittee and Department of Public Works would review, evaluate and rank the offers and select one or more projects to recommend receiving the support of the County of Los Angeles. Support activities would be negotiated with the project development teams, based on ranking and selection of project(s). As proposed, this competition would allow the County to support more than one project, perhaps with the highest level of benefits offered to the highest-ranked offer.

Standards set for the competition would include those that promote the overall objectives and goals of the project. Suggested standards could include the following:

Project Standards

- The project must be of a certain minimum size; e.g., 100 tons per day.
- The project must be capable of achieving operation by a specified date.
- The project must be capable of sustained operation at a market-competitive tip fee, if not initially, over the term of operation.
- The project must be designed to process MRF residuals and/or post-recycled municipal solid waste, and must have the potential to divert at least 75% (by weight) of this waste from landfill disposal.
- The project must have the ability to capture the gas produced and to generate electricity or a fuel product (e.g., biogas, synthesis gas, oil) and must have a defined use for the electricity and/or fuel product.
- The project must have the ability to capture and pre-clean the intermediate gas as necessary to meet permit requirements.
- The project must provide a permitting plan that demonstrates a reasonable chance of successful permitting.
- The project must provide a financing plan and assurance from the intended financing party that financing can be accomplished.
- The project must have a marketing plan for all products intended to be recovered and marketed, including power and secondary products, with provision of letters of intent to purchase from intended customers of key products.
- The project must be structured to provide for disclosure of non-proprietary project information to the County for public release, including technical, environmental and economic information, to promote the development of future projects.
- The project developer must offer a commitment to develop a “flagship facility”, to encourage and facilitate public tours, and public education programs.
- The project developer must provide assurance of its commitment to ensuring project success

The County could consider offering support to meet those needs essential to project development and other support activities that can facilitate project development. A suggested listing of such benefits is presented below. In addition to selecting specific support levels, or offering tiered levels of support based on rankings of proposed project offers, the County may wish to offer a menu of options to the facilities, and evaluate the project offers submitted based on the level of support requested in the offer.

Essential Support Activities for Private Project Development

- Provide for public waste supply agreements, or provide for public “back stop” to guarantee private waste supply agreements for the term of financing.

- Provide economic incentives in the form of a "bridge" that closes the gap, if any, between needed conversion technology tipping fees and market waste disposal fees, until such time as market waste disposal fees are sufficient to support a conversion technology project.

- In addition, if private activity tax-exempt bond financing is sought, lend County support to qualify for “volume cap” for such financing.

Other Support Activities to Facilitate Private Project Development

Develop Information, Facilitate Information Exchange

- Continue the development of information on technology suppliers and make the information available to MRF/TS site owner/operators.

- Continue the development of site information and make the information available to technology suppliers.

Funding Opportunities

- Continue to track and identify potential funding sources (e.g., grants, low interest loans, etc.) from state and federal sources to assist in payment of project development costs, construction costs and operating costs. Apply for and secure available state and federal grants (or assist project developers in doing so). Assist the facility developer in applying for and obtaining low interest loans available from the state or federal Government. Consistent with the CUP issued for Puente Hills Landfill, Public Works will request that CSD consider funding a pilot conversion technology facility.

Legislative Efforts

- Continue state legislative efforts to foster change in the solid waste management hierarchy in order to place conversion technologies within the context of beneficial uses rather than disposal.

- Continue state legislative efforts to ensure all conversion technologies that generate renewable energy are eligible to receive renewable energy credit.

Promote Beneficial Use of Products, Product Sales

- Assist site owner/operators and technology suppliers in identifying markets for products and in negotiating power or fuel sales agreements.

- Promote the use of more difficult-to-market products, such as compost and aggregate, by educating County and state departments that may use such products and integrating incentives or requirements for purchasing and use of such products into procurement practices for County and state projects. Support payment for testing services to develop engineering specifications for products and establish quality of products.

Foster Project Support with Municipal Leaders and General Public – Public Outreach

- Sponsor meetings and forums to encourage information exchange between technology suppliers, site owners/operators, municipal officials in which sites are located, State and Federal agencies, environmental and other advocacy groups and the general public to gain support for the project.

- Provide County “endorsement” of the project(s) to add credibility for purposes of public acceptance, permitting, financing, and publicity.

- Provide and reinforce public education efforts regarding the project, including publicizing the project, maintaining web and e-communications regarding the project, and seeking additional media coverage as appropriate.

Facilitate Permitting

- Assist the project in permitting efforts by:
    - making staff available to help in identifying permits needed;
    - obtaining information needed for permit applications; and
    - helping the project get priority at agencies in scheduling for permit review and receiving reasonable consideration concerning applicability/ interpretation of regulatory requirements.

Facilitate Design/Construction

- During facility design, assist the project by helping to obtain design related information available at the County, and support “green” building design.

- During facility construction, assist the project in obtaining information on local suppliers of materials and services.

Support Operations and Commercialization of Technology

- Once the facility is operational, participate in facility testing and data exchange for engineering performance and environmental data.

- Continue County promotional support during facility operation to promote facility attributes and enhance public awareness. Serve as a "reference", if requested by the facility developer, to expand the demonstration facility or to enhance the developer's efforts to develop other facilities in or outside of the area.

Schedule

The recommendation of this report is that, upon approval by the Board of Supervisors, the Task Force, Subcommittee and Department of Public Works establish a competition to solicit formal, site-specific offers for selection of one or more conversion technology demonstration projects for County support. Upon selection of a project(s) and negotiation of associated support activities to be provided by the County, the project would proceed to permitting, design and construction, and startup. The goal is to implement a project with expedited permitting by December 2011, as summarized in Table 6. More detailed, project-specific schedules would be requested as part of the recommended competition.

Table 6. Preliminary Project Implementation Schedule

Implementation Step	Time to Complete	Projected Completion
Initiate Competition (Issue Letter of Invitation)		Fall 2007
Offers Submitted	4 months	January 2008
Review, Evaluate and Rank Offers	3 months	April 2008
Selection of Project(s) for County Support	1 month	May 2008
Negotiate Support Activities, Other Agreements	3 months	August 2008
Permitting/Conceptual Design (1)	18 months	February 2010
Detailed Design/Construction	18 months	August 2011
Startup	4 months	December 2011

(1) Assumes permitting can be achieved with an amendment to the existing MRF/TS Solid Waste Facility Permit and an amendment to the non-disposal facility element.

GLOSSARY OF TERMS

A Compost: Acetogenic Compost

APC: Air Pollution Control

APCD: Air Pollution Control District

ARB: (California) Air Resources Board

ASR: Auto Shredder Residue

BACT: Best Available Control Technology

Biogas: a gas produced from the biological conversion of the biodegradable, organic fraction of MSW, typically composed of methane and carbon dioxide gases. Biogas can be converted to a product such as a transportation fuel, or converted to electricity by using it as a fuel in power generating equipment such as a reciprocating engine.

BMP: Best Management Practices

BOD: Biochemical Oxygen Demand

Btu: British Thermal Unit

C: Centigrade

C&D: Construction and Demolition

CA: California

CARB: California Air Resources Board

CCGT: Combined Cycle Gas Turbine

CCNGPP: Combined Cycle Natural Gas Power Plant

CEC: California Energy Commission

CEQA: California Environmental Quality Act – regulations that mandate the assessment of the potential environmental impacts of a project and detail mitigation measures. Triggered by the need for a project to obtain a discretionary land use permit.

CH_4: Methane

CIWMB: California Integrated Waste Management Board

CLARTS: Central LA Recycling & Transfer Station

CO: Carbon Monoxide

CO_2: Carbon Dioxide

CT: Conversion Technology - industrial plants that use one or more noncombustion processes (e.g., biological, chemical, thermal, and/or mechanical processes) to convert MSW into green fuels, renewable energy and other products. Conversion technologies make an intermediate fuel product (e.g., biogas, synthesis gas), and have the capability to capture these gases to utilize them to make fuels such as ethanol, hydrogen, liquefied natural gas, compressed natural gas, and diesel fuel. Conversion technologies have the capability to pre-clean the gases generated in the process prior to combustion, should those gases be combusted on site to make electricity.

C.U.P.: Conditional Use Permit

Dioxin: a general term used to collectively describe a large number of chemical species making up the dioxin and furan families of compounds. Dioxin is a trace-level byproduct of combustion and some industrial chemical processes. Dioxin is a toxic air pollutant of public concern, characterized by EPA as likely to be a human carcinogen.

DWP: (City of Los Angeles) Department of Water and Power

EIR: Environmental Impact Report

EJ: Environmental Justice – an area of study and evaluation for new projects that counters the tendency in our society to place the more impactful industrial operations (prisons, wastewater treatment plants, power plants, solid waste facilities, etc.) in ethnic areas of low economic standing.

EPA: (U.S.) Environmental Protection Agency

F: Fahrenheit

FOG: Fats, Oils and Greases

gpd: gallons per day

“Greenfield Pricing”: see “Integrated Pricing”

H_2: Hydrogen

H_2S: Hydrogen Sulfide

HCl: Hydrogen Chloride

HF: Hydrogen Fluoride

HDPE: High Density Polyethylene (plastic)

HRSG: Heat Recovery System Generator

Integrated Pricing: Several technology suppliers based their projected economics on “integrated pricing" that assumed use of existing scales, roads, and other site infrastructure at MRF/TS sites. This use enabled the technology suppliers to reduce project development and construction costs, since there was no need to duplicate such facilities. Other technology suppliers based their projected economics on “greenfield pricing” that assumed the use of an undeveloped site for which all ancillary infrastructure would need to be constructed. For each technology studied, the report indicates whether the pricing is based on a stand-alone, greenfield project or a project integrated with a MRF/TS through the intended use of existing, common-application site infrastructure.

IS: Initial Study

ITEQ: International Toxic Equivalents

kW: Kilowatts

kWh: Kilowatt Hours

LAER: Lowest Achievable Emission Rate

lb: pound

LEA: Local Enforcement Agency

LEED: Leadership in Energy and Environmental Design

M Compost: Methanogenic Compost

MND: Mitigated Negative Declaration

MO: Missouri

MRF: Materials Recovery Facility – an industrial facility where MSW and other materials are sorted and processed for recycling.

MRF Residual: Waste material left after MRF processing has removed recyclables.

MSW: Municipal Solid Waste

MW: Megawatts

MWC: Municipal Waste Combustor - also known as incinerators or waste-to-energy plants, municipal waste combustors are facilities that burn municipal solid waste at a very high temperature to generate electricity or steam power. Unlike Conversion Technology, MWCs by design do not make an intermediate product such as a synthesis gas that can be intercepted and modified (e.g., cleaned) prior to final use.

MWh: Megawatt Hours

NaOH: Sodium Hydroxide

ND: Negative Declaration

NDFE: Non-Disposal Facility Element – part of a jurisdiction's Solid Waste Management Plan that details the facilities that handle MSW or portions thereof that are not disposal facilities (typically: transfer stations, MRFs, greenwaste chipping & grinding, composting).

NOx: Nitrogen Oxides – generic term for a group of gases containing nitrogen coupled with oxygen in varying amounts (e.g., NO_2, N_2O). NO_x is a commonly found air pollutant (also known as a "criteria pollutant") that is formed when fuel is burned, and it contributes to the formation of ground-level ozone (smog).

NSPS: (U.S.) New Source Performance Standards as promulgated by the Environmental Protection Agency.

Off-Take Contracts: Off-take contracts are the contracts a facility would have with various parties for the sale of the energy and materials that would be produced or recovered by the facility. For example, a facility might have an off-take contract with a utility for the sale of electric power, and it may have contracts with secondary materials dealers for the sale of recovered materials such as metals, plastics or paper. Generally, energy sales contracts have terms that are coterminous with a facility's financing and frequently have set pricing; given the nature of the secondary materials markets, materials contracts usually have much shorter terms and may include variable pricing.

OSHA: (U.S.) Occupational Safety and Health Administration

pph: pounds per hour

ppm: parts per million

PET: Polyethylene Terephthalate (plastic)

psig: pounds per square inch gage pressure

RFI: Request for Information

RMDZ: Recycling Market Development Zone – areas of cities and counties designated by the State of California for siting of recycling industries where tax breaks and other incentives are provided.

RPS: Renewable Portfolio Standard

RWQCB: Regional Water Quality Control Board

SCAQMD: South Coast Air Quality Management District

SCE: Southern California Edison

SCR: Selective Catalytic Reduction

SIP: State Implementation Plan for California

SO_2: Sulfur Dioxide

SWFP: Solid Waste Facility Permit

SWRCB: State Water Resources Control Board

Syngas: Synthesis gas - a gas produced from the thermal conversion of the organic fraction of MSW, typically composed of hydrogen, carbon monoxide and carbon dioxide gases. Syngas can be converted to a product such as methanol, or converted to electricity by using it as a fuel in traditional boilers with steam turbines, reciprocating engines and combustion turbines.

tpd: tons per day

tph: tons per hour

tpy: tons per year

TS: Transfer Station – an industrial facility were MSW and other wastes are transferred from smaller refuse collection trucks to large 18-wheel semi-trucks for haul to disposal sites.

TSS: Total Suspended Solids

UASB: Upflow Anaerobic Sludge Blanket

U.K.: United Kingdom

U.S.: United States

VCAPCD: Ventura County Air Pollution Control District

SECTION 1
INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

Conversion technologies refer to a wide array of biological, chemical, thermal (excluding incineration) and mechanical technologies capable of converting post-recycled residual solid waste into useful products and chemicals, green fuels such as hydrogen, natural gas, ethanol and biodiesel, and clean, renewable energy such as electricity. In addition to the production of locally-generated renewable energy and green fuels, the use of conversion technologies in Southern California could effectively enhance recycling and beneficial use of waste, reduce pollution such as greenhouse gas emissions, and reduce dependence on landfilling and imported and domestic fossil fuels.

Conversion technologies are successfully used to manage solid waste throughout Europe, Israel, Japan, and other countries in Asia, but are not yet in commercial operation in the United States. While there are and have been pilot demonstrations of conversion technologies in the United States, the absence of larger scale demonstration facilities and commercial facilities in this country is an obstacle to demonstrating the benefits these technologies can offer. In addition to lack of U.S. experience, specific development hurdles for conversion technologies in California may include: cost, especially when compared to the current, relatively inexpensive cost of landfill disposal; the lack of a clear permitting and regulatory pathway; a lack of diversion credit, renewable energy credit, or other incentives for the development of emerging technologies; and misconceptions regarding the performance of these technologies.

For nearly a decade, the County of Los Angeles has been a consistent supporter of conversion technologies for their ability to manage post-recycling residual waste materials in an environmentally preferable manner and their potential to assist jurisdictions in meeting the State's waste diversion mandate. For example, the County has supported legislation and worked with State and local governments and other key stakeholders to advance research and development of conversion technologies. Below is a discussion of these efforts.

1.1.1 Assembly Bill 939

The California Integrated Waste Management Act of 1989 (Assembly Bill 939, as amended) requires each city and county to divert 50 percent of solid waste from disposal at landfills and/or transformation facilities. Failure to demonstrate achievement of this requirement may subject a jurisdiction to penalties of up to $10,000 per day.

Pursuant to AB 939, counties have the added responsibility of preparing and administrating the Countywide Siting Element and the Countywide Integrated Waste Management Summary Plan. The Summary Plan describes the steps that will be taken by local agencies, acting independently and in concert, to achieve the 50 percent waste diversion mandate. The Countywide Siting Element, which was adopted by a majority of the cities in the County of Los Angeles encompassing a majority of the cities' population, the County Board of Supervisors, and the State, is the current long-term planning document which provides for the County's solid waste disposal needs for the residual waste remaining after undergoing all recycling and other waste diversion efforts. Currently, residents and businesses in Los Angeles County generate over 24 million tons of trash each year, of which approximately 12 million tons, equivalent to over 40,000 tons of trash each day, must be properly disposed.

Meeting the mandates of AB 939 is especially challenging in Los Angeles County. The County of Los Angeles includes 88 cities and 134 unincorporated communities with a combined population in excess of 10 million. The County of Los Angeles has the largest and most complex solid waste management system in the country, with over 140 permitted waste haulers, 28 large transfer stations/material recovery facilities, 11 municipal solid waste landfills, 11 inert waste landfills, 2 waste-to-energy facilities, 43 construction and demolition debris recycling facilities and 350 recyclers. Each year, Los Angeles County residents and businesses generate approximately 24 million tons of materials, with approximately 50% being diverted through source reduction and recycling away from disposal. However, 12 million tons of trash remains each year, equivalent to approximately 40,000 tons which must be safely and properly disposed on a daily basis. This presents a challenge in not only protecting the public health and safety and the environment through effective solid waste management on a daily basis but also continuing to expand waste reduction, resource recovery, and recycling programs and policies.

1.1.2 County Government

The Los Angeles County Board of Supervisors is the legislative and executive branch of County government. The Board of Supervisors have been steadfast advocates of alternatives to landfills, and provided the leadership needed to advance the development of these emerging technologies. The Board of Supervisors have designated the Department of Public Works as the lead County agency advising the Board of Supervisors on waste management issues and responsible for the County's compliance with AB 939 mandates. This includes the waste diversion mandate for the unincorporated areas as well as Countywide solid waste planning responsibilities, in concert with the cities and the Task Force.

As part of its continuing efforts to evaluate and promote the development of conversion technologies, the County incorporated into the land use permit for the Puente Hills Landfill a condition requiring the owner/operator of the landfill, the County Sanitation Districts of Los Angeles County, to provide up to $100,000 in funding each year for the remainder of the landfill's lifespan, in order to study conversion technologies, and requires the Sanitation Districts consider funding a pilot conversion technology facility, should a suitable technology be identified. The Puente Hills Landfill land use permit also requires the County Sanitation Districts to develop a waste by rail system for remote waste disposal, with key benchmarks, and as the largest landfill in Los Angeles County the rates at the Puente Hills landfill and, eventually, processed via the rail haul system, will establish a market benchmark with significant implications for the waste industry in Southern California. The land use permit approved by the County Board of Supervisors also requested the Los Angeles County Solid Waste Management Committee/Integrated Waste Management Task Force (see description below) form the Alternative Technology

Advisory Subcommittee (Subcommittee), a multi-stakeholder group whose mission is to thoroughly evaluate and promote the development of conversion technologies.

Continuing this model, the County adopted a land use permit for the Sunshine Canyon landfill, owned and operated by Browning-Ferris, Industries, which included a condition for providing $200,000 per year in funding for 10 years. This funding will continue the work of the Subcommittee, the Task Force and the Department of Public Works in implementing the recommendations of this Report and advancing the vision of the Board of Supervisors to some day make landfills obsolete.

To further this goal in the near term, the County of Los Angeles Department of Public Works is collaboratively working with the Task Force and the Subcommittee to facilitate development of a fully operational conversion technology demonstration facility in Southern California. The goal of the County's project is to demonstrate technical, environmental and economic benefits of conversion technologies through design, construction and operation of a facility in Southern California, in order to forge permitting and legislative pathways for conversion technologies and promote development of future projects. This demonstration project is the first implementation resulting from the combined efforts to evaluate the feasibility of conversion technologies in Southern California, including a broad evaluation in Phase I and a more detailed evaluation in Phase II. A brief description of the Phases is included below, with a more detailed explanation in Sections 2 and 3 of this Report.

1.1.3 Los Angeles County Integrated Waste Management Task Force

Pursuant to Chapter 3.67 of the Los Angeles County Code and AB 939, the Task Force is responsible for coordinating the development of all major solid waste planning documents prepared for the County of Los Angeles and its 88 cities. Consistent with these responsibilities, and to ensure a coordinated and cost-effective and environmentally-sound solid waste management system in Los Angeles County, the Task Force also addresses issues impacting the system on a Countywide basis. The Task Force membership includes representatives of the League of California Cities-Los Angeles County Division, the County of Los Angeles Board of Supervisors, the City of Los Angeles, the waste management industry, environmental groups, the public, and a number of other governmental agencies.

In 2004, as requested by the County, the Task Force established the Alternative Technology Advisory Subcommittee to evaluate and promote the development of conversion technologies. The Subcommittee’s membership includes municipal officials, regulators, consultants, industry, environmental and community representatives, all experts in the field of conversion technologies and solid waste management.

1.1.4 Phase I

Beginning in 2004, the County contracted with URS Corporation to conduct a preliminary evaluation of a range of conversion technologies and technology suppliers, and initiated efforts to identify material recovery facilities (MRFs) and transfer stations (TSs) in Southern California that could potentially host a conversion technology facility. A scope beyond just Los Angeles County was considered important as stakeholders in the Subcommittee extended beyond Los Angeles County, and the implications of this effort will have many regional impacts.

In August 2005, the Task Force adopted the Subcommittee's *Conversion Technology Evaluation Report*. As more fully described in Section 2 of this report, Phase I resulted in identification of a preliminary short list of technology suppliers and MRF/TS sites, along with development of a long-term strategy for implementation of a conversion technology demonstration facility at one of these sites. The Department of Public Works and the Subcommittee intentionally pursued integrating a conversion technology facility at a MRF/TS site in order to further divert post-recycling residual waste from landfilling and take advantage of a number of beneficial synergies from co-locating a conversion facility at a MRF.

1.1.5 Phase II

In July 2006, the County contracted with Alternative Resources, Inc. (ARI) to further advance its efforts to facilitate development of a conversion technology demonstration facility (Phase II). The ARI team included multi-disciplined expertise, including Clements Environmental Corporation, Facility Builders and Erectors, Holland & Knight, and UltraSystems Environmental. Key Phase II services provided by the ARI team included:

- an independent evaluation and verification of the qualifications of selected technology suppliers and the capabilities of their conversion technologies;
- an independent evaluation of candidate MRF/TS sites, to determine suitability for installation, integration and operation of one of the technologies;
- a review of permitting pathways;
- identification of funding opportunities and financing means;
- identification of potential County incentives (i.e., supporting benefits) to encourage facility development amongst potential project sponsors; and
- negotiation activities to assist these parties in developing project teams and a demonstration project.

This report describes Phase II of the County's project to facilitate development of a conversion technology demonstration facility in Southern California, and represents a culmination of approximately one year of work conducted by the County and Subcommittee in conjunction with the ARI team.

1.1.6 Public Outreach

In January 2007, the County initiated efforts to develop and implement a public outreach and education plan for development of conversion technologies in Southern California. These public outreach efforts have been occurring integrally with the evaluations described in this report. This report is not intended to address the details of the public outreach plan. However, the findings presented herein are intended to be shared through the public outreach program, to facilitate the development of a conversion technology demonstration facility.

1.1.7 Phase III (Long-Term Development of Conversion Technologies)

As described previously, Los Angeles County residents and businesses generate approximately 24 million tons of materials, with approximately 50% being diverted through source reduction and recycling away from disposal. This results in over 12 million tons of trash left for disposal every year, a number that is expected to continue to grow, despite waste reduction and recycling programs, due to continued population and economic growth in the region. With the certainty that in-County landfill capacity will run out in the long term, and will be substantially diminished in the short term, the County of Los Angeles recognizes the imperative to develop technically, economically and environmentally feasible alternatives to landfills within Los Angeles County.

The goal of the County's demonstration project (Phase II) is to forge permitting and legislative pathways for conversion technologies and promote development of future projects. Building on the experiences gained after the successful development of one or more demonstration projects in Phase II, the next logical step is a focus on development of commercial scale facilities using proven technologies within Los Angeles County. To facilitate this goal, future, Phase III activities may include the following:

- Re-evaluating the marketplace of conversion technologies to consider new and emerging developments and to continue to pursue development of the most technically and environmentally effective technologies, focusing on the identification of potential sites within Los Angeles County, including key potential sites identified in Phase II;

- Developing partnerships with local cities within Los Angeles County interested in the development of conversion technology facilities within or adjacent to their borders; and

- Facilitating development of commercial-scale conversion technology facilities designed to manage Los Angeles County’s waste stream.

These activities can occur concurrently with the continued development of the Phase II demonstration projects.

1.2 THE COUNTY'S ROLE AS A PROJECT FACILITATOR

The County is promoting the development of a conversion technology demonstration facility by serving as a project facilitator. In this role, the County is effectively using its resources to promote project development in a variety of ways. In the work completed in Phase I and Phase II, the County has utilized the expertise of Department of Public Works staff, the Subcommittee, and its consulting teams to disseminate a wide range of information regarding conversion technologies, potential host locations, and project development activities. Overall, the County is providing a framework to bring technology suppliers and MRF/TS site owners and operators together for development of a project.

As the County continues to support and promote conversion technologies and works to achieve development of a demonstration facility in Southern California, its role of facilitator is likely to evolve. Each technology supplier and MRF/TS site owner/operator may have different needs and priorities for facilitation of project development. As a facilitator, the County can consider discrete actions along with invested public and private partners, such as County Sanitation Districts Board of Directors and BFI, it can take and specific incentives it can offer to promote project development. There are a wide range of potential opportunities for County facilitation and support of a conversion technology demonstration facility. Some of these are essential support activities, such as providing for public waste supply agreements or for public "backing" of private waste supply agreements for the term of financing. Others are support activities that would facilitate project development, such as developing and sharing technology and site information, and promoting beneficial use of products. These potential opportunities for County support of a conversion technology demonstration facility are further addressed in this report.

1.3 REPORT STRUCTURE

This report describes Phase II of the County's project to facilitate development of a conversion technology demonstration facility in Southern California. The beginning sections of the report present background information and an overview of the scope and methodology of the study. This overview is followed by evaluations of the technology suppliers, technologies, and candidate sites, as well as an economic analysis of the conceptual projects proposed for Southern California and funding issues related to such projects. The final section of this report summarizes findings and presents recommendations. For reference, the specific sections of this report are as follows, with supporting information provided in appendices, as applicable:

- Section 1: Introduction
- Section 2: Overview of Phase I Study
- Section 3: Scope and Methodology of Phase II Study
- Section 4: Resources and Financial Qualifications of Technology Suppliers
- Section 5: Technology Evaluations
- Section 6: Site Evaluations
- Section 7: Permitting Pathways and Regulatory Issues
- Section 8: Project Economic Analysis
- Section 9: Project Financing and Funding Opportunities
- Section 10: Summary of Key Findings and Recommendations

SECTION 2
OVERVIEW OF PHASE I STUDY

This report, which presents the findings and recommendations of Los Angeles County's Phase II evaluation of conversion technology suppliers and potential MRF/TS host locations, builds upon the Phase I work completed by the Task Force and its Subcommittee, together with DPW and its consultant, URS Corporation, in August 2005. To provide perspective on the starting point for this Phase II Report, a brief overview of the Phase I *Conversion Technology Evaluation Report* is provided here. (The full report can be accessed from www.SoCalConversion.org.)

The County's Phase I study consisted of an identification and initial evaluation of conversion technologies that could be suitable for Southern California, including analysis, screening and ranking of technologies and technology suppliers. A large number of conversion technologies and suppliers were identified, covering a wide range of thermal, biological and chemical processes, including pyrolysis, gasification, plasma gasification, thermal depolymerization, aerobic and anaerobic digestion, hydrolysis-ethanol production, and many other technology types. The following minimum requirements were established for evaluating technology suppliers:

- **Minimum waste diversion rate** of 50%, when processing residuals from a MRF and/or TS.
- **Demonstrated processing experience** of at least a pilot scale facility, designed to process MSW or similar feedstock at approximately 5 tons per day (tpd) or greater, with at least one year of operating experience. During any one-year period, the technology must have processed at least 1,000 tons of MSW or similar feedstock.
- Capability to convert waste into **marketable products and byproducts**, other than only RDF or compost.
- **Compliance with all regulatory requirements** (i.e., air emissions) in the state of California.
- **Responsive** to the County's information request in a timely manner.
- **Willing and able to create a partnership** with the owner and/or operator of a MRF/TS in Southern California, for development of a demonstration project.
- Capability to develop a facility with a **minimum capacity to process 100 tpd of MRF residuals**.

Preliminary information was obtained from the technology suppliers using a questionnaire. Twenty-eight technology suppliers submitted a response to the questionnaire; of these, half passed the screening analysis, which incorporated the minimum criteria listed above. These fourteen technology suppliers were further evaluated and then ranked, using a matrix of weighted criteria established to evaluate the potential for the technology to meet project objectives (i.e., maximize environmental suitability, maximize technical performance, and minimize net cost).

The ranking criteria were as follows:

- Waste suitability
- Need for equipment scaling
- Marketability of products
- Expertise in system design
- Operational experience
- Economics
- Landfill diversion potential
- Supplier credibility (i.e., technical and financial resources)

The Phase I evaluation and ranking process resulted in a recommended shortlist of six technology suppliers, consisting of the four thermal technology suppliers that received the highest ranked scores and two waste-to-fuel emerging technologies that passed the screening criteria:

- Interstate Waste Technologies (IWT) - Pyrolysis/Gasification
- Primenergy LLC - Gasification
- NTech Environmental - Gasification
- GEM America - Flash Pyrolysis
- Changing World Technologies (CWT) - Thermal Depolymerization
- BRI - Gasification/Fermentation to Ethanol

The Phase I study recommended siting a conversion technology at an existing MRF/TS, because of the potential benefits of co-location (e.g., readily available feedstock, appropriate zoning, transportation avoidance, etc.). Therefore, the Phase I study also included evaluation of MRFs/TSs in Southern California, to identify sites that are compatible for partnership with a conversion technology supplier. A survey was used to identify existing facilities and gather information on key site characteristics and interest in the project. A limited number of facilities responded to the survey. Additional information was gathered from these interested MRF/TS facilities, to evaluate site characteristics against a dozen criteria generally representative of site conditions necessary for successful project development (e.g., adequate space, sufficient quantity and quality of residue for conversion feedstock, utility availability, etc.). As a result of this process, six facilities were identified as preferred locations for development of a conversion technology demonstration facility:

<u>1st Priority Sites</u>

- Del Norte Regional Recycling and Transfer Station (Oxnard)
- Robert A. Nelson Transfer Station and MRF (RANT) (Aqua Mansa)
- Perris MRF/TS (Perris)

<u>2nd Priority Sites</u>

- Central Los Angeles Recycling Center and Transfer Station (Los Angeles)
- Community Recycling/Resource Recovery, Inc. (Los Angeles)
- Proposed Santa Clarita MRF/TS (Santa Clarita)

In addition to identifying and evaluating technology suppliers and potential sites to host a facility, the Phase I study also included development of a long-term strategy for implementation of a conversion technology demonstration facility. Key steps in the strategic plan included: verification and evaluation of technology supplier qualifications and technology capabilities, including tours of reference facilities; evaluation of candidate MRF/TS sites and verification of their ability and willingness to partner with a technology supplier; and other facilitation activities, such as funding research, partnership negotiation activities, and public outreach support. These key steps in the strategic action plan were undertaken in Los Angeles County's Phase II study, and are described in this report.

SECTION 3
SCOPE AND METHODOLOGY OF PHASE II STUDY

3.1 INTRODUCTION

Phase II activities began in July 2006, and progressed steadily through the development of this report. The scope of Phase II work has consisted of implementation of key activities identified in the Phase I strategic action plan, including: verification and evaluation of technology supplier qualifications and technology capabilities; evaluation of candidate MRF/TS sites and verification of their ability and willingness to partner with a technology supplier; and other activities aimed at promoting and facilitating development of a conversion technology demonstration facility. The scope and methodology of the Phase II study is summarized below.

3.2 SELECTION OF PARTICIPATING TECHNOLOGY SUPPLIERS

Technology suppliers were selected to participate in Phase II based on:

(1) The results of the Phase I evaluation and ranking;

(2) Consideration of new and relevant information regarding technology performance and development, including ancillary capabilities of technology suppliers (e.g., integrating combined heat and power or alternative fuels in project development activities); and

(3) The ability and willingness of the technology supplier to participate in Phase II, recognizing the substantial commitment to supply detailed information that would be required on their part. In addition to having the ability and willingness to partner with one of the candidate MRF/TS sites, the minimum commitment required of the technology suppliers included disclosure of technical, environmental and cost information for the technology, disclosure of technical and financial resources of the technology supplier, and identification of an operating reference facility.

Thirty-two technology suppliers were considered for participation in Phase II, including: the six technology suppliers previously short listed in Phase I; the eight technology suppliers that passed the screening criteria and were evaluated in Phase I, but at the time were not recommended for further evaluation; and eighteen additional technology suppliers that were not evaluated in the Phase I study, but had subsequently contacted Los Angeles County and expressed an interest in the County's conversion technology demonstration project. The technology suppliers that were considered for participation in Phase II are identified in Table 3.2-1. As described in the text following Table 3.2-1, the eighteen additional technology suppliers were evaluated using the minimum criteria established for the Phase I screening and applied to the other technologies, with a more stringent requirement for diversion potential.

Table 3.2-1. Technology Suppliers Considered for Participation in Phase II

<table>
<tr><th>Technology Suppliers Recommended (Shortlisted) in Phase I Report</th><th>"New" Technology Suppliers not Evaluated in the Phase I Report (1)</th></tr>
<tr><td>Interstate Waste Technologies
Primenergy
NTech Environmental
GEM America
Changing World Technologies
BRI Energy</td><td rowspan="3">Allan Environmental*
Arkenol/BlueFire Ethanol*
Choren BTL/ANRTL, LLC
Cleansave Waste Corporation*
Eco Waste Solutions
EnerTech Environmental, Inc.*
EnviroArc Technologies/Nordic American*
Enviro-Tech Enterprises, Inc.
Global Alternative Green Energy (GAGE)*
Global Recycling Group, LLC*
Harold Craig
Herhof Gmbh*
Integrated Environmental Technologies*
Prime Environmental International
Recycled Refuse International*
Wastes Conversion Company
World Waste Technologies, Inc.
Zero Waste Energy Systems*</td></tr>
<tr><th>Technology Suppliers Passing the Phase I Screening Criteria but not Recommended in the Phase I Report</th></tr>
<tr><td>Arrow Ecology and Engineering
Canada Composting
Ebara Corporation
Geoplasma LLC
Green Energy Corporation
International Environmental Solutions
Organic Waste Systems
Waste Recovery Systems</td></tr>
</table>

(1) The 18 technology suppliers identified as "new" were sent a questionnaire in September 2006, soliciting information on their technologies. The 11 identified with an asterisk (*) responded to the County's questionnaire.

The methodology for considering the three groups of technology suppliers listed in Table 3.2-1 is summarized below, with supporting documentation provided in Appendix A.

- In August 2006, a letter was sent to the six technology suppliers previously short listed in Phase I, to confirm their willingness and ability to participate in the Phase II process. All six technology suppliers responded affirmatively, and were recommended as participating technology suppliers.
- In August 2006, a letter was sent to the eight technology suppliers that passed Phase I screening, but were not recommended at the time. The purpose of the letter to these eight technology suppliers was to determine their interest in the Phase II process, and to provide the opportunity for disclosure and evaluation of new and relevant information regarding technology performance and development that may have occurred subsequent to the Phase I evaluation. In disclosing new information, the technology suppliers were asked to address factors that impacted their ranking in Phase I as well as specific issues unique to their technologies. Based on the responses received, three of these eight technology suppliers were recommended for participation in Phase II, due to

demonstration of further technology developments and/or confirmation of the availability of relevant new information:

- Arrow Ecology identified recent technology developments for its unique, two-stage wet anaerobic digestion technology, demonstrating it overcomes certain disadvantages of other anaerobic digestion technologies (e.g., greater diversion from landfill disposal, generation of less compost and more biogas, smaller facility footprint). Arrow Ecology also documented commencement of construction for a new facility in Australia, and demonstrated preliminary partnership activities with one of the sites on the County's Phase I list of MRFs/TSs.
- Ebara Corporation demonstrated significant commercial experience in Japan with their TwinRec/TIFG technology, with active development activities for the next generation of the technology, which would allow for collection of the synthesis gas to enable cleaning of the gas, as applicable, and use of the gas for generation of electricity or fuels.
- International Environmental Solutions demonstrated the formation of strategic alliances with Northern Power Systems (for facility design and construction) and Rainbow Disposal (for integrating and optimizing a pre-processing system). IES also confirmed that it has made significant progress in developing and validating its technology since completion of the Phase I evaluation, include a 14-day, 24/7 test with post-MRF residuals and South Coast Air Quality Management District source testing.

- In September 2006, a letter with a questionnaire was sent to the eighteen new technology suppliers that were not evaluated in Phase I. The questionnaire established minimum criteria for participation, and requested basic information on the technology supplier and technology offered to confirm that the minimum criteria were met. The minimum criteria were based on those established in Phase I, but the diversion potential was increased from a minimum of 50% to a minimum of 75% in consideration of the experience and capabilities of the top-ranked technology suppliers. Eleven technology suppliers responded to the questionnaire. Based on the responses, none of these technology suppliers were able to fully demonstrate compliance with the minimum criteria. Most were not able to demonstrate sufficient operating experience, and many did not provide information on an operating reference facility. As a result, none of these additional technology suppliers were recommended for participation in Phase II.

Ultimately, nine technology suppliers were selected for participation in Phase II, including the six that were recommended in Phase I and three additional technology suppliers that were evaluated in Phase I but not recommended at the time (Arrow Ecology and Engineering, Ebara Corporation, and International Environmental Solutions). The nine technology suppliers that were selected for participation, listed in alphabetical order, are identified in Table 3.2-2.

Table 3.2-2. Technology Suppliers Selected for Participation in Phase II

Technology Supplier
Arrow Ecology and Engineering (Arrow)
Bioengineering Resources (BRI)
Changing World Technologies (CWT)
Ebara Corporation
GEM America
International Environmental Solutions (IES)
Interstate Waste Technologies (IWT)
NTech Environmental (NTech)
Primenergy

After selection of the participating technology suppliers, a Request for Information (RFI) was issued to the nine selected participants. During the RFI response period, four of the nine selected technology suppliers chose to withdraw from the process for a variety of reasons on their part. The four that withdrew were BRI, Ebara Corporation, GEM America, and Primenergy. Therefore, the Phase II process proceeded with a final list of five technology suppliers, which are listed alphabetically in Table 3.2-3.

Table 3.2-3. Technology Suppliers Participating in Phase II

Technology Supplier	Technology Type
Arrow Ecology and Engineering (Arrow)	Anaerobic Digestion
Changing World Technologies (CWT)	Thermal Depolymerization
International Environmental Solutions (IES)	Pyrolysis
Interstate Waste Technologies (IWT)	Pyrolysis / High Temperature Gasification
NTech Environmental (NTech)	Low Temperature Gasification

3.3 METHODOLOGY FOR TECHNOLOGY EVALUATION

Information required for the technology evaluation and for evaluation of the resources and qualifications of the technology suppliers was gathered through a detailed Request for Information (RFI). The RFI described Los Angeles County's objectives for the demonstration project, and disclosed the technical, economic, and qualifications criteria that were established for the Phase II evaluation process. The RFI also identified the candidate MRF/TS sites, provided contact information for the MRF/TS site owner/operators along with key site information, and provided waste composition assumptions. The RFI was issued in October 2006, and responses were received in December 2006. A copy of the RFI is provided in Appendix B. The evaluation criteria are identified later in this report, as a preface to the review of resources and financial qualifications of the technology suppliers (Section 4) and the technology evaluations (Section 5).

In January 2007, after submittal and initial review of the RFI responses, interviews and working meetings were conducted with each of the technology suppliers in Los Angeles. This direct interaction with the technology suppliers provided the opportunity to confirm information and gather additional data and materials as needed. Throughout the review process, direct interaction and coordination with the technology suppliers continued, including visits to reference facilities from February through April 2007, to ensure the most accurate and complete information was available for review. Upon analysis of information obtained during the presentations and site visits, preliminary findings were summarized and a workshop was conducted with the Subcommittee to review and discuss the preliminary findings. Following the Subcommittee's review, the preliminary findings were shared with the technology suppliers in June 2007, to provide a final opportunity for data confirmation and input. That input is reflected in this report, as appropriate.

3.4 SELECTION OF CANDIDATE SITES

As summarized in Section 2, the Phase I study recommended six MRF/TS facilities as preferred locations for development of a conversion technology demonstration facility. Early in the Phase II process (July 2006), the owner/operators of the six potential sites were contacted and site visits were conducted to determine interest in continued participation in the County's demonstration project. Four of the original six sites expressed a willingness and ability to participate. Two of the sites, both identified in Phase I as "second priority" sites, dropped out: the Central Los Angeles Recycling Center and Transfer Station (CLARTS), because it is a potential site for the City of Los Angeles conversion technology project, and the proposed facility in Santa Clarita, because of uncertainty regarding the approval of the entire industrial development that would have encompassed the MRF/TS. Late in the Phase II process, a new MRF was added to the project, specifically in consideration of their relationship with one of the selected technology suppliers (International Environmental Solutions). This additional MRF (Rainbow Disposal in Huntington Beach) was evaluated under this project exclusively in partnership with IES. The five MRF/TS sites evaluated in Phase II are identified in Table 3.4-1, listed in alphabetical order.

Table 3.4-1. MRF/TS Sites Evaluated in Phase II

MRF/TS Facility	Location
Community Recycling/Resource Recovery Inc.	Los Angeles County (Los Angeles)
Del Norte Regional Recycling and Transfer Station	Ventura County (Oxnard)
Perris MRF/Transfer Station	Riverside County (Perris)
Rainbow Disposal Company, Inc. MRF(1)	Orange County (Huntington Beach)
Robert A. Nelson Transfer Station and MRF	Riverside County (Unincorporated)

(1) The Rainbow Disposal MRF was evaluated under this project exclusively in partnership with IES.

3.5 METHODOLOGY FOR SITE EVALUATION

As further described in Section 6 (Site Evaluations), criteria were established to evaluate the suitability of each facility to host a conversion technology demonstration facility. The criteria included the fundamental prerequisite of ability and willingness to partner with a technology supplier for development of a demonstration facility, along with primary criteria (e.g., space availability, feedstock quantity) and secondary criteria (e.g., ability to assist in marketing products, accessibility to major transportation routes). Information required for site evaluations was gathered through a series of site visits and meetings with each of the individual site owner/operators. The criteria that were established for the Phase II site evaluations (see Section 6.3) provide a template that may be useful by other entities that are similarly working on development activities for a conversion technology project.

3.6 REFERENCE FACILITY TOURS

Reference facility tours were an important component of the Phase II technology evaluations. The tours provided the opportunity to gather and confirm technology-specific information, and to gather valuable insight for development of a demonstration project in Southern California. Benefits of visiting the reference facilities included the ability to:

- Inspect and observe the facilities in operation, first-hand;
- Confirm the type of waste processed and compare the waste streams;
- Evaluate the generation and management of products and byproducts;
- Assess applicability and interface issues in consideration of co-location of a conversion technology at a MRF/TS in Southern California;
- Observe waste collection and handling practices;

- Observe site design and operational practices for ensuring employee occupational health safety and efficient operation;
- Observe public education practices, including facility design elements associated with educational tours;
- Observe the locational and aesthetic aspects of the facility, and its integration into the surrounding area and wider community; and,
- Meet with local regulators and other stakeholders.

Each participating technology supplier was required to identify an operating reference facility that could be visited to observe the technology. Members of the Subcommittee, Department of Public Works staff, and representatives of the ARI team participated in the tours, which took place from February through April 2007. When possible, meetings were also held with regulators and local government officials to gather insight regarding the development and operational history of the facilities. Table 3.6-1 identifies the reference facilities that were visited. Additional information on the reference facilities and relevant findings from the tours and meetings are integrated with the technology evaluations (Section 5).

Table 3.6-1. Reference Facility Visits

Technology Supplier	Reference Facility Visited (Location)	Date
Arrow Ecology	Hiriya, Israel	March 12, 2007
Changing World Technologies	Carthage, Missouri	April 25, 2007
International Environmental Solutions	Romoland, California	February 15, 2007
Interstate Waste Technologies	Chiba, Japan Kurashiki, Japan	April 2, 2007 April 3, 2007
NTech Environmental	York, England (pre-processing) Bydgoszcz, Poland (gasifier)	March 7, 2007 March 9, 2007

3.7 OTHER ACTIVITIES

In addition to conducting technology and site evaluations, Phase II also included parallel activities related to facilitation of partnerships and project development. A meeting was held in January 2007 with the South Coast Air Quality Management District (SCAQMD), to discuss conversion technologies and address permitting pathways and regulatory issues (see Section 7). Project financing and funding opportunities were addressed, including research on grants and funding opportunities from private and public sources as well as the possibility of financing through the issuance of bonds or special appropriations. In addition, meetings were held in May 2007 in New York City with bankers and financial advisors associated with the technology suppliers to solicit more information on financing requirements (see Section 9). Finally, initial negotiation efforts were conducted to facilitate partnerships between the technology suppliers and site owner/operators, including discussions regarding incentives the County may be able to offer that would be beneficial to the project participants (see Section 10).

SECTION 4
RESOURCES AND FINANCIAL QUALIFICATIONS OF TECHNOLOGY SUPPLIERS

4.1 INTRODUCTION

For the purpose of evaluating technology supplier qualifications, the Phase II RFI established criteria and requested information regarding the technology supplier and its team's business structure and organization, financial information, and other similar background information. The information provided was used to develop an understanding of each technology supplier regarding the following characteristics:

- **Corporate and team resources,** including:
  - business operations, business history and ownership structure, teaming arrangements or other strategic alliances that are pertinent;
  - the capability of the technology supplier to design, permit, construct, and operate a conversion technology project, considering the management structure and organization;
  - relationship with the proposed technology (e.g., ownership and/or license arrangements, other parties involved in the technology development and ownership, etc.); and,
  - the capability of the technology supplier to finance and meet the financial risks and obligations associated with the design, permitting, construction and operation of a conversion facility.
- **Financial security and risk considerations,** including the technology supplier's experience in offering single source guarantees and other financial security techniques; and the technology supplier's risk posture on matters such as financing, construction and facility performance, and product generation and sale.
- **Financing approach**, including the demonstration by a technology supplier of its understanding of, experience with and arrangements it might bring to finance a prospective project, recognizing that formal financing would be finalized in a subsequent stage of project development.

The evaluation criteria applied can be found in Attachment 3 of the October 2006 Request for Information, in Appendix B of this report. The criteria provide a template that may be useful for future evaluations, and are available for public usage.

The objective for the evaluation of technology supplier resources and financial qualifications was to develop a profile of prospective project developers. The information requested in the RFI was consistent with this objective. It should be noted that the depth of the information provided in the RFI responses was less than what would be expected in a formal procurement. In responding to a Request for Proposals, a proposer would be required to provide a formal proposal - with a firm price and schedule for delivery of services along with technical, environmental and financial information to sufficiently demonstrate that the service and performance requirements could be met for the prescribed terms and conditions of the contract. This typically requires sufficient design to develop firm pricing. The level of detail in the responses to Los Angeles County's Phase II RFI also reflects the nature of the emerging technologies market, with many of the technology firms in various stages of initial development in the U.S. marketplace. Several technology suppliers have, however, teamed with large firms in the U.S. experienced in the waste and energy businesses. This adds to the strength of those overall teams.

The RFI responses and subsequent evaluation assumed that any project(s) developed would be privately owned and financed. While there may be incentives and certain support that the County can provide, financability will ultimately be determined by the finance market, and the details of project structures and risk profiles may be more at the call of the market than at the County's discretion. Since these projects are likely to be private transactions, this is not necessarily an adverse condition. As privately financed, developed and managed projects, proper structuring will shift most risks to the private parties involved, lowering the County's risk.

Additional due diligence will be required in the next step of the program, when the County considers selection of one or more site-specific conversion technology demonstration projects to support. A significant portion of such information will become available as the technology suppliers and participating MRFs move forward in the development of partnerships, specific project definition and financing arrangements.

4.2 CORPORATE AND TEAM RESOURCES

The information that was requested by the RFI is important from several perspectives. First, it indicates the nature and business history of each company in the municipal solid waste business, including its experience with the offered technology. Second, it characterizes the relationship of each company with the technology (e.g., as licensee or developer/owner), which has implications regarding the availability of the technology, the permanency of the relationship and a company's long-term access to technical support. And finally, it provides an indication of each company's familiarity with and understanding of the U.S. solid waste market's standard industry practices.

4.2.1 Technology Supplier Teams

Typically, the teams assembled for MSW projects include the following key participants:

- Project developer to lead the development team, select the team members, manage and coordinate project development activities and construction and operation of needed facilities, and be the single point of responsibility to the customer (i.e., the party contracting with the project developer) for delivery of services. For the purpose of this report and the contemplated demonstration project, the project developer is considered to be the technology supplier, with the MRF/TS owner as a partner.

- An engineering, procurement and construction ("EPC") contractor, which would be responsible for designing the facility, procuring equipment, and constructing and participating in the start-up of the facility. The EPC contractor would be at risk for and provide guarantees on construction cost and schedule. The EPC contractor would also guarantee acceptance testing and initial performance. For the purpose of this report and the contemplated demonstration project, the EPC contractor would provide these services and guarantees to the project developer.

- A facility operator, which would be responsible for operating and maintaining the facility according to contract-set requirements (which would typically include technology-specific requirements, manufacturers' guidelines, standard industry practices, and regulatory requirements). The operator could be the project developer (i.e., the technology supplier), or an operations company that is under contract to the project sponsor. If a contract operator other than the project developer were involved, it would provide operating performance and cost guarantees to the project developer, including guarantees on the production or recovery of products such as energy and secondary materials over the contract term.

- A guarantor, which would provide the ultimate guarantee on the costs and performance of the project to the customer contracting with the project developer for services. Typically, the guarantor's position would be supported by guarantees provided by its EPC and operations contractors, as well as by other security measures such as bonds and comprehensive insurance coverage. Bank-issued letters of credit may also be included in the overall guarantee and security package. The guarantor could be the project developer and/or a parent company of the project developer.

- An investment banker, which would be responsible for developing the financing plan for the project and for securing the financing. The investment banker would perform significant due diligence on the principal aspects of the project (such as the technology, team members, waste supply assurance, product markets and contract terms and conditions) to assure that a financable project is being configured. Typically, the investment banker included on a project team has a long-standing relationship with, and has participated in other projects with, the project developer.

Table 4.2-1 identifies the technology suppliers and their teaming partners, as of June 2007. In evaluating this project structuring, it is important to consider the qualifications and resources of the team as a whole, since each team member has a specific role in ensuring the project's success, and in the case of the EPC contractor and operator, provides significant guarantees to the project developer. As indicated in a footnote to Table 4.2-1, the composition of individual teams could change as technology suppliers begin site-specific project development activities and identify additional development needs.

Table 4.2-1. Technology Supplier Teams (Listed Alphabetically)

Technology Supplier (Project Developer)	Teaming Partners[1]	
Arrow Ecology and Engineering (Arrow) Development Partner: CR&R	EPC: Operator: Guarantor: Banker: Technology:	Siemens (international engineering/ construction firm with US experience) Arrow Not Specified Investec Bank Developed and patented by Arrow
Changing World Technologies (CWT)	EPC: Operator: Guarantor: Banker: Technology:	Not Specified CWT CWT Goldman Sachs Exclusive worldwide license of depolymerization technology
International Environmental Solutions (IES) Development Partner: Northern Power Systems (NPS)	EPC: Operator: Guarantor: Banker: Technology:	Northern Power Systems (diverse US energy equipment and services provider) IES/NPS Distributed Energy Systems Corp. Morgan Stanley Developed and patented by IES; Northern Power exclusive US distributor
Interstate Waste Technologies (IWT)	EPC: Operator: Guarantor: Banker: Technology:	SNC Lavalin (international engineering/ construction firm with US experience); Thermoselect will design gasification component Veolia Environment (international infrastructure facilities operator with significant number of US MSW – waste-to-energy – projects) Interstate Business Corporation (Related Company) Morgan Stanley Developed and patented by Thermoselect; IWT has license for US, Mexico, Caribbean countries
NTech Environmental	EPC: Operator: Guarantor: Banker: Technology:	EMCOR (international engineering/ construction firm with US experience) NTech Environmental Not Specified New Century Finance Ltd. All major elements under exclusive agreement or license

(1) Team make-up as of June 2007 - the composition of individual teams could change as technology suppliers begin site-specific project development activities and identify additional development needs.

Based upon the information provided by the technology suppliers, and summarized in Table 4.2-1, the following can be concluded:

- The technology suppliers have different levels of financial resources and experience in developing projects, internationally and in the U.S. Some have commercial operating facilities overseas; others do not. All have yet to develop a commercial MSW conversion technology facility in the U.S. To fill this gap, and of key importance to the success of the conversion technology project, the technology suppliers have assembled teams with experienced EPC contractors, operators and banking institutions. In addition, partnering with MRF/TS owners/operators will add technical and financial resources and important knowledge of local practices and requirements. For example, Arrow, IWT and NTech Environmental, particularly, have selected major international engineering and construction companies with U.S. experience. IES's development partner, Northern Power Systems, is an experienced energy project EPC. CWT did not identify an EPC, but its team includes an experienced investment banker, and it has represented that it has worked with a major international EPC on other projects.

- All of the technology suppliers offer the advantage of being the developers/owners, licensees or sole representatives of what can be considered to be proprietary technology (i.e., they are not simply purchasers of individual equipment components from suppliers). Familiarity and experience with the technologies and, the proprietary, integrated nature of the technologies, will help assure the technology supplier's success in planning, implementing and operating facilities.

- Because of their close relationships to the technologies, all of the technology suppliers have long-term access to technical support, which will enable them to resolve difficulties that may arise over time or to benefit from technical enhancements that may be developed in later years. Given that many of the technologies have been developed and applied outside of the United States, the *ease* of access to technical support from non-U.S.-based providers should be addressed prior to Los Angeles County's commitment to a technology. Techniques such as requiring U.S. resident presence by the technology owner/licensor can be effective in this regard.

- All of the participating companies appear to have invested heavily (and to continue to invest) in the development, refinement and/or marketing of their technologies.

4.2.2 Team Financial Resources

The RFI requested data for the past five years on financial performance indicators, as well as summary discussions of financial resources. Financial resources and capabilities are important because they indicate the ability of a company to finance a project and to bear the financial risks associated with project development and operation, particularly of a privately owned and operated facility, and to provide meaningful and enforceable guarantees. The information provided by the technology suppliers is summarized in Table 4.2-2.

As shown in Table 4.2-2, when considering these financial resources, the technology suppliers are relatively small companies (assets measured in millions as compared to companies with assets of a billion dollars or more). However, the inclusion of major experienced engineering and construction firms operators and bankers, and teaming with MRF/TS owners enhances the technology suppliers overall project-related financial resources and capabilities. In structuring financings, lenders will give considerable weight to the overall capabilities of project teams and the manner in which the capabilities, resources and guarantees of individual members complement or augment those of other members.

Table 4.2-2. Corporate and Team Resources Summary

Company	Summary Information
Arrow Developer: Arrow & CR&R EPC: Siemens Operator: Arrow Guarantor: not specified Banker: Investec Bank	• Arrow: 8+ years experience; founded 1999 (spin-off of technology developer founded in 1974) • Arrow: Annual planned losses 2001-2005 (development mode); profitable in 2006 (Australia project), but associated net worth for 2006 not provided; low annual revenues • Arrow: reported to be negotiating new corporate funding arrangement • Siemens (EPC) is an international engineering and construction firm with US experience: $118 billion in annual revenues • Bonds and insurance from AON, an international risk manager and insurer, with $9 billion in annual revenues
CWT Developer: CWT EPC: not identified Operator: CWT Guarantor: CWT Banker: Goldman Sachs	• CWT: 10 years experience; founded in 1997 • CWT: +/- 10% owned by Goldman Sachs • CWT: Net worth +/- $29 million • CWT: $14 million in Federal development grants • CWT: continues to carry losses but has significant asset and net worth growth
IWT Developer: IWT EPC: SNC Lavalin Operator: Veolia Environment Guarantor: Interstate Business Corporation (related company) Banker: Morgan Stanley	• IWT: 15+ years experience; founded in 1990 • IWT: Significant project pursuit/development experience • IWT: Puerto Rico project moving toward closing (will add experience and revenue) • IWT: Revenues ($2.4 million, 2005); 2005 net worth $7.1 million • IWT: Guarantor's annual revenues +/- $24 million, net worth $46 million • SNC Lavalin (EPC) is an international engineering and construction firm with US Experience: $3.5 billion annual revenues • Veolia (Operator) is an international operations form with significant US MSW projects: $2.3 billion annual revenues • Bonds and insurance from AON, an international risk manager and insurer, with $9 billion in annual revenues

Company	Summary Information
IES/NPS Developer: IES/NPS EPC: Distributed Energy Operator: IES/NPS Guarantor: Distributed Energy Banker: Morgan Stanley	• IES: 15 year investment in technology development • IES: net worth/revenues not provided • IES: first commercial unit on line Summer 2007 • IES: alliances with Rainbow Disposal (project development), Air Products (hydrogen production technology) • Northern Power: Founded in 1974 (as North Wind Power Company, Inc.) • Northern Power: wholly owned by Distributed Energy Systems Corporation (NASDAQ-traded), a 2003 combination of NPS and Proton Energy Systems – strong energy project experience/experienced EPC • Distributed Energy's revenue doubled 2004-2005 to $45 million, 2005 net worth of $85 million • Distributed Energy has continuing losses due to planned investment in corporate build-out ($3 - $5 million/year R&D)
NTech Environmental Developer: EPC: EMCOR Operator: Guarantor: not specified Banker: New Century Finance Ltd.	• NTech: experienced team members/subcontractors/equipment suppliers • NTech: projects operating in UK, Canada, Germany, Mexico • NTech: merged with E Renewable Energy (principal technology partner, net assets of US $3.4 million) • EMCOR (EPC) is an international engineering and construction firm with US experience: $5 billion annual revenues • Bonds and insurance from AON, an international risk manager and insurer, with $9 billion in annual revenues

4.3 FINANCIAL SECURITY AND RISK CONSIDERATIONS

Although specific transactions and contractual terms and conditions have not been formally defined yet, the technology suppliers were asked to discuss their general postures regarding project risks. As discussed below, when viewed from the perspective of established U.S. industry practice for private parties involved in MSW projects, several conclusions can be drawn based on the information provided by the technology suppliers.

- **Project Cost and Performance Guarantees.** The industry standard in the U.S. market is the provision of "single-source" or corporate guarantee, through which one entity provides all of the schedule, cost and performance guarantees to a customer. Typically, those single-source guarantees to the customer are supported by cost and performance guarantees provided by the major design, construction and operations team members to the project developer. All of the participating companies recognized the importance of the "single-source" approach to the provision of construction, operation, performance and financial guarantees. The guarantees that the partners (who are accustomed to providing such) would provide to the technology suppliers (as the project developers) would, ultimately, be significant backstops for any guarantees provided directly by the project developers.

- **Security Instruments.** As is standard in the US market, single-source or corporate guarantees are typically paired with comprehensive performance bond and insurance packages. All of the technology suppliers acknowledged the need for such customary project security, with several specifically identifying their bond and insurance providers. It should be recognized that the very ability of a project developer to provide such security arrangements is, in itself, an indicator of financial capability, since bond and insurance providers will not write policies for clients that do not meet the providers' financial standards.

- **Commercial Product Market Risks.** The U.S. industry standard is that the project developer bear the risks associated with the production of marketable products (i.e., energy and secondary materials). Customarily, this requires the developer to take the risks regarding the quality and quantity of products produced or recovered (for example, that the project will generate a guaranteed amount of electric power or that it will recover a guaranteed volume of ferrous metals). These types of risks are usually not insurable and must be borne directly by the project. In some cases, the developers take the risks that energy or materials will be sold at certain prices. In the absence of defined project structures and contractual bases, the technology suppliers indicated that specific risk arrangements would be the subject of continuing development and negotiation. However, they generally recognized the importance of their risk taking regarding the commercial product risks. Their specific responses varied, as follows:

    - Arrow did not specifically address product risks;
    - CWT indicated that its risk profile would be determined, in part, by the financial returns it could expect;
    - IES/NPS indicated that actual performance and risk issues would be determined once the MSW specification was confirmed;
    - IWT stated that it would guarantee the production of recycled products of marketable quality and would pass through revenues to its customer;
    - NTech Environmental stated that its risk posture would be determined in part through due diligence that would be conducted by its funders and insurance underwriters.

Consistent with their positions on the need for further negotiation of product risk postures, several of the technology suppliers also indicated that specific risk postures and guarantees would be conditioned on assurances regarding the availability and specific characterization of the waste streams they would be processing. This degree of specificity will be provided in the next step of project development, where technology suppliers team with MRF/TS owners and operators and integrate their system with the specific waste supply and separation systems of the MRF/TS.

- **Financial Market Considerations.** All of the investment bankers identified by the technology suppliers have experience with the financing of MSW projects. Considerable confidence can be placed in the due diligence that would be performed by potential lenders and investors who, for their own purposes, would look to structure projects as securely as is practicable. The technology supplier's bankers have indicated that they believe that most risks can be addressed at the project level, and have also indicated that they are generally comfortable regarding key risk areas as technology capabilities and performance and construction risk.

Given the responses of the technology suppliers, the key financing issues that must be resolved are waste assurance and supportable tipping fees that are market competitive (see Section 9). The technology suppliers acknowledge and intend to follow standard U.S. industry practice in structuring projects. However, as project development continues, the guarantee and risk postures required for County support of individual projects should be clearly defined.

4.4 FINANCING APPROACH AND EXPERIENCE

With the assumption that any project resulting from this process would be privately financed, owned and operated, technology suppliers were requested to discuss their experience in financing projects and their ideas regarding a prospective demonstration project.

The working assumption of private finance and ownership is founded in part on the long experience of the private financing, ownership and operation of projects in diverse public infrastructure fields, including solid waste, water and wastewater treatment, and biosolids management. Private financing techniques for infrastructure projects are well established.

MSW projects are usually funded as "project financings." In the public infrastructure market, there are two principal types of financings, "general obligation financing" and "project financing." General obligation financing is typically used when the facility being financed does not have a specific or discrete revenue source (such as a new school building), and is paid for out of general tax revenues. Project financing is typically used when the facility does have a revenue source, such as a water system (which would have user rates paid by consumers) or an MSW facility (which would levy tipping fees for the disposal of MSW and receive revenues associated with sale of energy and/or marketable products). Project financing approaches can be applied to either publicly-owned projects or privately-owned projects. Publicly-owned projects can be financed with 100% debt (i.e., all of the money needed to construct the system can be borrowed, usually with most debt through tax-exempt bond issues). Project financings for privately-owned infrastructure projects typically require that the private owner invest its own capital or equity in the project (analogous to a homeowner's down payment on a home mortgage). This is required in order to reduce the amount of money borrowed and, thus, reduce the lender's risk. The amount of equity required will depend upon the lender's analysis of the amount of risk involved in any individual project: the more risk perceived, the more equity will be required. Typically in the public infrastructure market, lenders require an equity investment (a "down payment") of between 15% and 30% of total project design and construction costs, establishing, for example, a "debt-to-equity ratio" of 85%/15%. Private financing, with private ownership, can be accomplished for MSW projects using tax-exempt bonds, if IRS requirements can be met and volume cap (established for such purposes) is available. Private financing can also be accomplished with 100% equity financing and by commercial loan. Both of these later financing methods would have a higher lending rate than a private activity based financing. Therefore, tax-exempt, private activity project financings are likely to be the least costly means of financing, resulting in a lower tipping fee.

All of the technology suppliers acknowledged the preference for private finance and ownership. Four of the technology suppliers (Arrow, IES, IWT, and NTech) either have financed projects using customary solid waste project financing techniques, are in the process of structuring financings for projects being implemented, or are in the process of developing funding mechanisms with financial institutions. Changing World Technologies used private investment capital (equity) combined with Federal grants to fund its Carthage, MO project. The RFI did not require the submission of formal financing plans and, as could be expected, the commitment of all technology suppliers and their financial advisors to private financing and ownership was made contingent on the further definition of a project(s) and the negotiation of satisfactory waste supply, tipping fee, "off-take" (energy and materials sales) arrangements and contracts.

Every technology supplier expressed confidence in the ability to finance the project(s) contemplated, conditioned upon the type of waste supply and energy sales contractual arrangements that are customary in the US solid waste market. All of the technology suppliers are working with (or have worked with) experienced investment bankers and/or financial advisors, although two (Arrow and NTech) referenced the involvement of non-US institutions. All technology suppliers except CWT specifically mentioned the structuring of customary debt/equity project financings that would combine private investment capital with debt. The debt could be in the form of a commercial type of loan or another form, such as a bond issue. While referencing this type of financing, CWT also mentioned the potential use of 100% equity financing to finance the first, demonstration phase of its project.

Further discussions follow for the individual technology suppliers:

- **Arrow Ecology.** Arrow reported that it raised $12 million from local partners and Israeli banks to finance the development of its Tel Aviv plant. It also reported that, working with ANZ Investment Bank (based in Australia), it was able to finance its facility in Australia. Arrow also provided a letter of interest from Investec Bank, Ltd. (Australia) to either provide or arrange for debt and equity financing, subject to credit approval, and indicated some level of partnership involvement by the MRF owner, CR&R, to be defined.

- **Changing World Technologies.** CWT has retained Goldman Sachs as its financial advisor. The company cited its success in raising corporate development funding, as well as Federal development grants. CWT stated that it is "comfortable that there are a number of different debt and equity sources that could be identified for this opportunity," but did not provide any more material discussion or information, and stated that no predetermined financing arrangement had been set. CWT did state that it anticipates working with Los Angeles County to obtain state and/or federal grants and to access municipal (tax-exempt) financing. CWT's Carthage, MO facility, an industrial application, was funded primarily through equity, with some grant funds applied. CWT's estimated tipping fees for a demonstration project in Southern California are based on an assumed all-equity financing.

- **International Environmental Solutions.** IES's associate, Northern Power Systems (NPS), a wholly-owned subsidiary of NASDAQ-listed Distributed Energy Systems Corp., would own the project. NPS stated that it had established a separate division and fund to fund debt and equity for its projects, with anticipated financings typically with a 70/30 debt-to-equity ratio. As an example of its capability to provide financing, the company also cited its provision of leasing arrangements to its industrial customers.

  NPS reported that it is in the final stages of concluding a formal agreement with a major investment firm to establish an investment fund for these types of projects. It is intended that this fund will provide the equity for numerous projects, and NPS reports that the initial fund size will be in the hundreds of millions of dollars. NPS and this firm have executed a letter of intent for this fund, with the final term sheet to be concluded in the near future. This same firm will be providing the debt financing for these projects. NPS also stated that several other financial institutions have expressed interest in funding these projects should the first firm decline to participate.

- **Interstate Waste Technologies.** IWT's stated business plan is to privately finance, own and operate conversion technology facilities. The company reported that it is currently involved in financing a $660 million project in Caguas, Puerto Rico ($475 million construction, $185 million soft costs), and had, as a part of formal proposals, offered to finance another facility in Puerto Rico and one in Collier County, FL. It characterizes the Caguas transaction as a conventional project financing based on an equity investment of approximately 13%, with the balance of funds provided by a combination of taxable and tax-exempt bond debt. Equity sources are IWT and its investors. The financing plan for the Caguas project has been completed, and closing is anticipated for the third quarter of 2008. It conceived of a similar financing structure for a prospective demonstration project in Southern California, and included a letter of interest from Morgan Stanley in placing the taxable and tax-exempt debt that would be used in a financing (Morgan Stanley is also working with IWT on the Caguas, Puerto Rico project).

- **NTech Environmental.** NTech Environmental stated that it had arranged debt financing (apparently for both corporate development and project purposes) through two institutions, RoyCap Merchant Banking Group (Toronto, ON, Canada) and New Century Finance Ltd (United Kingdom). NTech also reported that it has developed projects in the United Kingdom, Mexico, Canada and Germany. NTech provided letters of interest and support regarding project financing from both of these groups (as could be expected, both conditioned on the need for satisfactory contractual arrangements).

A discussion of project financing requirements developed through discussions and meetings with the technology supplier bankers is provided in Section 9 of this report. The ability to satisfy such requirements will have a significant impact on the financing of the project(s) and the resulting financing costs.

Given the experience and corporate and team resources of the technology suppliers, and assuming that the types of financing requirements that are identified in Section 9 can be achieved, our analysis concluded that the technology suppliers are capable of structuring financable projects using customary US solid waste market project financing techniques.

SECTION 5
TECHNOLOGY EVALUATIONS

5.1 INTRODUCTION

The Southern California Conversion Technology Project includes development of one or more conversion technology demonstration projects at one or more of the candidate MRF/TS sites designed to process at least 100 tons per day (tpd) of MRF residuals and/or post-recycled, municipal solid waste. A technical review was conducted to establish confidence in each technology's capability to manage this feedstock. In the RFI issued to technology suppliers to gather technical information (copy provided in Appendix B), evaluation criteria were specified that reflected the goals of the Project, which have been applied for the technology evaluations. These key aspects are described below.

A detailed technology evaluation has been completed for each of the five technology suppliers and their associated technologies. Following those technology-specific evaluations is a summary and inter-comparison of key performance factors (see Section 5.7, Comparative Summary of Technology Evaluations).

5.1.1 Project Definition

As stated in the RFI, the project's primary goal is to facilitate development of a successful conversion technology demonstration facility. Certain prerequisites for County support were established, including the ability to process at least 100 tpd of MRF residuals and post-recycled MSW, and development of a complete design concept (i.e., one that includes necessary pre-processing and/or post-processing or management of products and/or residuals, in addition to the conversion process). An upper limit was not defined for project capacity, but it is the County's intent is to support a demonstration-scale project to obtain confidence in the technology, promote the development of conversion technologies, and to forge permitting and legislative pathways for future projects. Technology suppliers were advised to consider optimal throughput for the technology, site limitations, market conditions, stipulations by funders/financial backers, and community reaction. Technology suppliers were invited to propose a project for one or more sites, ideally sized for optimization at a particular site, and to propose a more viable, commercial-scale facility.

The technology suppliers each proposed different project concepts. The proposed concepts, as follows:

- **Arrow Ecology and Engineering.** Arrow proposed a 300-tpd demonstration facility specifically for the Perris MRF/TS. Arrow stated its technology could be considered for application at the other candidate sites, but did not study or propose any other sites in its response to the RFI. For comparative purposes, Arrow also provided some limited information on a larger, 1,050-tpd commercial facility. Because of Arrow's preference for the smaller facility, the technical evaluation of the ArrowBio technology was completed based on the 300-tpd demonstration facility.

- **Changing World Technologies.** CWT proposed a 200-tpd demonstration facility (220 tpd including water), and suggested scale-up to a 900-tpd commercial facility after a few years of operation (1,000 tpd including water). However, almost all of the information provided by CWT pertained to the smaller demonstration facility. CWT identified the Del Norte Regional Recycling and Transfer Station in Oxnard and the Robert A. Nelson Transfer Station and MRF in Riverside County as sites of interest. The technical evaluation of the CWT technology was completed based on the 200-tpd demonstration facility.

- **International Environmental Solutions.** IES proposed a single project concept, consisting of a 125-tpd demonstration unit (accounting for feedstock drying). The IES facility would receive approximately 242 tpd of MSW, prior to drying. IES responded that a larger, commercial-scale facility would not be required for economic viability, and therefore, did not propose a larger capacity. IES identified the Perris MRF/Transfer Station and the Robert A. Nelson Transfer Station and MRF as sites of interest. Subsequently, IES disclosed a developing partnership between its technology and Rainbow Disposal Company. As a result, the Rainbow Disposal MRF in Huntington Beach was added as a potential site for IES's project concept. The technical evaluation of the IES technology was completed based on its 242-tpd project.

- **Interstate Waste Technologies.** IWT proposed three project concepts: 1 unit, 2 units and 3 units, which would have respective design capacities of 312 tpd, 624 tpd and 936 tpd, and which could be considered demonstration or commercial facilities. IWT expressed a preliminary interest in all of the candidate sites, subject to space availability. IWT's 3-unit concept is the largest capacity that IWT could construct for any of the candidate sites, based on the site acreage reported to be available. The 3-unit facility would fit on only the Del Norte Regional Recycling and Transfer Station in Oxnard, unless additional space could be made available at the other sites. IWT's 2-unit concept could fit at the Oxnard site, and at the Perris MRF/TS and the Robert A. Nelson Transfer Station and MRF sites. IWT's 1-unit concept could fit at all of the sites except Community Recycling, unless additional, adjacent land was made available at that site. The technical evaluation of IWT's technology was completed for their 2-unit, 624-tpd project, since the 1-unit concept is not economically competitive (see Section 8) and the 3-unit concept has limited application at only one site, unless additional space can be made available.

- **NTech Environmental.** NTech Environmental proposed a single project concept consisting of a facility design capacity of 413 tpd for the Perris MRF/TS, which could be considered a demonstration or a commercial facility. Although not part of its RFI response, NTech Environmental expressed an interest in also exploring suitability of its project concept at the other candidate MRF/TS sites.

5.1.2 Waste Characterization

As described above, the demonstration projects are to be designed to process MRF residuals and/or post-recycled, municipal solid waste (MSW). This waste generally consists of all residuals that, after recyclable materials are recovered, would otherwise proceed to a landfill for final disposal. Based on the proposed project concepts and specific waste characterization assumptions, Arrow, IWT and NTech Environmental would process municipal solid waste and MRF residuals. CWT would also process municipal solid waste and MRF residuals, but as part of a blended feedstock with auto shredder residue (ASR), fats oils and grease (FOG), and used oil. These are additional waste components that were not specified by the RFI but are included by CWT because of the specific technical and economic benefits these additional waste streams could add to CWT's process. IES would process only MRF residuals. IES could also process municipal solid waste, but would require additional front-end processing to prepare the waste as a suitable feedstock.

Site-specific waste characterization data was not available for the candidate MRF/TS sites to provide with the RFI, for either municipal solid waste or MRF residuals. Therefore, the RFI included waste characterization data for post-recycled, MSW, as reported in the City of Los Angeles *Evaluation of Alternative Solid Waste Processing Technologies* (URS, September 2005). The data presented in the City report and provided with the RFI was based on a one-day sampling program at a City-owned transfer station where post-source separated MSW from all waste sheds in the City of Los Angeles were delivered. While it was a limited sampling program, the data were reported as being comparable to a larger waste sampling program conducted for the City in 2000.

Recognizing the limitations of the waste characterization data, and specifically the absence of a characterization for MRF residuals, the RFI specified that technology suppliers could use refined assumptions. Technology suppliers were requested to disclose its waste composition assumptions if such assumptions differed from those included in the RFI. Three of the technology suppliers chose to use different waste composition assumptions (Arrow, IES and NTech Environmental). As further disclosed in the individual technology evaluations, Arrow and NTech Environmental both used state-wide data for post-source separated residential waste, published by the California Integrated Waste Management Board in 2004. Similar to the data provided in the RFI, this alternate characterization is representative of municipal solid waste. IES used waste characterization information specific to MRF residue from the Rainbow Disposal facility in Huntington Beach.

An important consideration in the next step of project development will be for technology and site partners to consider site-specific waste characteristics and technology-specific feedstock requirements. The extent to which the conversion technology can be integrated into MRF operations should be assessed, to optimize, as necessary, the feedstock going to the conversion facility and the resulting performance of that facility.

5.1.3 Technical Evaluation Criteria

As described by the RFI, evaluation criteria included criteria for technology performance, reflective of the project goals (i.e., to promote the development of conversion technologies that will generate products that can be beneficially used, and that will significantly increase the cost-competitive diversion of MRF/TS residual solid waste and/or post-recycled MSW from landfill disposal). The criteria that were established for evaluating technology performance are summarized in Table 5.1-1. The criteria shown in Table 5.1-1 are addressed as part of each technology evaluation, with the exception of space/utility requirements and site integration aspects, which are addressed in Section 6 (Site Evaluations).

Table 5.1-1. Technology Performance Evaluation Criteria

Evaluation Criteria	Key Evaluation Factors
Readiness and Reliability of Technology	Readiness of the technology for application in California to process MRF residuals and post-recycled MSW must be demonstrated, based on experience with existing or previously operated pilot, demonstration and/or commercial facilities using the technology. Reliability of the technology to perform as a system, meeting performance expectations for waste throughput, product output and landfill diversion, must be demonstrated, based on performance of past technology applications.
Development of a Complete Process	Process schematics, equipment arrangements, site layout and description of major system components must demonstrate a complete process.
Processing Capability	The proposed capacity for the demonstration project must be supportable based on unit capacity and throughput demonstrated at existing or previously operated pilot, demonstration and/or commercial facilities using the technology.
Material and Energy Balance	The technology supplier must provide a material and energy balance that supports technology performance claims regarding conversion efficiency, energy generation, type and quantity of products, and diversion potential.
Diversion Potential	The technology must achieve significant diversion from landfill disposal when processing MRF residue or post-recycled MSW.
Generation of Marketable Products	The technology must provide for the beneficial use of waste through the production of marketable products, fuel and/or energy.
Environmentally Sound	The technology supplier must provide sufficient environmental data to provide confidence that the technology can be permitted in Southern California and meet expected emission levels.
Space/Utility Requirements and Site Integration (1)	The proposed demonstration facility must be designed such that the components of the proposed system fit within the space available at the MRF/TS sites.

(1) Space/utility requirements and site integration are addressed in Section 6.

5.2 ARROW ECOLOGY AND ENGINEERING (Arrow)

The ArrowBio anaerobic digestion technology consists of a water-based, up-front, integrated MSW separation and preparation system followed by a two-stage wet anaerobic digestion process (acetogenic bioreactor followed by a methanogenic Upflow Anaerobic Sludge Blanket (UASB) bioreactor). The biological conversion process produces digestate (to be marketed as a compost) and a methane-rich biogas. Limited post-processing of the digestate is required due to the extensive amount of separation and preparation that occurs before digestion. The digestate is dewatered, and passive aerobic composting may be conducted, if necessary. The biogas can be combusted on-site to generate electricity or be used in other ways as a renewable fuel. Examples of potential renewable fuel uses for the biogas include introduction into a natural gas pipeline distribution system and compression or liquefaction for use as vehicle fuel.

5.2.1 Reference Facilities

Arrow Ecology & Engineering Overseas Ltd., with headquarters in Tel Aviv, Israel, is the project sponsor for the patented, wet anaerobic digestion technology called the ArrowBio technology. The ArrowBio anaerobic digestion technology is specifically designed to process mixed MSW, because the upfront MSW separation and preparation system is an integrated component of the ArrowBio technology. Pre-processing of MSW prior to introduction of the feedstock to the ArrowBio process can, however, be helpful and is not precluded by the process. The system can process biosolids and other organic wastes along with MSW. As with other technologies, the benefits of processing biosolids must be evaluated on a project-specific basis, considering the potential impact on the quality of the resulting digestate and the quantity of biogas production.

As summarized in Table 5.2-1 below, Arrow has one reference facility, located at a transfer station in Tel Aviv, Israel, which has been processing MSW commercially since late 2003. Arrow's reference facility has a *digestion* capacity of approximately 73,000 tpy (200 tpd, based on continuous operation 365 days per year). However, for the ArrowBio process, the front-end processing capability of the wet, dirty MRF typically defines the facility throughput rate since it is usually more limited than the digestion processing capability. At the Israeli facility, pre-existing space limitations within the layout of the transfer station allowed for installation of only one, rather than two, separation and preparation lines in support of the digestion process. Therefore, Arrow's reference facility can only process approximately 31,000 tpy (100 tpd) of MSW, given operation at a rate of one shift per day.

Table 5.2-1. Arrow Reference Facility	
Name:	Arrow Dan Ltd.
Location:	Hiriya, Israel
Design Capacity:	100 tpd[(1)]
Annual Throughput:[(2)]	31,000 tpy
Availability:	85% front end (100% back end)
Type of Waste:	Residential MSW
Owner:	Arrow Ecology & Engineering Overseas Ltd.
Operator:	Arrow Ecology & Engineering Overseas Ltd.
Commercial Operation:	Late 2003

(1) Representative of one shift per day of operation. The reported design capacity for this facility at two shifts per day of operation is 150 tpd.

(2) Based on the design capacity of 100 tpd and 85% availability.

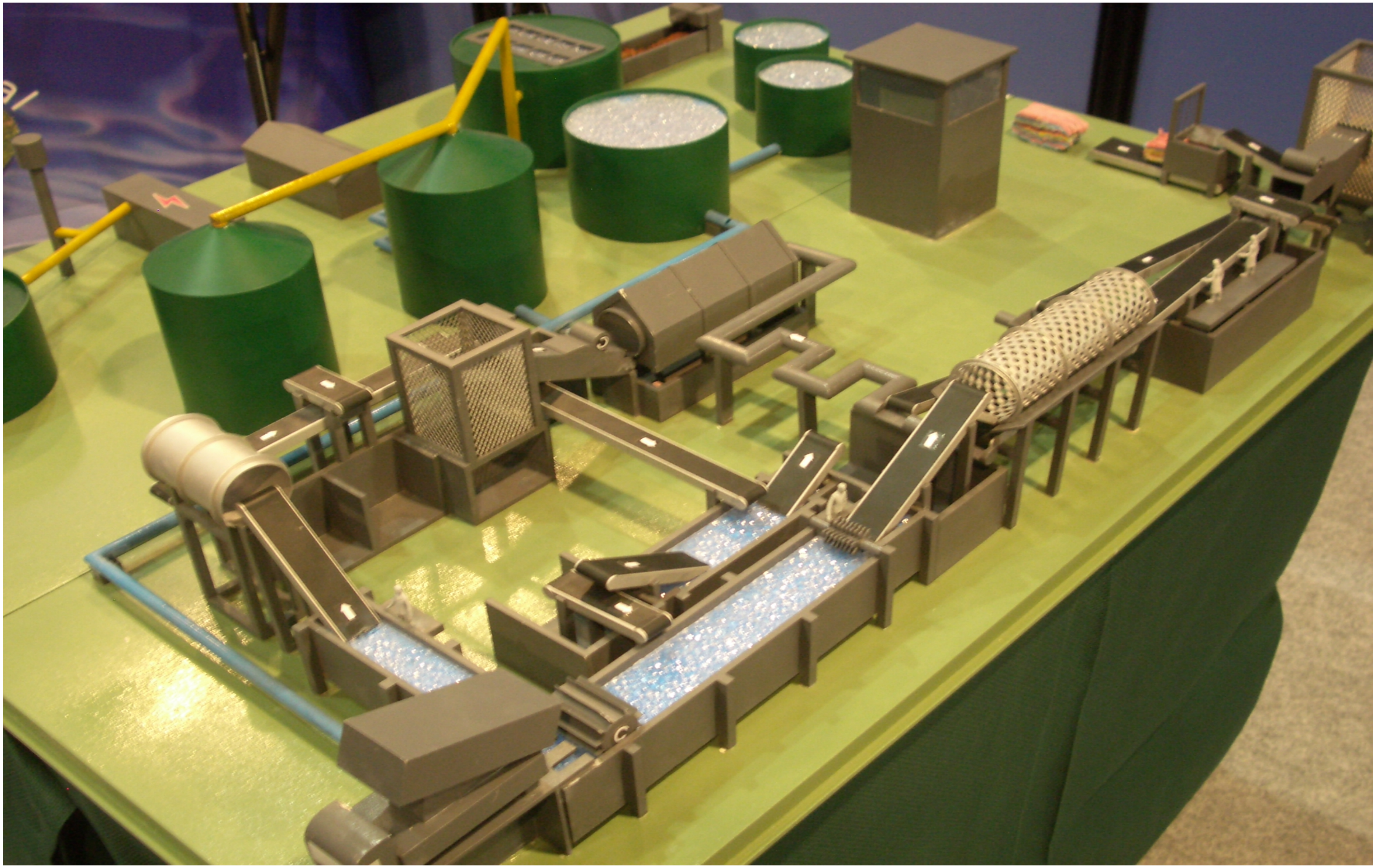
Arrow is actively pursuing development of its technology in other locations. Arrow was awarded a contract by the South West Sydney Councils Resource Recovery Project for development of a 300-tpd facility in a western suburb of Sydney, Australia, referred to as "Jacks Gully". The Jacks Gully project is currently under construction and expected to be operational in 2008, and will process 90,000 tpy (247 tpd) of MSW, in two process lines.

Members of the Subcommittee, DPW staff, and representatives of the ARI team visited Arrow's Hiriya, Israel reference facility in March of 2007, and observed the facility in operation (see Section 5.2.7).

5.2.2 Description of the ArrowBio Technology

The ArrowBio technology consists of two integrated subsystems: (1) physical, water-based separation and preparation, and (2) biological treatment using two-stage anaerobic digestion, including an acetogenic bioreactor and a methanogenic, Upflow Anaerobic Sludge Blanket (UASB) bioreactor. The two components are integrated. Specifically, the digestion component requires a watery slurry (3-4% solids), similar to a wastewater from municipal sewage, in which the biodegradable organics are dissolved or present as fine particulates. Therefore, water-based separation techniques are used to separate and recover recyclables and remove inorganic materials, while simultaneously preparing the biodegradable organics into a watery slurry. The digestion process is a net generator of water. Water generated during the digestion process is recycled back to the separation and preparation component as process water. These integrated components of the ArrowBio technology are shown in the model plant provided in Figure 5.2-1, and further described below.

Figure 5.2-1. Model Plant: ArrowBio Anaerobic Digestion Technology



The separation and preparation subsystem of the ArrowBio technology is a water-based system, integrated with traditional mechanical sorting equipment. At the ArrowBio reference facility in Israel, incoming MSW is deposited directly into the water bath as it is received. The facility under construction in Australia will allow for tipping in an enclosed tipping area ahead of the water bath with dry pre-sorting (specifically, optional mechanical removal of paper and cardboard) and inspection of waste, as appropriate. A similar configuration could be installed for a project in Southern California, or the same purpose may be achieved through direct integration with the host MRF/TS. However, dry pre-sorting was not specifically included in Arrow's initial project concept for the project.

The water bath in the ArrowBio system is a flotation tank. Water streams through the flotation tank, separating materials by density. Water is continuously recirculated through the flotation tank, creating a flow current that facilitates separation of materials. The continuous recirculation of the water also keeps the organic material in suspension and reduces odors. The separation of recyclables and inorganic material in the water bath is based upon the differing buoyancy of the fractions of the MSW. As the heavy materials sink, they are removed by a submerged walking floor. Upon removal, these heavy materials proceed through a bag opener (trommel screen) followed by magnetic separation for ferrous metal recovery, eddy current separation for nonferrous metal recovery, and manual sorting for other materials such as glass and textiles. The remaining material is returned to the flotation tank for further separation. At the end of the water bath, the lighter stream (e.g., plastics), which float, are directed by paddles on the surface of the water bath to an "air float" system, where they are removed from the water bath. Lighter materials proceed through a trommel, bag opener, and subsequently automatic and manual separation of plastic for recycling. The organic fraction that is suspended in the water is size-reduced in a hydrocrusher, followed by filtering for additional removal of plastic and inorganic residual (grit). Some of the organic fraction and water is returned to the flotation tank for hydraulic balancing (along with water from the digestion process). The remainder of the prepared organic fraction is pumped to the digestion system as a watery, organic slurry (approximately 3-4% solids). Arrow's proposed design for a 300-tpd plant, includes two up-front processing lines.

After material separation and organic preparation, biological treatment occurs in two types of bioreactors constructed in series: an acetogenic bioreactor, followed by a methanogenic bioreactor. Arrow's proposed design uses two acetogenic reactors (in parallel) followed by two methanogenic bioreactors (in parallel). In the acetogenic reactors, a specialized population of micro-organisms converts the organic material, by fermentation, into alcohols, sugars, and organic acids, which are then readily degradable in the second stage anaerobic reactor, the methanogenic reactor. Organic material must be sufficiently digested in the acetogenic reactor in order to pass through a fine screen into the methanogenic reactor. Fibrous material that is not susceptible to microbial attack and that is not sufficiently digested cannot pass through this fine screen and is periodically removed from the acetogenic reactor as digestate.

The second stage methanogenic digester is the Upflow Anaerobic Sludge Blanket (UASB) type. UASB digesters have successfully been used to process wastewaters generated by the food- and beverage-processing industries. ArrowBio has applied this to processing MSW. In the UASB methanogenic bioreactor, micro-organisms convert the alcohols, sugars, and organic acids into biogas, which consists mainly of methane and carbon dioxide, and biomass, also known as digestate. The UASB reactor has a high solids retention time, which is the average amount of time that the micro-organisms (i.e., solids) remain in the reactor. For the ArrowBio process, the solids-retention time is approximately 75-80 days. The high solids-retention time provides for an efficient digestion process, resulting in a biogas with a significantly higher percentage of methane than other anaerobic digestion technologies. Also, the process results in a lower volume of well-stabilized digestate. Arrow Bio reports that the digestate requires only dewatering and “passive” aerobic composting for finishing, as the digestate is well stabilized when it leaves the reactor.

A technical review and evaluation of Arrow's anaerobic digestion technology follows.

5.2.3 Proposed Facility Capacity for Conversion Technology Demonstration Project

As part of the Phase II Study, Arrow was requested to designate a capacity for a demonstration facility that would be optimal for the ArrowBio technology. As summarized in Table 5.2-2, Arrow designated a demonstration facility with a design capacity of 300 tpd and availability of 93%, resulting in an annual waste throughput of approximately 100,000 tpy of MSW. Arrow also provided information for a larger, commercial facility with a design capacity of 1,050 tpd and availability of 93%, resulting in an annual waste throughput of approximately 350,000 tpy of MSW.

The ArrowBio technology employs a modular design strategy. Each 150-tpd modular design unit consists of a separation/preparation line (wet, dirty MRF) and a pair of bioreactors (one acetogenic and one methanogenic), considered by Arrow to be a single “module”. The 300-tpd facility proposed consists of two modules. Although the unit design capacity appears lower for the Israeli reference facility, which is specified to be 100 tpd and which would indicate the need for design scale-up, the reference facility operates for a single shift of operation per day. The 150-tpd modules proposed for the demonstration project, and being constructed in Australia, represent the same scale as the Israeli plant, except the equipment will operate two shifts. Therefore, no scaling of modules (scaling of 1:1) would be needed for the demonstration facility, relative to both the Israeli demonstration facility and the Australian facility that is under construction.

Table 5.2-2. Arrow Facilities Proposed for the Conversion Technology Demonstration Project

Arrow	Demonstration Facility	Commercial Facility
Unit Design Capacity: Number of Units: Facility Design Capacity:	150 tpd 2 300 tpd	150 tpd 7 1,050 tpd
Annual Availability:	93%	93%
Annual Throughput:	100,000 tpy	350,000 tpy
Land Area Required:	4 acres	12 acres

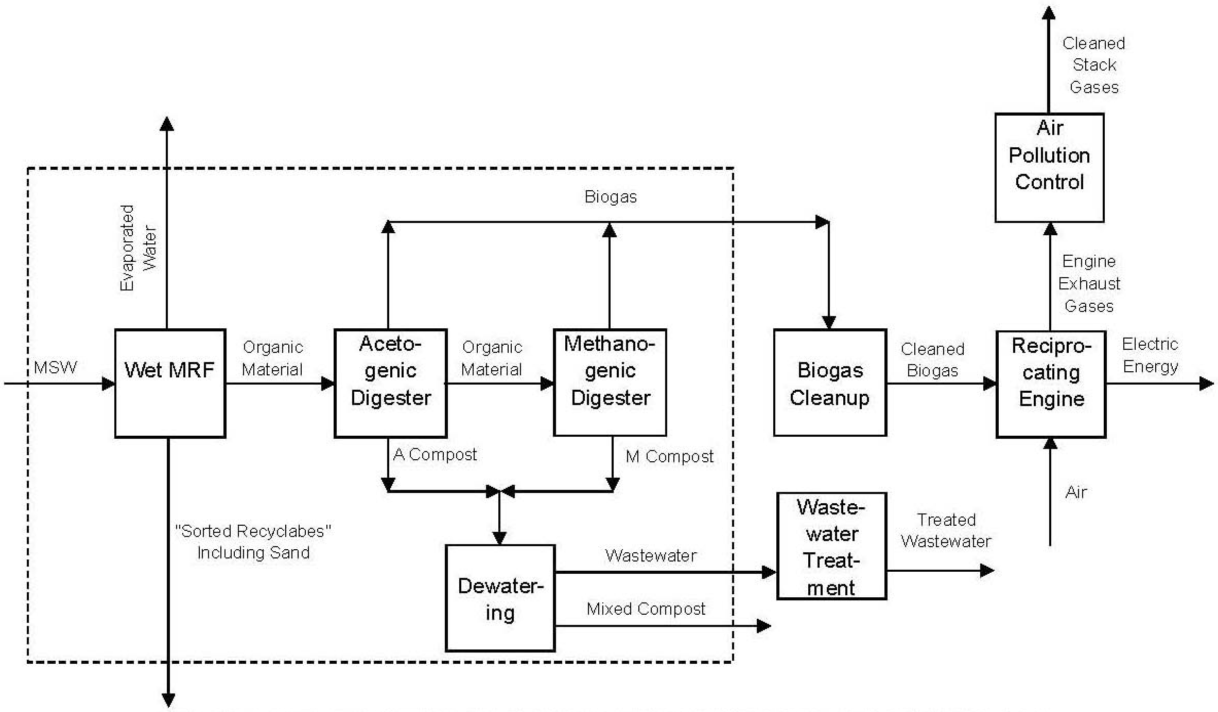
Arrow estimates an annual facility availability of 93 percent, measured on an hourly basis. Arrow reports that it bases the estimated plant availability for the project on experience at their Israeli demonstration plant coupled with engineering analysis of reliability of plant equipment components. Arrow's availability of 93 percent appears reasonable considering the facility would operate for two shifts per day, allowing time for daily maintenance and repair. Arrow did not provide historical waste throughput availability for the Israeli plant, since that plant is operated regularly, but intermittently and at varying processing rates, for the primary purpose of technology testing and development.

5.2.4 Mass Balance

A mass balance provides an accounting of the material inputs to the process and the corresponding outputs from the process. Because mass is conserved, the total amount of mass input should equal the total amount of mass output. To check the fundamental process bases, independent calculations, using data provided by the technology suppliers, were conducted. Arrow provided a complete mass balance for both the demonstration plant and the commercial plant concepts. Independent calculations were performed for review of the demonstration plant data.

For evaluation of the conversion technologies in general, mass balance boundaries were drawn around the primary production process. In the case of the ArrowBio technology, the balance was drawn around the wet MRF, the digesters, and the digestate dewatering operation. The reciprocating engines used for power generation were not included in the mass balance. A diagram depicting the balance boundary and the mass inputs and outputs of the process are shown in Figure 5.2-2.

Figure 5.2-2. Arrow Process Flow Diagram & Mass Balance Schematic



Note: The dashed line indicates the boundaries of the mass balance verification conducted for the LA County project.

Independent calculation of the mass balance was conducted for the 300-tpd (100,000 tpy) demonstration facility using information provided by Arrow. A summary of the material inputs and outputs associated with the ArrowBio process is presented in Table 5.2-3.

Table 5.2-3. Arrow Mass Balance

Material	Amount (%)[1]	Amount (tpy)[2]
INPUTS		
MSW	100.0%	100,000
Total	100.0%	100,000
OUTPUTS		
Lost Water[3]	29.5%	29,500
Water to Sewer[3][4]	9.9%	9,860
Dewatered Digestate	17.3%	17,300
Residue for Disposal	12.9%	12,890
Biogas	12.4%	12,360
Sorted Recyclables[5]	18.1%	18,090
Total	100.0%	100,000

(1) Percent by weight of MSW received for processing, which also represents the total process input.

(2) For a demonstration facility with a throughput of 100,000 tpy.

(3) Lost water includes evaporated water and water leaving the plant in digestate, residue and products.

(4) Equivalent to a flow rate of 7,131 gpd as shown in Section 5.2.4.7.

(5) Sorted recyclables include traditional recyclables and sand, and are itemized in Section 5.2.4.2 below.

As presented by Arrow and summarized above, the process inputs and process outputs are equal, representing 100 percent closure of the mass balance. ARI was able to replicate the balance through independent calculation.

Specific elements of Arrow's mass balance are further discussed below.

5.2.4.1 Waste Characterization Basis. Arrow considered the waste characterization provided in the RFI and, as allowed, chose to use the California Integrated Waste Management Board's (CIWMB) statewide characterization of residential waste, as published in 2004. Arrow sought out detailed knowledge regarding the origins of waste streams received by particular Conversion Technology Demonstration Project MRFs, and consider their selected waste characterization as more representative of municipal solid waste and MRF residuals.

5.2.4.2 Recovery of Recyclables. The ArrowBio process recovers traditional recyclables from the incoming MSW in the water bath (wet MRF), supplemented by some hand picking. Materials that are recovered in the wet MRF include cardboard, ferrous metal, aluminum, sorted plastics (HDPE, PET and mixed film plastic), and glass. The strength and stability of secondary material markets are expected to vary for these recyclables. Table 5.2-4 summarizes the amount of recyclables that ArrowBio expects to recover:

Table 5.2-4. Arrow Recyclables Recovery Efficiency

Material	Recovered Amount (%)(1)	Recovered Amount (tpy)(2)	Recovery Efficiency
Cardboard	2.7%	2,710	80%
Ferrous Metal	3.3%	3,320	95%
Aluminum	0.4%	370	84%
Film Plastics	4.4%	4,400	90%
Mixed Plastics	4.5%	4,470	90%
Glass	1.7%	1,660	80%
Sand	1.2%	1,160	75%
Total / Average	18.1%	18,090	87%

(1) Percent by weight of MSW received for processing.

(2) For a demonstration facility with a throughput of 100,000 tpy.

Arrow used the CIWMB 2004 waste characterization and estimated recovery efficiencies in order to arrive at the estimated quantities projected to be recovered. The basis of the recovery efficiencies is Arrow's experience at the Israeli facility. As proposed, iterative processes and combinations of mechanical and manual sorting, as proposed, would be used to achieve the estimated recovery efficiencies.

During the Israeli facility tour, it was disclosed that dry paper recycling, prior to introduction of the MSW to the water bath (wet MRF), was planned for the Australian facility. The dry paper recycling equipment is planned for optional use, when merited by market conditions. Addition of this option is being considered for future projects, including any project developed by Arrow in conjunction with the Conversion Technology Demonstration Project.

5.2.4.3 Residue Requiring Landfill Disposal. During front-end separation and preparation, recyclables and biodegradable organic materials are separated from inorganic and non-biodegradable material (e.g., grit, textiles, rubber, and composite packaging or consumer materials). The fraction that is not recyclable or biodegradable is considered residue requiring disposal at a landfill. For the ArrowBio process, an estimated 12.9 percent by weight of the MSW received for processing will be residue requiring disposal. Unlike some other anaerobic digestion technologies, the ArrowBio technology does not generate residue after digestion. This is because the ArrowBio technology includes an extensive, water-based, hydro-mechanical separation and preparation process integral to, and preceding the digestion process, avoiding the need to screen the digestate or the finished compost after the digestion process.

5.2.4.4 Organic Material Input to Anaerobic Digestion. Based on information selected by Arrow for use in characterization of the project waste, a significant fraction of the project’s waste stream is organic in nature, including paper. Arrow's mass balance did not indicate the percent of MSW that would go to the digestion process as an organic slurry. However, it can be estimated that up to 60 percent of the incoming MSW travels to the digesters, given the amount of total incoming MSW, less sewered water, residue to the landfill, sorted recyclables and sand. The organic material is converted into biogas and digestate.

5.2.4.5 Compost Produced. A product that may be marketable as a compost results from dewatered digestate, with only passive aerobic finishing, if required (i.e., further stabilization of the digestate via on-site storage, with no active management to mix, turn or otherwise mechanically aerate the material). The digestate production rate is estimated by Arrow to be approximately 17.3 percent of the incoming MSW (on a wet weight basis). No screening is conducted on the digestate, because there is reported to be little to no foreign, man-made material present. However, no analytical data was provided to confirm the absence of foreign, man-made material or contaminants in the digestate. Specifically, the fate of potential chemical and biological contaminants in the Arrow process has not been tracked.

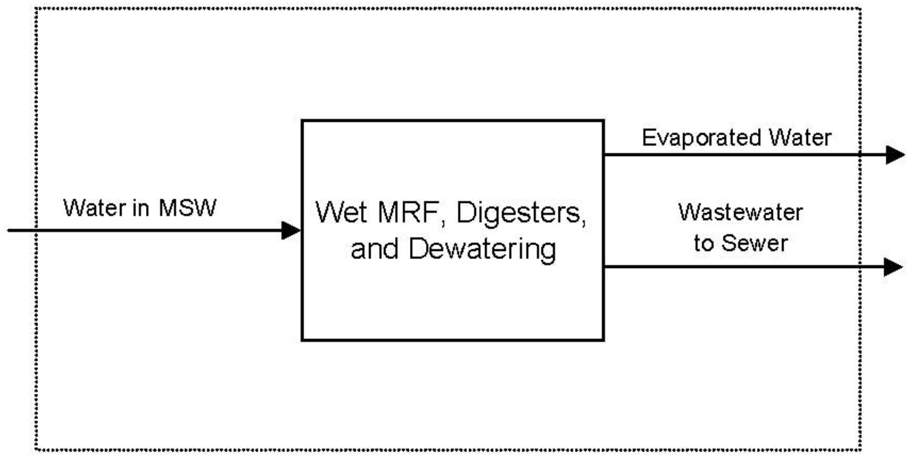
During the facility tour, the digestate was visually inspected. The material was earthy in nature and was not odorous. However, there were small bits of plastic mixed in with the organic material. Arrow reports that they are working on refining their process to reduce the amount of plastic in the digestate. Arrow initially planned to place the material as alternative daily cover material at landfills, while markets for the product in Southern California were identified. Following the project tour of the Israeli reference plant, Arrow has begun to send the digestate from the Israeli plant to local markets as a soil amendment. The acetogenic and methanogenic digestates are currently being added separately to soil materials and sold at a positive value, net of transportation costs. In addition to the recent marketing developments in Israel, evaluations of the digestate have been conducted by Southern California soil amendment companies. Specifically, the technology supplier Arrow and the Perris MRF have independently sent digestate to two different soil amendment marketers in Southern California. Arrow received a response based on Israeli samples indicating that the material should be marketable if the Southern California digestate will be similar. Perris received a response indicating that the marketer believed his company would be able to accept and sell the digestate product.

Arrow provided the results of an independent technical review prepared as due diligence for project development activities in Australia. The independent review included analytical testing of material taken from the digesters (i.e., the digestate, or compost), and reported the material to have a high nutrient value and a low potential for mobility of heavy metals. At the reference facility in Israel, the material has previously been provided to an agricultural school, but is now being actively marketed. Arrow disclosed, and provided third party presentation during the reference facility tour, that testing demonstrates the material provides excellent results in terms of plant germination, and root and above-ground development.

5.2.4.6 Biogas Produced. The biogas produced by the digesters is a methane rich fuel, which could have a variety of uses. The production rate predicted by the mass balance provided by Arrow is 258 pounds of biogas from the digesters per ton of MSW input to the front-end processing. The biogas is reported to be predominately composed of methane (70 to 75 percent) and carbon dioxide (25 to 30 percent). The biogas does contain some hydrogen sulfide (90 to 100 ppmv), which would likely require pre-scrubbing before use as a fuel source. The biogas could potentially be cleaned and injected directly into natural gas delivery pipelines or used in fleet vehicles, or it can be used as a fuel for stationary power generating equipment such as reciprocating engines and possibly microturbines or fuel cells. To date, its use has only been demonstrated for fueling of a reciprocating engine at the Israeli facility. Arrow is currently working on a reciprocating engine selection that can meet South Coast Air Quality Management District permitting requirements and provide good energy efficiency. An engine manufacturer has indicated that the ArrowBio technology produces a biogas of a quality that is compatible with its lower emitting, lean burn engine technology.

5.2.4.7 Water Balance. Water is released from the organic matter during the anaerobic digestion process. This water is returned to the water bath, as needed, with the excess disposed as wastewater to the sewer or used as irrigation water. Some amount of evaporation also occurs, as well as exit from the system via products and residues. Arrow did not provide detailed water balance information for the process. However, they did state quantities for the net output of water (39,360 tpy for the 300-tpd demonstration facility) and the expected amount of wastewater intended to be sewered (27 cubic meters per day, or approximately 7,100 gallons per day, for the 300-tpd demonstration facility). A diagram depicting known water balance elements for the ArrowBio process is shown in Figure 5.2-3.

Figure 5.2-3. Arrow Plant-Wide Water Balance Schematic



Water use and losses for the 300-tpd (100,000 tpy) demonstration facility are accounted for as shown in Table 5.2-5.

Table 5.2-5. Arrow Water Balance[1]

Material	Amount (tph)	Amount (gpd)
INPUT		
Water from MSW Input	4.9	28,453
Total	4.9	28,453
OUTPUTS		
Wastewater to Sewer Evaporation[2]	1.2 3.7	7,131 21,322
Total	4.9	28,453

(1) For a demonstration facility with a throughput of 100,000 tpy.

(2) For purpose of the water balance, evaporated water also includes water leaving the facility in digestate, residue and products.

5.2.5 Energy Balance

An energy balance provides an accounting of the energy inputs to the process and the corresponding outputs (which can be chemical, mechanical, thermal or electrical) from the process. Because energy is conserved, the total amount of energy input should equal the total amount of energy output. To check the fundamental process bases, independent calculations, using data provided by the technology suppliers, were conducted. Arrow provided data in the RFI submittal and also during interviews, which allowed independent derivation of balances for the demonstration plant. The data were organized during the review into several energy balances.

For the evaluation of the conversion technologies in general, several energy balances for different processes were prepared to aid in the technical evaluation. For the ArrowBio technology, three energy balances were evaluated in order to determine and review expected efficiencies:

- Energy efficiency of the biogas production process;
- Energy efficiency of the power generating equipment; and
- Plant-wide energy efficiency.

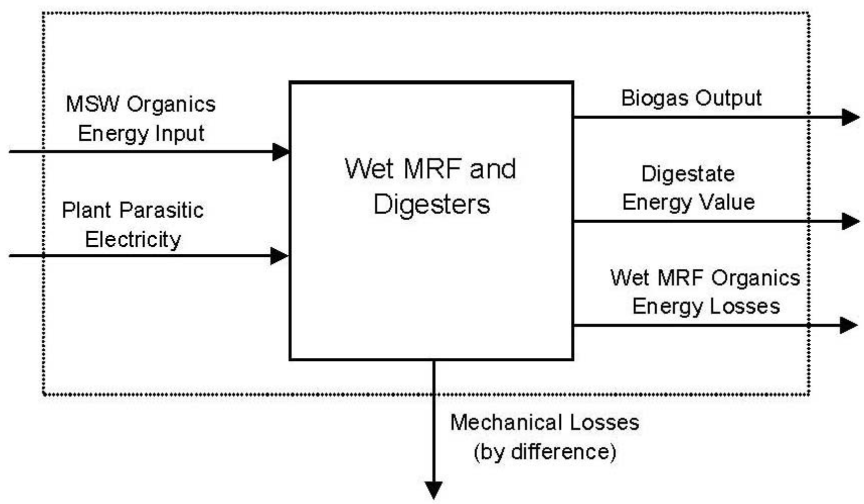
Each balance provides a different perspective of the process and serves a different evaluation purpose. The primary purpose of each evaluation is to estimate an energy conversion efficiency. Such conversion efficiencies can be used comparatively between the technologies and against traditional technologies, to assess reasonableness of the process assumptions. For example, the biogas conversion efficiency can be compared to fuel production efficiency of the different conversion technologies, the power generating equipment efficiency can be compared to similar power generating equipment (i.e., for Arrow, reciprocating engines in general), and the net electric generating efficiency of the entire plant can be compared to waste processing technologies in general and to the other conversion technologies.

It is necessary to recognize that electricity production and use is handled in various fashions in the different balances. For the ArrowBio process, the reciprocating engines produce a gross electric output, and the efficiency of the engines is evaluated on that basis. Some of the gross output from the engines is used to run the plant, including all the mechanical equipment in the up-front processing lines. That electric use is considered to be the “plant parasitic use”, because it represents the draw for operation of the plant. For the ArrowBio process, the biogas production efficiency is assessed, including deduction for the plant parasitic use to run the front end process. When the plant parasitic use of electricity is subtracted from the gross output of the engines, the net plant export of electricity for sale can be derived. For evaluation of plant electric generating efficiency, only net export of electricity is included as an energy product.

The energy balance verifications were conducted for the 300-tpd (100,000 tpy) demonstration facility. ARI was able to assess these balances by independent calculation.

5.2.5.1 Biogas Production Efficiency. The efficiency of the ArrowBio process in generating biogas can be assessed by comparing energy inputs to the system to the energy of the biogas generated. A diagram depicting the balance boundary, and energy inputs and outputs assessed to verify biogas production efficiency, is shown in Figure 5.2-4.

Figure 5.2-4. Arrow Energy Balance Schematic for Biogas Production



Energy inputs include the energy value of the organic materials extracted from the incoming MSW and the plant parasitic electricity needs. A summary of the biogas production energy balance for the 300-tpd (100,000 tpy) demonstration facility is shown in Table 5.2-6.

Table 5.2-6. Arrow Biogas Production Efficiency(1)

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
MSW Organics Energy Plant Parasitic Electricity	1,334 73	16.4 0.9	133,433 7,290
Total	1,407	17.3	140,723
OUTPUTS			
Biogas Output Loss to Digestate MSW Organics Energy Loss from Wet MRF(2) Mechanical Losses(3)	841 360 133 73	10.3 4.4 1.6 0.9	84,063 36,027 13,343 7,290
Total	1,407	17.2(4)	140,723

(1) For a demonstration facility with a throughput of 100,000 tpy.

(2) ArrowBio estimates that 10% of incoming MSW Organics energy does not reach the digesters.

(3) Estimated by difference.

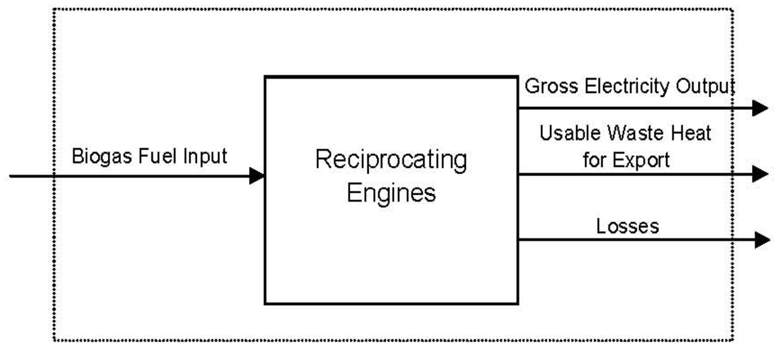
(4) Total output does not sum to 17.3 MW due to rounding.

Based on the information provided by Arrow, the gross energy conversion efficiency of the wet MRF and digesters is estimated to be 60 percent. This calculated conversion efficiency is based on the energy input of the MSW organics and the parasitic electricity use, versus the heat output of the biogas.

As represented here, the process inputs and process outputs are equal, representing 100 percent closure of the mass balance.

5.2.5.2 Power Generating Equipment Efficiency. The efficiency of power generation can be assessed by comparing the energy input of the biogas to the gross electric power output of the power generating equipment. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify power generating equipment production efficiency for the ArrowBio process, is shown in Figure 5.2-5.

Figure 5.2-5. Arrow Energy Balance Schematic for Power Generating Equipment



As shown in Figure 5.2-5, Arrow's project configuration uses a reciprocating engine to generate power. The engine is fueled with the biogas, with no supplemental fossil fuel input to the engine. A summary of the results of the verification of the power generating equipment production energy balance for the 300-tpd (100,000 tpy) demonstration facility is shown in Table 5.2-7.

Table 5.2-7. Arrow Power Generating Equipment Efficiency(1)

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
Biogas Fuel	841	10.3	84,063
Total	841	10.3	84,063
OUTPUTS			
Gross Electric Output	325	4.0	32,546
Usable Waste Heat	135	1.7	13,514
Losses by Difference	381	4.7	38,003
Total	841	10.4	84,063

(1) For a demonstration facility with a throughput of 100,000 tpy.

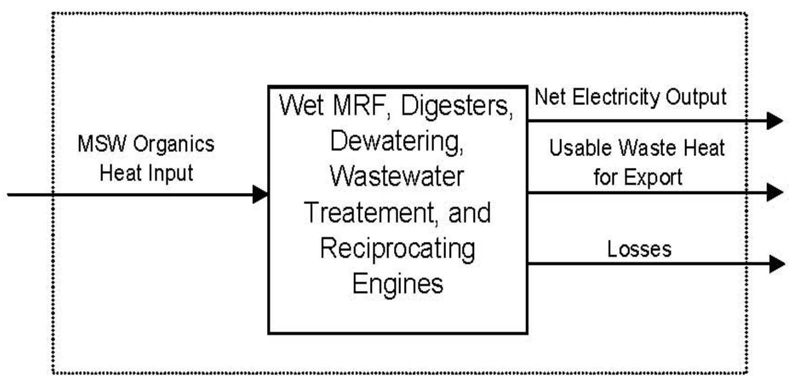
Based on information provided by Arrow, the gross energy conversion efficiency of the reciprocating engine is estimated to be 39 percent. This calculated conversion efficiency is based on the energy input of the biogas fuel, versus the gross electric output. If the useable waste heat is credited to the output as well, the engine cogeneration efficiency rises to 55 percent. However, while feasible and potentially practical depending on site considerations, Arrow has not yet provided information showing use of the waste heat from the process.

The 39 percent electric generating efficiency is consistent with advanced engine designs that are available, and considered reasonable based on the characteristics of the biogas as a fuel. As reported by Arrow and confirmed by independent calculations, the biogas has a heating value of approximately 11,500 Btu/lb. The biogas fuel has sufficient quality and can be expected to have the necessary consistency for sustained engine operation without supplemental fueling, as has also been demonstrated at sludge digestion facilities, which combust a similar, methane-based gas.

Arrow did not provide a complete energy balance for energy conversion. In order to achieve 100 percent closure for an independent balance, losses were assumed by calculating the difference between the total energy of the biogas less the gross electric output and the usable waste heat.

5.2.5.3 Overall Plant Balance. Overall energy balance is a measure of net energy (electricity) output compared to all energy inputs for the complete system. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify Arrow's overall plant efficiency, is shown in Figure 5.2-6.

Figure 5.2-6. Arrow Energy Balance Schematic for Overall Plant



A summary of the results of the verification of the overall plant energy balance for the 300-tpd (100,000 tpy) demonstration facility is shown in Table 5.2-8.

Table 5.2-8. Arrow Overall Plant Energy Efficiency(1)

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
MSW Organics Energy	1,334	16.4	133,433
Total	1,334	16.4	133,433
OUTPUTS			
Net Electric Output(2)	253	3.1	25,256
Usable Waste Heat	135	1.7	13,514
Plant Losses by Difference(3)	946	11.6	94,663
Total	1,334	16.4	133,433

(1) For a demonstration facility with a throughput of 100,000 tpy.

(2) Net electric output represents only the electricity that leaves the plant and is to be sold or used by others. Net electric output is derived by subtracting the plant parasitic electric use from the gross power production.

(3) Includes losses to digestate (360 kWh/ton MSW), losses of MSW Organics energy from the wet MRF (133 kWh/ton MSW), engine losses (381 kWh/ton MSW) and other plant losses.

Based on information provided by Arrow, the net export electric energy conversion efficiency of the complete plant is estimated to be 19 percent. This calculated conversion efficiency is based on the energy input provided the MSW organics, versus the net electricity output (export only). If the useable waste heat is credited to the output as well, the plant cogeneration efficiency rises to 29 percent.

The plant-wide energy balance closes 100 percent here because losses are calculated by difference.

5.2.6 Diversion Potential

Based on the mass balance shown in Section 5.2.4, the ArrowBio process generates residue requiring landfill disposal at a rate of approximately 13 percent by weight of the incoming waste, when processing MRF residuals of the characteristics estimated by Arrow. Therefore, Arrow has a diversion potential of approximately 87 percent. Arrow's diversion potential could be impacted by waste characteristics, for example, if the expected quantities of marketable recyclables are not present and recovered. However, the greatest impact to the diversion potential could be the ability to market the digestate (marketable as compost) in Southern California. Digestate is produced at a rate of approximately 17 percent of incoming MSW. Arrow recognizes the challenges in marketing this material, and plans to initially establish a beneficial use as landfill daily cover while identifying higher-end uses for the material. Although preliminary indications are favorable for the marketability of the product, under a worst-case scenario, the digestate would require landfill disposal. If a suitable market for the digestate cannot be found, the diversion potential of this technology would be reduced to 70 percent.

5.2.7 Reference Plant Tour

Members of the Subcommittee, DPW staff, and representatives of the ARI team visited Arrow's reference facility in Hiriya, Israel in March of 2007. During the visit the reviewers had the opportunity to meet with local and Federal government and regulatory officials, as well as the owner's engineers for the Australian project. The facility was receiving and processing waste and in full operation during the visit, including the wet MRF equipment and the digestion process. The facility is equipped with a single reciprocating engine to convert the biogas to electricity, as well as a flare for biogas management when the engine is not operating. The engine is reportedly used six days per week.

The visit satisfied several primary objectives, including: inspecting and observing the equipment in operation; confirming the type of waste processed; evaluating the generation and management of products and byproducts (e.g., recyclables, biogas, digestate); and understanding the local management practices and regulatory environment for municipal solid waste. Key observations and findings relevant to evaluation of the ArrowBio technology and potential application in Southern California are as follows:

- **Type of Waste, Receiving & Handling Issues.** During the plant tour, differences in local practices were observed. It was noted that recycling is not widely practiced in the country and therefore the Israeli plant has a relatively high yield of recyclables. Also, the MSW collected and delivered to the Arrow plant was tipped directly into the water bath. In Southern California, tipping on to a floor for inspection would be required before introduction of the waste into the wet MRF. Similarly, dry sorting prior to the water-based separation and preparation system would also be considered for a project in Southern California.

  The ArrowBio process has a complex up-front waste sorting process equipped with conveyors, trommels, screens and other moving parts. Industrial waste that can cause snagging or tangling in the equipment was observed to be problematic during the facility tour. Operator intervention and removal of waste that cannot be processed by the system is an ongoing and integral part of the operation. There appear to be a number of points of removal of non-processible waste from the wet MRF system. The waste that cannot be processed results in the residue from the facility.

- **Wet MRF Operation – Recyclables Recovery, Safety, Odor.** The wet MRF equipment was observed in operation and was processing incoming waste. For a California facility, more attention would be necessary to occupational safety measures, given the rotating and moving equipment. Odor from the wet MRF and digestion processes was not noted, and although site odors were present, they appeared to be originating from the transfer station and not the Arrow processes.

- **Digester Operation and Digestate Quality and Use.** The digesters and filtration operations were observed, as well as the digestate product. The product was attractive, aside from the small bits of plastic, and was not odorous. The digestate product was being tested for soil blending in Israel and a representative of the third party blending company was on hand for interview during the site visit.

- **Biogas Use.** In addition to a single reciprocating engine, the Israeli facility was equipped with a flare for controlled combustion of the biogas when the engine was not operating. For the 100,000 tpy demonstration facility proposed for the project, three engines would be likely necessary, therefore a flare may not be necessary.

- **Water Reuse.** Water is separated from the digestate and recycled back to the wet, front-end separation process. However, the makeup water is sent to the front-end of the process in quantities that do not utilize all of the water generated. Excess water, which is also water removal necessary to prevent buildup of salts in the system loop (bleed stream), is reused at the Israeli site for irrigation of landscaping.

- **Plastics Recycling Example.** During the site visit, a plastic bucket was observed. The bucket had reportedly been manufactured using the film plastic that the Israeli plant recovered. The bucket was manufactured off-site.

5.2.8 Air Pollution Controls and Emissions

Arrow did not provide air emissions information as a part of their RFI response. In order to perform a focused evaluation regarding air emissions from each of the technology suppliers, detailed information was requested in follow-up questions to Arrow, specifically regarding NOx emissions. The pollutants NOx and dioxin were selected as indicator pollutants for the evaluation process. Other pollutants, including carbon monoxide, particulate matter and mercury will be of interest during permitting of the conversion technology processes. However, NOx was selected as a key indicator of environmental acceptability because smog is one of the most significant pollution issues in Southern California, and, from combustion sources, NOx is the most significant pollutant that contributes to smog. Dioxin was selected as a key, representative toxic pollutant of concern. Following are the results of the air pollution control and emissions evaluations for the ArrowBio process.

5.2.8.1 NOx Emissions. The sources of NOx emissions from the proposed ArrowBio demonstration facility are the reciprocating engines, which convert biogas to electricity. For the 300-tpd (100,000 tpy) demonstration facility, three, 16-cylinder, lean burn engines have been identified by Arrow as candidates for electrical generation. The uncontrolled annual NOx emissions from each of these engines are projected by the engine manufacturer to be 8 tpy. For three engines, the total uncontrolled NOx emissions would therefore be 24 tpy.

Given the stringency of air permitting in Southern California, and the fact that Best Available Control Technology (BACT) would need to be employed for a project of any size and Lowest Achievable Emission Rate (LAER) would need to be implemented for projects exceeding 10 tpy of NOx, add-on controls for NOx would be necessary to permit the engines. It is assumed that Selective Catalytic Reduction (SCR) would be required for add-on NOx control, and that the SCR control would have a NOx removal efficiency of 90 percent. If such control were employed with the engines currently identified, annual facility NOx emissions would be less than 4 tpy. This value is below the South Coast Air Quality Management District's threshold for requiring purchase of NOx offsets. Consequently, as configured here, the facility would not be required to purchase NOx offsets.

Currently, there is uncertainty as to whether biogas cleanup to remove hydrogen sulfide and siloxanes would be necessary. Such pollutants are known to exist in landfill gas and in sewage sludge digester gas, and may be present in the biogas. If siloxanes are present in the biogas at high levels, they can accelerate engine wear. The presence or absence of siloxanes has not been determined by Arrow. Reportedly, the Israeli engine that converts biogas to electricity at the demonstration facility has not shown excessive wear. Even at low levels that do not accelerate engine wear, siloxanes are recognized as a SCR catalyst poison (i.e., their presence in exhaust gas can cause rapid deactivation of the catalyst) and would need to be removed if they are determined to be present in the biogas.

Add-on NOx controls and biogas cleanup systems were not included in the description of the Arrow demonstration or commercial facility, therefore the system is considered to be incomplete since such controls and systems are likely necessary for permittability in Southern California.

In summary, Arrow is not likely to need to purchase NOx offsets for a demonstration facility assuming it installs additional control equipment. In the economic sensitivity analyses addressed in Section 8.4 of this report, additional project capital cost for the ArrowBio process was assessed to account for additional control equipment.

5.2.8.2 Dioxin Emissions. The ArrowBio process is not known to be a source of dioxin emissions. Although no testing has been done on the Israeli plant for this pollutant, the process could be considered similar to either: (1) fueling of engines with natural gas, due to the high methane content of the biogas; or (2) to fueling of engines with sewage sludge digester gas. Neither of these sources is currently recognized as a significant source of dioxin emissions. Some level of dioxin emissions can be expected from any combustion source, although for less significant sources measured emissions may approach background, ambient levels.

5.3 CHANGING WORLD TECHNOLOGIES (CWT)

CWT's technology is primarily a two-stage process, consisting of thermal depolymerization of the feedstocks followed by hydrolysis, for the conversion of wastes to renewable diesel. Pre-processing of the incoming MSW is expected to be required and post-processing of the renewable diesel product, as well as the solid residue, is also anticipated to be necessary.

5.3.1 Reference Facilities

CWT is headquartered in West Hempstead, New York, and is the developer of a conversion technology that creates renewable diesel fuel from feedstocks that are ordinarily considered to be wastes. The CWT technology was first developed to make useful energy products from animal and food processing wastes. CWT has also invested in significant research and development work to evaluate the feasibility of processing auto shredder residue and components of municipal solid waste (MSW). The system can in theory co-process sewage sludge along with other wastes, although there may be limitations on the proportionate quantity that would make technical and economic sense in a multi-waste feedstock to a CWT facility.

As summarized below, CWT has two reference facilities. The larger facility is located in Carthage, Missouri and has been operated by Renewable Environmental Solutions, LLC (RES) with poultry processing waste as a feedstock for approximately two years. The smaller, pilot facility is located in Philadelphia, Pennsylvania, and has been used for research and development activities since the year 2000. The pilot facility is operated by Thermo Depolymerization Process, LLC (TDP). Information regarding the two reference facilities is summarized in Table 5.3-1.

Table 5.3-1. CWT Reference Facilities		
Name:	RES, LLC	TPD, LLC
Location:	Carthage, MO	Philadelphia, PA
Design:	248 tpd	7 tpd (demonstrated)
Capacity:	63,400 tpy	Not applicable
Availability:	70%	Not applicable
Type of Waste:	Food processing (agricultural) waste	Mixed plastics, post-consumer tires, auto shredder residue
Owner:	CWT, Inc.	CWT, Inc.
Operator:	RES, LLC	TDP, LLC
Operational History:	2005 - present	2000 - present

CWT is actively pursuing development of commercial scale plants using food processing wastes as feedstocks in other locations. Concurrently, major development investment is being made to also advance experience with auto shredder residue and mixed municipal solid waste.

Members of the Subcommittee, DPW staff, and representatives of the ARI team visited CWT's Carthage, Missouri reference facility in April of 2007, and observed the facility in operation (see Section 5.3.7).

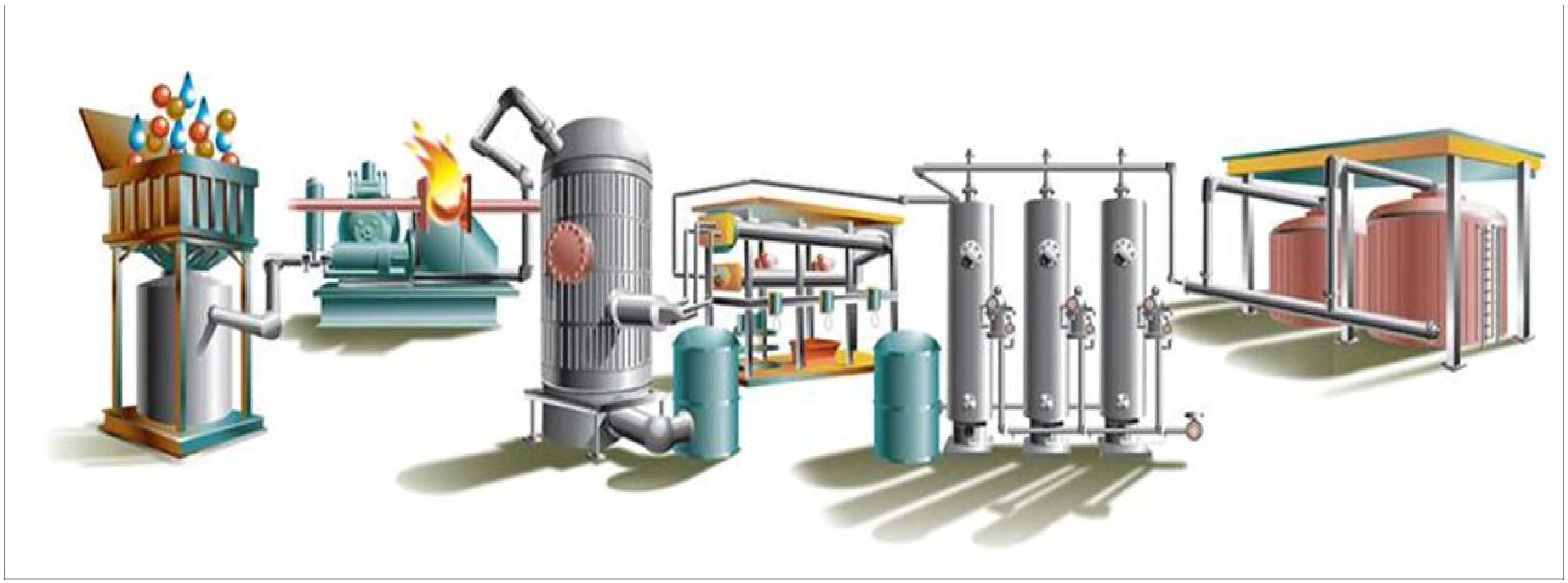
5.3.2 Description of the CWT Technology

The primary processing elements of CWT's technology are thermal depolymerization and hydrolysis. Separation steps proceed and follow each of the primary processing elements. Trommels, screening, filtration, settling and magnets are planned for use in the separation steps. Auxiliary equipment includes a boiler for supply of steam heat to the processes and odor control equipment (scrubbers and a thermal oxidizer). Figure 5.3-1 shows a schematic of the process.

Pre-processing of the MSW, and presumably of the auto shredder residue (ASR), is to consist of removal of dirt fines with a trommel and mechanical screening. There is some indication that magnetic separation may be applied in the pre-processing step and that metal will be removed. After the pre-processing, the various feedstocks are to be combined in holding vessels under slight pressure. The feedstocks that will be combined in the holding vessels are the MSW, ASR, fats, oils and greases (FOG), and used motor oil. The mix and proportion of feedstocks was carefully considered by CWT and is intended to facilitate processing and provide a good renewable diesel product yield.

From the holding vessels, the feedstocks are planned to be transferred by conveyors and augers to the high temperature depolymerization reactor. The depolymerization process takes place at elevated temperature (300 to 350 degrees C, equal to 572 to 662 degrees F) and pressure. Tops and bottoms are recovered from the depolymerization

Figure 5.3-1. Schematic Diagram of CWT's Technology



Preprocessing **Thermal Depolymerization** **Hydrolysis** **Separation Processes**

reactor. The tops, or overs, consist of water vapor and light hydrocarbons. The water vapor and light hydrocarbons are passed through a condenser and the liquids recovered from the condenser are transferred to the hydrolysis reactor. The non-condensable gas exhausted from the condenser creates a product with significant heating value.

For the Conversion Technology Demonstration Project, the non-condensable gas is not planned to be utilized. CWT proposed a two phase construction approach: (1) installation of a demonstration projects; followed by (2) expansion to a commercial scale. It is possible that CWT is planning to flare the gas in the first phase of the project, until a commercial scale plant can be constructed. For a commercial scale plant, the non-condensable gas is planned for use as fuel for the auxiliary boiler.

The bottoms, or unders, from the thermal depolymerization reactor consist of solids and heavier liquids. The heavier liquids are hydrocarbon oils. The solids will consist of fixed carbon particulates, mineral ash and metals. Likely, there will also be glass and other inerts in the mix. However, the hydrocarbon liquids are assumed here to be easily separated from the solids. The mechanism of separation of the fine carbon particulate product from the mineral ash and other residue containing inerts is not described; however, such a separation appears to be accomplished at the Carthage plant.

The condensable liquids (water and light hydrocarbons) and the heavier hydrocarbons from the depolymerization process are conveyed to the hydrolysis reactor. The mixture is heated to 250 degrees C (382 degrees F) under a pressure of 600 to 700 psi. An oil equivalent to the American Petroleum Institute standard of 30 to 40 API results. The oil contains a significant amount of water. The water has further use in the process besides its employment in the hydrolysis reaction because it removes some soluble pollutants from the oil, such as chlorides, bromides and a number of metals. After the processing in the hydrolysis reactor, the reactor effluent is sent to a liquid/liquid centrifuge where the oil and water are separated.

5.3.3 Proposed Facility Capacity for the Demonstration Project

As part of the Phase II Study, CWT was requested to designate a capacity for a demonstration facility and for a commercial facility for the project. CWT proposed a demonstration facility and a subsequent expansion of the demonstration facility to commercial scale, as shown in Table 5.3-2.

Table 5.3-2. CWT Facilities Proposed for the Conversion Technology Demonstration Project

CWT	Demonstration Facility(1)	Commercial Facility(2)
Daily Design Capacity(1)(2)	200 tpd	900 tpd
Annual Availability:	70%	90%
Annual Throughput (all wastes): Annual Throughput (MSW only):	51,100 tpy 25,550 tpy	295,650 tpy 147,825 tpy
Avg. Daily Throughput (at 365 days/yr):	140 tpd	810 tpd
Land Area Required:	3 acres	5-8 acres

(1) Daily design capacity for the demonstration facility, including water input, is stated to be 220 tpd by CWT. Here it is shown at 200 tpd of waste handling capacity, excluding water that is recycled into the process. Of the 200 tpd waste handing capacity, 100 tpd of the feedstock is planned to be MSW.

(2) Similarly, for the commercial facility, it is assumed here that of the 1,000 tpd capacity provided by CWT, approximately 100 tpd is due to water input. Of the 900 tpd waste handling capacity, 450 tpd of the feedstock is assumed here to be MSW.

The 200-tpd CWT demonstration plant represents an approximately 1:1 sizing when compared to the RES reference plant in Carthage, MO. However, significantly heterogeneous and abrasive feedstocks such as auto shredder residue and MSW have not been tried at this scale.

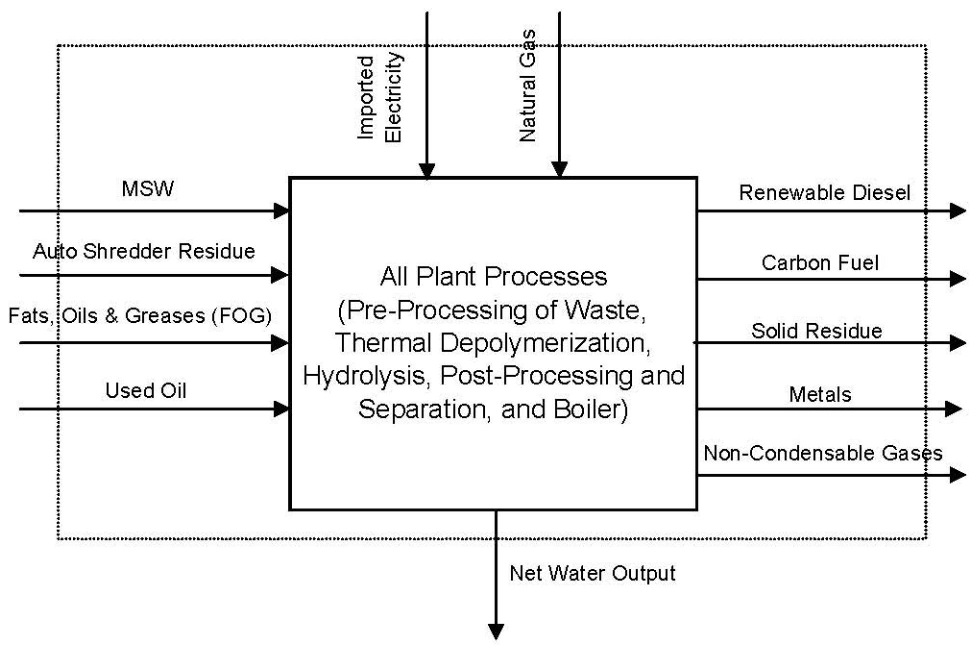
Currently, piloting work is underway in Philadelphia to develop design information necessary to construct a demonstration facility of the Carthage, MO scale for the more heterogeneous wastes (i.e., auto shredder residue and MSW). The core technologies for which piloting of these wastes have been conducted (i.e., the thermal depolymerization step and the hydrolysis step) is of a 7-tpd scale. Extensive work at this scale has been performed for use of auto shredder residue and several specific components of MSW. Details of materials handling strategies are being developed at this time. Materials handling aspects of a significant process scale-up, potentially on the order of 30:1 (estimated here as a worst case) present technical challenges to CWT.

5.3.4 Mass Balance

A mass balance provides an accounting of the material inputs to the process and the corresponding outputs from the process. Because mass is conserved, the total amount of mass input should equal the total amount of mass output. To check the fundamental process bases, independent calculations, using data provided by the technology suppliers, were conducted. CWT provided a complete mass balance for the demonstration facility concept. Independent calculations were performed for review of the demonstration facility data.

For the evaluation of the conversion technologies in general, mass balance boundaries were drawn around the primary production process. CWT provided a mass and energy balance on a “black box” basis, that is, mass and energy flows to, from and between subsystems were not provided. In the case of the CWT technology, the balance was drawn around the entire demonstration plant. A simplified process flow diagram depicting the balance boundary and the material and energy inputs and outputs of the process is shown in Figure 5.3-2.

Figure 5.3-2. CWT Mass and Energy Balance Schematic



Note: This process flow diagram is applicable only to the proposed demonstration facility.

Independent calculation of the CWT mass balance was conducted for the 51,100 tpy (total waste input basis) demonstration plant. A summary of the material inputs and outputs associated with the CWT process is presented in Table 5.3-3.

Table 5.3-3. CWT Mass Balance[1]

Material	Amount (%)[2]	Amount (tpy)
INPUTS		
MSW	50.0%	25,550
Auto Shredder Residue	30.0%	15,330
Fats, Oils & Greases	10.0%	5,110
Used Oil	10.0%	5,110
Total	100.0%	51,100
OUTPUTS		
Renewable Diesel	36.8%	18,805
Carbon Fuel	18.3%	9,351
Residual Solids[3]	10.0%	5,110
Metals[3]	10.0%	5,110
Non-Condensable Gas	9.2%	4,701
Net Water[4]	15.7%	8,023
Total	100.0%	51,100

(1) For a demonstration facility with a throughput of 51,100 tpy of waste, including 25,550 tpy of MSW.
(2) Percent by weight of total input and total output.
(3) CWT assumes that 50 percent of the solids from the process will be recoverable metals.
(4) Water is an input to the process, as well as an output. There is more water generated in the process than is used. Shown here is only the net water output.

CWT provided sufficient technical information to enable verification of the mass balance for the plant-wide production process. As presented by CWT, the process inputs and process outputs are equal, representing 100 percent closure of the mass balance. ARI was able to replicate the balance through independent calculation.

Specific elements of CWT's mass balance are further discussed below.

5.3.4.1 Waste Characterization Basis. CWT used the waste characterization provided in the RFI. The basis of this waste characterization was limited sampling of black bin waste conducted by the City of Los Angeles in their Phase I "Evaluation of Alternative Solid Waste Processing Technologies" (September 2005). In addition to the City of Los Angeles compilation, assumptions based on U.S. EPA waste component characteristics (ultimate analysis and heating value) were made in the development of the characterization for the RFI.

5.3.4.2 Recyclables. The CWT technology does not include front-end recovery of recyclable materials. However, the company plans to recover metal (presumably ferrous and non-ferrous) at the back end of the process, where it will be mixed with the solid, residual material.

5.3.4.3 Renewable Diesel Product. The primary product from a CWT plant is the renewable diesel. This product has a heating value almost equivalent to commodity, fossil-derived diesel. The sulfur content of the renewable diesel is estimated by CWT to be 0.2 percent (2,000 parts per million), which will influence the ultimate end use of the product. Current diesel standards in Southern California require products to equal or better a 15 part per million limit for fuel sulfur. CWT is considering selling the renewable diesel either to a local refinery for additional sulfur removal or out of the area, in locations where less stringent requirements apply. CWT does have sulfur removal equipment at their Carthage plant, but it has not proved economical to operate at the small scale of that plant. Such on-site refining is also not anticipated to be economical at a scale of the proposed Conversion Technology Demonstration Project plants (demonstration or commercial).

5.3.4.4 Carbon Fuel Product. Fixed carbon is a co-product of the renewable diesel from the depolymerization process. The intended market for this less valuable product is coal, or other solid fueled, power plants.

5.3.4.5 Non-Condensable Gas Product. A gaseous hydrocarbon fuel is another co-product of the renewable diesel from depolymerization process. This gaseous fuel may be used at a CWT facility site for fueling the boiler that produces steam to heat the conversion processes. However, for the demonstration scale facility, the boiler is intended to be fueled with natural gas only and the non-condensable gas product would not be utilized. Presumably, the excess gas would need to be flared at the demonstration facility. For the larger commercial scale plant, CWT intends to fuel the boiler with the non-condensable gas product.

5.3.4.6 Residue Requiring Disposal. A solid residue is generated when the oil is separated from the water used in the hydrolysis process. This residue does not have any value, except to the extent that it contains metals that may be removed by electromagnets and eddy current magnets. CWT estimates that, based on the feedstock mix proposed for the project, approximately half the solid residue will be recoverable as metal. The remaining solids will need to be disposed.

5.3.4.7 Water Use and Wastewater Treatment and Discharge. The CWT process is a net generator of water. Water is used in the hydrolysis process, at a rate for the 200-tpd demonstration plant of 20 tons per day. However, the commensurate plant output is 51.4 tpd of water. Therefore, the net wastewater discharge rate of the demonstration plant is 31.4 tpd, and 20 tpd is recycled back in to the hydrolysis process. A 31.4-tpd sewer discharge rate is equivalent to 7,566 gallons per day (GPD).

5.3.5 Energy Balance

An energy balance provides an accounting of the energy inputs to the process and the corresponding outputs (which can be chemical, mechanical, thermal or electrical) from the process. Because energy is conserved, the total amount of energy input should equal the total amount of energy output. To check the fundamental process bases, independent calculations, using data provided by the technology suppliers, were conducted. CWT provided data in the RFI submittal which allowed independent derivation of balances for the demonstration plant.

For the evaluation of the conversion technologies in general, where possible, several energy balances were prepared to aid in the technical evaluation. In the case of CWT's project offering, only one energy balance was evaluated in order to determine and review expected conversion efficiency, since energy transfers between intermediate process steps were not disclosed. Specifically, reviewed here is the plant-wide energy conversion efficiency. In the case of CWT, the energy balance data were provided for the demonstration plant only, and therefore the evaluation was conducted for that facility scale.

5.3.5.1 Overall Plant Balance. The overall energy balance for CWT is a measure of renewable diesel output compared to all energy inputs for the complete system. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify CWT's overall plant energy efficiency, is shown in Figure 5.3-2. A summary of the results of the independent calculation of the overall plant energy balance for the 51,100 tpy (total waste input basis) demonstration facility is shown in Table 5.3-4.

Table 5.3-4. CWT Overall Plant Energy Efficiency[1]

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
MSW Energy Input	3,496	14.6	89,320
Auto Shredder Residue	2,792	11.6	71,348
Fats, Oils and Greases	1,984	8.3	50,681
Used Oil	2,166	9.0	55,353
Electric Power	633	2.6	16,175
Natural Gas	302	1.3	7,728
Total	11,374	47.4	290,605
OUTPUTS			
Renewable Diesel	7,294	30.4	186,368
Carbon Fuel	2,574	10.7	65,777
Losses, by Difference[2]	1,505	6.3	38,460
Total	11,374	47.4	290,605

(1) For a demonstration facility with a throughput of 51,100 tpy of waste, including 25,550 tpy of MSW.

(2) Calculated here by difference. Losses include the unused heating value of the unused non-condensable gas, which only occurs for the demonstration scale facility.

Based on information provided by CWT, the net energy conversion efficiency of the entire plant/process is estimated to be 87 percent. This calculated conversion efficiency is based on the energy input provided by the four feedstocks (MSW, ASR, FOG and Used Oil), parasitic electric power, and natural gas input, versus the two fuel products intended for export (renewable diesel and carbon fuel).

Based on this energy balance, the annual renewable diesel output is estimated to be 5 million gallons. This amounts to a yield of 98 gallons per ton of total waste feedstock. Both of these statistics are based on an assumption made here that the renewable diesel density is approximately 7.5 pounds per gallon.

The plant-wide energy balance closes 100 percent here because losses are calculated by difference.

5.3.6 Diversion Potential

CWT has a diversion potential of 90 percent, given a prediction of 20 percent solids from the process, of which half is assumed to be recoverable metal. At the level of design conducted for the RFI response, this appears to be an adequate estimate, although it is not likely tied directly to the waste characterization that was used as the basis for the RFI response.

5.3.7 Reference Plant Tour

Members of the Subcommittee, DPW staff, and representatives of the ARI team visited CWT's reference facility in Carthage, Missouri, on April 25, 2007. During the visit, the reviewers had the opportunity to meet with local officials and environmental regulators. The facility was receiving and converting poultry processing waste and in full operation during the reviewer's visit.

The visit satisfied several primary objectives, including: inspecting and observing the equipment in operation and understanding local and regulatory issues regarding the startup and operation of the plant. Key observations and findings relevant to evaluation of CWT's technology and its potential application in Southern California are as follows:

- **Type of Waste, Receiving & Handling Issues.** During the plant tour, delivery of poultry processing waste was observed. This waste contained bones, feathers, excess fat, offal and other residuals from turkey processing at an adjacent manufacturing plant. Relative to MSW, the feedstock appeared denser than MSW and relatively homogeneous. Reportedly, small metal items, such as broken cutting knife blades in the feedstock were problematic for material handling in the plant.

  Front end processing of MSW intended for feedstock to the CWT process will be necessary. CWT proposes to remove dirt and fines in a trommel and to conduct mechanical screening, followed by transfer into the reactors via conveyors and augers. MSW will certainly present more challenges in the form of material handling and conveyance issues, than the agricultural wastes. CWT did not indicate any waste size or characteristics constraints in their proposal, but it is likely there will need to be some limitations placed upon the MSW feedstock for a CWT facility.

- **Safety and Odor.** CWT subscribes to the American Petroleum Institute's (API's) training programs for plant operators and contractors. These training programs are designed to conform to and satisfy OSHA requirements for operator and contractor safety. Additional safety measures, with regard to housekeeping issues and handling of putrescible waste may need to be considered.

  Tipping and processing areas of the plant were totally enclosed. Three types of odor scrubbers were in use (two chemical scrubbers and one thermal oxidizer). CWT has found, during the development of the Carthage plant, that particular odor controls work best on specific air exhaust streams, such that three types of control are necessary. During the plant visit, outside the receiving and processing buildings, a slight, mild odor was apparent.

Local officials and environmental regulators indicated that, upon plant startup, there were seriously objectionable odors generated by the plant. During the reference tour, in the enclosed processing area, the odors were found to be quite noxious. Although CWT had made significant progress in capturing and controlling odors, officials and regulators indicated there were still episodic problems.

When processing MSW, odor characteristics may differ from a CWT plant processing agricultural waste such as the poultry processing waste.

- **Products Observed.** Renewable diesel tankage was observed at the site, containing the product that results from the poultry processing waste feedstock. Also, the solid residue from the plant was observed. For the Carthage plant, the solid residue is primarily resulting from the bones in the feedstock. The residue had the appearance of wet bone meal. For MSW process, solid residue will likely be considerably different in characteristics, appearance and disposition. The solid residue from the Carthage plant is used as a fertilizer. The solid residue from an MSW processing facility will most likely end up being sent to landfill. Also, metal will be a significant component of the solid residue from an MSW and auto shredder residue fed plant and will require separation at both the front end and the back end of the processing.

- **Renewable Diesel Use.** During the plant tour, it was learned that the renewable diesel is used locally in Missouri at a complex of greenhouses. Reportedly, the diesel distribution piping at the greenhouse complex required upgrade to stainless steel, due to accelerated corrosion with use of the renewable diesel. This upgrade was conducted at the greenhouse complex, therefore it is likely that the benefit of using the renewable diesel outweighed the cost of the upgrade.

- **Water Export.** Excess water produced by the Carthage plant, as operated with the agricultural feedstock, has a value as a fertilizer. Depending on economics, the Carthage plant wastewater is either used as a fertilizer or trucked off site as a wastewater. Due to the nature of the feedstock, beneficial use of the excess water is not expected for a plant processing MSW and auto shredder residue. The latter plant type will likely need to send the excess water to a wastewater treatment plant.

- **Plant Scaleup and Startup.** The construction and startup of the Carthage plant represented a substantial scaleup relative to the Philadelphia pilot plant. Problems were encountered regarding initial specification of inadequate equipment and lack of sufficient odor controls. However, most, if not all, of those problems appear to have been overcome at considerable effort and expense, and with a strong commitment by CWT. Many of the issues were related to the technical challenge of the magnitude of plant scaleup (30:1).

5.3.8 Air Pollution Controls and Emissions

CWT provided air emissions information for criteria pollutants (e.g. NOx, CO, SO2) on a ton per year basis for the small boiler planned for installation at the demonstration scale facility proposed for the Conversion Technology Demonstration Project. In order to perform the focused evaluation regarding air emissions from CWT's process, detailed information regarding the derivation of the ton per year emission estimate for NOx emissions from the boiler was requested for further evaluation. The pollutants NOX and dioxin were selected as indicator pollutants for the evaluation process. Other pollutants, such as carbon monoxide, particulate matter and mercury will be of interest during permitting of the conversion technology processes. However, NOx was selected as a key indicator of environmental acceptability because smog is one of the most significant pollution issues in Southern California, and, from combustion sources, NOx is the most significant pollutant that contributes to smog. Dioxin was selected as a key, representative toxic pollutant of concern. Following are the results of the air pollution control and emissions evaluations for CWT.

5.3.8.1 NOx Emissions. The sources of NOx emissions from the CWT technology are the boiler that produces process heat and, if installed, a flare for the disposal of non-condensable gases from the depolymerization process. For the 51,100 tpy plant, one boiler has been identified as the source of facility NOx emissions. The uncontrolled annual NOx emissions from this boiler is projected by CWT to be 4 tpy. If the boiler is the only source of emissions at the demonstration facility, and if its emissions are less than 4 tpy, then purchase of NOx offsets would not be required, since 4 tpy is the South Coast Air Quality Management District's limit for applicability of purchase of NOx offsets.

Although BACT would need to be installed for the boiler, the NOx control requirements might be limited to a low NOx burner, possibly with the inclusion of flue gas recirculation. Such controls have minimal capital and operating costs, relative to more complex add-on control technologies (such as Selective Catalytic Reduction) which are typically applied to more significant sources.

In summary, CWT may not need to purchase NOx offsets for a demonstration facility and expensive add-on air pollution control equipment may not be required. Therefore, for CWT, no economic sensitivity analyses were conducted for evaluation of purchase of NOx offsets or add-on air pollution control devices (reference Section 8.3.2).

5.3.8.2 Dioxin Emissions. For the demonstration plant proposed by CWT, there does not appear to be a significant potential for dioxin emissions. The primary air emission source is a small, natural gas fueled boiler, from which dioxin emissions would not be expected. Flared emissions of non-condensable gas, if that is how such gases would be handled, might be comparable in emissions characteristics to flared emissions of non-condensable gases from a petroleum refinery. Such emissions sources are not generally recognized as producers of dioxin.

5.4 INTERNATIONAL ENVIRONMENTAL SOLUTIONS (IES)

IES's thermal technology centers around generation of a syngas by a retort reactor, followed by combustion of the syngas in a thermal oxidizer. The technology includes pre-drying of the waste and capture of the thermal energy using a heat recovery steam generator (HRSG). The process converts MSW to useful energy in the form of electricity for net export. A small amount of residue, which will require disposal, is generated by the process.

5.4.1 Reference Facilities

IES, with headquarters located at Romoland, California, is the developer of a pyrolytic gasification technology. This technology is currently under development for use with a variety of feedstocks, including MSW and MRF residuals. Because a dryer is integral to the process, as currently configured, the system can process sewage sludge and other organic wastes along with MSW.

As summarized in Table 5.4-1 below, IES has one reference facility, located in Romoland, California. This facility has been used to demonstrate operation with a variety of feedstocks since 2004. The Romoland facility has two pyrolysis units. One has an 8-tpd capacity and the other has a 50-tpd capacity. The 50-tpd unit has been extensively stack tested while operating with MRF residuals as a feedstock. Except for several case specific allowances made by the South Coast Air Quality Management District to enable extended test durations, the 50-tpd pyrolysis unit is generally limited by permit to operate less than a full day at a time. An annual throughput capacity of 16,425 tpy is estimated using the assumption that the system could hypothetically be operated 328 days per year and 24 hours per day. However, the demonstration facility does not currently operate continuously with an MSW type of feedstock.

Table 5.4-1. IES Reference Facility	
Name:	Romoland Facility
Location:	Romoland, California
Design:	50 tpd
Capacity:	16,425 tpy
Availability:	NA
Type of Waste:	A wide variety of waste types have been demonstrated, including MRF residuals
Owner:	IES
Operator:	IES
Operation for Demonstration Purposes:	2004 – present

Members of the Subcommittee, DPW staff, and representatives of the ARI team visited the Romoland facility in February of 2007 and viewed it in operation (see Section 5.4.7).

In addition to the 8-tpd and 50-tpd units in operation at Romoland, IES has made significant progress in the design and fabrication of a 125-tpd unit. The 125-tpd retort reactor has already been fabricated and will likely be located outside of California to be used for demonstration purposes.

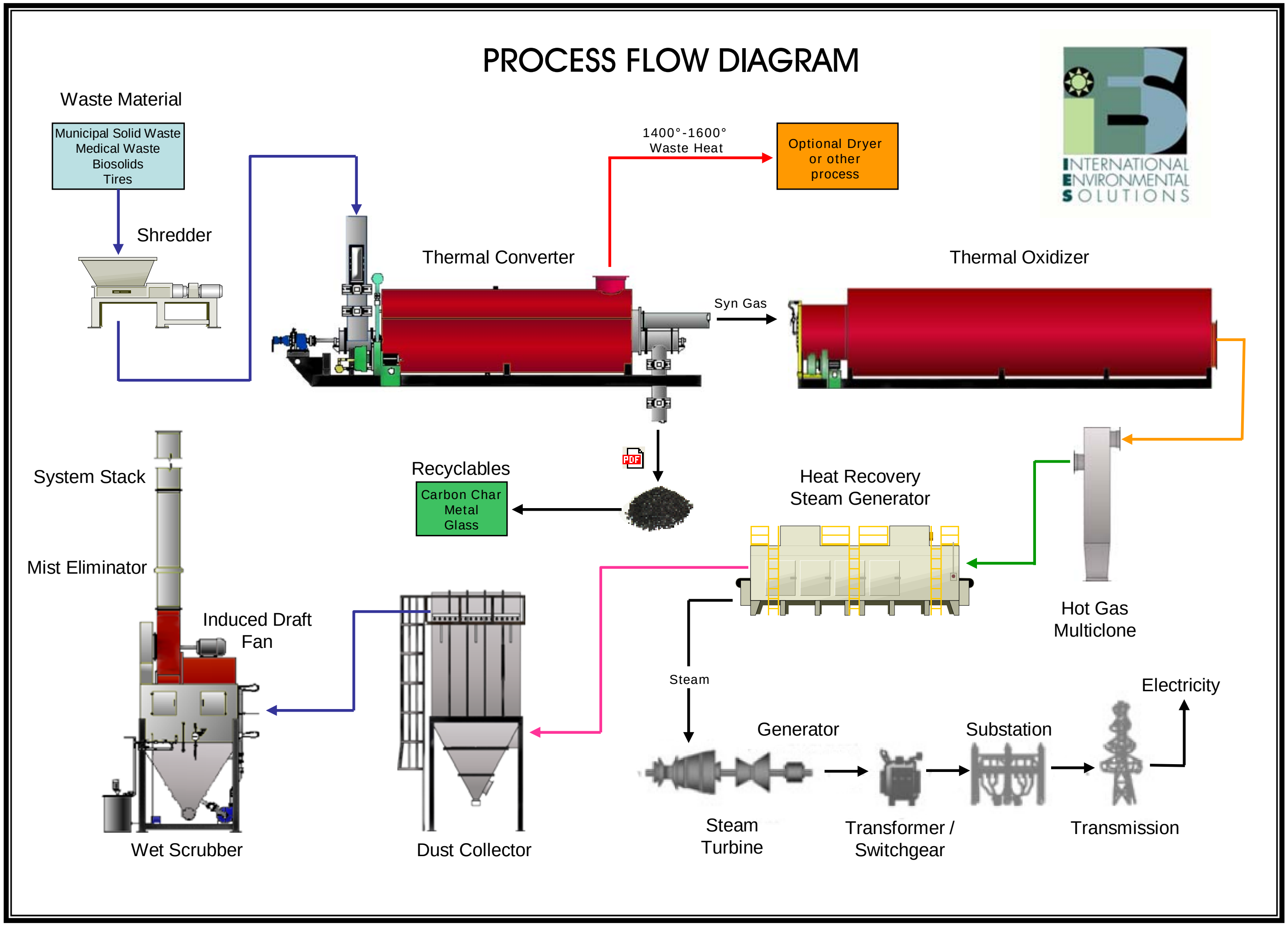
5.4.2 Description of the IES Technology

The IES technology consists of waste pre-processing systems, a pyrolytic gasifier for production of syngas, a thermal oxidizer for combustion of the syngas, waste heat recovery for operation of a steam turbine, and air pollution control technologies for the reduction of emissions from the combustion of the syngas. For the project, pre-processing equipment would consist of a grinder and a dryer. Figure 5.4.1 shows a schematic of the process.

Residuals are intended to be received directly from the host MRF as no feedstock storage related to the project is proposed. The MRF residuals would be passed through a grinder for size reduction to 2 inch minus, and then dried from 58.9 percent moisture to 20 percent moisture. The dryer would likely be heated using syngas combustion or steam extracted from the steam turbine, as no parasitic fuel or electricity use for the dryer is noted.

The current method of feeding the processed MRF residuals to the retort is via conveyors to a feed chute. Knife gate valves isolate the waste and allow for intermittent introduction of metered quantities into the retort.

Figure 5.4-1. Schematic Diagram of IES's Technology



The retort is contained within a metal cylinder, or jacket. Within the jacket, a natural gas burner allows for heat-up of the retort. During the site visit it was pointed out that natural gas was also being used as an occasional and intermittent (startup, shutdown, loss of temperature level) supplemental fuel for the thermal oxidizer. The retort heating via the natural gas burner is conducted during steady state operation. IES has future plans for firing the retort burner with syngas rather than natural gas, which would reduce or virtually eliminate the fossil inputs to the process.

The pyrolysis chamber design, as mentioned, is a retort vessel within a metal jacket. The retort vessel for the 125-tpd design is a three-arch, triangular chamber which will contain two proprietary rotating augers (screws). The rotating augers transport the fuel horizontally from the feed end of the retort to the char collection point at the other end. The gas path in the retort is concurrent with the solids flow. The pyrolysis takes place between 1,200 and 1,800 degrees F (approximately 650 to 980 degrees C). The primary pathway for decomposition of the solid feed to syngas is destructive distillation and molecular decomposition. A small amount of solid residue remains after the conversion from solid feedstock to syngas. This solid residue is termed “char” because it has a dark color indicated some residual carbon content. The char also contains sterile sands and glass, and metals that are most typically fixed and non-leachable.

The syngas that is produced by the pyrolysis unit is piped to a thermal oxidizer for combustion. Capture of the syngas is currently feasible and further conversion to hydrogen fuel is being considered as a further advancement of operational modes. However, at this stage of technology development, combustion of the syngas has been proven and is proposed for the Conversion Technology Demonstration Project. The thermal oxidizer is operated at approximately 2,250 degrees F (approximately 1,230 degrees C) at a sufficient residence time for essentially complete combustion of all hydrocarbons, including dioxins and furans, in the syngas. Excess combustion air is supplied to the thermal oxidizer to allow for the complete combustion. Natural gas is typically supplied on an as needed basis to maintain the elevated temperature in the thermal oxidizer, and such supplemental use was observed during the facility tour. Use of on-demand natural gas in the thermal oxidizer ensures continuity of combustion even if there are temporary periods of low syngas yield or heating value. Therefore, consistency of the syngas quality for the IES process is less of a concern than for some other conversion technologies. Resulting products of combustion are primarily carbon dioxide and water vapor.

The exhaust gases leave the thermal oxidizer at approximately 2,000 degrees F (approximately 1,090 degrees C), are passed through a cyclone for removal of some particulate matter, and then flow through a heat recovery steam generator (HRSG, also termed a boiler). The particulate matter collected by the cyclone is combined with the char from the retort and with the spent air pollution control reagents for disposal off-site. The purpose of the cyclone removal of particulate matter is to prevent excessive fouling of the HRSG, for reduction of maintenance and downtime. The design steam condition in the HRSG is superheated steam produced at 900 psig and 1,000 degrees F (approximately 540 degrees C). The steam produced by the HRSG is used to power a steam turbine-generator for production of electric power. The type of steam turbine planned for the project is a condensing turbine, which is of a type which will maximize electricity yield from the steam. Electric power is generated for parasitic use at the proposed plant, but a substantial excess of electricity available for export is estimated.

Two options for heat rejection equipment are currently under consideration for the project: (1) cooling towers; or (2) air cooled condensers. When the final selection has been made, a water balance for the plant can be completed and a more refined estimate of facility electric output can be made.

After leaving the HRSG, the exhaust gases from the thermal oxidizer are cleaned using a baghouse for particulate matter and metals control, selective catalytic reduction (SCR) for nitrogen oxides (NOx) control, and a wet scrubber/demister for acid gas control and polishing for further particulate matter and metals removal.   Additional solids generated by the air pollution control equipment are to be combined with the char and cyclone materials to generate the total residue from the facility.

5.4.3 Proposed Facility Capacity for the Demonstration Project

As part of the Phase II Study, IES was requested to designate a capacity for a demonstration facility and for a commercial facility for the project. IES proposed one facility size, as shown in Table 5.4-2.

Table 5.4-2. IES Facility Proposed for the Conversion Technology Demonstration Project

IES	One Unit Facility
Facility Design Capacity (MSW @ 58.9% moisture:[(1)]	242.5 tpd
Facility Design Capacity (MSW @ 20% moisture):	125 tpd
Annual Availability:	90%
Annual Throughput @ 58.9% moisture:[(1)]	79,661 tpy
Annual Throughput @ 20% moisture:	41,062 tpy
Avg. Daily Throughput (at 365 days/yr):	112.5 tpd
Land Area Required:	$\pm$1 acre

(1) “As Received” basis.

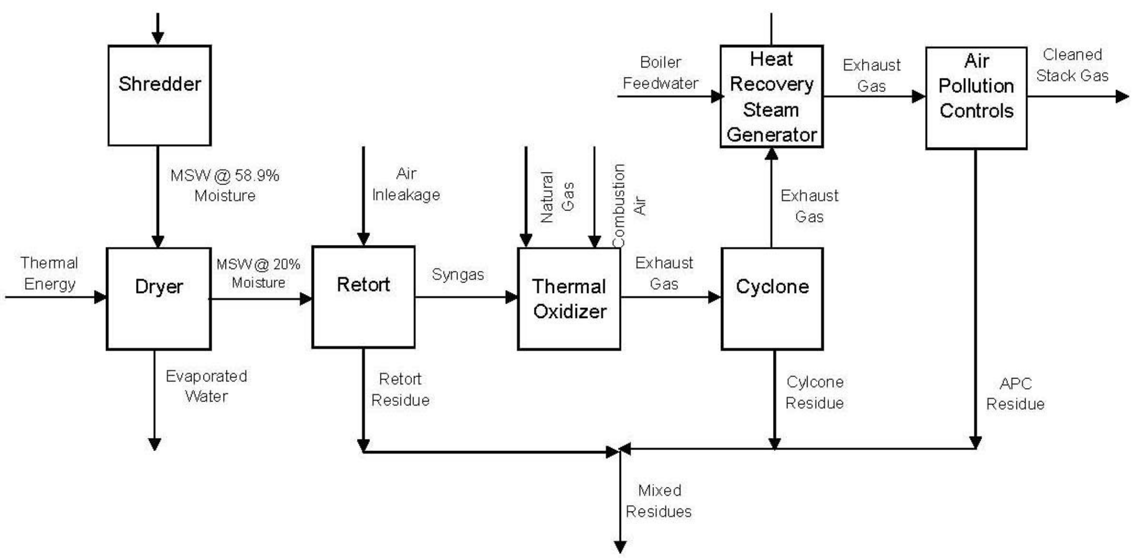
The modular unit design rating for the demonstration project is 125 tpd (242.5 tpd on an “as received” basis). The largest modular unit currently in operation is located at Romoland. The Romoland unit capacity is 50 tpd. A 2.5:1 module scale-up is required for the demonstration project. Such a level of scale-up minimizes, but does not eliminate, technological risk. Also, in moving from a single screw in the demonstration facility retort to a twin screw in the proposed facility retort for the 125-tpd unit, there has been a significant design change.

IES's plant availability has been estimated on an hourly basis given engineering assessment of plant equipment components. The estimate of 90 percent availability has been made in the absence of significant, continuous demonstration plant operating experience.

5.4.4 Mass Balance

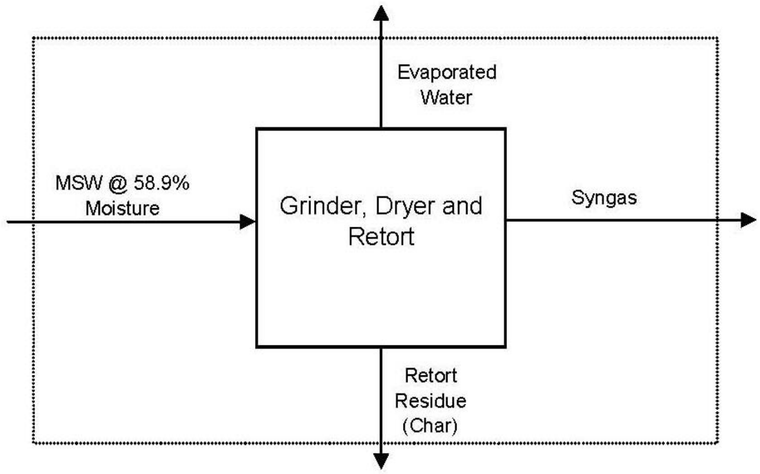
A mass balance provides an accounting of the material inputs to the process and the corresponding outputs from the process. Because mass is conserved, the total amount of mass input should equal the total amount of mass output. To check the fundamental process bases, independent calculations, using data provided by the technology suppliers, were conducted. IES did not provide a mass balance, but limited information available in the proforma submitted in response to the RFI supplied some data. A process flow diagram, shown in Figure 5.4-2, was developed specifically for the Conversion Technology Demonstration Project based on information obtained in the RFI response, and from later meetings and communications, in order to aid in evaluation of mass and energy balances for the technology.

Figure 5.4-2. IES Process Flow Diagram



For evaluation of the conversion technologies in general, mass balance boundaries were drawn around the primary production process. In the case of the IES technology, the balance was drawn around the MSW grinder, dryer and retort vessel. A simplified process flow diagram depicting the balance boundary and the mass inputs and outputs of the process is shown in Figure 5.4-3.

Figure 5.4-3. IES Mass Balance Schematic



Independent calculation of the IES mass balance was conducted for the 125-tpd plant (242.5 tpd on an "as received" basis). A summary of the results of the independent calculation is presented in Table 5.4-3.

Table 5.4-3. IES Mass Balance(1)

Material	Amount (%)(2)	Amount (tpy)
INPUTS		
MSW	100.0%	79,661
Total	100.0%	79,661
OUTPUTS		
Syngas, by difference(3)	46.4%	36,968
Evaporated Water	48.4%	38,586
Residue (Char)(4)	5.2%	4,108
Total	100.0%	79,661

(1) For a commercial facility with a throughput of 79,661 tpy @ 58.9% ("as received" basis) moisture and 41,062 tpy @ 20% moisture.
(2) Percent by weight of total MSW input @ 58.9% moisture.
(3) Syngas production is estimated here by difference. If evaporated water is excluded from the balance, syngas production is estimated at 95% of dried MSW input (20% moisture).
(4) Residue may include not only char from the retort reactor, but also cyclone and air pollution control residues.

The above balance does not recognize any air infiltration and the incorporation of components of air into the syngas produced. A mass balance was not available from IES that characterized the syngas production rate. Therefore, the syngas production rate was estimated here by difference. IES is currently undertaking a comprehensive, independently conducted, testing program which is expected to yield very detailed mass and energy balance information soon.

An analysis of the mass balance indicates 100 percent closure, on an output over input basis. The closure of 100 percent occurs here because the syngas production rate is calculated by difference.

Specific elements of IES's mass balance are further discussed below.

5.4.4.1 Waste Characterization Basis. IES did not use the waste characterization provided in the RFI. IES has focused its demonstration of MSW feedstock with the Romoland equipment on MRF residuals from the Rainbow MRF located in Orange County. Based on sample MRF residuals transported from Rainbow to Romoland, IES has conducted extensive testing for moisture and thermal yield from processing that specific waste stream.

IES believes, based on their experience with the MRF residuals, that the moisture content of the incoming waste averages 58.9 percent. Due to the high “as received” moisture content, IES relies on a dryer to bring the moisture content of the waste down to approximately 20 percent. Note that the moisture content of the waste predicted by the RFI, and based on the limited City of Los Angeles sampling in 2005, was 20.45 percent.

5.4.4.2 Recyclables. IES is planning to accept MRF residuals, from which recyclables have already been removed. The IES technology does not include front-end recovery of recyclable materials. All of the MRF residual is processed through the retort vessel to produce syngas and char. The char has no appreciable recyclables that can be recovered.

5.4.4.3 Syngas Production. The sole material product of the IES process is the syngas, produced by pyrolytic gasification. Test reports from an independent laboratory which characterized the syngas were provided by IES. Heating value of the syngas was reported to be from 409 to 536 Btu per cubic foot (assumed here to be on a higher heating value basis and to be measured on a standard cubic foot basis). The estimated syngas production rate has not been published by IES, however, based on the mass balance it can be estimated to be approximately 928 pounds of syngas per ton of MSW feedstock (MSW on an “as received” basis). Although IES does not currently intercept the syngas prior to combustion, for pre-cleaning, such an intervention in the process is possible. Also, in addition to electric generation with the syngas, manufacture of fuel products, such as hydrogen, are actively under investigation by IES.

5.4.4.4 Marketable Products. Currently, the only marketable product from the IES process is electricity. Electricity is produced by the combustion of the syngas in the thermal oxidizer for generation of thermal energy, which is then transferred to steam in the heat recovery steam generator, and finally converted to electricity by the steam turbine for both plant parasitic use and export.

5.4.4.5 Residue Requiring Disposal. The IES process generates residue requiring disposal from three sources: (1) the char from the retort vessel; (2) particulate matter collected by the cyclone; and (3) air pollution control system residues. Air pollution control system residues would include particulate matter, a caustic substance such as lime used for acid gas scrubbing, and a small amount of carbon used for mercury and dioxins/furans scrubbing. Although no mass balance was provided, in the RFI response there were certain assumptions made in the proforma that was presented. One such assumption was that 5.2 percent by weight of the quantity of incoming MSW would need to be disposed. Relative contributions of the three sources of residue to this total were not disclosed in the RFI response.

5.4.4.6 Water Use and Wastewater Treatment and Discharge. IES did not provide a water balance. However, in the RFI response it was stated that a facility would be designed for zero wastewater discharge. It is known that the evaporated water from the dryer is intended for conditioning and use in the boiler feedwater system. Because IES has not finalized their plans for the heat rejection equipment (i.e., air cooled condensers or cooling towers), a water balance cannot yet be completed.

5.4.5 Energy Balance

An energy balance provides an accounting of the energy inputs to the process and the corresponding outputs (which can be chemical, mechanical, thermal or electrical) from the process. Because energy is conserved, the total amount of energy input should equal the total amount of energy output. To check the fundamental process bases, independent calculations, using data provided by the technology suppliers, were conducted. IES did not provide an energy balance with the RFI response. However, data provided in the proforma section of the RFI submittal contained data that were extracted and used by ARI to prepare energy balances for the IES process. The data were organized during the review into two energy balances.

For the evaluation of the conversion technologies in general, more than one energy balance was prepared for different processes to aid in the technical evaluation. For the IES technology, two energy balances were evaluated in order to determine and review expected efficiencies:

- Energy efficiency of the steam generation process (“boiler efficiency”); and
- Plant-wide energy efficiency.

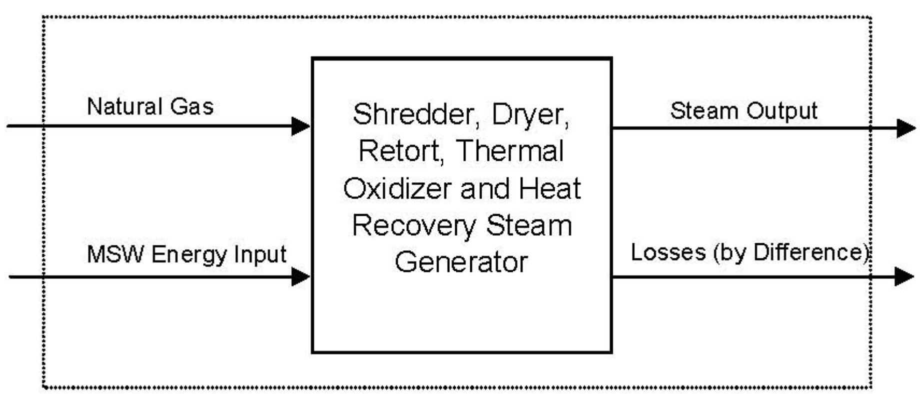
Each balance provides a different perspective of the process and serves a different evaluation purpose. The primary purpose of each evaluation is to estimate an energy conversion efficiency. Such conversion efficiencies can be used comparatively between the technologies and against traditional technologies, to assess reasonableness of the process assumptions. For example, the boiler conversion efficiency can be compared to traditional boiler process efficiencies and the net electric generating efficiency of the entire plant can be compared to waste processing technologies in general and to the other conversion technologies.

It is necessary to recognize that electricity production and use is handled in various fashions in the different balances. For the IES process, the steam turbine produces a gross electric output, and the efficiency of the gasifier, thermal oxidizer, heat recovery steam generator and steam turbine is evaluated on that basis. Some of the gross output from the steam turbine-generator is used to run the plant, including all the mechanical equipment. That electric use is considered to be the “plant parasitic use”, because it represents the draw for operation of the plant. When the plant parasitic use of electricity is subtracted from the gross output of a facility, the net plant export of electricity for sale can be derived. For evaluation of plant electric generating efficiency, only net export of electricity is included as an energy product. Because IES did not provide gross electric output or plant parasitic use, the type of energy efficiency evaluations that could be conducted for the plant were limited. However, from the proforma, ARI deduced the net export of electricity from the IES facility.

For IES, the independent energy balance calculations were conducted for the 79,661 tpy @ 58.9% moisture facility (equivalent to 242.5 tpd on an “as received” basis, and also equivalent to 41,062 tpy @ 20% moisture).

5.4.5.1 “Boiler Efficiency”. The inputs used to assess the steam production efficiency of the IES process are MSW energy and natural gas energy and the outputs are the steam energy produced and the plant losses. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to independently calculate, to the extent possible, steam production efficiency, is shown in Figure 5.4-4.

Figure 5.4-4. IES Energy Balance Schematic for Steam Production



Although syngas yield and heating value were not provided in an energy balance format by IES, the proforma provided in the RFI response indicated an assumed steam yield, which made it was possible to estimate a “boiler efficiency” for the thermal processes. Syngas production energy efficiency can be expected to be greater than the “boiler efficiency” calculated here.

A summary of the independent calculation results of the “boiler efficiency” (steam production efficiency) is shown in Table 5.4-4.

Table 5.4-4. IES “Boiler Efficiency”(1)

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
MSW Energy Input	2,579	26.1	205,378
Natural Gas	467	4.7	37,199
Total	3,045	30.8	242,577
OUTPUTS			
Steam Output(2)	2,205	22.3	175,675
Losses by Difference(3)	840	8.5	66,902
Total	3,045	30.8	242,577

(1) For a commercial facility with a throughput of 79,661 tpy @ 58.9% moisture (“as received” basis) and 41,062 tpy @ 20% moisture.

(2) Estimated from the steam flow rate provided in the proforma from the RFI response (54,360 pph of steam) with an assumption here that the steam quality was 800 psig and 800 deg.F (i.e., an enthalpy of 1,399 Btu/lb).

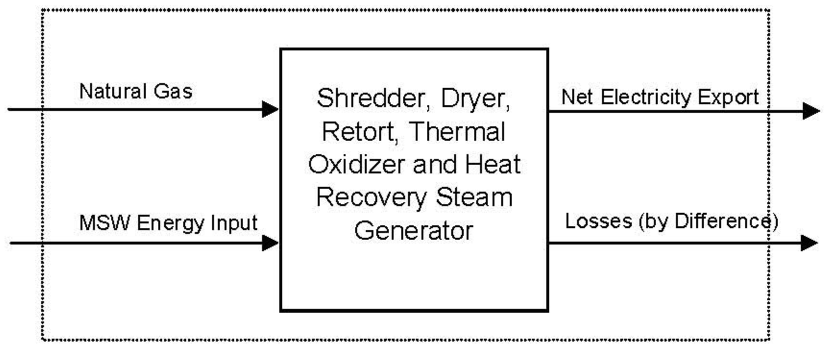
(3) Estimated by subtracting the steam output from the total energy inputs (i.e., MSW Energy and Natural Gas).

Based on information provided by IES, and on the steam quality assumption noted in the table footnote above, the “boiler efficiency” of the thermal system is estimated to be 72 percent. This calculated conversion efficiency is based on the energy input provided by the MSW and the supplemental natural gas use, versus the steam output of the boiler. The 72 percent “boiler efficiency” is consistent with a low efficiency combustion and boiler system, and therefore has not likely been overstated.

The balance used to assess the steam generating efficiency of the IES equipment closes 100 percent here because energy losses are calculated by difference.

5.4.5.2 Overall Plant Balance. For the IES process an overall energy balance is a measure of net energy (electricity) output compared to all of the energy inputs (i.e. MSW and natural gas) for the complete system. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify IES's overall plant efficiency, is shown in Figure 5.4-5.

Figure 5.4-5. IES Energy Balance Schematic for Overall Plant



A summary of the results of the independent calculation of the IES overall plant energy balance follows in Table 5.4-5.

Table 5.4-5. IES Overall Plant Energy Efficiency(1)

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
MSW Energy Input Natural Gas	2,579 467	26.1 4.7	205,378 37,199
Total	3,045	30.8	242,577
OUTPUTS			
Net Electricity Export Losses, by Difference	489 2,556	4.9 25.8	38,986 203,591
Total	3,045	30.8	242,577

(1) For a commercial facility with a throughput of 79,661 tpy @ 58.9% moisture ("as received" basis) and 41,062 tpy @ 20% moisture.

Based on information provided by IES, the net export energy conversion efficiency of the complete plant is estimated to be 16 percent. This calculated conversion efficiency is based on the energy input provided by the MSW and natural gas, versus the net electricity output (export only). This energy conversion efficiency is slightly lower than the efficiency achieved with traditional waste-to-energy technology, which generally ranges from approximately 17 to 20 percent (for net electrical output ranging from 500 kWh/ton of MSW to 600 kWh/ton of MSW).

An analysis of the overall plant energy balance indicates 100 percent closure, on an output over input basis. The closure of 100 percent occurs here because losses are calculated by difference.

5.4.6 Diversion Potential

IES has a diversion potential of 95 percent, given a prediction of 5 percent residue generation rate, by weight, relative to incoming MSW. IES has experience with the measurement of the char product and the air pollution control technology waste reagent. Due to the existence of direct experience with a Southern California waste, there is a comfort factor associated with the predicted diversion potential. Because the potential for rejection of materials at the front end is small, there appears to be a likelihood that the 95 percent diversion prediction can be achieved by the IES technology.

5.4.7 Reference Plant Tour

Members of the Subcommittee, DPW staff, and representatives of the ARI team visited IES's reference facility in Romoland, California on February 15, 2007. The facility had received MRF residuals from the Rainbow Waste Disposal Facility to demonstrate processing of that feedstock and was processing the waste during the visit. During the visit, the MRF residuals were being sent to the pyrolysis unit without pre-drying, although pre-drying would be a planned mode of commercial operation.

The visit satisfied several objectives, including; inspecting the configuration of equipment at the pilot facility, for comparison to the planned equipment for a Conversion Technology Demonstration Project facility; confirming the type of waste processed and its characteristics; and evaluating the generation and handling of the residues from the process. Key observations and findings relevant to evaluation of the IES technology and its potential commercial application are as follows:

- **Type of Waste, Receiving and Handling Issues.** MRF residuals from the Rainbow facility had been delivered to the Romoland facility prior to the plant tour. This waste feedstock was observed by the reviewers. It appeared to be shredded and fairly homogenous and consistent in appearance.

  IES has tested multiple feedstocks at the Romoland facility. However, a major focus of their development efforts have been with MRF residuals. IES has determined that MRF residuals that have been shredded and dried are most compatible with their retort equipment. The reviewers saw that the use of the screw in the retort makes it imperative that waste that could tangle or snag must not be introduced into the system. Shredding of the waste should help avoid any problems with the operation of the screw.

MRF residuals may be a more consistent type of feedstock than raw MSW and/or black bin waste. The grinding and drying process achieves further consistency. Therefore, a more predictable and uniform syngas production may be expected from the IES process when fueled with the pre-processed MRF residuals. Also, occurrences of rejected residuals appear to be less likely with this type of waste feedstock.

- **Equipment and Operations.** Equipment observed during the site visit included the retort, thermal oxidizer, waste heat boiler, and air pollution control systems. More air pollution control equipment is planned for a Conversion Technology Demonstration Project facility than is currently supplied at the Romoland pilot plant. For example, a cyclone between the thermal oxidizer and the heat recovery steam boiler, for removal of particulate matter and reduced fouling of the boiler, plus installation of Selective Catalytic Reduction for NOx control, are planned for the project and are not included at the Romoland pilot facility. Continuous air emissions monitoring was not installed at the pilot facility at the time of the site visit, but is planned for future installation at that location.

  During the site visit, at the control panel, supplemental fueling with natural gas was observed to be taking place in a pulsing manner, as the temperature set point demanded. IES personnel explained that during the brief period of operation that day, the retort could not be expected to reach steady state conditions.

  The Romoland pilot plant does not have steam turbine and thus does not generate electricity. A Conversion Technology Demonstration Project plant would include a steam turbine and would generate electricity.

  The twin-screw, triangular-arch retort was on-site at the time of the visit. The reviewers observed that the cast retort section of the planned, larger, twin screw equipment had been finished and delivered to the site.

- **Residue.** Residue generated by the pyrolysis unit was observed. This residue was dark in color, indicating that some residual carbon remained, which is consistent with the technology supplier's characterization of the residue as a char. The char was automatically removed from the back end of the retort and conveyed to a collection bin.

5.4.8 Air Pollution Controls and Emissions

IES provided two full stack test reports, conducted in 2005 and 2006, as part of the RFI response and subsequent requests. It is notable that IES has considerable experience with permitting and stack testing under the jurisdiction of the South Coast Air Quality Management District. Although the stack testing data were complete for the 50-tpd pilot facility, detailed information was requested in follow-on questions to IES regarding NOx emissions consistent with a larger demonstration facility. The pollutants NOx and dioxin were selected as indicator pollutants for the evaluation process. Other pollutants, such as carbon monoxide, particulate matter and mercury will be of interest during permitting of the conversion technology processes. However, NOx was selected as a key indicator of environmental acceptability because smog is one of the most significant pollution issues in Southern California, and, from combustion sources, NOx is the most significant pollutant that contributes to smog. Dioxin was selected as a key, representative toxic pollutant of concern. Following are the results of the air pollution control and emissions evaluations for the IES process.

5.4.8.1 NOx Emissions. The source of NOx emissions from the IES technology is primarily the thermal oxidizer, which combusts the syngas from the pyrolysis unit. For the 79,661 tpy plant ("as received" basis), the controlled NOx emissions are estimated by IES to be less than 5 tpy. The bases for the IES estimate are uncontrolled emissions as measured by a stack test at the 50-tpd pilot facility, scaled to the larger, demonstration facility, with the planned project application of Selective Catalytic Reduction (SCR) for 85 to 90 percent NOx removal. Because emissions from the facility may be greater than 4 tpy, purchase of approximately 5 tpy of NOx offsets[1] may be required. Four (4) tpy is the South Coast Air Quality Management District's threshold for applicability of the NOx offset purchase requirement.

Application of SCR for 85 to 90 percent NOx removal is likely to be recognized by South Coast Air Quality Management District as Best Available Control Technology (BACT), which is the level of stringency of controls which would be required for a facility of IES's size (i.e., less than 10 tpy of NOx).

In summary, purchase of NOx offsets is likely to be required for a project of the demonstration facility scale, but add-on air pollution controls are already accounted for in the design of the IES proposal and therefore, in the facility economics. In the economic sensitivity analysis addressed in Section 8.3.2 of this report, additional project capital cost for the IES process was assessed to account for the purchase of offsets.

5.4.8.2 Dioxin Emissions. IES measured dioxin emissions at their Romoland pilot facility while using MRF residuals feedstock. The results were published in terms of total mass of dioxins and furans, as well as International Toxic Equivalents (ITEQ's). Compared here are the results of the stack testing by IES, with the Federal New Source Performance Standards (NSPS) for Large Municipal Waste Combustors (MWC). For comparison purposes, results are characterized as pounds of dioxins and furans per ton of municipal solid waste feedstock utilized (lb/ton MSW). Actual compliance testing of a demonstration facility may involve comparison to concentration based standards.

[1] Although offsets are typically required to be purchased at a rate 10 or 20 percent higher than the actual emission rate, at the precision of estimate used in this study, the required quantity of offsets is assumed to be equivalent to the estimated emissions.

On a total mass basis, IES test results from 2006 stack testing indicate emissions of 4.4×10^{-9} lb/ton MSW. In comparative units (total mass basis), the Federal NSPS requirement for large MWC is estimated to be 1.05×10^{-7} lb/ton MSW. As previously mentioned, IES also tested on an ITEQ basis and the 2006 test results on that basis indicate emissions of 1.4×10^{-11} lb/ton MSW. In comparative units (ITEQ basis), the Federal NSPS requirement for large MWC is estimated to be 1.62×10^{-9} lb/ton MSW. Reviewed on this basis, the IES emissions appear to be significantly lower than the Federal requirements for large MWC. South Coast Air Quality Management District (SCAQMD) limits based on air toxics new source review are often more stringent than the Federal NSPS and are established on a case-by-case, site specific basis. Therefore, relative status regarding SCAQMD requirements cannot be established until air permit preparation has been conducted.

5.5 INTERSTATE WASTE TECHNOLOGIES (IWT)

IWT's thermal technology is a closed-loop process based on high-temperature gasification with an extended residence time for process gases. The technology simultaneously gasifies organic materials and melts down inert materials. There is no size reduction or separation of the MSW prior to gasification, and no front-end recovery of recyclables. Rather, all MSW is input to the process and is either converted to energy or extracted as a product. Assuming all products can be marketed, which has reportedly been demonstrated at operating facilities in Japan, the technology generates no residue requiring disposal.

5.5.1 Reference Facilities

Interstate Waste Technologies represented in the United States out of Middleburg, Virginia, and Malvern, Pennsylvania, offers the Thermoselect high-temperature gasification technology. IWT is sole North American licensee of the Thermoselect technology. The technology can process various types of waste, including MSW, construction waste, industrial waste and sewage sludge.

The Thermoselect technology is currently in commercial operation at seven locations in Japan (Chiba, Mutsu, Kurashiki, Nagasaki, Yorii, Tokushima, and Izumi). Chiba is the longest-operating facility in Japan. Kurashiki is one of the newest facilities, but has the largest capacity of all the facilities currently in operation. Both of these facilities have processed or do process MSW, along with other types of waste.

As summarized in Table 5.5-1 below, IWT suggested three of the Thermoselect installations as reference facilities. All three reference facilities were designed to process MSW and other types of waste, and demonstrate performance of the technology over a period of almost eight years.

Table 5.5-1. IWT (Thermoselect) Reference Facilities			
Name:	Nagasaki Facility	Chiba Facility	Kurashiki Facility
Location:	Nagasaki, Japan	Chiba, Japan	Kurashiki, Japan
Design:	110 tpd x 3 modules	165 tpd x 2 modules	204 tpd x 3 modules
Capacity:	110,330 tpy	105,200 tpy	191,000 tpy
Historical Availability:	91.6%	87.3%	85.5%
Type of Waste:	MSW, Industrial, Auto Shredder Residue	MSW initially Industrial currently	MSW, Industrial, Plastic Auto Shredder Residue
Owner:	Kenou-Kennan Kouiki Kankyo Kumiai	JRC (Japan Recycling Corp.)	Mizushima Eco Works
Operator:	JFE Environmental	JRC	JFE Environmental
Commercial Operation:	March 2005 - present	Sept. 1999 - present	March 2005 - present

Of the three reference facilities, members of the Subcommittee, DPW staff, and representatives of the ARI team visited the Chiba and the Kurashiki facilities in April of 2007 and viewed them in operation (see Section 5.5.7).

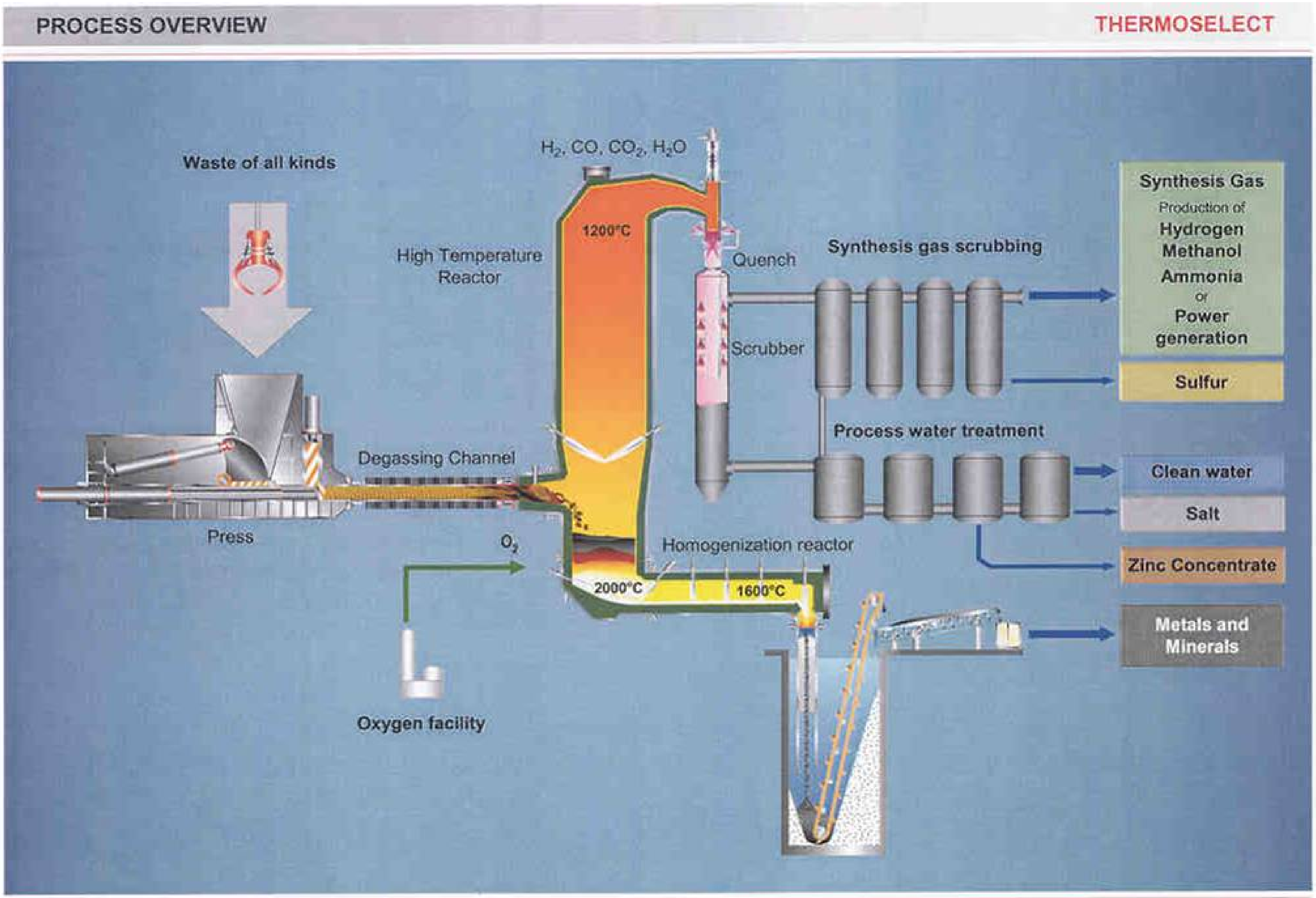
5.5.2 Description of the Thermoselect Technology

The core components of IWT's application of the Thermoselect technology include a feed chamber, gasification reactor, synthesis gas cleanup, combustion of the cleaned syngas using a combined cycle gas turbine, and addition of air pollution controls for reduction of emissions from the combustion of the syngas. Support systems include an oxygen plant, water treatment, and cooling towers. Figure 5.5-1 shows a schematic of the process.

Waste is received in an enclosed area and discharged to a receiving pit. Overhead cranes are used to load the waste into hoppers that feed the processing lines. No sorting, separation, size reduction, or other pre-processing is conducted prior to loading the waste. Even bulky items (e.g., furniture, appliances, other large waste items) are reported to be feasible for loading into the hoppers for processing. Upon loading, waste is compressed using standard, hydraulic scrap metal presses, forcing out air and uniformly distributing liquids (including sludge, if sludge is also being processed). Compacted waste is pushed into a degasification channel, which is indirectly heated using radiant heat from the gasification reactor. Within the heated, degasification channel, water and gases are driven off and some pyrolysis occurs as the feedstock approaches the gasification reactor.

By the time the waste reaches the end of the degasification channel, it has reached an elevated temperature of approximately 570°F (300 degrees C). The feedstock is pushed into the reactor. In the high-temperature reactor, waste (in the form of solids and gases) is combined with limited amounts of pure oxygen and natural gas at temperatures as high as 2,200°F (approximately 1,200 degrees C), forming a synthesis gas from the organic components of the waste (i.e., carbon and hydrogen based material, including food waste, yard waste, paper, plastic, rubber, textiles, etc.). The syngas leaves the top of the reactor, upon which it is cooled, cleaned and

Figure 5.5-1. Schematic Diagram of IWT's Thermoselect Technology



combusted to generate electricity. The inorganic components of the waste, which are primarily metals and silica, melt into a molten liquid ("slag") and move by gravity to the bottom of the reactor. The slag is discharged, upon which it is quenched in a water bath to cool the material. The quenching process turns the slag into a granular product, with the metal and silica-based materials granulating separately due to different physical properties associated with cooling. Magnetic separation is then used to separate the metal granules from the sand-like aggregate. The metal granules are typical of an alloy with iron content greater than 80%, and also containing nickel, copper and traces of other heavy metals. The metal and aggregate are marketed as products.

The synthesis gas created in the high-temperature reactor consists of carbon monoxide (32%), hydrogen (32%) and carbon dioxide (27%), along with nitrogen and water. The syngas exits the top of the gasifier, upon which it flows into a water-jet quench. The quench rapidly cools the gas from approximately 2,000°F (approximately 1,090 degrees C) to below 200°F (approximately 90 degrees C) in less than one second ("shock cooling"), which prevents the formation of dioxins, furans and other organic compounds. The quenching process removes metals, dusts, hydrogen chloride (HCl) and hydrogen fluoride (HF). The cooled gas is then cleaned to remove sulfur, heavy metals, industrial salts and other impurities. Cleaning is achieved through a series of scrubbers, in which the syngas interacts with a liquid to remove unwanted compounds. First is an acid scrubber, where water is used to remove additional HCl and HF ("acid gases"). The acid scrubber is followed by an alkaline scrubber, which uses sodium hydroxide (NaOH) in solution to further reduce HCl and HF and to reduce sulfur dioxide (SO_2). These scrubbers result in the formation of salts, which IWT collects as a marketable product. The synthesis gas is then passed through a desulfurization process to remove hydrogen sulfide (H_2S). The desulfurization process generates elemental sulfur, which is collected as a marketable product.

After cleaning, the gas is dried and then combusted to generate electricity. The power generating equipment proposed to be used by IWT consists of a combined cycle gas turbine, which will operate on synthesis gas. Air pollution controls are applied to the exhaust from the gas turbine. Specifically, catalytic air pollution control systems are applied to remove NOx and CO from the exhaust gases. Catalytic control systems have long been demonstrated for gas turbine exhausts where the primary fuel is natural gas, and should perform comparably for engine exhausts where synthesis gas is the primary fuel.

A technical review and evaluation of IWT's Thermoselect technology follows.

5.5.3 Proposed Facility Capacity for the Demonstration Project

As part of the Phase II Study, IWT was requested to designate a capacity for a demonstration facility and for a commercial facility for the project. As shown in Table 5.5-2, IWT proposed three optional facility sizes, consisting of one, two and three modular units.

Table 5.5-2. IWT Facilities Proposed for the Conversion Technology Demonstration Project

IWT	One Unit Facility	Two Unit Facility	Three Unit Facility
Unit Design Capacity: Number of Units: Facility Design Capacity:	312 tpd 1 312 tpd	312 tpd 2 624 tpd	312 tpd 3 936 tpd
Annual Availability:	85.6%	85.6%	85.6%
Annual Throughput:	97,350 tpy	194,700 tpy	292,050 tpy
Avg. Daily Throughput (at 365 days/yr):	267 tpd	533 tpd	800 tpd
Land Area Required:	3.5 acres	5 acres	8 acres

Each modular unit's design rating for the Conversion Technology Demonstration Project is 312 tpd. The largest modular units currently in operation are located at Kurashiki. The Kurashiki modules are 204 tpd. A 1.5:1 module scale-up is required for the demonstration project.

Regarding total plant design capacity, a Conversion Technology Demonstration Project with the two-line plant option (312 x 2) would be on parity (1:1) with the Kurashiki plant (204 x 3). A demonstration plant with the three-line option (312 x 3) would be a 1.5:1 scale-up compared to the Kurashiki plant. The Kurashiki plant is the largest Thermoselect technology plant currently operating. A scale-up of 1.5:1 is considered to be a reasonable level of scaling.

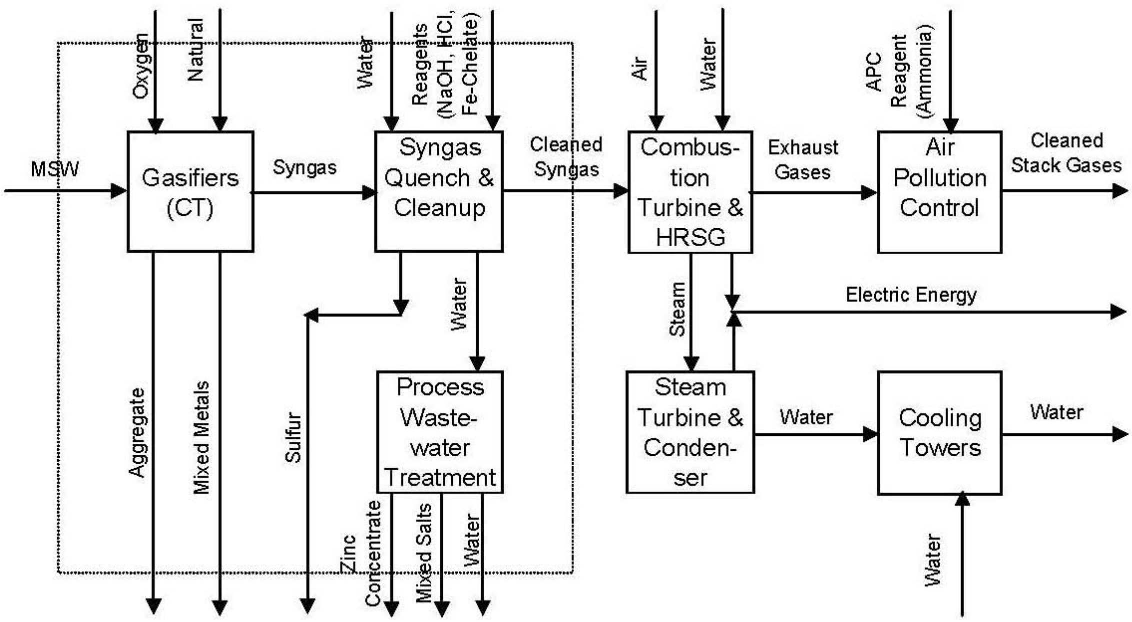
The projected annual throughput statistics for the demonstration plant are consistent with the plant design capacities and the annual availability. Annual availability projected for the Conversion Technology Demonstration Project of 85.6 percent is consistent with historical availability data (waste throughput basis) published for the reference plants (85.5 – 91.6 percent).

5.5.4 Mass Balance

A mass balance provides an accounting of the material inputs to the process and the corresponding outputs from the process. Because mass is conserved, the total amount of mass input should equal the total amount of mass output. To check the fundamental process bases, independent calculations, using data provided by the technology suppliers, were conducted. IWT provided a complete mass balance for the three demonstration plant concepts. Independent calculations were performed for review of the two-line plant data.

For evaluation of the conversion technologies in general, mass balance boundaries were drawn around the primary production process. In the case of IWT's Thermoselect technology, the balance was drawn around the gasification reactor, syngas cleanup system and water treatment system. The combined cycle gas turbine equipment used for power generation was not included in the mass balance. A diagram depicting the balance boundary and the mass inputs and outputs of the process is shown in Figure 5.5-2.

Figure 5.5-2. IWT Process Flow Diagram & Mass Balance Schematic



Note: The dashed line indicates the boundaries of the mass balance verification conducted for the LA County project.

Verification of the IWT mass balance was conducted for the two-line plant (624 TPD). A summary of the results of the verification is presented in Table 5.5-3.

Table 5.5-3. IWT Mass Balance[1]		
Material	**Amount (%)[2]**	**Amount (tpy)**
INPUTS		
MSW	59.7%	194,700
Oxygen	33.4%	108,383
Sodium Hydroxide (NaOH)	3.7%	12,029
Natural Gas	1.8%	5,884
Hydrogen Chloride (HCl)	1.0%	3,102
Iron Chelate	0.4%	1,337
Total	100.0%	325,889
OUTPUTS		
Dry Syngas[3]	58.7%	191,327
Process Water[3]	22.3%	72,594
Aggregate[4]	7.6%	24,824
Mixed Metals[4]	7.6%	24,825
Mixed Industrial Salts	2.0%	6,537
Elemental Sulfur	1.2%	3,835
Zinc Concentrate	0.6%	1,947
Total	100.0%	325,889

(1) For a commercial facility with a throughput of 194,700 tpy.
(2) Percent by weight of total process input or output.
(3) Wet syngas production is the sum of the dry syngas and the process water output, equivalent to 81.0% and 263,921 tpy.
(4) IWT has assumed that the granulate product is 50% aggregate and 50% mixed metals. This is not precisely consistent with the waste characterization used, which would indicate somewhat less metal and more aggregate yield from the granulate.

IWT provided sufficient technical information to enable verification of the mass balance for the gasification process. Measured as process outputs divided by process inputs, IWT's mass balance results in 100% closure.

Specific elements of IWT's mass balance are further discussed below.

5.5.4.1 Waste Characterization Basis. IWT used the waste characterization provided in the RFI. The basis of this waste characterization was limited sampling of municipal solid waste conducted for the City of Los Angeles in their Phase I "Evaluation of Alternative Solid Waste Processing Technologies" (September 2005). In addition to the City of Los Angeles compilation, assumptions based on

U.S. EPA waste component characteristics (ultimate analysis and heating value) were made in the development of the characterization for the RFI.

5.5.4.2 Recyclables. The Thermoselect technology does not include front-end recovery of recyclable materials. All MSW, including large bulky waste, is processed through the gasifier, where it is either converted to a synthesis gas or recovered as a product. Metal that is recovered as a recyclable by certain other technologies is recovered as a product in the Thermoselect technology. Products, including metal, generated in the Thermoselect process are further discussed below.

5.5.4.3 Syngas Production. One product of the IWT process is the syngas, produced by high temperature gasification. The higher heating value of the cleaned syngas produced by the Thermoselect process, using the waste characterization provided in the RFI, is estimated by IWT to be 256 Btu per cubic foot. The estimated syngas production rate was provided by IWT in the mass and energy balance information submitted in response to the RFI. Based on the mass balance the production rate can be estimated to be approximately 2,711 pounds of wet syngas per ton of MSW feedstock. IWT's Thermoselect technology currently intercepts the syngas prior to combustion, for pre-cleaning. Also, in addition to electric generation with the syngas, use of the syngas for manufacture of chemicals is in use at one or more facilities in Japan. In theory, the syngas could also be used to produce other fuels instead of electricity.

5.5.4.4 Marketable Products. The Thermoselect technology generates electricity from the synthesis gas as well as products from all components of MSW that are not converted to a synthesis gas. Aggregate and mixed metals are generated from the melting of inorganic material in the high-temperature reactor. The aggregate is silica-based, and includes encapsulated impurities that are rendered inert. The mixed metals include iron, aluminum and copper. Industrial salts (sodium chloride, sodium fluoride and other minor salts), sulfur, and zinc hydroxide are generated during the cleaning of the synthesis gas and process water.

Table 5.5-4 shows material product outputs for a two-line, 194,700 tpy plant.

Table 5.5-4. IWT Material Products[1]		
Material	**Amount (%)[2]**	**Amount (tpy)**
OUTPUTS		
Aggregate[3]	12.75%	24,824
Mixed Metals[3]	12.75%	24,825
Mixed Industrial Salts	3.36%	6,537
Elemental Sulfur	1.97%	3,835
Zinc Concentrate	1.00%	1,947
Total	31.83%	61,967

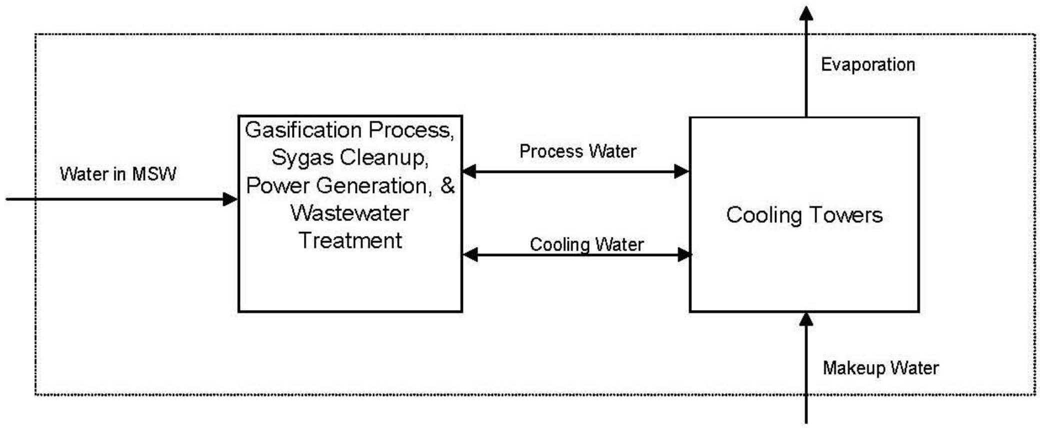
(1) For a commercial facility with a throughput of 194,700 tpy.
(2) Percent by weight of MSW input.
(3) IWT has assumed that the granulate product is 50% aggregate and 50% mixed metals. This is not precisely consistent with the waste characterization used, which would indicate somewhat less metal and more aggregate yield from the granulate.

The total quantity of solid products generated in the Thermoselect process amounts to approximately 19 percent by weight of the total mass input to the plant, or 32 percent by weight of MSW received for processing. If IWT were unable to successfully market these products, the materials would require disposal as hazardous and non-hazardous residues. However, these materials are currently being marketed as products at the operating facilities in Japan, and were marketed at the Karlsruhe reference facility in Germany while that plant was in operation. Based on information provided by IWT and review of the product quality information, it is assumed that IWT would successfully find markets for these products. Based on information provided to IWT regarding the characterization of the waste stream and technical information provided by IWT, the types and quantities of products are reasonable.

5.5.4.5 Residue Requiring Disposal. Based on the assumption that all products can be marketed, which is supported based on performance at existing facilities, the Thermoselect process generates no residue requiring disposal in a landfill.

5.5.4.6 Water Use and Wastewater Treatment and Discharge. A diagram representing input and output streams for a water balance for IWT process approach is shown in Figure 5.5-3.

Figure 5.5-3. IWT Plant-Wide Water Balance



A significant quantity of water is required for makeup to the cooling system. Although there is net water generation by the process when the syngas is dried, additional makeup water is required to counter evaporation from the cooling tower.

Thermoselect facilities are designed for zero wastewater discharge. The technology incorporates a number of conventional water treatment systems to convert process discharges to useable process and/or cooling water. Treatment systems include settling and precipitation to capture and remove solids, which are returned to the high-temperature reactor. Other treatment methods used include neutralization, ion exchange, reverse osmosis, and evaporation.

Water use and losses for a two-line, 194,700 tpy plant are accounted for as shown in Table 5.5-5.

Table 5.5-5. IWT Water Balance[1]

Material	Amount (tph)	Amount (gpd)
INPUTS		
Water from MSW Input	2.7	15,600
Water from Reactions	1.8	10,416
Makeup Water	37.4	215,896
Total	41.9	241,896
OUTPUT		
Cooling Tower Evaporation	41.9	241,896
Total	41.9	241,896

(1) For a commercial facility with a throughput of 194,700 tpy.

IWT notes that this water balance is representative of a nominal design using cooling towers, which may be modified or changed based on site specific conditions. IWT would consider other cooling system designs, including air cooled condensing.

As provided by IWT, the water balance is independently calculated to have 100 percent closure.

5.5.5 Energy Balance

An energy balance provides an accounting of the energy inputs to the process and the corresponding outputs (which can be chemical, mechanical, thermal or electrical) from the process. Because energy is conserved, the total amount of energy input should equal the total amount of energy output. To check the fundamental process bases, independent calculations, using data provided by the technology suppliers, were conducted. IWT provided complete energy balances in the RFI submittal, which allowed independent derivation of balances for the demonstration facility concepts. The data were organized during the independent review into several energy balances.

For the evaluation of the conversion technologies in general, several energy balances for different processes were prepared to aid in the technical evaluation. For IWT's Thermoselect technology, three energy balances were evaluated in order to determine and review expected efficiencies:

- Energy efficiency of the syngas production process;
- Energy efficiency of the power generating equipment; and
- Plant-wide energy efficiency.

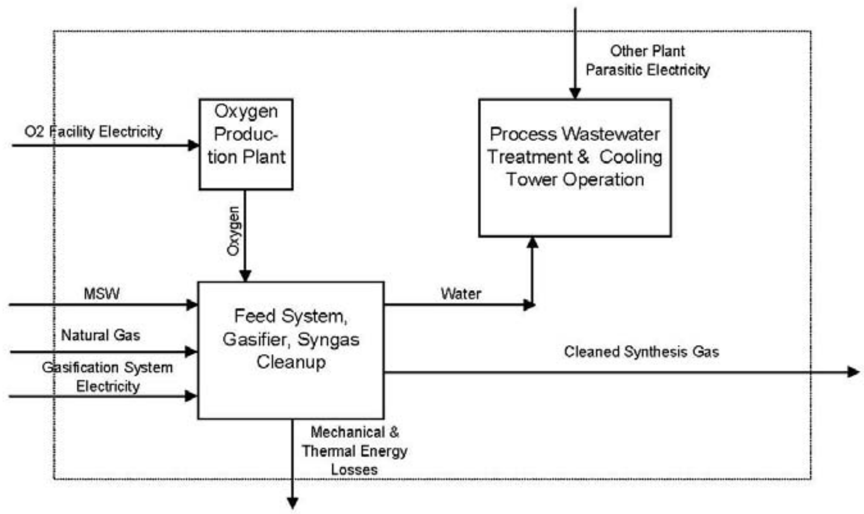
Each balance provides a different perspective of the process and serves a different evaluation purpose. The primary purpose of each evaluation is to estimate an energy conversion efficiency. Such conversion efficiencies can be used comparatively between the technologies and against traditional technologies, to assess reasonableness of the process assumptions. For example, the syngas conversion efficiency can be compared to fuel production efficiency of the different conversion technologies, the power generating equipment efficiency can be compared to similar power generating equipment (i.e., for IWT, combined cycle gas turbines in general), and the net electric generating efficiency of the entire plant can be compared to waste processing technologies in general and to the other conversion technologies.

It is necessary to recognize that electricity production and use is handled in various fashions in the different balances. For the IWT process, the combined cycle gas turbine (CCGT) produces a gross electric output, and the efficiency of the CCGT is evaluated on that basis. Some of the gross output from the engines is used to run the plant, including air separation for production of oxygen and mechanical equipment operation. That electric use is considered to be the "plant parasitic use", because it represents the draw for operation of the plant. For the IWT process, the syngas production efficiency is assessed, including deduction for the plant parasitic use to run the gasification plant. When the plant parasitic use of electricity is subtracted from the gross output of the CCGT, the net plant export of electricity for sale can be derived. For evaluation of plant electric generating efficiency, only net export of electricity is included as an energy product.

The energy balance verifications were conducted for the two-line, 624-tpd (194,700 tpy) commercial facility. ARI was able to duplicate the IWT energy balances by independent calculation and convert the data provided in European units of measure to U.S. units.

5.5.5.1 Syngas Production Efficiency. The efficiency of syngas production can be assessed by comparing energy inputs to the gasification system to the energy of the syngas generated. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify syngas production efficiency, is shown in Figure 5.5-4.

Figure 5.5-4. IWT Energy Balance Schematic for Syngas Production



A summary of the results of the independent calculation of the syngas production energy balance for a two-line IWT plant is shown in Table 5.5-6.

Table 5.5-6. IWT Syngas Production Energy Efficiency(1)

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
MSW Energy Input	3,496	90.8	680,651
Natural Gas	422	10.9	82,085
O2 Facility Electricity	177	4.6	34,365
Gasification System Parasitic Electricity	128	3.3	24,840
Other Plant Parasitic Electricity	120	3.1	23,295
Total	4,343	112.7	845,237
OUTPUTS			
Cleaned Syngas	2,297	59.6	447,165
Gasification System Losses	1,743	45.3	339,362
Total	4,040	104.9	786,527

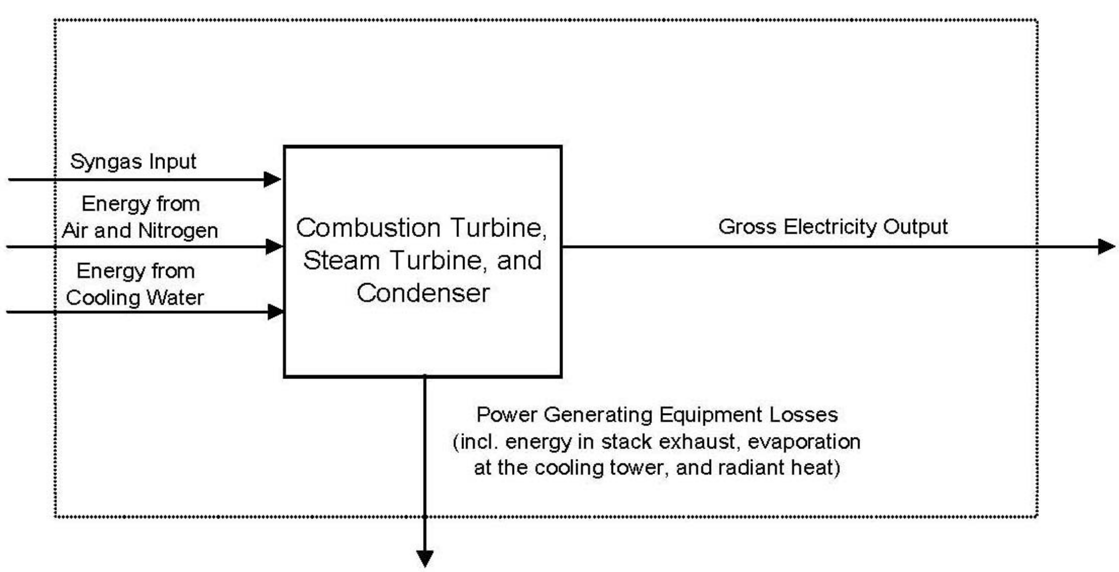
(1) For a commercial facility with a throughput of 194,700 tpy.

Based on information provided by IWT, the gross energy conversion efficiency of the high-temperature gasification reactor is estimated to be 53 percent. This calculated conversion efficiency is based on the energy input provided by the MSW and the natural gas and parasitic electricity use, versus the heat output of the cleaned synthesis gas. The 53 percent energy conversion efficiency is consistent with submittals evaluated previously by ARI for this technology and, compared to fuel production efficiencies for the other technologies evaluated for the Conversion Technology Demonstration Project, appears reasonable.

An analysis of the syngas production energy balance indicates 93 percent closure, on an output over input basis. When parasitic electric load is excluded from the balance, the closure is 103 percent. These closure statistics are satisfactory and indicate that substantially all significant inputs and outputs have been reported by IWT, within the level of detail required for this study.

5.5.5.2 Power Generating Equipment Efficiency. The efficiency of power generation can be assessed by comparing the energy input of the syngas, energy from combustion air and nitrogen, and energy from cooling water, to the gross electric power output of the power generating equipment. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify power generating equipment production efficiency, is shown in Figure 5.5-5. For IWT's demonstration plant offering, the power generating equipment is a combined cycle gas turbine. The CCGT is fueled solely with the cleaned syngas and there is no supplemental fossil input to the equipment planned on a steady-state basis.

Figure 5.5-5. IWT Energy Balance Schematic for Power Generation Equipment



A summary of the results of the verification of the power generating equipment production energy balance for a two-line plant is shown in Table 5.5-7.

Table 5.5-7. IWT Power Generating Equipment Efficiency[1]

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
Cleaned Syngas	2,261	58.7	440,165
Energy from Air/Nitrogen	655	17.0	127,476
Energy From Cooling Water	46	1.2	8,998
Total	2,962	76.9	576,639
OUTPUTS			
Export Electricity	851	22.1	165,718
Plant Parasitic Electricity	424	11.0	82,484
Power Generating Equipment Losses	1,687	43.8	328,437
Total	2,962	76.9	576,639

(1) For a commercial facility with a throughput of 194,700 tpy.

Based on information provided by IWT, the gross energy conversion efficiency of the CCGT is estimated to be 43 percent. This calculated conversion efficiency is based on the energy input provided by the syngas, air, nitrogen and cooling water, versus the gross electricity output (export plus plant parasitic).

The 43 percent energy conversion efficiency is consistent with industry efficiencies for CCTG technology using traditional fossil fuels and other industrial fuel gases. In addition to this independent comparative, IWT reports that they have worked closely with the potential turbine equipment vendors to verify the feasibility of using the Thermoselect process synthesis gas with the equipment with positive results.

Although the syngas heating value looks promising for use with the CCGT technology, consistency of syngas energy value may be a detail that requires further due diligence due to the heterogeneity of the MSW feedstock. If syngas energy value consistency cannot be maintained, it is possible that on-demand, supplemental fossil fuel (i.e., natural gas) might be necessary to sustain continuity of the gas turbine operation during periods of low energy productivity.

As provided by IWT, the power generating equipment energy balance indicates 100 percent closure.

5.5.5.3 Overall Plant Balance. For IWT, the overall energy balance is a measure of net energy (electricity) output compared to all energy inputs for the complete system. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify IWT's overall plant efficiency, is shown in Figure 5.5-6.

Figure 5.5-6. IWT Energy Balance Schematic for Overall Plant

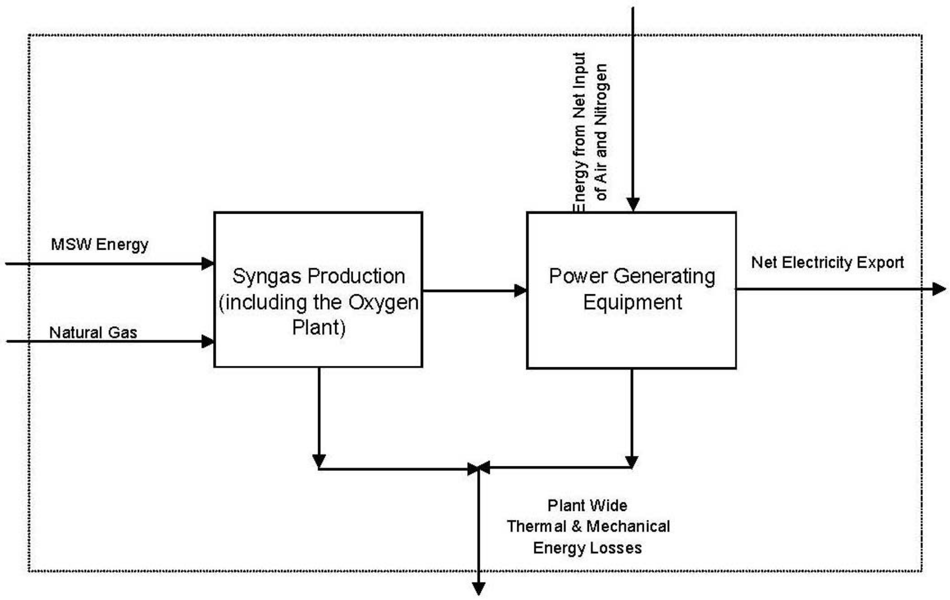


Figure5.5-6. Energy Balance Verification Boundary for Overall Plant Balance

A summary of the results of the independent calculation of the overall plant energy balance for a two-line, 194,700 tpy plant is shown in Table 5.5-8.

Table 5.5-8. IWT Overall Plant Energy Efficiency[1]

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
MSW	3,496	90.8	680,651
Natural Gas	422	10.9	82,085
Net Air & Oxygen	200	5.2	38,940
Total	4,117	106.9	801,677
OUTPUTS			
Export Electricity	851	22.1	165,750
Gasification System Losses	1,693	44.0	329,627
CCGT System Losses	1,687	43.8	328,500
Total	4,232	109.9	823,877

(1) For a commercial facility with a throughput of 194,700 tpy.

Based on information provided by IWT, the net export energy conversion efficiency of the complete plant is estimated to be 21 percent. This calculated conversion efficiency is based on the energy input provided by the syngas, natural gas, net air, and net nitrogen, versus the net electricity output (export only). This energy conversion efficiency is slightly higher than the efficiency achieved with traditional waste-to-energy technology, which generally ranges from approximately 17 to 20 percent (for net electrical output ranging from 500 kWh/ton of MSW to 600 kWh/ton of MSW).

An analysis of the overall plant energy balance indicates 103 percent closure. This closure statistic is satisfactory and indicates that substantially all significant inputs and outputs have been accounted for, within the level of detail required for this study. Likely the lack of 100 percent closure is due to some double counting of losses between the gasification system losses and the CCGT system losses, since the balances for those two subsystems were prepared by IWT separately.

5.5.6 Diversion Potential

IWT's Thermoselect technology offers the highest diversion potential of all the technology suppliers, with a zero residue output, i.e., 100 percent diversion. Based on information gathered on the plant tours, product quality data provided in the RFI response, and on the IWT marketing plans, generation of zero residue output from the process appears feasible. During the plant tours, no incoming waste diversion was observed. There might be hypothetically expected occasions where a particular waste or waste load might be rejected, but with proper waste acceptance management such occurrences can likely be minimized.

5.5.7 Reference Plant Tours

Members of the Subcommittee, DPW staff, and representatives of the ARI team visited two IWT reference plants in Japan, Chiba and Kurashiki, on April 2 and 3, 2007, respectively. Subsequent to the plant visits to the reference plants, the reviewers had the opportunity to meet with regulatory and government officials. Both plants were in full operation during the reviewers' visits. The Chiba plant was processing industrial waste and the Kurashiki plant was processing a mixture of residential, commercial and industrial waste at the time.

The plant visits satisfied several primary objectives, including, inspecting and observing the equipment in operation; confirming the type of waste processed; evaluating the generation and management of products (e.g. aggregate, mixed metals, etc.); and understanding local waste management practices and the regulatory environment for municipal solid waste. Due to the language barrier, some details of interest were not obtained during the Japanese plant tours. For example, real time emissions monitors and control screens were not easily interpreted. Also, some questions were unanswered because of translation difficulties. However, the plant tours in Japan were particularly useful to the project for getting a feel for the scale of the commercial plants and the differences in waste feedstocks relative to Southern California wastes. Key observations and findings relevant to evaluation of the Thermoselect technology and its potential application in Southern California are as follows:

- **Role of Recycling and Relation to the Technology.** The Thermoselect technology can accept raw MSW with little, if any, sorting or processing before hand. This might lead to the conclusion that the technology is not compatible with household recycling and MRF pre-processing. Quite the contrary was found during the site visit. Specifically, there is a elaborate and thorough pre-sorting of wastes prior to disposal in Japan, and a significant amount of recyclable material is collected prior to delivery of the remaining waste to thermal processing plants.

- **Type of Waste, Receiving and Handling Issues.** No front end processing of the MSW feed is practiced at existing and formerly operating facilities for the Thermoselect technology. The size limitation on the waste feed is the cross sectional area of the press feed hopper. The Japanese press feed hopper is 1.7 meters square at its narrowest point (approximately 4.3 feet by 4.3 feet), therefore, large, bulky waste can be accepted. The hydraulic presses are quite powerful and can compress large metal objects.

  At Chiba, high glass content was mentioned as problematic in that it resulted in a stringy product from the homogenizer section of the gasifier, rather than the glassy aggregate that is more readily marketable. However, IWT states that this problem does not occur if the waste stream contains less than 10 percent glass, a level of glass content that is not expected to be encountered with the municipal solid waste or MRF residuals streams.

Waste feed with a high heating value, such as was observed at Chiba, can significantly reduce the throughput capacity of the gasification reactor. In Chiba, MSW feedstock was demonstrated during the first year of operation. Subsequently, that facility is almost exclusively feeding the process with a mixture of waste cardboard and plastics. If this especially calorific feedstock is used and fed at too high a rate, the syngas flow from the reactor achieves a high velocity which entrains and carries over excessive solids which would ordinarily drop out at the bottom, or homogenizer, section of the vessel.

To a large extent, variety of waste characteristics can be made more homogenous by blending with the feed hopper grapple cranes and other mechanisms, as was observed at the Kurashiki plant. Interestingly, at Kurashiki, the plant was accepting not only MSW, industrial waste, and sludges, but also ash from more traditional waste-to-energy plants. Since ash disposal to landfills is prohibited in Japan, ash from the older technology is sent to facilities that have a vitrified product output, such as the Thermoselect facilities.

According to IWT, if significant amounts of wet sludge are to be considered for a project, pre-drying may be required to ensure efficient operation of the gasification reactor.

- **Plant Siting and Location of Products End Users.** Both Chiba and Kurashiki are located in heavy industrial areas. Based on the discussions with the tour hosts, the industrial users of the products such as sulfur, mixed salts, and zinc concentrate seemed to be adjacent to the waste processing facilities. In Southern California, the users of these products might be significantly more distant and scattered.

- **Equipment and Maintenance.** Of the two Japanese plants, Kurashiki was of more recent construction and more similar to an operation that might be constructed in Southern California. The Chiba plant did not have the currently standard technology that the later built plants have, for example, instead of recovering mixed salts, brine was discharged to the ocean.

  Because of the high temperature gasification, maintenance of the refractory in the gasification vessels was reported by the plant operators to be an ongoing and significant process. Therefore, for this technology, scheduled maintenance is relatively higher than for a traditional waste-to-energy plant. However, the basis for the projected availability for a demonstration project appears sound. It is expected that, due to the significant operating experience of this technology, that the maintenance costs would be well defined at this time.

5.5.8 Air Pollution Controls and Emissions

IWT provided air emissions in a concentration based format as part of their RFI response. In order to perform a focused evaluation regarding air emissions from IWT, detailed information was requested in follow-up questions to IWT, specifically regarding mass emission rates of NOx and dioxin to the atmosphere. These pollutants were selected as indicator pollutants for the evaluation process. Other pollutants, such as carbon monoxide, particulate matter and mercury will be of interest during permitting of the conversion technology processes. However, NOx was selected as a key indicator of environmental acceptability because smog is one of the most significant pollution issues in Southern California, and, from combustion sources, NOx is the most significant pollutant that contributes to smog. Dioxin was selected as a key, representative toxic pollutant of concern. Following are the results of the air pollution control and emissions evaluations for the IWT process.

5.5.8.1 NOx Emissions. The source of NOx emissions from IWT's Thermoselect technology is primarily the combined cycle gas turbine, which combusts the cleaned syngas from the pyrolysis/gasification unit. IWT proposed three plant sizes for consideration, and for every plant size, add-on control of NOx via Selective Catalytic Reduction (SCR) was proposed. Application of SCR is likely to be recognized by South Coast Air Quality Management District as Best Available Control Technology (BACT) and/or Lowest Achievable Emission Rate (LAER), depending on the control efficiency of the equipment.

For the 97,350 tpy, one-unit, plant, the controlled NOx emissions are estimated by IWT to be approximately 5 tpy, controlled. Similarly, for the 194,700 tpy, two-unit, plant, the controlled NOx emissions are estimated to be 10 tpy, and for the 292,050 tpy, three-unit, plant, the NOx emissions are estimated to be 15 tpy, controlled. Because emissions from each of the facilities are projected to be greater than 4 tpy, purchase of NOx offsets[1] commensurate with the estimated facility NOx emissions (i.e., 5 tpy, 10 tpy, and 15 tpy) will be required. Four (4) tpy is the South Coast Air Quality Management District's limit for applicability of purchase of NOx offsets.

In summary, purchase of NOx offsets is likely to be required for any of the IWT facility concepts, but add-on air pollution controls are already accounted for in the design of the IWT proposal and therefore, in the facility economics. In the economic sensitivity analysis addressed in Section 8.3.2 of this report, additional project capital cost for IWT's Thermoselect process was assessed to account for the purchase of offsets.

5.5.8.2 Dioxin Emissions. Dioxin emissions have presumably been measured at multiple facilities using the Thermoselect technology. However, emissions have been reported in various units of concentration which are related to specific combustion sources using the syngas generated (boilers, reciprocating engines, etc.). Also, information on dioxin and furan emissions for the Thermoselect facilities have historically all been reported only on an International Toxic Equivalents (ITEQ) basis, since the facilities are all located outside of the U.S. For comparison purposes, results are characterized here as pounds of dioxins and furans per ton of municipal solid waste feedstock (lb/ton MSW). Actual compliance testing at a demonstration facility may involve comparison to concentration based standards.

[1] Although offsets are typically required to be purchased at a rate 10 or 20 percent higher than the actual emission rate, at the precision of estimate used in this study, the required quantity of offsets is assumed to be equivalent to the estimated emissions.

IWT presented test data based on measurement of dioxins and furans in the syngas on an ITEQ basis. The syngas concentration, based on testing at Karlsruhe, Germany, is estimated to be 8.1 x 10^{-14} lb/ton MSW. In comparative units (ITEQ basis), the Federal New Source Performance Standard (NSPS) for large Municipal Waste Combustors (MWC) is estimated to be 1.62 x 10^{-9} lb/ton MSW. Reviewed on this basis, the IWT projected emissions appear to be significantly lower than the Federal requirements for large MWC. South Coast Air Quality Management District (SCAQMD) limits based on air toxics new source review are often more stringent than the Federal NSPS and are established on a case-by-case, site specific basis. Therefore, relative status regarding SCAQMD requirements cannot be established until air permit preparation has been conducted.

5.6 THE NTECH SOLUTION™ (NTech)

The NTech Solution™ integrates three distinct technologies provided by three different technology suppliers. The core technology is the Entech gasifier, which consists primarily of a low temperature gasification unit and syngas fueled boiler. Additional equipment associated with the Entech gasifier includes a dryer for pre-processing, a steam turbine and condenser, and air pollution controls. Pre-processing of the incoming MSW prior to gasification entails use of the Wastec Kinetic Streamer technology for front-end removal of recyclables. Some of the mixed plastics that are removed in the preprocessing step are used as a feedstock for conversion to oil via the Royco technology.

5.6.1 Reference Facilities

NTech Environmental, Ltd. is headquartered in Devon, England, and is the integrator of the three conversion technologies proposed for the Conversion Technology Demonstration Project. Entech headquarters are located in Australia, Wastec headquarters are located in England, and Royco headquarters are located in China. The Entech gasification technology can process a variety of wastes, including MSW and sewage sludge.

The Entech gasification technology has been in use around the world since the first installation of a unit in 1989, and over 100 Entech gasification units have been installed since that time, and more than 20 of these installations are fueled with municipal solid waste. As summarized in Table 5.6-1, NTech Environmental identified two Entech gasifier reference facilities.

Table 5.6-1. Entech Reference Facilities

Name:	Genting Corporation	Centre for Oncology
Location:	Genting, Malaysia	Bydgoszcz, Poland
Design:	67 tpd	3 tpd[(1)]
Capacity:	22,254 tpy	996 tpy[(1)]
Availability:	91%	91%
Type of Waste:	MSW	Clinical & Hospital
Owner:	Genting Corporation	Centre for Oncology
Operator:	Genting Corporation	Centre for Oncology
Commercial Operation:	1998 – present	2005 – present

(1) Medical waste is more calorifically dense than MSW. An equivalent MSW feed rate for this size unit would be 12 – 15 tpd or approximately 4,000 – 5,000 tpy.

Of the two reference facilities, members of the Subcommittee, DPW staff, and representatives of the ARI team visited the Bydgoszcz, Poland facility in March of 2007 and viewed it in operation (see Section 5.6.7). Although more comparable in size and feedstock, the Malaysian reference facility was determined to be difficult logistically to access.

The Wastec Kinetic Streamer technology was developed in 2001 based on mineral ore sorting equipment. One Wastec installation is in commercial operation, as summarized in Table 5.6-2. The single installation of the Wastec system, located in the United Kingdom, was commercially operated but has not been in commercial operation recently, and is currently being optimized. Renewal of continuous operation is planned for 2008.

Table 5.6-2. Wastec Reference Facility

Name:	Seamer Carr Landfill Site
Location:	North Yorkshire, England
Design:	220 tpd
Capacity:	82,500 tpy
Availability:	90%
Type of Waste:	MSW
Owner:	North Yorkshire County Council
Operator:	Wastec
Clean MRF Operation: Dirty MRF Operation:	2001 – 2004 (demonstration) 2005 – present (commercial)

Members of the Subcommittee, DPW staff, and representatives of the ARI team visited the Yorkshire site in March of 2007 and viewed the Wastec Kinetic Streamer technology in operation, as well as ancillary sorting and conveying equipment and a bag splitter (see Section 5.6.7).

The Royco Plastics to Oil technology was scheduled for its third operating facility startup in March 2007 at a North Korean location. Two other facilities have been installed in North Korean and South Korea. Therefore, several Royco installations should currently be in commercial operation, with information regarding the largest and most recently constructed facility summarized in Table 5.6-3.

Table 5.6-3. Royco Reference Facility	
Name:	Royco Asia
Location:	Nampo, DPK Korea
Design:	6 tpd
Capacity:	1,862 tpy
Availability:	85%
Type of Waste:	Mixed Plastics
Owner:	Royco Hong Kong
Operator:	Royco Beijing
Commercial Operation:	March 2007 - present

In addition to the North Korean facility, an Australian installation is under development. The capacity of that installation is planned for 18 tpd. The reviewers did not view a Royco installation during the facility tour phase of the project.
NTech Environmental has not previously integrated the three different technologies.

5.6.2 Description of The NTech Solution™ Processes

The NTech Solution™ consists of four integrated subsystems: (1) a front-end waste sorting technology; (2) a dryer; (3) a gasification system for generation of electricity; and (4) a stand-alone plant for converting plastics to oil. For each of these technologies, a supplier was identified and each supplier supported NTech Environmental in the integration of the systems. The front-end waste sorting system is supplied by Wastec of England, the gasification system is supplied by Entech of Australia, and the plastics to oil processing plant is supplied by Royco. Although instrumental to the integrated process, the dryer is a standard technology to be supplied by a well known vendor and is not discussed in detail here. A diagram showing the layout of the key equipment items is shown in Figure 5.6-1 follows. A generalized process flow diagram showing major process components is shown in Figure 5.6-2.

A description of each of the three key subsystems follows.

5.6.2.1 The Wastec Kinetic Streamer Technology. Wastec supplies a dirty MRF system for receiving black bag waste and sorting recyclables out of the waste. The process is predominately automated rather than operated with hand picking. Wastec has two unique technologies that are instrumental in their waste sorting system: (1) the bag splitter; and (2) the Kinetic Streamers©. The bag splitter does not use rotating blades; it gently rips the bags open using hanging knives without damaging the contents of the bags. Bulky waste that cannot fit through the bag splitter is removed and set aside, as the bag splitter does not accomplish any size reduction.

Figure 5.6-1. Generic Layout of The NTech Solution™

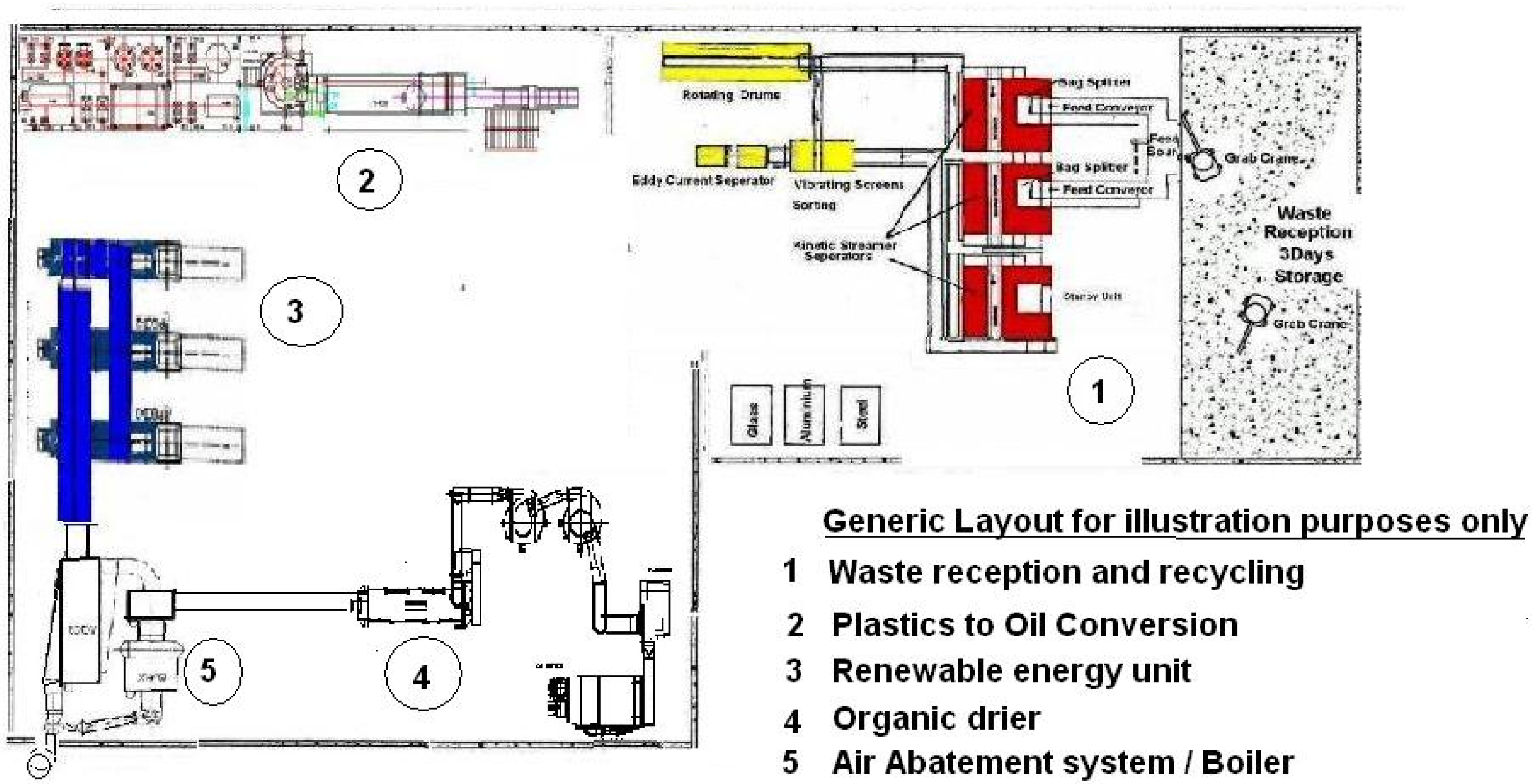
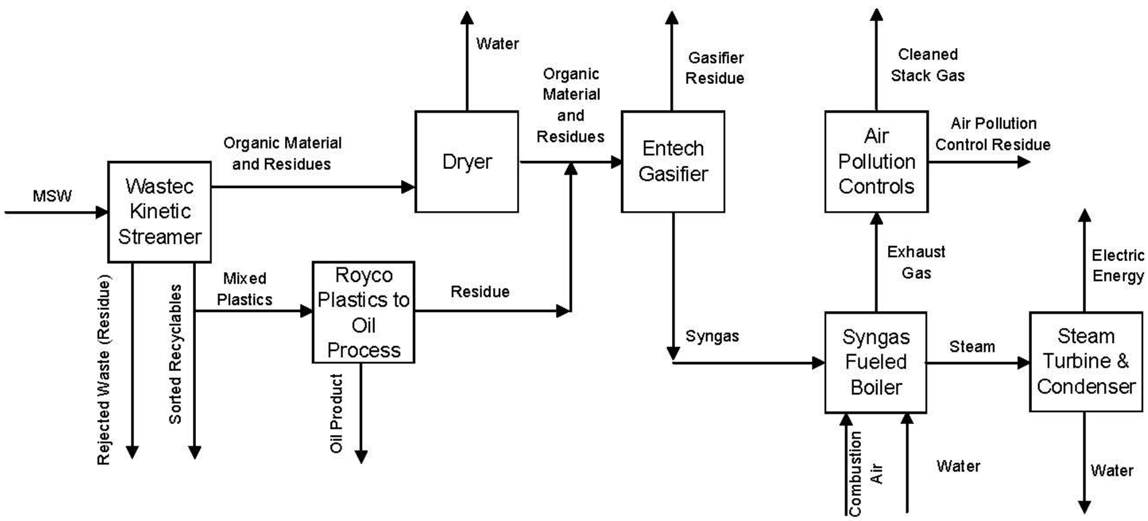


Figure 5.6-2. The NTech Solution™ Generalized Process Flow Diagram



After the bags are opened using the bag splitter, the contents are conveyed to the Kinetic Streamers. The Kinetic Streamers are large mineral ore sorting machines that pass the waste in one of two different directions, depending on shape and density. Stream 1 (the lighter stream) falls forward and consists more prevalently of loose paper and plastics. Stream 2 (the denser stream) falls sideways and more prevalently contains books, glossy magazines, glass, rigid plastic, and metal. Both streams contain organic fines and film plastic.

After the crude sorts performed by the Kinetic Streamers, specialized, traditional mechanical sorting equipment is customized for each of the two streams. The sorting is then finished by a minimal amount of hand picking.

5.6.2.2 The Entech Gasifier. The basic train of gasification equipment consists of a low temperature gasification unit, a syngas fueled boiler, a quench, carbon injection, a fabric filter, and a wet scrubber (in order of gas flow). For the demonstration project, steam generated in the syngas fueled boiler will be used to power a steam turbine for electric generation. For The NTech Solution™ integrated technology, pre-drying of organic fines (food waste) from the waste sorting operation is planned. In addition to the organic fines, other selected wastes recovered from the MSW will be blended and used as feedstock to the gasifier.

In the RFI response, it was stated that the desired operating temperature of the low temperature gasification unit is approximately 1,500 degrees F (600 to 875 degrees C). This is a low temperature gasification process. The operating temperature is modulated and maintained by monitoring and adjusting the feed rate of the waste materials. Sub-stoichiometric air is supplied to the low temperature gasification unit along with the charging of the waste feedstock. Because the air supply is sub-stoichiometric, the process is sometimes referred to as pyrolytic gasification and the primary thermal unit is sometimes termed the pyrolysis unit rather than the gasifier. Here we will use the terminology “low temperature gasification” and gasifier. Because of the introduction of some limited air, the reaction in the gasifier is exothermic, therefore, only oil for startup is required and at steady state operation no supplemental fuel is proposed. The resulting syngas from the low temperature gasifier is high in carbon monoxide (CO), methane (CH_4) and higher hydrocarbons (C_nH_n) but low in hydrogen (H_2) content. In order to utilize almost all of the carbon in the process, the residence time of the gasifier is extended to a long duration. Some feedstock materials that are introduced will be entrained in the gasifier for up to 24 hours.

Following the gasifier, the syngas fueled boiler combusts the syngas. Complete combustion is achieved in the boiler with high excess air supply and elevated temperatures of at approximately 2,000 degrees F (approximately 1,090 degrees C). As proposed by NTech Environmental in the RFI response, there would be no auxiliary or supplemental steady state firing of fossil fuels in the syngas fueled boiler.

5.6.2.3 The Royco Plastics to Oil Process. The Royco plastics to oil technology is proposed as a fully stand-alone process which reportedly generates electricity and thermal energy sufficient to meet its own parasitic needs. Unit processes contained within the Royco offering include reactors, separation and fractionation equipment, cooling and heating systems, and scrubbing systems.

The core technology is reported to be a pyrolytic cracking process using infra-red heating. This process is said to occur in the absence of air at relatively low temperatures ranging from 350 to 450 degrees C (approximately 750 degrees F). The cracking process yields a mixture of hydrocarbons which include non-condensable gases, diesel oil, and some coke (fixed carbon). Some residues are generated and these will be integrated into The NTech Solution™ as a feedstock to the low temperature gasifier.

The actual mix of fuels produced by the Royco process will be dependent on the mixture of plastics feedstocks. Such mixtures may be optimized after installation to yield the most marketable product mix.

A technical review and evaluation of The NTech Solution™ follows.

5.6.3 Proposed Facility Capacity for the Demonstration Project

As part of the Phase II Study, NTech Environmental was requested to designate a capacity for a demonstration facility and for a commercial facility for the project. As summarized in Table 5.6-4, NTech Environmental proposed one system size that integrated the three core technologies.

Table 5.6-4. NTech Environmental Facility Proposed for the Conversion Technology Demonstration Project

The NTech Solution™	Facility Summary	Wastec Kinetic Streamer	Entech Gasifier	Royco Plastics to Oil
Unit Design Capacity: Number of Units: Facility Design Capacity:	NA NA 413 tpd	220 tpd 4 880 tpd	89 tpd 3 267	22 tpd 1 22 tpd
Annual Availability:	91.4%	66%	91.4%	75%
Annual Throughput:	137,790 tpy	137,790 tpy(1)	89,100 tpy	6,693 tpy(2)
Avg. Daily Throughput (at 365 days/yr):	378 tpd	378 tpd	244 tpd	15 tpd
Land Area Required:	Total Facility: 3.5 acres			

(1) Represents 43 percent utilization of the equipment capacity.

(2) Requires utilization of the equipment at 83 percent of capacity.

The primary equipment, the Entech gasifier, requires scaling of 1.3:1 for the demonstration project, relative to the Malaysian reference facility. Such a scale-up is considered within the range of low risk technical feasibility. The front-end Wastec Kinetic Streamer is proposed for the demonstration project at the same scale as is currently in use at the North Yorkshire reference facility (1:1). The Royco plastics to oil technology would require a significant 4:1 scale-up between a Conversion Technology Demonstration Project installation and the currently operating North Korean plant. However, relative to the Australian Royco plant reportedly under construction, only 1.2:1 scale-up would be required.

The overall plant availability for The NTech Solution™ is estimated to be equivalent to the Entech gasifier availability of 91.4 percent. This availability appears to be equivalent to the hourly availability of the Malaysian Entech gasification unit.

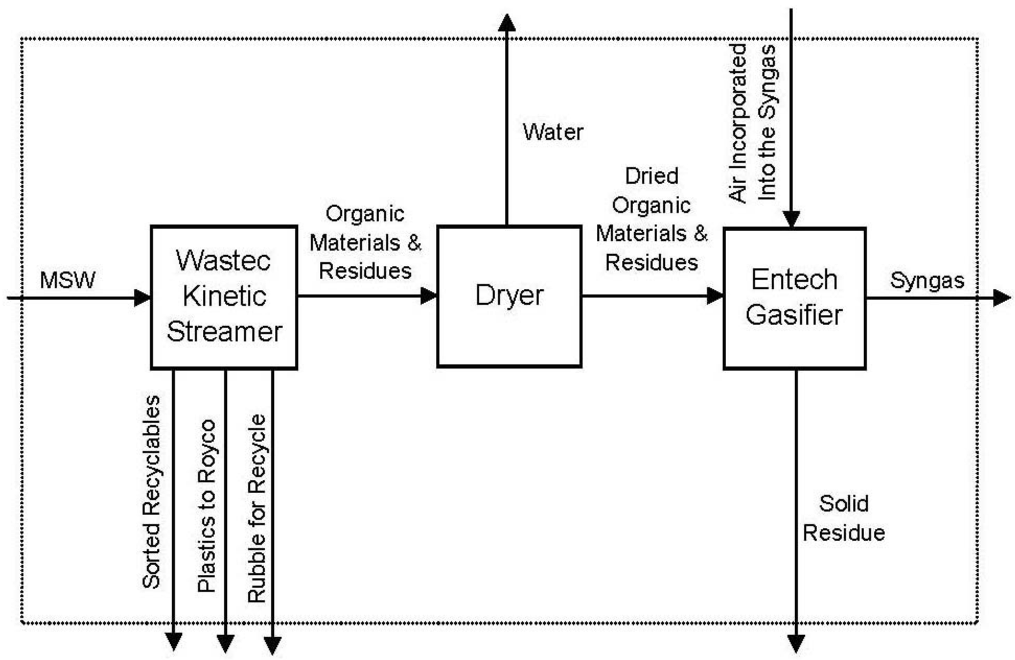
5.6.4 Mass Balance

A mass balance provides an accounting of the material inputs to the process and the corresponding outputs from the process. Because mass is conserved, the total amount of mass input should equal the total amount of mass output. To check the fundamental process bases, independent calculations, using data provided by the technology suppliers, were conducted. NTech Environmental provided a complete mass balance for both the demonstration facility concept. Independent calculations, including solicitation of clarifications and receipt of corrections to the original data, were performed for review of the demonstration plant data.

For evaluation of the conversion technologies in general, mass balance boundaries were drawn around the primary production processes. In the case of The NTech Solution™, the primary mass balance boundary was drawn around the Wastec Kinetic Streamers, the dryer and the Entech gasifier. The Royco plastics to oil technology was considered stand alone and evaluated separately. Verification of the NTech Environmental mass balance was conducted for the only proposed facility size.

5.6.4.1 Primary Processes. The primary processes are considered to include the front-end recyclables collection using the Wastec Kinetic Streamer, the dryer and the gasifier. A diagram depicting the balance boundary for evaluation of the primary processes and the mass inputs and outputs of those processes is shown in Figure 5.6-3.

Figure 5.6-3. Wastec/Entech Mass Balance Schematic



A summary of the independent calculation results of the primary process mass balance is presented in Table 5.6-5.

Table 5.6-5. NTech Mass Balance for Primary Processes(1)

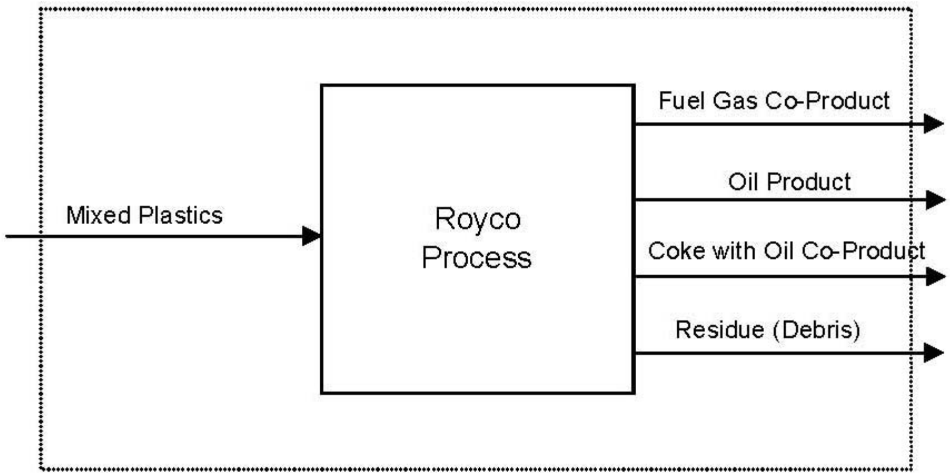
Material	Amount (%)(2)	Amount (tpy)
INPUTS		
MSW	44.3%	137,789
Air Incorporated into Syngas	55.7%	173,479
Total	100.0%	311,268
OUTPUTS		
Syngas	82.4%	281,626
Sorted Recyclables(3)	9.6%	32,990
Plastics to Royco(3)	2.0%	6,693
Rubble for Recycle(4)	2.1%	7,096
Excess Water	2.0%	6,779
Inert Ash & Residue(5)	2.0%	6,717
Total	100.0%	341,901

(1) For a commercial facility with a throughput of 137,789 tpy.
(2) Percent by weight of total process input or output.
(3) The total sorted recyclables output includes the plastics to the Royco process, and therefore sums to 11.6% or 39,683 tpy.
(4) Rubble for recycle is called out as a separate line item here, rather than included with the sorted recyclables, since it is not considered a traditional recyclable product.
(5) Residue is slightly overestimated here because it includes the air quality control residues, which are not strictly within the mass balance boundaries drawn for this analysis.

NTech Environmental provided sufficient technical information to enable verification of the mass balance for the primary production processes. Measured as process outputs divided by process inputs, NTech Environmental's mass balance achieves 110 percent closure. This closure statistic is satisfactory and indicates that substantially all significant inputs and outputs have been accounted for, within the level of detail required for this study.

5.6.4.2 Royco Plastics to Oil Process. The Royco plastics to oil process is a stand alone system. A diagram depicting the balance boundary and the mass inputs and outputs of the plastics to oil process is shown in Figure 5.6-4. A mass balance for this process specific to the demonstration project was not provided, however, results of bench scale studies were provided in the RFI response. An independent mass balance calculation, based on provided bench scale data for conversion of polypropylene to oil, co-products, and residue was developed during the technical review, using engineering assumptions, and is presented here.

Figure 5.6-4. Royco Mass & Energy Balance Schematic



A summary of the results of the Royco process mass balance, as independently estimated, is presented in Table 5.6-6.

Table 5.6-6. NTech Mass Balance for Oil Production(1)

Material	Amount (%)(2)	Amount (tpy)
INPUTS		
Mixed Plastics	100.%	6,693
Total	100.%	6,693
OUTPUTS		
Oil Product	68.%	4,551
Fuel Gas	19.%	1,272
Coke with Oil	11.%	736
Residue (Debris)	2.%	134
Total	100.%	6,693

(1) For a stand-alone unit with throughput of 6,693 tpy.
(2) Percent by weight of plastics input.

NTech Environmental provided enough information regarding the Royco plastics to oil process to estimate a mass balance here. Further information obtained during the operation of the demonstration or commercial scale plants using this technology will provide more reliable information to enable further evaluation of the process and its production capability.

The mass balance shown here closes 100 percent, on an input over output basis. This is because the bench scale data reported, which was used to produce the mass balance here, closed 100 percent.

Specific elements of NTech Environmental's mass balance are further discussed below.

5.6.4.3 Waste Characterization Basis. NTech Environmental considered the waste characterization provided in the RFI and chose a different characterization that they thought was more representative. NTech Environmental chose to use the California Integrated Waste Management Board's statewide characterization of residential waste, as published in 2004. This characterization shows the separate waste stream components, but does not predict the moisture content or heating value associated with the mixture of components. NTech Environmental conducted their own independent analysis of the expected moisture content of the organics content of the MSW that are intended to be fed to the dryer and then the gasifier and used to create the syngas. This analysis was shared in the RFI response. The characteristics of the waste to be fed to the gasifier were calculated by NTech Environmental to contain 14.4 percent moisture and a calorific value of 6,900 Btu per pound (assumed here to be represented as a higher heating value). These characteristics cannot be compared to MSW characteristics used by other technology suppliers evaluated for the project because NTech Environmental selected a blend of specific feedstocks from the incoming MSW. The selected blend is to be achieved through pre-sorting, mixing and drying of waste components.

5.6.4.4 Recovery of Recyclables. The Wastec Kinetic Streamer and associated equipment recovers traditional recyclables from the incoming MSW, supplemented by some hand picking. Materials that are recovered in the process include paper & cardboard, mixed metals, film plastics, rigid plastics and glass. The strength and stability of the secondary materials markets are expected to vary for these recyclables, and NTech Environmental assumed, conservatively, no revenues from these products. The amount of recyclables that are represented to be recovered by the Waste Kinetic Streamer system is shown in Table 5.6-7.

Table 5.6-7. NTech Recyclables Recovery Efficiency(1)

Material	Recovered Amount (%)(2)	Recovered Amount (tpy)	Recovery Efficiency
Cardboard & Paper	11.1%	15,300	50%
Mixed Metals	5.4%	7,440	90%
Film Plastics	3.2%	4,450	95%
Rigid Plastics	5.3%	7,360(3)	88%
Glass	3.7%	5,130	98%
Total / Average	28.7%	39,680	69%

(1) For The NTech Solution™ with a throughput of 137,789 tpy.
(2) Percent by weight of MSW received for processing.
(3) Of NTech Environmental's recovered rigid plastids, 6,693 tpy is to be sent to the plastics to oil process and 748 tpy is to be sold as a recyclable.

NTech Environmental used the CIWMB 2004 waste characterization and estimated recovery efficiencies to arrive at the quantities projected to be recovered. The basis of the recovery efficiencies was not disclosed in the RFI, but is assumed to be founded on Wastec's experience with both the clean and dirty MRF installations of the Kinetic Streamers and associated equipment.

5.6.4.5 Syngas Production. A significant material product of The NTech Solution™ is the syngas, produced by low temperature gasification. Higher heating value of the syngas was reported to be approximately 2,043 Btu per pound. The estimated syngas production rate was provided by NTech Environmental in the mass balance. Based on the mass balance it can be estimated to be approximately 4,088 pounds of syngas per ton of MSW feedstock (MSW on an "as received" basis at the plant gate). Although Entech does not currently intercept the syngas prior to combustion at any of its installations, for pre-cleaning, such an intervention in the process is possible. Also, in addition to electric generation with the syngas, manufacture of fuel products is also possible.

5.6.4.6 Marketable Products. The NTech Solution™ produces three primary products: (1) electricity from syngas; (2) oil from plastics; and (3) traditional recyclables (discussed in Section 5.3 above). The Entech gasifier syngas product is combusted for generation of thermal energy, which is then converted to electricity for both parasitic use and export.

The oil that will be produced, presumably by the thermal depolymerization of the plastics, is expected to be similar in composition to a diesel product. A product specification for the oil was supplied by NTech Environmental, however, that specification does not make a representation of the heating value of the product. The sulfur content of the product was represented in the specification as 50 parts per million. This sulfur content is higher than allowable for use in Southern California, where the limit is 15 parts per million. However, when a more exact specification for the types of plastics to be fed to the Royco process is developed, there may be an opportunity to exclude sulfur containing plastics and reduce the sulfur content of the oil. The oil is intended to be produced for both parasitic use (gasifier startup) and export.

5.6.4.7 Residue Requiring Disposal. NTech Environmental gave a detailed breakdown of the types and quantities of residues generated from The NTech Solution™ integrated technologies. There are three sources of materials that NTech Environmental identified as requiring disposal: (1) lime from air pollution control scrubbing; (2) residue from waste sorting (non-processable waste); and (3) process residue that results from gasification of the debris from the Royco process ("process residue"). The third element "process residue" would appear in the inert ash from the gasifier, and is perhaps inadvertently counted out separately.

In addition to the residues identified by NTech Environmental, there are two process outputs that it is assumed for this evaluation could potentially end up as residue for disposal: (1) inert ash from the gasifier; and (2) rubble and dirt from the front-end waste sorting.

Table 5.6-8 summarizes the various residues which likely will require disposal, and products which could potentially require disposal.

Table 5.6-8. NTech Residues & Potential Residues[(1)]

Material	Amount (%)[(2)]	Amount (tpy)
THE NTECH SOLUTION™ RESIDUES		
Lime from Scrubbing	1.2%	1,670
Residue from MSW Sorting	0.3%	360
Process Residue[(3)]	0.1%	130
Total	1.6%	2,160
PRODUCTS THAT COULD POTENTIALLY BECOME RESIDUES		
Inert Ash from Gasifier	3.3%	4,570
Rubble for Recycle[(4)]	5.1%	7,096
Total	8.4%	11,666

(1) For a commercial facility with a throughput of 137,789 tpy.
(2) Percent by weight of total MSW input.
(3) The process residue appears to represent the inert ash that remains from the disposal of the Royco debris in the gasifier.
(4) Rubble for recycle is said to consist of dirt and inert debris.

5.6.4.8 Water Use and Wastewater Treatment and Discharge. NTech Environmental did not provide a water balance. However, in the RFI response it was stated that a facility would be designed for zero wastewater discharge. Because NTech Environmental did not finalize their plans for heat rejection equipment (i.e., air cooled condensers or cooling towers), a water balance cannot yet be completed.

5.6.5 Energy Balance

An energy balance provides an accounting of the energy inputs to the process and the corresponding outputs (which can be chemical, mechanical, thermal or electrical) from the process. Because energy is conserved, the total amount of energy input should equal the total amount of energy output. To check the fundamental process bases, independent calculations, using data provided by the technology suppliers, were conducted. NTech Environmental provided complete energy balances in the RFI submittal, which allowed independent derivation of balances for the facility concepts. The data were organized during the independent review into several energy balances. ARI was able to duplicate or estimate the NTech Environmental energy balances by independent calculation and convert the data provided in European units of measure to U.S. units.

For the evaluation of the conversion technologies in general, several energy balances for different processes were prepared to aid in the technical evaluation. For NTech Environmental's technologies, four energy balances were evaluated in order to determine and review expected efficiencies:

- Energy efficiency of the syngas production process;
- Energy efficiency of the power generating equipment
- Energy efficiency of the plastics to oil process; and
- Plant-wide energy efficiency.

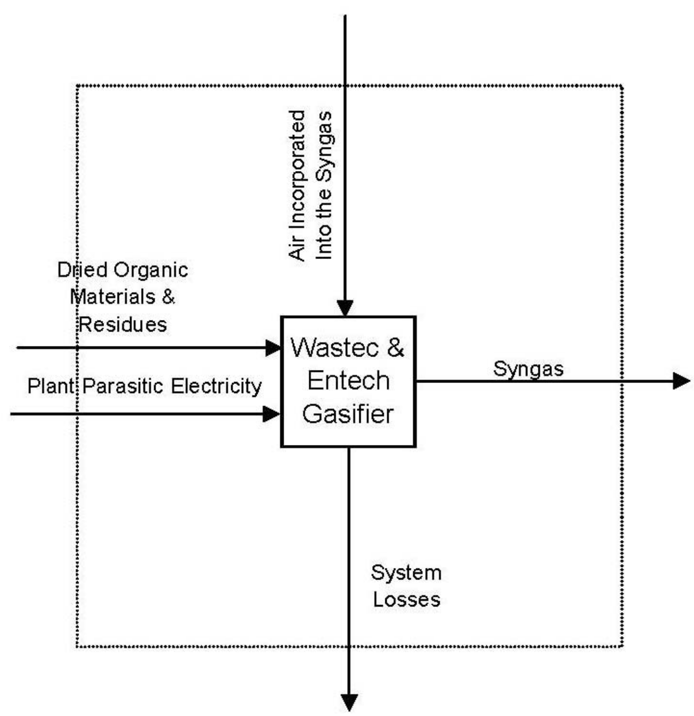
Each balance provides a different perspective of the process and serves a different evaluation purpose. The primary purpose of each evaluation is to estimate an energy conversion efficiency. Such conversion efficiencies can be used comparatively between the technologies and against traditional technologies, to assess reasonableness of the process assumptions. For example, the syngas conversion efficiency can be compared to fuel production efficiency of the different conversion technologies, the power generating equipment efficiency can be compared to similar power generating equipment (i.e., for NTech Environmental, the gasifier, syngas fueled boiler and steam turbine-generator), and the net electric generating efficiency plus the net oil production efficiency of the entire plant can be compared to waste processing technologies in general and to the other conversion technologies.

It is necessary to recognize that electricity production and use is handled in various fashions in the different balances. For the NTech Environmental processes, the combination of the gasifier, syngas fueled boiler and steam turbine produces a gross electric output, and the efficiency of the combination of equipment is evaluated on that basis. Some of the gross output from the system is used to run the entire plant, including operation of the mechanical waste sorting equipment. That electric use is considered to be the “plant parasitic use”, because it represents the draw for operation of the plant. For the NTech Environmental processes, the syngas production efficiency is assessed, including deduction for the plant parasitic use. When the plant parasitic use of electricity is subtracted from the gross output of the power generating system, the net plant export of electricity for sale can be derived. For evaluation of plant electric generating efficiency, only net export of electricity is included as an energy product. Similarly, for evaluation of plant oil generating efficiency, only net oil export is included as an energy product.

For NTech Environmental, all four of the energy balance verifications were conducted for the 137,789 tpy facility size that was proposed.

5.6.5.1 Syngas Production Efficiency. The efficiency of the Wastec/Entech process in generating syngas can be assessed by comparing the energy inputs to the system to the energy of the syngas generated. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify syngas production efficiency, is shown in Figure 5.6-5.

Figure 5.6-5. Wastec/Entech Energy Balance Schematic



A summary of the results of the independent calculation of the syngas production energy balance for the proposed integrated waste sorting and gasification system is shown in Table 5.6-9.

Table 5.6-9. NTech Syngas Production Energy Efficiency(1)

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
MSW Organics	3,445	59.5	474,683
Plant Parasitic Electricity	125	2.2	17,224
Total	3,570	61.7	491,907
OUTPUTS			
Syngas Chemical Energy	2,453	42.4	337,859
Syngas Thermal Energy	993	17.2	136,824
Gasification System Losses	107	1.8	14,743
Total	3,552	61.4	489,427

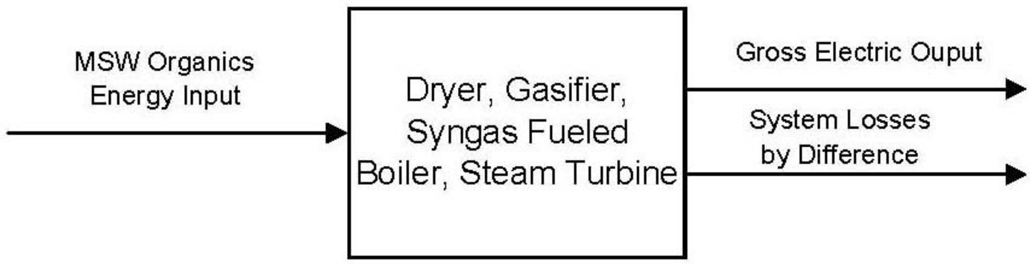
(1) For The NTech Solution™ with a throughput of 137,790 tpy.

Based on information provided by NTech Environmental, the gross conversion efficiency of the Entech gasifier is estimated to be 69 percent. This calculated conversion efficiency is based on the energy input provided by the MSW organics fraction, which is the specialized feedstock to the gasifier, plus the plant parasitic electric use, versus the chemical energy (heating value) of the syngas. The 69 percent energy conversion efficiency is comparable to fuel production efficiencies for the other technologies evaluated for the demonstration project, and therefore appears reasonable.

This energy balance results in 99.5 percent closure, on an output over input basis, when the plant parasitic electricity consumption is accounted for. Without accounting for the plant parasitic electricity consumption, this energy balance closes within 103 percent. These closure statistics are satisfactory and indicate that substantially all significant inputs and outputs have been reported by NTech Environmental, within the level of detail required for this study.

5.6.5.2 Gross Gasifier Electricity Production Efficiency. The efficiency of the Entech gasifier, syngas fueled boiler and steam turbine system in generating gross electric output can be assessed by comparing inputs to the system to the electric output of the equipment. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify gross gasifier electricity production efficiency, is shown in Figure 5.6-6.

Figure 5.6-6. NTech Schematic for Gasifier System Energy Balance



A summary of the results of the independent calculation of the gross electricity production energy balance for the proposed process components (dryer, gasifier, syngas fueled boiler and steam turbine) is shown in Table 5.6-10.

Table 5.6-10. NTech Gasifier Electric Generating Efficiency(1)

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
MSW Organics	3,445	59.5	474,683
Total	3,445	59.5	474,683
OUTPUTS			
Gross Electric Output System Losses by Difference	700 2,745	12.1 47.4	96,456 378,227
Total	3,445	59.5	474,683

(1) For The NTech Solution™ with a throughput of 137,789 tpy.

Based on information provided by NTech Environmental, the gross electric conversion efficiency of the Entech gasifier and associated systems (dryer, syngas fueled boiler and steam turbine) is estimated to be 20 percent. This calculated conversion efficiency is based on the energy input provided by the MSW organics fraction, which is the specialized feedstock to the gasifier, versus the gross electric output.

This energy balance results in 100 percent closure, on an output over input basis, because losses have been calculated by difference here.

5.6.5.3 Plastics to Oil Efficiency. The efficiency of the Royco process for conversion of plastics to oil can be assessed by comparing the heating value of the plastics to the heating value of the oil product output. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify plastics to oil production efficiency, is shown previously in Figure 5.6-4. An energy balance for this process specific to the demonstration project was not provided, however, results of bench scale studies were provided in the RFI response. An energy balance calculation, based on provided bench scale data for conversion of polypropylene to oil, co-products, and residue was developed during the technical review, using engineering assumptions, and is presented here. A summary of the results of the estimation of the oil production energy balance for the proposed integrated facility is shown in Table 5.6-11.

Table 5.6-11. NTech Energy Balance for Oil Production(1)

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
Rigid, Mixed Plastics	7,533	0.68	5,389
Total	7,533	0.68	5,389
OUTPUTS(2)			
Oil Product	5,482	0.49	3,922
Fuel Gas	1,402	0.13	1,004
Coke w/oil	647	0.06	462
Debris	nil	nil	nil
Total	7,532	0.68	5,388

(1) For The NTech Solution™ with a throughput of 137,790 tpy. For the system design, the plastics throughput to the Royco process is estimated to be 6,693 tpy.

(2) The Royco system will likely have additional energy losses, which are not estimated here due to insufficient information in the RFI submittal.

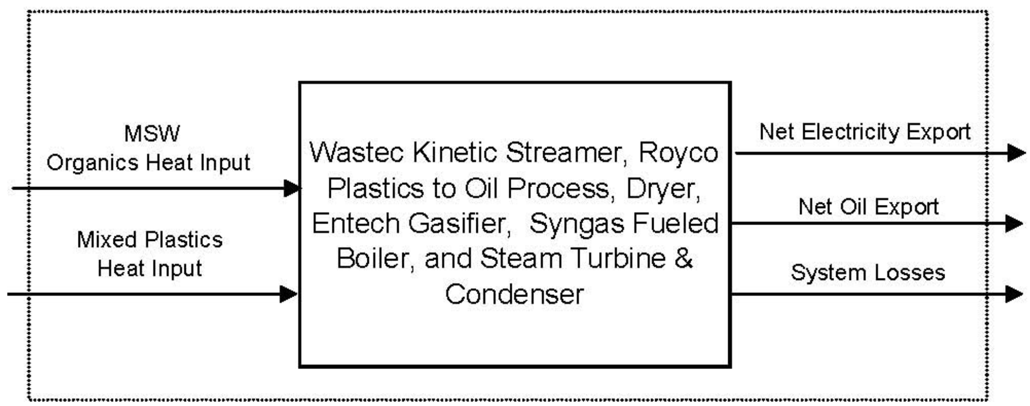
Based on the estimated energy balance shown above, the net energy conversion of the Royco process is estimated to be 73 percent. This calculated conversion efficiency is based on the energy input provided by the plastic feedstocks, versus the oil product intended for both parasitic use and net export. The fuel gas and coke products are assumed here to be utilized internal to the energy generation needs of the Royco process, and therefore are considered to account for system losses.

Based on this energy balance, the annual gross oil output is estimated to be 1.2 million gallons. The plant parasitic requirement has been estimated by NTech Environmental to be approximately 120,000 gallons per year, or 10 percent of the gross estimated here, resulting in a net export potential of 1.1 million gallons. This amounts to a yield of 8.8 gallons per ton of total MSW input to the plant. All of these statistics are based on an assumption made here that the oil density is approximately 7.5 pounds per gallon.

Due to the nature of the calculations conducted to estimate the balance, the balance closes 100 percent.

5.6.5.4 Overall Plant Balance. The overall plant efficiency of The NTech Solution™ is a measure of the net energy output (electricity and oil) compared to all energy inputs to the plant. A diagram depicting the balance boundary, and the energy inputs and outputs assessed to verify The NTech Solution™ overall plant efficiency, is shown in Figure 5.6-7.

Figure 5.6-7. NTech Overall Plant Energy Balance Schematic



A summary of the results of the independent calculation of the overall plant energy balance for the proposed integrated facility is shown in Table 5.6-12.

Table 5.6-12. NTech Overall Plant Energy Efficiency(1)

Energy	kWh/ton MSW	MW	MWh/yr
INPUTS			
MSW Organics Energy	3,445	59.5	474,683
Plastics Energy Input	676	11.7	93,145
Total	4,121	71.2	567,828
OUTPUTS			
Net Export Electricity(2)	573	9.9	78,919
Net Export Oil	492	8.5	67,792
Plant Losses by Difference	3,056	52.8	421,117
Total	4,121	71.2	567,828

(1) For The NTech Solution™ with a throughput of 137,790 tpy.

(2) The original RFI response indicated a net electricity export equivalent to 398 kWh/ton MSW (6.9 MW and 54,840 MWh/yr). The increased export shown in the above table represents a more accurate picture of equipment capability.

Based on information provided in the RFI response by NTech Environmental, the net export electric energy conversion efficiency is estimated to be 12 percent. However, due to the noted revision upward, the net export electric energy conversion efficiency is now estimated to be 17 percent. This calculated conversion efficiency is based on the energy input provided by the MSW organics, versus the net electricity output (export only). Similarly, the net oil export energy conversion efficiency is estimated to be 73 percent. This calculated conversion efficiency is based on the energy input provided by the plastics, versus the net oil output.

The overall plant energy export efficiency is now estimated to be 26 percent (based on the RFI response this statistic was formerly 22 percent), based on the net electricity and oil exports versus the combined energy input of the MSW organics and the plastics that are presented to the Royco process as feedstock.

Because the plant losses are calculated here by difference, the balance shows 100 percent closure.

5.6.6 Diversion Potential

The NTech SolutionTM has a diversion potential of 98 percent, given a prediction of approximately 1.6 percent residue generation by weight relative to incoming MSW. However, if in addition to the residue, two of the products (inert ash and rubble for recycle) cannot be marketed, the diversion potential of this technology would be reduced to

90 percent. The inert ash is predicted to be generated at a rate of 3.3 percent and the rubble for recycle is predicted to be generated at a rate of 5.1 percent (by weight), relative to incoming MSW.

5.6.7 Reference Plant Tours

Two plant reference tours were conducted in conjunction with NTech's technology offerings: one for the Wastec front-end sorting technology and one for the Entech gasification technology. Results of the reference tours, pertaining to the technical analysis, are presented below for each of these technologies. The Royco plastics to oil process was not viewed. Although there was not a reference tour conducted for the Royco technology, it is appropriate here to discuss the implications of not having viewed a demonstration or commercial plant and to discuss possible issues regarding siting of the plant in Southern California.

5.6.7.1 Wastec Kinetic Streamers. Members of the Subcommittee, DPW staff, and representatives of the ARI team visited the Wastec reference facility in North Yorkshire, England on March 7, 2007. During the visit the reviewers had the opportunity to meet with representatives of the landfill site operator that has contracted with Wastec for use of the equipment on site. The Wastec equipment was receiving and processing waste during the reviewers' visit. In addition to seeing the Wastec equipment in operation, the accumulated recyclables from the dirty MRF operation were observed.

The visit satisfied several primary objectives, including: inspecting and observing the equipment in operation; confirming the type of waste processed; evaluating the generation and management of products and residues (i.e., traditional recyclables, organics, and bypass residues); and understanding local management practices and the regulatory environment for municipal solid waste. Key observations and findings relevant to evaluation of the Wastec technology and potential application in Southern California are as follows:

- **Type of Waste, Receiving and Handling Issues.** The Kinetic Streamers are used to pre-sort recyclables, which then are subjected to additional, downstream sorting using various mechanical means and hand sorting. During the facility tour it was observed that a significant amount of material was being rejected at the bag splitter where the waste was being introduced. The rejection was accomplished through operator intervention at this location in the process. The reviewers raised questions regarding the magnitude of rejected materials at the feed end of the system (i.e., at the bag splitter), the speed and efficiency of processing, and noise potential of the equipment. Additional understanding of the type and quantity of waste typically rejected will be important to refinement of a Conversion Technology Demonstration Project installation of the front-end handling equipment.

- **Noise and Safety Issues.** The Kinetic Streamer equipment emits a persistent and periodic, low frequency, impact noise associated with the motion of the equipment. This noise would likely require mitigation should the equipment be located in Southern California, both for reduction of occupational impact and impact on neighbors. Also requiring consideration is addition of safety equipment (i.e., railings and guards) which may be necessary to meet OSHA requirements in the U.S.

- **Equipment and Integration Issues.** The Wastec Kinetic Streamer system is not a stand-alone piece of equipment. Included with the core separation technology are various ancillary separation equipment items, such as trommels, drums, screens, conveyors, magnets, and etc. as described previously. In addition, at the North Yorkshire installation, the Kinetic Streamer equipment is preceded by a "bag splitter" of unique design. The Wastec sorting process had been allocated a small space in which to develop the process. The processing could benefit from a larger footprint.

- **Recovered Recyclables.** The products of the Kinetic Streamer system were observed during the site visit. These products were aluminum, ferrous metal, color sorted glass, film plastic, rigid plastic, organic fines (reportedly 90 percent organics and 10 percent inorganics), and fuel pellets composed primarily of paper. The products observed on site did not appear to contain any significant amount of mis-sorted materials. Due to the mixed residential and commercial (primarily hospitality industry, including restaurants) nature of the incoming waste at York, approximately 30 to 40 percent of the waste stream is recovered as the organic fines.

5.6.7.2 Entech Gasifier. Members of the Subcommittee, DPW staff, and representatives of the ARI team visited the Entech reference facility in Bydgoszcz, Poland on March 9, 2007. During the visit, the reviewers had the opportunity to meet with representatives of the owner and operator of the equipment, which was a hospital. One Entech gasifier was located at the site and was operating during the reference visit.

The visit satisfied several primary objectives, including: inspecting and observing the equipment in operation; review of the differences between the reference plant installation and the planned gasifier installation for the demonstration facility; viewing the type of waste processed at the reference facility and evaluation of the differences in feedstock; evaluation of the generation and management of residues (i.e., inert ash and air pollution control residues).

- **Type of Waste, Receiving and Handling Issues.** The Entech gasifier has been proposed for the project to handle a subset of the incoming MSW feedstock. Specifically, the types of waste that are proposed to dominate the gasifier feed are: food and mixed organic waste, wood, textiles, and green waste. Also in the feed to the gasifier will be paper, cardboard and plastics that escape sorting and removal in the up-front recyclables collection. Of these waste streams, the wetter wastes (food, mixed organic, and green) are planned to be dried prior to introduction to the gasifier. This feedstock is reported to have a heating value of 6,900 Btu per pound, which is more calorific than ordinary mixed MSW (typically 4,500 Btu per pound) and therefore will allow the gasifier to produce more energy more efficiently. However, NTech Environmental emphasizes that the Entech gasifier is flexible and can handle many types of waste, including mixed MSW. Therefore, if the pre-sorting of waste is not selected for the Conversion Technology Demonstration Project, the Entech gasifier can still be used.

During the site visit the type of waste used as a feedstock to the gasifier was hospital and/or clinical waste of high calorific value (approximately 11,000 to 13,000 Btu per pound). For the demonstration project, if the Royco plastics to oil process were not selected, certain plastics could be fed to the gasifier, along with the specialized feedstock noted above. The addition of the plastics to the specialized feedstock with the heating value that is higher than that of MSW would further boost the energy output and efficiency of the gasifier and be more similar to the hospital/clinical waste feedstock.

Based on the ultimate design of the feed system to the gasifier and the opening at the feed end of each unit, there will be size limitations on the waste that can be introduced.

- **Equipment Considerations.** During the tour several items were noted to be different than would be supplied for the demonstration project. Specifically, during the tour NTech Environmental representatives agreed that the feed system and the inert ash conveying systems would need to be modified to accommodate the higher throughputs anticipated for the demonstration project. The reviewers noted that the hood that was exhausted to the roof, which captured smoke that escaped upon opening of the gasifier for waste feed, would need to be replumbed to exhaust into the syngas fueled boiler for control of fugitive emissions.

  One feature that was not proposed for the demonstration project, which is a regulatory requirement in Europe, is a secondary burner in the thermal oxidizer. At all times a modulated burner is firing with natural gas to ensure consistency of elevated temperature in the thermal oxidizer. Parallel to IES, which also fuels a burner with natural gas in the thermal oxidizer for temperature control, similar installation and operation may be required in Southern California for an Entech system. However, the NTech configuration planned for the demonstration project includes a syngas fueled boiler rather than a thermal oxidizer. Although startup use of oil for the gasifier is planned for the demonstration project, there is no provision for added, steady state use of oil or natural gas in the syngas fueled boiler.

  Continuous emissions monitors were installed on the primary exhaust stack and readings were observed during the tour. The facility was observed to be operating within its permitted regulatory limits during the tour.

- **Generation and Management of Residues.** Batch cleanout was the method of collection of the inert ash residue from the gasifier, at the reference plant. The inert ash was observed to be white in color. It is currently disposed of at a landfill, although it was reported to be of sufficient quality for use in the construction industry. According to Entech, the bottom ash has been tested by a third party and is classified as non-hazardous by the pertinent regulatory authority. As opposed to batch collection at the hospital, a continuous collection system would be necessary for the demonstration project.

  Flyash is collected from the baghouse in dedicated drums. The flyash must be directed to a specially controlled landfill, reportedly due to the high pH from the use of lime scrubbing reagent.

5.6.7.3 Royco Plastics to Oil. Because of the reference facility start-up status and the difficulty of travel to North Korea, the Royco process was not observed. There are some disadvantages to the lack of observation of this technology, especially because there is less known about this process than the other aspects of The NTech Solution™. Concerns that could be addressed with observation relate to air pollution from the presumed use of the fuel gas and the coke in the system. The method of use of these fuels and controls applied are unknown at this time.

Limitations on the types of plastics and level of contaminants for the Royco system are not well defined at this time. However, based on observation of the waste sorting in North Yorkshire with the Wastec technology, a plastic feedstock relatively free of contaminants was observed. Unknown at this time is the influence on the sulfur content of the oil product output given specific types of plastics. There is the possibility that removal of specific sulfur containing plastics may allow for production of a lower sulfur oil product.

5.6.8 Air Pollution Control and Emissions

NTech Environmental provided air emissions in a concentration based format as part of their RFI response. In order to perform a focused evaluation regarding air emissions from NTech Environmental, detailed information was requested in follow-up questions to NTech Environmental, specifically regarding mass emission rates of NOx and dioxin to the atmosphere. These pollutants were selected as indicator pollutants for the evaluation process. Other pollutants, such as carbon monoxide, particulate matter and mercury will be of interest during permitting of the conversion technology processes. However, NOx was selected as a key indicator of environmental acceptability because smog is one of the most significant pollution issues in Southern California, and, from combustion sources, NOx is the most significant pollutant that contributes to smog. Dioxin was selected as a key, representative toxic pollutant of concern. Following are the results of the air pollution control and emissions evaluations for the NTech Environmental processes.

5.6.8.1 NOx Emissions. The source of NOx emissions from the NTech Environmental proposed technologies is primarily the boiler, which combusts the syngas from the multiple low temperature gasification units. For the 137,390 tpy plant, three Entech gasifiers, which will be ducted to one boiler, have been proposed for the production of the syngas. The uncontrolled annual NOx emissions from this process configuration are estimated by NTech Environmental to be 93 tpy.

Given the stringency of air permitting in Southern California, and the fact that Best Available Control Technology (BACT) would need to be employed for a project of any size and Lowest Achievable Emission Rate (LAER) would need to be implemented for projects exceeding 10 tpy of NOx, it appears inevitable that stringent add-on controls for NOx would be necessary in order to permit The NTech Solution™. It is assumed here that Selective Catalytic Reduction (SCR) would be required for add-on NOx control, and that the SCR control would have a NOx removal efficiency of up to 90 percent. If such control were employed with the process configuration currently identified, annual facility NOx emissions would be approximately 10 tpy. The 4-tpy threshold is the South Coast Air Quality Management District's limit for applicability of purchase of NOx offsets. Consequently, as configured here, the facility would be required to purchase approximately 10 tpy of NOx offsets.[1]

In summary, NTech Environmental would likely need to both purchase NOx offsets for the demonstration facility and also add air pollution control equipment that is not considered in the proposed design. In the economic sensitivity analyses addressed in Section 8.3.2 of this report, additional project capital cost for the NTech Environmental facility was assessed to account for additional control equipment and also cost of NOx offsets.

5.6.8.2 Dioxin Emissions. Emissions at the Kuznica plant in Poland, which is reportedly fueled with MSW, were measured in terms of International Toxic Equivalents (ITEQ's). Compared here are the results of the stack testing reported by NTech Environmental, with the Federal New Source Performance Standards (NSPS) for Large Municipal Waste Combustors (MWC). For comparison purposes, results are characterized as pounds of dioxins and furans per ton of municipal solid waste feedstock utilized (lb/ton MSW). Actual compliance testing of a demonstration facility may involve comparison to concentration based standards.

On an ITEQ basis, Kuznica test results from April 2004 indicate emissions of 8.8×10^{-11} lb/ton MSW. In comparative units (ITEQ basis), the Federal NSPS for large MWC is estimated to be 1.62×10^{-9} lb/ton MSW. Reviewed on this basis, the Entech gasifier emissions appear to be lower than the Federal requirements for large MWC. South Coast Air Quality Management District (SCAQMD) limits based on air toxics new source review are often more stringent than the Federal NSPS and are established on a case-by-case, site specific basis. Therefore, relative status regarding SCAQMD requirements cannot be established until air permit preparation has been conducted.

[1] Although offsets are typically required to be purchased at a rate 10 or 20 percent higher than the actual emission rate, at the precision of estimate used in this study, the required quantity of offsets is assumed to be equivalent to the estimated emissions.

5.7 COMPARATIVE SUMMARY AND FINDINGS OF TECHNOLOGY EVALUATIONS

Consistent with evaluation criteria established for the Conversion Technology Demonstration Project, and expressed in the RFI, comparative tables have been prepared for the purpose of summarizing the results of the technology reviews. Table 5.7-1 summarizes the technology suppliers and their suggested projects, which are evaluated here comparatively.

Table 5.7-1. Overview of Technology Suppliers

Technology Supplier	Technology Type	Proposed Capacity	Major Products	Diversion Potential[1]
Arrow	Anaerobic Digestion	300 tpd	Biogas (Electricity) Digestate (Compost) Recyclables	87%
Changing World Technologies (CWT)	Thermal Depolymerization	200 tpd	Renewable Diesel Carbon Fuel Metals	90%
International Environmental Solutions (IES)	Pyrolysis	242.5 tpd @ 58.9% moisture 125 tpd @ 20% moisture	Syngas (Electricity)	95%
Interstate Waste Technologies (IWT)	Pyrolysis/ Gasification	312 tpd (1 unit) 624 tpd (2 units) 935 tpd (3 units)	Syngas (Electricity) Mixed Metals Aggregate	100%
NTech Environmental	Gasification	413 tpd	Syngas (Electricity)	98%

(1) Provided markets can be identified for secondary products. See Section 5.7.6 for more detail.

Specific criteria for which comparative reviews are summarized are:

- Readiness and reliability;
- Development of a complete process;
- Processing capability;
- Material balances;
- Energy balances;
- Diversion potential, and
- Generation of marketable products.

More detailed, comparative tables are provided in Appendix C. An overview of the comparative summary is provided below, followed by a summary of key findings from the technology evaluations.

5.7.1 Readiness and Reliability

Readiness of the technology for application in Southern California to process MRF residuals and post-recycled MSW, and reliability of the technology to perform as a system, meeting performance expectations for waste throughput, product output and landfill diversion, can be assessed based on experience with existing or previously operated pilot, demonstration and/or commercial facilities using the technology. Table 5.7-2 summarizes the readiness and reliability of the technologies, based on status of development.

As shown in Table 5.7-2, the Thermoselect technology, provided by IWT, and the Entech gasification technology, provided by NTech Environmental, have substantial commercial plant operating experience overseas for MSW and can be considered conversion technologies that are ready, from a technical experience standpoint, for application in the United States. The Wastec kinetic streamer system, offered by NTech Environmental as part of its project concept, has been operating at commercial scale at a single location in the U.K. The Royco plastics to oil process, also part of NTech Environmental's project concept, has commercial operating experience in North Korea and South Korea. Further development and demonstration of the kinetic streamer system and plastic-to-oil technologies proposed by NTech Environmental may be necessary for successful application in Southern California.

The ArrowBio technology and IES's pyrolysis system have been operating at demonstration facilities for several years and have been demonstrated with MSW. IES's demonstration facility is located in Romoland, California, and has demonstrated the ability to obtain permits from SCAQMD to do so and to process MRF residuals. Arrow and IES are advancing their technologies to commercial application. Arrow has a commercial facility under construction in Australia, and IES has been working collaboratively with Rainbow Disposal Company to develop a project in Southern California.

CWT has one commercial facility in Carthage, MO, which has been operating with non-MSW waste (i.e., turkey renderings) for over two years, and a pilot unit in Philadelphia, PA, which has operated intermittently for testing for the past seven years. CWT has demonstrated the ability to process poultry processing waste, but does not have experience processing MSW or MRF residuals. Further development of CWT's technology for processing MSW and MRF residuals is required for application in Southern California.

Table 5.7-2. Readiness and Reliability of Conversion Technologies

<table>
<tr><th>Commercial
for MSW</th><th>Demonstration/Pilot
for MSW</th><th>Experience with
other Wastes</th></tr>
<tr><td><u>IWT</u>

7 plants in Japan
Largest = 612 tpd (Kurashiki)
Oldest = 8 years (Chiba)</td><td><u>Arrow</u>

1 plant in Israel (100 tpd), operating continuously for more than 3 years

300 tpd commercial plant under construction in Sydney, Australia</td><td rowspan="2"><u>CWT</u>

1 commercial plant in Carthage, MO, processing poultry waste (250 tpd), operating for more than 2 years.

1 pilot unit (7 tpd) in Philadelphia, PA, operating intermittently for testing for past 7 years (including testing for components of MSW).</td></tr>
<tr><td><u>NTech Environmental</u>

over 100 Entech gasifier installations overseas
Largest = 67 tpd (Malaysia)
Oldest = 18 years (Malaysia)

1 Wastec kinetic streamer in UK (220 tpd), operating continuously for 2 years processing MSW(1)

Several Royco plastics to oil processes in operation and startup in North Korea and South Korea (up to 6 tpd), with fourth facility under construction in Australia (18 tpd)</td><td><u>IES</u>

1 plant in Romoland, CA
(50 tpd), operating intermittently for testing for 3 years.

Second demonstration unit
(125 tpd) under construction, for installation in the U.S.</td></tr>
</table>

(1) The Wastec equipment has not been in continuous operation recently, and is currently being optimized. Renewal of continuous operation is planned for 2008.

Each of the technology suppliers has proposed something new and different, relative to previous installations, for a conversion technology demonstration project in Southern California. Table 5.7-3 summarizes and highlights these aspects.

Table 5.7-3. New Aspects Proposed for the Conversion Technology Demonstration Project

Technology Supplier	What's New for the Project
Arrow	Addition of biogas cleanup and air pollution controls for the reciprocating engines. Use of tipping floor. No direct tipping to the water bath.
CWT	Use of MSW as a feedstock.
IES	Use of a twin screw retort rather than a single screw retort. Addition of catalytic air pollution controls.
IWT	Combustion of syngas in a combined cycle combustion turbine (CCGT) has previously been accomplished, but only when the IWT syngas makes a small contribution to the total fuel gas to the CCGT.
NTech Environmental	Combined and integrated installation of the three different technologies proposed: (1) Entech gasifier; (2) Wastec kinetic streamer system; and (3) Royco plastics to oil process.

5.7.2 Development of a Complete Process

The RFI specified development of a complete design concept (i.e., inclusive of pre-processing to obtain a suitable feedstock, conversion, and post-processing or management of products and/or residuals, as appropriate). IWT was the only technology supplier that provided a complete process. The other technology suppliers omitted certain processes or equipment elements, as follows:

- Arrow and NTech Environmental did not include air pollution control technology that would be required to make their processes permittable in Southern California. Required controls are likely feasible, but their inclusion will affect the capital and operating costs of the facilities. An economic sensitivity analysis has been conducted to assess the impact of the associated, additional cost on the projected tipping fee. (See Section 8.3.2.)

- IES and NTech Environmental have not yet identified specific heat rejection equipment (air cooled condensers or cooling towers). Final selection of heat rejection equipment can affect project energy conversion efficiency as well as economics.

- CWT is expected to require further refining of its biodiesel for sulfur removal, which was not included in its project concept. Refining would likely take place off-site. The Carthage, MO, plant includes on-site desulfurization equipment, but the equipment is no longer operated as it is not economical on a small scale. In addition, for CWT's demonstration-scale project, a flare may be required to dispose of non-condensable gas produced by the depolymerization process.

5.7.3 Processing Capability

Each technology supplier has proposed a project concept for a demonstration facility, based on a design capacity optimal for its technology. Processing capability was evaluated on both a ton per day (tpd) basis and a ton per year (tpy) basis, considering experience at reference facilities and the need for unit scale-up. Less scaling is desirable, as it reduces technical risk and cost of plant development. Table 5.7-2 summarizes the processing capability of the technologies based on the scale-up that would be required considering the reference facility unit size, and the availability that would be required to achieve the projected annual waste throughput.

As shown in Table 5.7-4, no modular unit scaling is required for the ArrowBio technology and for the Wastec kinetic streamer systems (supplied by NTech Environmental), for development of a demonstration facility for the project. Little scaling is required for the IWT gasifier vessels (1.5:1) and for the Entech gasifiers to be provided by NTech Environmental (1.3:1). A moderate amount of scaling is proposed by IES (2.5:1) and there will be a change of feed system design from single screw to twin screw operation, which involves a larger degree of technical risk. Significant scaling (4:1) is required for the Royco plastics to oil technology (supplied by NTech Environmental), compared to the sole reference plant. The CWT proposal for the project appears to require no scaling compared to the Carthage, MO plant. However, such a comparison may not be appropriate due to the nature of the feedstock. The Carthage plant has never processed MSW, and further demonstration of the ability of the technology to process MSW is required. If this testing were performed at the 7-tpd pilot facility in Philadelphia, a large degree of scaling would be required (30:1) for the proposed demonstration facility.

Table 5.7-4. Processing Capability

Technology Supplier	Unit Scale-up Required	Proposed Facility Availability(1)
Arrow	1:1 (Israel, Australia)	93%
CWT	1:1 (Carthage, MO) 30:1 (Philadelphia pilot plant)	70%
IES	2.5:1 (Romoland, CA)	90%
IWT	1.5:1 (Kurashiki, Japan)	85.6%
NTech Environmental Entech Gasifier Wastec Kinetic Streamer Royco Plastics to Oil	1.3:1 (Malaysia) 1:1 (York) 4:1 (North Korea)	91.4%

(1) Based on historical reference plant availability for CWT, IWT and the Entech Gasifier. In the cases of Arrow and IES, engineering estimates are the basis of the proposed facility availability.

The estimates of annual availability, provided by the technology suppliers and summarized in Table 5.7-2, represent the technology-specific availability that is required to achieve the projected annual waste throughput for the proposed projects. The availabilities are based on engineering analyses and operating experience at the reference facilities, and are considered generally reasonable for conceptual project planning, with the following conditions:

- There is some uncertainty that CWT's operating experience at the Carthage facility regarding annual availability can be directly applied to a facility that would process MSW, since CWT does not have experience in processing this waste stream.
- There is some uncertainty of IES's ability to achieve its stated availability, since its experience with continuous operation of the demonstration plant equipment is limited. There is also the need to accommodate the uncertainty of converting from a single to a new twin screw unit.
- For the Royco plastics to oil equipment (supplied by NTech Environmental), an apparent discrepancy has been identified. Although the stated availability of this equipment is represented as 75 percent, the annual throughput proposed for the project requires 83 percent availability. The consequence of a lower actual availability would be reduced oil production with commensurate economic impact, which has been addressed in this study in the economic sensitivity analysis (see Section 8.3.3).

5.7.4 Material Balances

Material (mass) balances were independently calculated for each of the technologies, and reviewed in terms of technology performance claims regarding conversion efficiency, energy generation, type and quantity of products generated, and diversion potential. The mass balances also quantify inputs to the process, including MSW (i.e., post-recycled, municipal solid waste and MRF residuals), other types of waste, supplemental fuel, and other materials, as applicable. The mass balances for all of the technology suppliers were verified through independent calculations. Comparative highlights of the mass balances are as follows:

- Arrow and IES are the only two technology suppliers that have processes for which the only significant input appears to be MSW. IWT and NTech Environmental use substantial inputs of either oxygen (IWT) or air (NTech Environmental). For these two technologies, the oxygen, or oxygen content of the air, become substantial components of the syngas. For CWT, municipal solid waste is only 45 percent (by weight) of the total mass inputs. CWT's mass balance also includes auto shredder residue, used oil, and fats, oils and grease as waste inputs to its process.

- Only two technology suppliers, Arrow and NTech Environmental, integrated recovery of recyclables into the front-end of their process. Arrow anticipates an average collection efficiency of recyclables of approximately 87 percent and NTech Environmental estimates an average of 69 percent. Both technology suppliers assume that approximately 40 percent of the incoming waste contains traditional recyclables.

5.7.5 Energy Balances

Energy balances were independently calculated for each of the technologies, to assess conversion efficiency, energy efficiency of the power generating equipment (as applicable), and plant-wide energy efficiency.

Table 5.7-5 summarizes conversion efficiency of waste feedstock to the intermediate energy products (e.g., biogas, syngas, steam, biodiesel). As shown in the table, conversion efficiencies range from 53 to 87 percent.

Table 5.7-5. Summary of Energy Efficiency of Intermediate Energy Products Generation

Technology Supplier	Conversion Process	Conversion Efficiency
Arrow	MSW organics to biogas	60%(1)
CWT	Waste feedstocks to renewable diesel and carbon fuel	87%(2)
IES	MSW to gross steam output	72%(3)
IWT	MSW to syngas	53%(4)
NTech Environmental	MSW organics to syngas Plastics to oil	69%(1) 73%(5)

(1) Energy conversion efficiency relative to the prepared feedstock to the process (i.e., MSW organics), with recyclables removed.
(2) Energy conversion efficiency relative to multiple waste feedstocks (MSW, auto shredder residue, waste oil, fats, oils and greases).
(3) IES did not provide a material and energy balance that would allow assessment of the conversion efficiency of MRF residuals to syngas. However in the proforma and project description there was enough information to estimate the efficiency of gross steam generation from the MRF residuals.
(4) Energy conversion efficiency relative to municipal solid waste as received.
(5) Energy conversion efficiency relative to the energy value of the plastics feedstock.

In addition to the energy products from the conversion processes noted in the above table, useful thermal energy (waste heat) will be available from the technologies that produce electricity (Arrow, IES, IWT and NTech Environmental). In fact, Arrow identified the amount of useful thermal energy available from their process (see Table T-7 in Appendix C). For the next step of the Phase II process, it would be desirable for the technology suppliers and MRF sites to collaborate to identify on-site uses for waste heat. Use of excess thermal energy can beneficially increase the overall energy efficiency of the technologies.

Table 5.7-6 summarizes energy efficiency of the power generating equipment. The energy efficiency statistics are within expected industry standards.

Table 5.7-6. Summary of Energy Efficiency of Gross Electricity Generation

Technology Supplier	Conversion Process	Conversion Efficiency
Arrow	Reciprocating engines	39%
CWT	Not applicable(1)	--
IES	Heat recovery steam boiler and steam turbine	Not provided(2)
IWT	Combined cycle combustion turbine	43%
NTech Environmental	Syngas fueled steam boiler and steam turbine	20%

(1) CWT generates renewable diesel and carbon fuel, which are proposed for off-site use (i.e., no power generation on-site with generated fuels). Depending on the ultimate use of the renewable diesel and/or carbon fuel, conversion efficiency can range from 33% (use in some engines) to 80% (use for heating).
(2) Gross electric generating rate was not provided, therefore, the power generating efficiency cannot be estimated.

Table 5.7-7 gives an overview of the plant-wide energy balances for all five of the proposed technologies. The overall plant energy efficiency for CWT is higher than the other conversion technologies, because the fuel products are used off-site.

Table 5.7-7. Overall Net Plant Electric Generating Efficiency

Technology Supplier	Conversion Process	Conversion Efficiency
Arrow	Electricity: 253 kWh/ton	19%(2)
CWT	Not applicable(1)	--
IES	Electricity: 489 kWh/ton	16%(3)
IWT	Electricity: 851 kWh/ton	21%(4)
NTech Environmental	Electricity: 573 kWh/ton	17%(2)

(1) CWT does not use its renewable diesel and carbon fuel products for on-site generation of electricity.

(2) Energy efficiency relative to prepared feedstock material that has some materials (recyclables) with energy value removed.

(3) Energy efficiency relative to MRF residuals feedstock.
(4) Energy efficiency relative to municipal solid waste feedstock.

5.7.6 Diversion Potential

Diversion potential represents the amount of waste that would be diverted from landfill disposal as a result of the conversion of that waste to energy and marketable products. The goal of the project is to achieve significant diversion from landfill disposal when processing MRF residue or post-recycled municipal solid waste. As shown in Table 5.7-8, diversion potential of the five technologies ranges from 87 to 100 percent.

Table 5.7-8. Diversion Potential

Technology Supplier	Estimated Diversion Rate(1), (2)	Reduced Diversion Rate(3)
Arrow	87%	70%(4)
CWT	90%	--
IES	95%	--
IWT	100%	--
NTech Environmental	98%	90%(5)

(1) Percent by weight of waste received for processing.
(2) Assumes stable markets are found for all products.
(3) Assumes specifically named products that are judged here to have less stable or well established markets must be disposed.
(4) If the digestate (compost) cannot be marketed, the diversion rate would be reduced.
(5) If the inert ash and rubble cannot be marketed, the diversion rate would be reduced.

As discussed in Section 5.2, there is uncertainty about the ability of Arrow to market the digestate (compost) generated in its process. If that material were to require landfill disposal, Arrow's diversion potential would be reduced to approximately 70%.

As discussed in Section 5.6, NTech Environmental produces an inert ash that is proposed for use as a building material or road aggregate. Also, in its front-end sorting process, NTech Environmental recovers and plans to recycle rubble material (e.g., stones, dirt, etc.). If the ash and rubble from NTech's process cannot be marketed and requires landfill disposal, NTech Environmental's diversion potential would be reduced to approximately 90%. As discussed in Section 5.5, IWT generates numerous products, including a vitrified (glassy) aggregate. The aggregate is being marketed at the reference facilities, and is expected to be sold locally to a ready mix concrete company. If IWT were unable to market this aggregate, the diversion potential would be reduced to approximately 87%. This is unlikely, however, and IWT has stated it would be willing to guarantee the generation of marketable products.

5.7.7 Generation of Marketable Products

Marketable products include energy products (electricity, renewable diesel, and oil), front-end (traditional) recyclables, and other material products (compost, sand, industrial feedstocks). Table 5.7-9 summarizes the types and quantities of products generated by the conversion technologies. The table shows that significant quantities of energy, recyclables and material products may be recovered by the five conversion technologies.

Table 5.7-9. Generation of Marketable Products

Technology Supplier	Primary Energy Products	Secondary Recyclables/ Material Products
Arrow	Biogas to Electricity (253 kWh/ton MSW, net)	Sorted Recyclables (18%) Compost (17%)
CWT	Bio-diesel (98 gallons/ton waste)	Carbon Fuel (18%) Recyclable Metals (10%)
IES	Syngas to Electricity (489 kWh/ton MSW, net)	None
IWT	Syngas to Electricity (851 kWh/ton MSW, net)	Recyclable Metals (13%) Glassy Aggregate (13%) Mixed Industrial Salts (3%) Sulfur (2%) Zinc Hydroxide (1%)
NTech Environmental	Syngas to Electricity (573 kWh/ton MSW, net) Plastic to oil (8.8 gallons/ton MSW)	Sorted Recyclables (29%) Inert Ash (3%)

5.7.8 Summary of Key Findings for Technology Evaluations

Based on the technology evaluations completed for the five, participating technology suppliers, key findings regarding the capabilities of the conversion technologies are as follows:

- Four of the five technology suppliers have demonstrated their conversion technologies with MSW (Arrow, IES, IWT and NTech Environmental). While the level of demonstration varies (i.e., from demonstration testing to commercial operation), and recognizing some ancillary project components require further conceptual development and refinement, these four conversion technologies are "ready" for application as part of a conversion technology demonstration project in Southern California processing MRF residuals and post-recycled, municipal solid waste. It should be recognized that specific waste characteristics, waste receiving and separation requirements, specific regulatory requirements, and specific product markets will need to be considered in any such application.

- CWT has demonstrated its technology with agricultural waste, including development and operation of a commercial facility in Missouri processing poultry waste, but has not demonstrated its technology with MSW. Further development of CWT's technology for processing MSW (and, specifically, MRF residuals and post-recycled municipal solid waste), is required for application in Southern California as part of the conversion technology demonstration facility.

- The conversion technologies have the capability of achieving significant diversion of MRF residue and municipal solid waste from landfill disposal, as a result of the conversion of waste to energy and other products. The expected diversion ranges from 87 to 100 percent. Two of the conversion technologies (Arrow and NTech Environmental) generate products that may be difficult to market. If those products require landfill disposal, Arrow's diversion potential would be reduced from 87 to 70 percent, and NTech's diversion potential would be reduced from 98 to 90 percent.

- The conversion technologies have the capability of converting waste into intermediate energy products (e.g., biogas, syngas, steam, biodiesel), at efficiencies ranging from 53 to 87 percent. The technologies that subsequently use the fuel products on-site to generate power have overall plant energy efficiencies ranging from 16 to 26 percent. The fuel product, or the resulting power generated on-site from such fuel, is considered the primary product of each conversion technology. On-site power generation is currently the proposed alternative due to strong market demand for electricity, particularly from renewable energy sources.

- The conversion technologies have the capability of generating secondary material products (compost, sand, industrial feedstocks), and two of the conversion technology suppliers (Arrow, NTech Environmental) have proposed project concepts that would specifically recover traditional recyclables ahead of the conversion process. Sustained product markets for certain of these materials are not demonstrated.

- Capture of intermediate gaseous and liquid products (i.e., biogas, syngas, renewable diesel, carbon fuel, oil from plastics), as well as generation of other material products, is possible for all of the conversion technologies evaluated. In the future, refining, chemicals production, and/or wholesale fuels production may be conducted using municipal solid waste and MRF residuals as feedstocks. Therefore, by design, all of the five technologies qualify as conversion technologies, as opposed to incineration.

- The technologies are expected to be permittable in Southern California, meeting all environmental standards. Appropriate air pollution controls will be required. The fuel gas (e.g., biogas, syngas) can be collected and cleaned prior to use for power generation, as necessary for permitting. Purchase of NOx offsets are expected to be required for many of the technologies, even with the application of NOx controls. When compared to landfilling, the conversion technologies will significantly reduce greenhouse gas emissions.

SECTION 6
MRF EVALUATION

6.1 INTRODUCTION

As part of this project, Los Angeles County has pursued integration of a conversion technology facility at a MRF/TS site in order to further divert residual waste from landfilling and to take advantage of a number of beneficial synergies associated with co-location. Compared to development at a "Greenfield" site, the advantages of co-location of a conversion technology facility at an existing, fully-permitted, fully-operational MRF/TS include:

- Existing permits (i.e., for land use, stormwater, wastewater, solid waste facility and others);
- Available land within or adjacent to the MRF's permitted footprint;
- Experienced owner/operators skilled in project development, finance, public and government relations, engineering and other disciplines;
- Waste supply, and MRF processing capability for feedstock preparation, as necessary;
- Existing traffic patterns;
- Possible product end use (energy, compost, etc.); and,
- Existing relationships with the regulatory agencies.

The County's Phase I study recommended six MRF/TS facilities as preferred locations for development of a conversion technology demonstration facility:

1st Priority
- Del Norte Regional Recycling and Transfer Station (Del Norte)
- Robert A. Nelson Transfer Station and MRF (R.A.N.)
- Perris MRF/TS (Perris)

2nd Priority
- Central Los Angeles Recycling Center and Transfer Station (CLARTS)
- Community Recycling/Resource Recovery, Inc. (Community)
- Proposed Santa Clarita MRF/TS

These six sites were retained as candidate sites for the Phase II evaluation. The purpose of the Phase II evaluation was to refine and enhance the evaluation of MRFs conducted in Phase I by providing a detailed analysis of the six MRFs previously selected in regards to their potential to host a conversion technology demonstration facility.

During the early stages of the Phase II project, two of the original MRF/TS facilities dropped out. CLARTS is being reserved for an ongoing conversion technology project sponsored by the City of Los Angeles. Because CLARTS will likely be a site for a City-sponsored facility in the future, it was taken off the list for this project. Santa Clarita was a proposed MRF/TS by Burrtec. Burrtec withdrew the site from consideration due to uncertainty regarding the approval of the entire industrial development of which the MRF/TS was included. Burrtec has since discontinued development activities at that site, and instead is pursuing another site in the Santa Clarita area. Burrtec continues to express a strong interest in participating in a conversion technology project, including a future project with Los Angeles County. This new site could be a potential, future host for a conversion technology facility as part of the next phase of the County's project development activities (i.e., Phase III).

During the latter stage of Phase II, the Rainbow Disposal MRF in Huntington Beach was added as a potential site for development of a conversion technology project, specifically because of their extensive work and developing relationship with IES, one of the technology suppliers. The Rainbow Disposal MRF was evaluated under this project exclusively in partnership with IES, and has confirmed that its interest is to partner only with IES for this project.

The final MRF/TS sites evaluated for Phase II are listed alphabetically in Table 6.1-1.

Table 6.1-1. MRF/TS Sites Evaluated in Phase II

MRF/TS Facility	Location
Community Recycling/Resource Recovery Inc.	Los Angeles County (Los Angeles)
Del Norte Regional Recycling and Transfer Station	Ventura County (Oxnard)
Perris MRF/Transfer Station	Riverside County (Perris)
Rainbow Disposal Company, Inc. MRF(1)	Orange County (Huntington Beach)
Robert A. Nelson Transfer Station and MRF	Riverside County (Unincorporated)

(1) The Rainbow Disposal MRF was evaluated under this project exclusively in partnership with IES.

6.2 MRF/TS LOCATIONS, SITE LAYOUTS AND KEY CHARACTERISTICS

Figure 6.2-1 shows the relative locations of each of the five candidate sites. The County of Los Angeles is outlined in blue. As shown on the figure, the five sites are distributed across the greater Los Angeles area with one in the City of Oxnard (Ventura County), one in the City of Los Angeles (Los Angeles County), one in the City of Huntington Beach (Orange County), one in the City of Perris (Riverside County), and one near the City of Riverside in an unincorporated area (Riverside County).

Figures 6.2-2 through 6.2-6 are Google Earth™ images for each MRF/TS site. The images show the layout of structures and roadways, the boundaries of the facilities (shown in yellow) and most importantly, the designated areas available for development of a conversion technology facility (shown in pink). Site acreage as well as acreage available for a conversion technology facility are indicated below each figure.

All five facilities are major regional MRF/TSs processing over 1,000 tpd and permitted to receive much more. They all have or in the case of Perris, soon will have, substantial material processing capability with various wastestreams. All can customize feedstock for a particular conversion technology, as necessary.

Table 6.2-1 provides general information on each of the MRF/TSs and key characteristics related to conversion technology development.

Figure 6.2-1
Map of MRF Locations

Figure 6.2-2

Community Recycling Site and Facilities

Total site area (shown in yellow): 5 acres
Area available for development (shown in pink): 1.5 acres

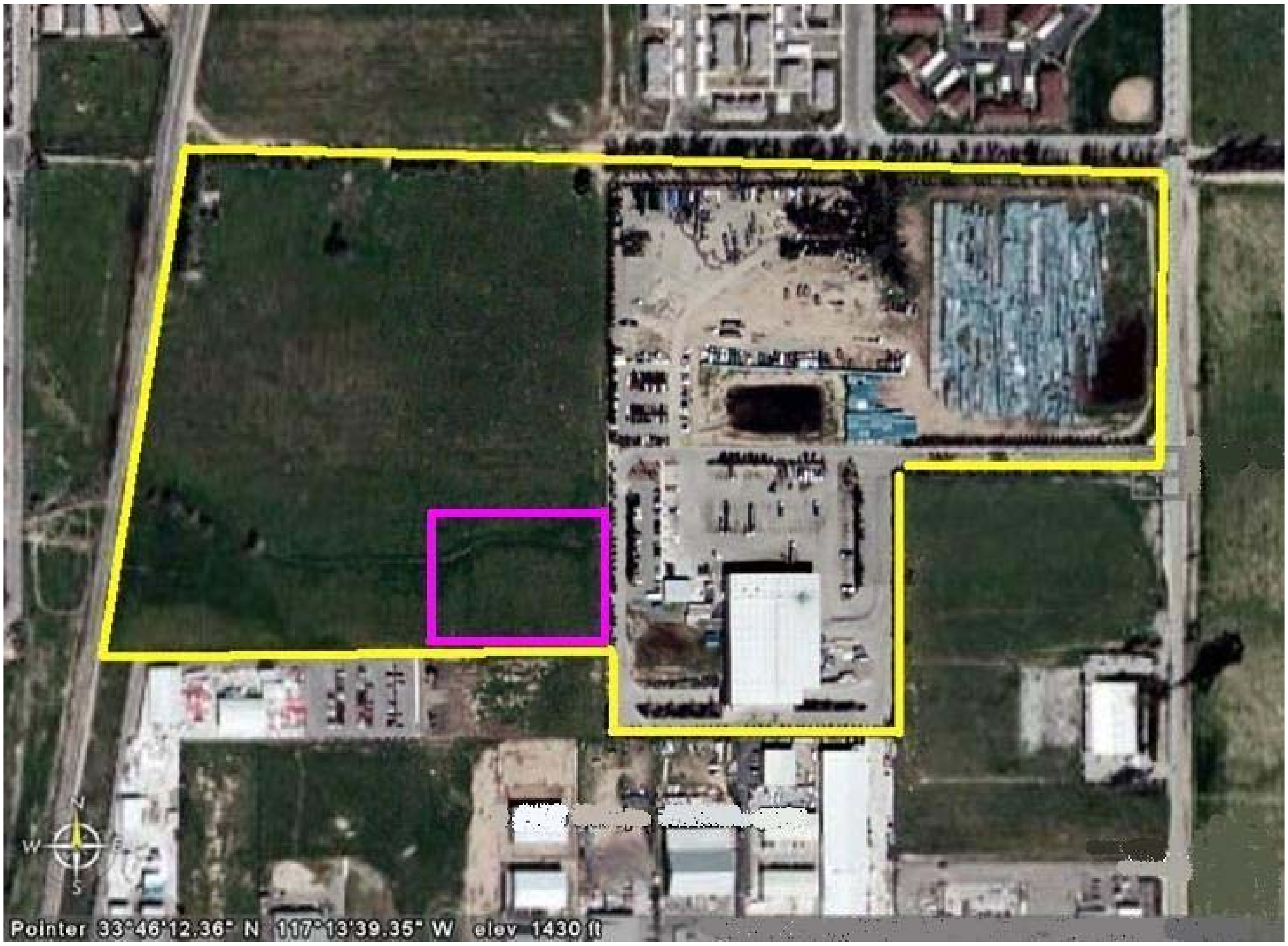
Figure 6.2-3

Del Norte Site and Facilities

Total site area (shown in yellow): 16 acres
Area available for development (shown in pink): 8 acres

Figure 6.2-4

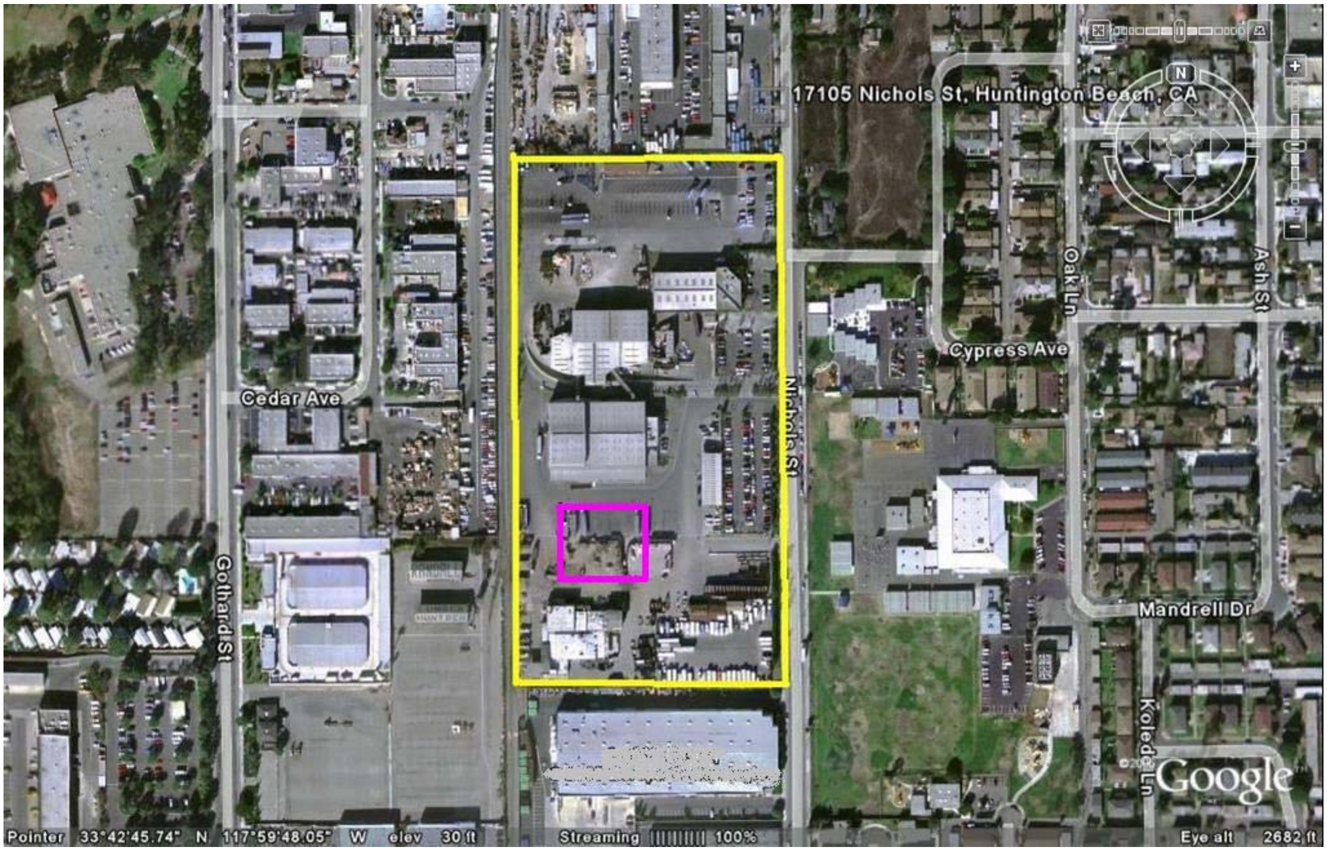
Perris Site and Facilities



Total site area (shown in yellow): 50 acres
Area available for development (shown in pink): 5+ acres

Figure 6.2-5

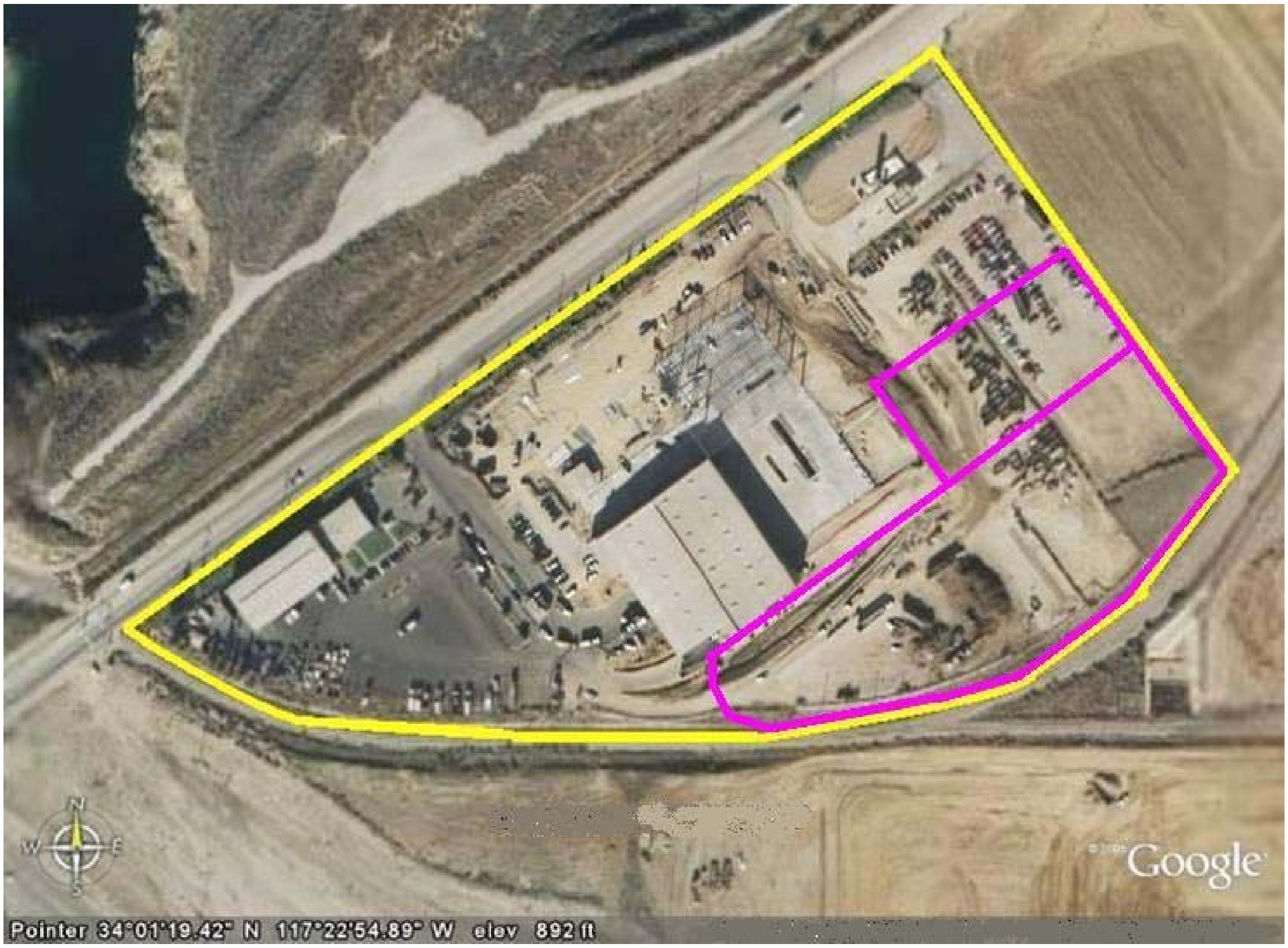
Rainbow Site and Facilities



Total site area (shown in yellow): 17 acres
Area available for development (shown in pink): <1 acre

Figure 6.2-6

Robert A. Nelson Site and Facilities



Total site area (shown in yellow): 12 acres
Area available for development (shown in pink): 5-7 acres

Table 6.2-1. Summary Information on Candidate MRFs

	MRF Name	Owner/Operator	Location	Capacity (TPD)	Acreage for CT	MRF Capability	Regulatory Agencies	Known Construction Constraints	Feedstock for CT
1	Community Recycling 9147 De Garmo Avenue Sun Valley, CA 91352	Community Recycling John Richardson General Manager	9147 De Garmo Avenue Sun Valley, CA 91352 (Los Angeles County)	1,700 (permitted) 2,500 (proposed) 1,250 (throughput)	1.5 offsite, adjacent and owned by Community	Full system Commingled Curbside Select commercial Greenwaste	City of Los Angeles (Dept. of Env. Affairs) SCAQMD Los Angeles RWQCB CIWMB	40 ft max. ht, but 100 ft possible with variance	MRF residual Ground greenwaste Unsorted waste
2	Del Norte Recycling and TS 111 South Del Norte Blvd. Oxnard, CA 93030	City of Oxnard/Republic Dennis Scala Int. Env. Resources Mgr. City of Oxnard	111 S. Del Norte Blvd. Oxnard, CA 93030 (Ventura County)	2,779 (permitted) 1,500 (throughput)	8 offsite, adjacent and owned by City of Oxnard City considering several options to date.	Full system Commingled Curbside Select commercial	City of Oxnard Ventura APCD Los Angeles RWQCB Ventura County Health Dept. CIWMB	Shallow groundwater	MRF residual Mixed commercial Unsorted waste
3	Perris TS & MRF 1706 Goetz Road Perris, CA 92570	CR&R Paul Relis Sr. Vice-President	1706 Goetz Road Perris, CA 92750 (Riverside County)	1,800 (permitted) 3,000 (pending) 1,200 (throughput)	5+ onsite	Partial MRF Full MRF in future	City of Perris SCAQMD Santa Ana RWQCB Riverside County Health Dept. CIWMB	50 ft max. ht but up to 100 ft ht. permissible with set back	MRF residual Mixed commercial Unsorted waste
4	Rainbow Disposal 17121 Nichols Street Huntington Beach, CA 92647	Rainbow Disposal Bruce Shuman CEO	17121 Nichols Street Hunt. Bch, CA 92647 (Orange County)	2,800 (permitted) 4,000 (proposed) 1,800 (throughput)	30,000 sf new building for direct integration into MRF	Full system Commingled curbside Select commercial Greenwaste	City of Huntington Beach SCAQMD Santa Ana RWQCB Orange County Health Care Agency CIWMB	Previous contamination Clean up complete	MRF residual Unsorted waste Ground greenwaste Ground woodwaste
5	Robert A. Nelson TS & MRF 1830 Agua Mansa Road Rubidoux, CA 92509	Riverside Co./Burrtec Chuck Tobin Development Director Burrtec	1830 Agua Mansa Rd. Rubidoux, CA 92509 (Riverside County)	4,000 (permitted) 2,800 (throughput)	5-7 onsite	Full system Commingled Curbside Select commercial Greenwaste	County of Riverside SCAQMD Santa Ana RWQCB Riverside County Health Dept. CIWMB	None	MRF residual Ground greenwaste Ground woodwaste Unsorted waste

Notes:
a) Unsorted waste refers to mixed, unsorted MSW from residential or commercial generators, after source-separation of recyclables (i.e., post-recycled), sometimes referred to as "black bin" waste from 3-bin curbside recycling programs.
b) All sites have full utilities available: electricity, gas, water, sewer
c) For connection to power grid assume sub-station will be required by technology supplier
d) TS = transfer station; MRF = material recovery facility

6.3 MRF/TS ANALYSIS

The Phase II MRF/TS evaluation included the following activities:

1. Review Phase I Data
2. Conduct Site Tours and Meetings with MRF owner/operators
3. Conduct meetings with Key Elected Officials and Regulators
4. Perform Engineering analysis

For purpose of evaluating the willingness and suitability of each MRF/TS site to partner with a technology supplier and host a conversion technology facility, evaluation factors were developed. The factors were grouped into the following three categories:

- Fundamental Prerequisite
- Primary Criteria
- Secondary Criteria

These evaluation factors are described below.

Fundamental Prerequisite

Ability and willingness to partner with a technology supplier for development of a conversion technology (CT) facility and to participate in good faith in the Los Angeles County project.

Primary Criteria

1. ***Space availability***

   Objective: Provide sufficient space to accommodate the proposed CT plants.
   Characteristics evaluated include:
   a. Sufficient space onsite for demonstration plant
   b. Sufficient space onsite for larger commercial plant
   c. Sufficient space immediately adjacent to the site for either the demonstration or commercial plant

2. ***Adequacy of utilities (power, water, wastewater, gas)***

   Objective: Provide sufficient utility capacity for operation of the proposed CT plants, both demonstration and commercial installation.
   Characteristics evaluated include:
   a. Hook-up to sewer with sufficient hydraulic capacity
   b. Wastewater pre-treatment requirements and surcharges
   c. Natural gas line capacity
   d. Sufficient fresh water supply without capacity constraints, or uncertain future
   e. Sufficient power availability and requirements for project sub-station; interconnection
   f. Adequate Telecomm / Internet access

3. ***Feedstock quantity, quality, and dependability of supply***

   Objective: Provide the capability, control, and processing flexibility to meet CT feedstock requirements.

   Characteristics evaluated include:

   a. Sufficient quantity of “post MRF” material for a demonstration plant and a larger commercial plant
   b. Long-term MSW supply (franchise agreements, own hauling operations, municipal agreements), recognizing that public waste supply agreements facilitate project financing
   c. Ability of MRF to produce feedstock that minimizes the need for CT pre-processing
   d. Ability to customize feedstock to meet CT specifications
   e. Waste Characterization – historic record and on-going assessment policy

4. ***Land Use***

   Objective: Provide industrial zoning suitable for development of the CT plant.

   Characteristics evaluated include:

   a. Site zoning (land uses and zoning within 1,000 ft)
   b. General and Specific Plan designation
   c. Proximity of compatible industrial, institutional, governmental facilities, including facilities that may use the energy or products generated by the conversion process

5. ***Regulatory, permitting and environmental issues***

   Objective: Provide positive regulatory, permitting and environmental quality setting for CT development

   Characteristics evaluated include:

   a. History of regulatory performance (notices of violation, recurring problems, etc.)
   b. History of interactions with the LEA, AQMD, RWQCB, City Code Enforcement and others
   c. NPDES stormwater permit
   d. Industrial wastewater discharge permit
   e. Air permits
   f. Solid waste permit in good standing

6. ***Location of sensitive receptors***

   Objective: Provide site in location with compatible surrounding uses and remote from sensitive receptors

   Characteristics evaluated include:

   a. Location of residences, schools, churches, health care and other sensitive receptors

7. ***Environmental Justice (EJ) issues***

   Objective: Provide site in location with minimal EJ issues

   Characteristics evaluated include:

   a. Location in an Environmental Justice Zone
   b. Location in a low-income or ethnic community

Secondary Criteria

8. CT product marketing

Objective: Assist in marketing of CT products

Characteristics evaluated include:

a. Access to established markets for the CT products
    i. Electricity
    ii. Fuels (Biodiesel, Ethanol, H2, Methane)
    iii. Thermal load / combined heat and power
    iv. Recyclables
    v. Compost and soil amendments
b. Control of CT product markets
c. Ability / Need / Economics of use of CT products

9. Cost of construction and constraints

Objective: Minimize unusual construction costs and limitations

Characteristics evaluated include:

a. High groundwater, height constraints, liquefaction zones or other factors that could adversely impact the cost of construction for a CT plant
b. Ease and expense of connection to power grid. Anticipated need to develop a dedicated substation.
c. Existing site and equipment layout and material flow related to CT equipment and layout requirements

10. Recycling Market Development Zone (RMDZ) Location

Objective: Assist CT in financing

Characteristics evaluated include:

a. Location in a Recycling Market Development Zone

11. Accessibility to major transportation routes

Objective: Provide direct heavy truck and rail access

Characteristics evaluated include:

a. Access via major truck arterials for waste delivery to MRFs
b. Access via major truck arterials to markets and disposal
c. Rail access for transportation flexibility
d. Truck routes that avoid residential areas

12. Competing disposal options

Objective: Avoid location in regions or jurisdictions with restrictive, low-cost disposal options

Characteristics evaluated include:

a. Presence of competing, low-cost, long-term disposal options (or binding contracts) that would reduce CT prospects through economic competition

13. “Flagship” project potential

Objective: Provide setting conducive to a “platinum” level CT project open to public tours

Characteristics evaluated include:

a. Existing MRF green building (e.g. LEED) features
b. MRF site and facility aesthetics
c. Surrounding land use aesthetics
d. Positive relationship with host community
e. Receptive to developing flagship facility (meeting LEED standards, hosting tours, etc.)

Table 6.3-1, provided at the end of this section, summarizes the analysis for each MRF/TS in all criteria listed above. Appendix F provides a detailed summary of the engineering aspects of the sites as they relate to hosting each of the conversion technology projects evaluated under Phase II. The sections below briefly highlight areas of interest, significance or challenge for the individual sites:

6.3.1 Community Recycling/Resource Recovery, Inc.

The Community Recycling facility is located in the County of Los Angeles. The owner/operator is the most "vertically integrated" of all the MRF/TS sites - in addition to the MRF, Community owns and operates a greenwaste and foodwaste composting operation near Bakersfield, acres of farmland, and two biomass power plants in the San Joaquin Valley with capacity to process several hundred tons per day of biomass. Thus, Community Recycling could possibly handle at its own facilities one or more of the secondary products from the conversion technologies (e.g., digestate, solid carbon).

The closure of the adjacent Bradley Landfill, and pending closure of the Puente Hills landfill, will put substantial pressure on pricing making a conversion technology at the Community Recycling MRF/TS more competitive.

This facility’s biggest challenges are the small size of the available site (only 1.5 acres), which is sufficient only for the proposed IES project, and an active LEA Cease & Desist Order, which poses a somewhat uncertain regulatory environment. Community Recycling is continuing to operate under an Interim Operating Agreement with the LEA while the Company is consolidating its operations under one 6,700 TPD permit, and designing site improvements (including two buildings) to mitigate impacts. An EIR is in progress.

Due to these space limitations and regulatory factors, Community Recycling is not recommended for further consideration for this project. However, the Company does have access to large acreage near its composting facility (Bakersfield) and is willing to consider hosting a conversion technology facility there. This alternate site may be suitable for consideration in the next phase of the County's project development activities (Phase III). Community has expressed a strong interest in remaining in consideration for potential future conversion technology projects.

6.3.2 Del Norte Regional Recycling and Transfer Station

The Del Norte MRF/TS is owned by the City of Oxnard. Early in the Phase II process, City staff provided site information and expressed an interest in participating in the project. To date, however, the primary City decision-makers have not made a commitment to participate. Further, the City has received and is evaluating a project offer that could result in development of the land adjacent to the MRF/TS, which was identified for location of a conversion technology facility. Therefore, the future of Oxnard's participation in this project is uncertain.

Should the Del Norte facility remain a participant in the project, this site offers certain advantages. Because the facility is owned by the City and supplied primarily by City collected waste, it could provide the best waste supply guarantee of all the MRFs, which is critical for financing. Also, the available acreage is sufficient to support the largest of the conversion technology projects evaluated under Phase II, and is the only site to be able to do so based on allocated space. The Del Norte facility also has excellent aesthetics, and has the best rail access of all the candidate sites.

The City currently has a tonnage commitment to one of the local landfills. This commitment ends in 2012, and because of that timing would not be expected to impact delivery of waste to a conversion technology project.

Del Norte is recommended for continued inclusion in the County's project, subject to their willingness to remain a participant.

6.3.3 Perris MRF/TS

The Perris facility has an ample supply of land and has some flexibility to adjust the space provided for a conversion technology to meet project needs. In addition, expansion at the facility is still in development and can customize MRF processing to meet the feedstock requirements of a conversion technology.

The Perris facility is a strong candidate for conversion technology co-location in almost all categories. It should be noted that there are residential areas bordering the site on two sides. However, the conversion technology would be located in the interior of the site, away from the residential areas. Also, as part of its approval for facility expansion, the facility has already committed to extensive screening measures along the property boundaries that border the residential areas.

Perris is recommended for continued inclusion in the County's project.

6.3.4 Rainbow Disposal Company MRF

Rainbow has been included for consideration in this project because of its pioneering work with one of the technology suppliers, IES. A 30,000 sf building (not yet constructed) has been sized and dedicated to house the IES conversion technology facility. A power purchase agreement has already been signed with Southern California Edison. MRF reconfiguration and expansion is underway to provide, among other things, a feedstock for the IES plant.

The major challenge of the Rainbow location is the large elementary school located across the street. This will mandate the highest level of environmental control and an extensive outreach and education program. The fact that the MRF has co-existed with the school for many years is a good indication of the Company's ability to operate as a good neighbor.

Rainbow is recommended for continued inclusion in the County's project, in partnership with IES.

6.3.5 Robert A. Nelson Transfer Station and MRF (R.A.N.)

The R.A.N. facility is somewhat unique, in that the land on which the R.A.N. facility was developed is owned by Riverside County, the buildings and improvements are owned by Burrtec (who also operates the facility), and the majority of the waste stream processed in the facility comes from the City of Riverside. A successful project at the R.A.N. site would require the cooperation of all three of these parties. Burrtec and the County of Riverside have been actively investigating conversion technologies, and a condition of the CUP for the site is the investigation of a conversion technology facility.

The facility is very well situated in a remote industrial area, with the nearest sensitive receptors (e.g., residences, schools, churches, health care facilities) located about 1/2 mile away.. The facility is strong in almost all categories (e.g., space availability, adequacy of utilities, accessibility to major transportation routes), and has no real weakness.

R.A.N. is recommended for continued inclusion in the County's project.

Table 6.3-1. MRF Summary Analysis

Evaluation Criteria	Community	Del Norte	Perris	Rainbow	Robert A. Nelson
Fundamental Prerequisite Willingness to partner with CT vendor	YES	Uncertain	YES (focus to date on ArrowBio)	YES (focus to date on IES)	YES
Primary Criteria **1. Space Availability**	1.5 acres offsite, adjacent Owned by Community	8 acres offsite, adjacent Owned by City	5+ acres onsite Owned by CR&R	30,000 sf bldg onsite dedicated to CDT integrated with MRF	5-7 acres onsite Owned by County
Sufficient space onsite for demonstration plant	Yes	No	Yes	Yes	Yes
Sufficient space onsite for full-scale plant	No	No	Yes	Yes (*)	Yes
2. Adequacy of Utilities Sufficient space adjacent to MRF for full-scale	Possible larger site in future	Yes, largest land availability	N/A	N/A	N/A
Hook-up to sewer with sufficient hydraulic capacity	Yes	Yes	Yes	Yes	Yes
Wastewater pre-treatment requirements and surcharges	OK	OK	OK	OK	OK
Natural gas line capacity	OK	OK	OK	OK	OK
Sufficient fresh water supply	Yes	Yes	Yes	Yes	Yes
Sufficient power availability; sub-station issues	OK	OK	OK	Already designed	OK
Adequate Telecom/Internet access	OK	OK	OK	OK	OK
3. Feedstock Quantity, Quality, Dependability Sufficient quantity of feedstock material	Yes, commercial, industrial MRFs	Yes, commercial and curbside MRFs	Partial MRF now; full MRF in design	Yes, commercial and curbside MRFs	Yes, commercial and curbside MRFs
Long-term MSW Supply and level of guarantee	Franchise contracts; open competition; long, stable history	Best control, public collected MSW; but issue with 5-year commitment of residue to local landfill	Ability to tailor MRF to CT	Franchise contracts; open competition; long, stable history	Franchise contracts; open competition; long, stable history
Produce feedstock that minimizes pre-processing by CT	Yes	Yes	Yes	Yes	Yes
Ability to customize feedstock to meet CT specifications	Yes	Yes	Yes	Yes	Yes
Waste characterization data	Yes	Yes	Yes	Yes	Yes
4. Land Use Site zoning (land uses within a 1,000 ft radius)	All M-3 heavy industrial	All heavy industrial	Industrial site; however, immediate adjacent residential	Industrial; however, immediate adjacent school	Heavy industrial
General and Specific Plan designation	Heavy manufacturing	Light industrial	Industrial	General industrial	Public facility
Proximity of compatible/synergistic facilities	Minimal	Adjacent manufacturing; possible synergy for energy use	Possible future industrial development	Possible energy for school	Possible future industries

Evaluation Criteria	Community	Del Norte	Perris	Rainbow	Robert A. Nelson
5. Regulatory, Permitting and Environmental Issues History of regulatory performance	Fair	Good	Good	Good	Good
History of interactions with the LEA, AQMD, RWQCB, City	Contentious, SCAQMD issues LEA Cease & Desist Order	Good	Good	Good	Good
NPDES Stormwater permit	OK, possible issues – no bldg	OK	OK	OK	OK
Existing industrial wastewater discharge permit	OK	OK	OK	OK	OK
Existing air permits	Possible SCAQMD issues with Rule 410	OK	OK	New design for Rule 410	OK
Solid waste permit	OK	OK	OK	OK	OK
6. Location of Sensitive Receptors Location of residences, schools, churches, health care	Approx. ¼ mile	Over 1 mile	1,000 ft (**)	400 ft	Approx. ½ mile
7. Environmental Justice (EJ) Issues Location in an EJ zone	Yes	No	No	No	No
Location in low-income, ethnic community	Yes	No	Yes	Yes	No
<u>Secondary Criteria</u> **8. CT Product Marketing** Access to established markets for the CT products	Good	Good	Good	Good	Good
Control of CT product markets	Excellent. Own both composting and biomass power facilities; also farmland	Big fuel/energy uses within City	CR&R has access through its outlets	Rainbow has access through its outlets	Burrtec has access through its outlets
Ability/Need/Economics of use of CT products	Large truck fleet, MRF energy demand DWP to purchase excess power	Big fuel/energy uses within City; MRF energy SCE to purchase excess power demand	Large truck fleet; MRF energy demand SCE to purchase excess power	Large truck fleet; MRF energy demand SCE power purchase in hand	Large truck fleet; MRF energy demand SCE to purchase excess power
9. Cost of Construction and Constraints High groundwater, height constraints, liquefaction zones	50 ft max. ht., with 100 ft with City approval	High groundwater	50 ft max. ht., with 100 ft with City Approval	Soil clean-up	OK
Ease and expense of connection to power grid	OK	OK	OK	Already designed	OK
MRF site and equipment layout related to CT requirements	Feedstock handling possible logistics challenge; not adjacent to CT	Feedstock handling possible logistics challenge; not adjacent to CT	Good, can be tailored	Possible custom design for CT	OK
10. Recycling Market Development Zone (RMDZ) Location Location in RMDZ	Yes	Yes	Yes	No	Yes
11. Accessibility to Major Transportation Routes Access via major truck arterials for waste delivery	Yes	Yes	Yes	Yes	Yes

Evaluation Criteria	Community	Del Norte	Perris	Rainbow	Robert A. Nelson
Access via major truck arterials to markets and disposal	Yes	Yes	Yes	Yes	Yes
Rail	No	Yes	Yes	Yes	Yes
Truck Routes that avoid residential areas	Yes	Yes	Yes, but residents in proximity	Yes, but residents in proximity	Yes
12. Competing Disposal Options Competing, low-cost, long-term disposal options	Yes, but Bradley closure and Puente Hills in 2013 = upward pressure on pricing	Yes, up to 2012 829 TPD to Simi Landfill	Landfills at $32/ton range	Landfills at $25/ton range	Landfills at $32/ton range
Current diversion levels and programs that could affect CT	No	No	No	No	No
13. "Flagship" Project Potential Existing MRF LEEDs features	None	Some	Planned for future construction	Planned for future construction	None
MRF site and facility aesthetics	Poor	Excellent	Good	Good	Fair
Surrounding land use aesthetics	Poor	Good	Good; in development	Good	Fair
Positive relationship with host community	Strained, at present, but facility is major City of LA contractor	They are host community	Yes	Yes	Yes

(*) Only major components of IES gasification, with all other functions and facilities by existing MRF

(**) As mandated in CR&R's permit, the residential area to the north will be screened from view of the site by a 12 ft high wall & extensive landscaping with trees, and the residential area to the west, which is more distant, will be screened from view of the site by landscaping

SECTION 7
PERMITTING PATHWAYS AND REGULATORY ISSUES

7.1 INTRODUCTION

The intent of this section is to summarize the key permits that will likely be required of a conversion technology facility located within the footprint of an existing MRF/TS. Due to the uncertain state of the regulatory framework in Sacramento related to conversion technologies, and the fact that no such commercial facilities similar to those evaluated by the County have been permitted in California to set the precedent, there is some uncertainty as it relates to solid waste permitting aspects. Other key permits are more clearly delineated, although the permitting process is expected to be demanding.

The intent of this section is to highlight and discuss the key permits that will likely be required. These permits potentially include some or all of the following:

- Revised MRF/TS Land Use Permit from the host jurisdiction Planning Department, including compliance with the California Environmental Quality Act (CEQA) which evaluates the potential environmental impacts and mitigation measures related to the conversion technology facility
- Revised Air Permits from the local Air Quality Management District
- Revised MRF/TS Stormwater Permits from the State Water Resources Control Board and the local Regional Water Quality Control Board
- Wastewater Permit
- Revised Solid Waste Facility Permit from the Local Enforcement Agency and the California Integrated Waste Management Board
- Amendment to the jurisdiction’s Non-Disposal Facility or Siting Element

7.2 LAND USE

All MRF/TS facilities have an existing Land Use Permit and/or Zoning Variance issued by the host jurisdiction planning department that controls (sets conditions for) the facility design and operation. Within this permitting process, the CEQA analysis is also conducted, as described below.

It is likely that co-location of a conversion technology facility at an existing MRF/TS will require a revision of the existing facility's Land Use Permit/Zoning Variance. The only way this might be avoided would be if the conversion technology facility had such minimal impacts as analyzed in the CEQA process as to not require any new conditions on the overall operation. A revised Land Use Permit/Zoning Variance, if needed, would require preparing and submitting the following documents to the planning department:

- Project description
- Photographs of site and equipment
- Detailed site plan

- Radius map with owners list and labels (for mailing of hearing announcements)

Once the submittal was deemed complete, the planning body would hold a public hearing soliciting comments and would then make a decision. Typically, the decision can be appealed to the City Council or Board of Supervisors, depending on whether the site is in a City or County unincorporated area.

Land Use permits and revisions to the permits can often be the most difficult of the permits, because it is here that the most vocal opposition would likely be found. Many projects have been stopped by challenges to the CEQA portion of the land use permitting process. Whether such opposition will materialize for a conversion technology facility embedded within a large MRF/TS is yet to be determined. Much will depend on the site itself and the technology to be developed.

7.3 CALIFORNIA ENVIRONMENTAL QUALITY ACT

A conversion technology project is likely to be subject to review under the California Environmental Quality Act (CEQA). CEQA requires that decision-makers take environmental impacts into account when approving projects, and it requires mitigation, to the greatest extent feasible, of potentially significant impacts. CEQA documents are prepared by "lead agencies," which are either agencies that wish to carry out a project (e.g. Caltrans building a road) or those that have the authority and responsibility to approve or deny actions by private parties, such as a city or county. The three main instruments for implementing CEQA are the negative declaration (ND), the mitigated negative declaration (MND), and the environmental impact report (EIR). The negative declaration states that there are no significant impacts, while the MND states that, while there are potentially significant impacts, they can be mitigated to the point of not being significant. EIRs are prepared for projects that have potentially significant impacts that may or not be mitigated, are large and/or complex, or otherwise require a great deal of technical analysis.

Mitigation is a very significant part of CEQA. Note that compliance with the requirements of environmental agencies does not constitute mitigation. For example, if a project complies with all the South Coast Air Quality Management District's rules and permit conditions, there are non-permitted emissions such as greenhouse gases, construction emissions, mobile source emissions, odors, etc., as well as cumulative impacts, and these must be mitigated. In many cases, a follow-up program of mitigation monitoring is instituted to ensure that the mitigation measures are actually implemented.

7.4 AIR QUALITY ISSUES

The foundation for most air quality regulation in the United States is the Clean Air Act, as amended in 1990. It authorizes and requires the U.S. Environmental Protection Agency (USEPA) to set and enforce ambient air quality standards, emission limits, performance standards, and other measures. It also requires States that are not in compliance with national ambient air quality standards to prepare and execute plans for achieving compliance. At the State level, the principal agency is the California Air Resources Board (ARB). The ARB is responsible mainly for preparing state implementation plans (SIPs) for achieving compliance with ambient air quality standards, for regulating mobile sources and preparing “model rules” for stationary sources.

A major difference between California’s air quality regulatory structure and that of most other states is that air regulations - - including those of the USEPA - - are administered and enforced at the level of the local air pollution control district (APCD). Two local agencies will be involved with conversion technology projects in this program. Projects in Los Angeles, Orange, or Riverside Counties would be under the jurisdiction of the South Coast Air Quality Management District (SCAQMD), located in Diamond Bar. A project in Oxnard would come under the Ventura County Air Pollution Control District (VCAPCD), located in Ventura.

A meeting was held in January 2007 with SCAQMD, to discuss conversion technologies and address permitting pathways and regulatory issues. Many components of conversion technology systems will require permits from the SCAQMD, which is considered to be the most stringent air regulatory agency in the country. A detailed discussion of air quality issues and permitting under SCAQMD is provided in Appendix D, including but not limited to a discussion of: pollutants of concern; ambient air quality standards; new source review; air toxics, and the Title V (facility permit) program, which regulates air emissions and establishes standards for monitoring, recording, and reporting emissions.

The conversion technology projects are expected to be permittable in Southern California, meeting applicable environmental standards. The technologies would likely be subject to "Lowest Achievable Emission Rate" (LAER) requirements for all pollutants, and would require application of "Best Available Control Technology" (BACT). The fuel gas (e.g., biogas, syngas) can be collected and cleaned prior to use for on-site power generation, as necessary for permitting. The technologies may require the purchase of emission reduction credits to offset facility emissions. As discussed in the technology reviews (Section 5), purchase of NOx offsets is expected to be required for many of the technologies, even with the application of NOx controls. The cost impact of purchasing emission reduction credits for NOx is addressed in the economic analysis (Section 8).

7.5 STORMWATER PERMITS

In California, industrial projects of over one acre are required to obtain a permit from the State Water Resources Control Board (SWRCB) for stormwater discharges associated with industrial activity. This permit and the attendant plans are designed to minimize contamination of surface and ground waters due to stormwater runoff from industrial sites. The plans contain detailed information on how stormwater falling on the site will be controlled, treated if necessary, and released using Best Management Practices (BMPs).

All the MRF/TS sites involved in this project will have existing stormwater plans and permits. Depending on the configuration of the conversion technology facility and the amount of exposure of new materials and processes to stormwater, those plans and permits will likely need to be modified.

If construction is involved, a Construction Stormwater Pollution Prevention Plan must be prepared and submitted to the local Regional Water Quality Control Board (RWQCB) prior to construction. For operations, a second Stormwater Pollution Prevention Plan and Mitigation Program Plan must be prepared and submitted to the RWQCB. As part of the stormwater permit program, each year during the winter wet season the facility must sample the runoff from two storms and report the results in an Annual Report to the SWRCB by July 1st. The report must also include visual observations of runoff during storms and of non-storm related waste discharges.

7.6 WASTEWATER PERMIT

The conversion technology facility will be required to obtain a wastewater discharge permit from the appropriate, local provider (e.g., the City of Oxnard for the Del Norte Site, Eastern Municipal Water District for the Perris MRF/TS, and other applicable agencies as noted in Appendix F). The engineering analysis showed that all the MRFs individually as well as the wastewater agencies in the MRF locations have sufficient hydraulic and treatment capacity to handle the flows from the conversion technology projects.

It should be a relatively straight-forward process to obtain this wastewater discharge permit. However, to minimize sewer connection and treatment surcharges, it will be important for the conversion technology projects to reduce the volume of wastewater generated (i.e., reduce the maximum flow rate) and reduce concentrations of biochemical oxygen demand (BOD) and total suspended solids (TSS) present in the wastewater (i.e., reduce the "strength" of the wastewater).

Given the arid climate in the MRF areas, it would be advantageous if the effluent from the conversion processes could qualify for use as irrigation or cooling water at the MRF, as is currently done on a large scale for watering landscaping along the freeways with reclaimed water.

7.7 SOLID WASTE FACILITY PERMIT

All the MRF/TS sites involved in this project will have existing Solid Waste Facility Permits for Large Volume Transfer Processing Facilities. The question at this point is whether or not the addition of a conversion technology facility would trigger the need for the MRF/TS to revise its existing Solid Waste Facility Permit. It is not yet determined what the permitting requirements would be.

In California, any facility handling solid waste is required to obtain a permit from the CIWMB and the Local Enforcement Agency (LEA). This permitting structure includes: transfer stations, material recovery facilities, composting sites, greenwaste chipping & grinding operations, landfills, construction and demolition debris processors (C&D), and waste-to-energy plants. The CIWMB determines whether or not a recycling facility or manufacturing plant is exempt from its regulations by applying the following, three-part test:

- The incoming feedstock must be source-separated for recycling;
- The incoming feedstock can contain no more than 1% putrescible waste; and,

- The outgoing residue for disposal can equal no more than 10% of the incoming tonnage.

To be exempt, the recycling facility or manufacturing plant must pass all three tests. Historically, this has meant that recycling plants processing source-separated recyclables (i.e., from curbside programs) have not had to obtain Solid Waste Facility Permits. As the industry and its technologies are becoming more varied and complex, the CIWMB is re-visiting the three-part test and discussing the use of different tests for various types of facilities. This could affect the need in the future for conversion technology facilities to obtain a Solid Waste Facility Permit from the CIWMB.

A revision to an existing Solid Waste Facility Permit, should such a revision be necessary, will require the following:

- Revision to the Transfer/Processing Report including site plan and facility design and operations description
- Revision to the Alternate Odor Impact Management Plan
- Participation in an LEA lead public informational hearing, most likely held at the MRF/TS
- Evaluation of Environmental Justice issues and past MRF/TS performance issues by the LEA
- Preparation of revised draft Permit and review by the CIWMB staff
- Preparation of revised final Permit and hearing before the CIWMB Permitting & Enforcement Committee and the full Board leading to final concurrence in the permit

7.8 AMENDMENT TO NON-DISPOSAL FACILITY ELEMENT OR SITING ELEMENT

7.8.1 Amendment to Non-Disposal Facility Element (NDFE)

For conversion technology facilities that do not fall under the definition of disposal (as defined in State law), an amendment to the non-disposal facility element (NDFE) will likely be required. In California, a jurisdiction (City or County) must amend its NDFE when siting a new non-disposal facility within its jurisdiction. **This holds true for all non-disposal facilities that require a solid waste facility permit (SWFP)**, whether the facility is sited:

- at an existing landfill or transfer station and included in the landfill's/transfer station's permit;
- at the landfill or transfer station and has a separate permit; or
- not at a landfill or transfer station and has a separate permit.

To amend an NDFE requires the following:

1. Presentation of the amendment to the Local Task Force for review and comment;
2. Adoption of the amendment by resolution of the City Council or Board of Supervisors at a public hearing; and
3. Review and approval of the amendment by the CIWMB.

7.8.2 Amendment to Siting Element

For conversion technology facilities that are defined as "disposal" facilities, an amendment to the Siting Element, not the NDFE, is necessary.

The Countywide Siting Element identifies goals, policies, and strategies to maintain adequate permitted disposal capacity through a 15-year planning period. To provide this needed disposal capacity, the Siting Element identifies areas/sites within the host County which may be potentially suitable for development of new facilities or expansion of existing facilities.

In addition, the Siting Element identifies out-of-County disposal facilities that may be available to receive waste generated in the County for disposal, and identifies alternatives to disposing of waste in landfills or transformation facilities.

The revision process is arduous and involves numerous statutory and regulatory requirements. Once it is revised to include a new conversion technology project, the Siting Element must be approved at a number of levels, first by the Task Force, then by the cities in the County, and ultimately to the Board of Supervisors and the Waste Board for final approval.

Requiring conversion technology projects to be incorporated into the Siting Element is a significant hurdle, since revising the Siting Element takes several years, is a significant cost, and requires the approval of a majority of cities with a majority of the population in the County.

7.9 AB 32: GLOBAL WARMING SOLUTIONS ACT

7.9.1 Capping Global Warming Emissions

In response to concerns about global warming, the state of California has shown national and international leadership in committing to reduce its global warming emissions to 2000 levels by 2010 (11% below current levels), to 1990 levels by 2020 (25% below current levels), and 80% below 1990 levels by 2050.

Existing policies, such as California’s global warming emissions standard for vehicles and renewable energy and efficiency requirements will move the state half-way toward meeting the 2020 target. Additional policies are essential to get the rest of the way there.

7.9.2 AB 32 – Global Warming Solutions Act of 2006

AB 32, authored by Assembly Speaker Fabian Nunez and Assembly Member Fran Pavley, codifies the state's goal by requiring that the state's global warming emissions be reduced to 1990 levels by 2020. This reduction will be accomplished through an enforceable statewide cap on global warming emissions that will be phased in starting in 2012. In order to effectively implement the cap, AB 32 directs the California Air Resources Board (ARB) to develop appropriate regulations and establish a mandatory reporting system to track and monitor global warming emissions levels.

Additionally, AB 32 requires that the ARB use the following principles to implement the cap:

- Distribute benefits and costs equitably.
- Ensure that there are no direct, indirect, or cumulative increases in air pollution in local communities.
- Protect entities that have reduced their emissions through actions prior to this regulatory mandate.
- Allow for coordination with other states and countries to reduce emissions.

7.9.3 Southern California Conversion Technology Demonstration Project

Conversion technology facilities have the potential to significantly contribute positively towards the State's Global Warming Solutions Act goals. These technologies achieve significant diversion from landfill disposal and convert organic waste material into renewable energy, fuels and other products, while adding only minimal or no greenhouse gas emissions to the atmosphere. The net impact, when factoring in diversion of materials from disposal as well as offsets from transportation and energy production, is a significant net reduction in greenhouse gas emissions.

The diversion of waste from landfill disposal is a significant benefit of conversion technologies. Decomposition of waste in a landfill produces a gas consisting of approximately 50% methane (CH_4) and up to 50% Carbon Dioxide (CO_2). Methane is a potent greenhouse gas, over 20 times more effective than CO_2 at trapping heat in the atmosphere. According to USEPA's 2005 data (the most recent available), landfills are the largest anthropogenic source of methane emissions in the United States, even though landfill methane emissions nationwide have declined as the amount of landfill gas collected and burned has increased (USEPA, #430-R-07-002, April 2007). In California, more stringent regulations require methane collection and destruction in the form of flaring or energy recovery, however the efficiency of landfill gas collection systems is still being investigated, and a nationwide or California standard has not been adopted. In addition, landfill gas collection systems are not 100% effective, especially for active, operating landfills (from which conversion technologies would divert material). Operating landfills also utilize significant resources for operations and maintenance of the landfill.

As a result, each ton of waste diverted from disposal to a conversion facility will reduce emissions that would otherwise have been generated from the disposal of that waste. By co-locating with a MRF, conversion facilities also eliminate the need to transport waste to remote disposal sites, additionally reducing the use of fossil fuels associated with transportation, congestion, etc., and further reducing net greenhouse gas emissions.

Furthermore, by selling renewable power or renewable fuels to DWP, SCE, or another third party, the conversion technology facilities would assist those utilities in off-setting fossil fuel use and reducing their carbon footprint as well as meeting Statewide renewable energy mandates. If a cap and trade system is instituted for carbon (similar to the one for NOx emissions), the conversion technology facilities could possibly sell their carbon credits, thus increasing revenues and potentially reducing tipping fees.

In this way, the AB32 program is seen as a positive force in the development of conversion technology facilities in California.

7.10 SB 1368: GREENHOUSE GAS PERFORMANCE STANDARDS FOR ELECTRIC GENERATORS

SB 1368 requires the establishment of greenhouse gas emissions performance standards for new baseload electric generators in the State of California. Baseload generation is defined in the law to apply to electricity generation at a plant with an annual capacity factor of 60 percent or more. The law prohibits long term power purchase agreements between electric utilities and baseload electric generators, unless greenhouse gas emissions from the baseload generator are equivalent to or better than the performance of a combined cycle natural gas power plant. Draft regulations resulting from the enactment of SB 1368, currently under development, have tentatively established the performance of a combined cycle natural gas power plant (CCNGPP) at 1,100 pounds of carbon dioxide per MWh of electric generation. SB 1368 alternatively allows compliance through an exemption in the law which specifically allows power plants that use technologies that are eligible for the California Energy Commission's (CEC) Renewable Portfolio Standard (RPS) to enter into power purchase agreements without demonstrating that they meet the CCNGPP performance standard. (See Section 8.2 for a discussion of RPS eligibility.)

The ability of the conversion technologies to meet the CCNGPP performance standard depends on requirements ultimately established by CEC and the Air Resources Board for calculating greenhouse gas emissions. If greenhouse gases resulting from the biogenic fraction of the MSW can be counted as carbon neutral, the conversion technologies will likely meet the CCNGPP performance standard. Current indications are that this approach is already in use in California, and such an approach is consistent with U.S. EPA and Kyoto Protocol methodologies.

7.11 REGULATORY ISSUES

At this point, there are several issues concerning legislation passed by the State of California that may inhibit or otherwise affect the ability of conversion technology facilities to be developed in the State. These issues are:

- Some conversion technologies, specifically including pyrolysis, distillation, and biological conversion, do not receive credit for "diversion" but rather all tonnage processed would count as "disposal" against the generating jurisdiction in regards to AB 939 reporting (see Section 1 for a discussion of AB 939) .

- Some thermal technologies, specifically including gasification, are prohibited from utilizing oxygen in the conversion process or generating any water, hazardous waste, or air emissions (in essence, a zero discharge system).

Periodically, these regulations come under review and attempts at revision. For example, current legislative proposals (AB1075 and SB 842) would strike the requirement for zero air emissions and instead tie the emissions to those that could be permitted in that air basin.

State law requires the LEA to hold a public hearing on all permit revisions, which would likely apply for any conversion technology project at a MRF. In addition, the legislation provides further definition of what constitutes a "significant change" at an existing facility. The legislation does provide some discretion on the part of the LEA in determining "significant change". Depending on how this is interpreted, a conversion technology facility may or may not qualify as a significant change, although it is most likely to be deemed so.

7.12 PERMITTING SCHEDULE

With an abbreviated land use permit process and no Solid Waste Facility Permit, it is conceivable that the permitting could be completed in as little as 12 months, but this is very optimistic. It is more likely, given the complexity and sheer volume of permitting effort, and the fact that none of these facilities has been permitted to date in California at a similar scale as proposed and the uncertainty as to how they should be classified, that the overall permitting will take 24 months, or longer if there is controversy.

SECTION 8
PROJECT ECONOMIC ANALYSIS

8.1 INTRODUCTION

As part of the RFI response, each technology supplier was asked to provide economic and financial information, including:

- estimated construction costs;
- estimated operations and maintenance costs;
- assumed financing structures and the costs related to financing;
- prices for energy and other recovered or generated products, and
- key assumptions and conditions that affected costs and prices.

The technology suppliers were instructed to assume that any projects developed would be privately financed, owned, constructed and operated. Using that information, each technology supplier was asked to estimate a "Year 1" tipping fee for its suggested project.

The Phase II RFI process was designed as an information process intended to verify and evaluate technology supplier qualifications, technology capabilities and cost, and suitability of potential sites. As such, the cost and pricing estimates provided by the technology suppliers should be considered planning level estimates based upon the best information available at this point in the process. Such planning-level estimates are appropriate at this point in the process. All technology suppliers acknowledged that their estimates would be subject to further refinement as individual projects became better defined and key elements such as sites, facility configurations, energy markets, waste supply arrangements and contractual terms and conditions were solidified.

The planning-level cost and pricing estimates provided by the technology suppliers, including the estimated tipping fees, were independently reviewed and evaluated to determine:

- completeness and reasonableness of cost and pricing assumptions;

- consistency of estimated tipping fees with cost and pricing assumptions and technical data (e.g., annual waste throughput, quantity of products, quantity of residue); and,

- sensitivity of estimated tipping fees to outside influences.

The evaluation included economic modeling to independently estimate tipping fees. The tipping fees resulting from these analyses were compared to the estimates provided by the technology suppliers to determine whether independent analyses would confirm the estimates, and to indicate areas of potential cost sensitivity. The results of the economic evaluation are presented within this Section 8 of the report.

8.2 REVIEW OF COST AND PRICING ASSUMPTIONS

In support of their projected tipping fees, the technology suppliers provided estimated costs to design and construct the project (e.g., structures, equipment, environmental control systems, ancillary systems, and engineering and design costs). The technology suppliers also provided operating costs (e.g., labor, residuals disposal, utilities, chemicals, maintenance and repair, and capital repair and replacement). For informational and comparative purposes, these parameters, as provided by the technology suppliers, are shown in Tables 8.2-1 and 8.2-2, respectively.

As part of the economic review, the technology suppliers' assumptions regarding construction and operating costs were reviewed to determine that all project components were provided (i.e., completeness of data) and, as applicable, to compare assumptions to the costs for similar waste management facilities as a measure of the reasonableness of the assumptions. Based on the review, the following determinations were made:

- Development, design and construction costs on a unit-price basis appear generally reasonable. However, some of the technologies may require the purchase of emission reduction credits (e.g., NOx credits) to offset facility emissions, which would be an initial, one-time project cost. Also, two of the technology suppliers did not include the application of NOx controls, which are expected to be required. The cost impact of purchasing emission reduction credits for NOx and, as applicable, installing control equipment, is addressed in the economic sensitivity analysis (Section 8.4).

- Estimated operating costs appear reasonable.

- Estimated costs for residue disposal appear reasonable.

- Estimated energy prices, and the corresponding revenue from planned electricity sales, appear reasonable.

- Estimated unit prices for sale of technology-specific, secondary products (e.g., compost, chemicals, oil) appear generally reasonable and supportable. Two uncertainties have been identified and are evaluated in the economic sensitivity analysis (see Section 8.4).

- Estimated unit prices for sale of recovered recyclables (e.g. cardboard, plastic, aluminum), as applicable, appear conservative.

- Financing assumptions appear reasonable. The ability of the projects to use tax-exempt, private activity bonds for portions of their financings might reduce costs, and has been addressed in the sensitivity analysis (Section 8.4).

Further observations regarding these specific determinations about the completeness and reasonableness of the cost and pricing assumptions follow Tables 8.2-1 and 8.2-2.

TABLE 8.2-1. SUMMARY OF DEVELOPMENT, DESIGN AND CONSTRUCTION COST ESTIMATES

	Arrow	CWT	CWT	IES	IWT	IWT	IWT	NTech
Greenfield (GP) or Integrated (IP) Pricing [(1)]	**IP**	**GP**	**IP**	**IP**	**GP**	**GP**	**GP**	**IP**
Design Capacity (tpd)	**300**	**200**	**200**	**242.5**	**312**	**623**	**935**	**413**
Cost Components								
Development	$500,000	$1,000,000	$1,000,000	$3,676,000	$6,000,000	$8,000,000	$10,000,000	$175,000
Engineering & Design	$2,480,000	$4,000,000	$4,000,000	$1,500,000	$3,500,000	$4,000,000	$4,500,000	$2,270,000
Structures	$3,330,000	$4,000,000	$4,000,000	$0	$6,100,000	$11,119,000	$16,627,000	$9,475,000
Pre-Processing Equipment	$1,250,000	$3,000,000	$3,000,000	$4,441,000	$0	$0	$0	$5,425,000
Processing Equipment	$8,362,000	$7,000,000	$7,000,000	$12,725,000	$21,179,000	$35,174,000	$48,246,000	$27,951,810
Power Generation Equipment	$2,700,000	$1,000,000	$1,000,000	$7,800,000	$10,000,000	$26,784,000	$36,525,000	$6,000,000
Storage Facilities	$750,000	$3,000,000	$3,000,000	$0	$322,000	$509,000	$671,000	$0
Utilities	$400,000	$3,000,000	$3,000,000	$0	$600,000	$600,000	$750,000	$1,500,000
Environmental Control Systems	$550,000	$2,000,000	$2,000,000	$0	$6,582,000	$12,456,000	$18,275,000	$1,967,750
Ancillary Systems	$400,000	$2,000,000	$2,000,000	$0	$7,222,000	$11,084,000	$14,481,000	$1,279,500
Vehicles	$200,000	$0	$0	$0	$220,000	$220,000	$250,000	$175,000
Other	$0	$5,000,000	$3,500,000	$0	$13,500,000	$16,500,000	$20,100,000	$375,000
Total Capital Costs	**$20,922,000**	**$35,000,000**	**$33,500,000**	**$30,142,000**	**$75,225,000**	**$126,446,000**	**$170,425,000**	**$56,594,060**
Cost per Design Capacity ($/tpd)	**$70,000**	**$175,000**	**$168,000**	**$124,000**	**$241,000**	**$203,000**	**$182,000**	**$137,000**

(1) Integrated Pricing means use of existing scales, roads, and other MRF infrastructure, as applicable.

TABLE 8.2-2. SUMMARY OF OPERATING AND MAINTENANCE COST ESTIMATES, FIRST YEAR OF OPERATION

	Arrow	CWT	CWT	IES	IWT (1 unit)	IWT (2 units)	IWT (3 units)	NTech
Greenfield (GP) or Integrated (IP) Pricing [(1)]	**IP**	**GP**	**IP**	**IP**	**GP**	**GP**	**GP**	**IP**
Annual Waste Throughput (tpy)	**100,000**	**51,100**	**51,100**	**79,661**	**97,350**	**194,700**	**292,050**	**137,790**
Cost Components								
Labor	$540,000	$3,031,140	$3,031,140	$865,000	$2,400,000	$2,700,000	$3,500,000	$3,433,305
Residuals Disposal (2)	$480,000	$864,200	$864,200	$230,000	$0	$0	$0	$250,000
Utilities	$103,025	$520,344	$520,344	$1,154,000	$860,610	$1,696,220	$2,536,830	$138,024
Chemicals	$50,000	$384,000	$384,000	$75,000	$1,460,077	$2,920,341	$4,354,830	$580,148
Maintenance and Repair	$480,600	$1,530,000	$1,530,000	$238,000	$1,000,000	$2,000,000	$3,000,000	$1,830,000
Capital Repair & Replacement (3)	$0	$0	$0	$0	$2,000,000	$3,200,000	$4,800,000	$130,000
Miscellaneous/Other	$260,000	$2,670,000	$420,079	$150,000	$3,300,000	$4,350,000	$6,400,000	$400,000
Total Operating Costs	**$1,913,625**	**$8,999,684**	**$6,749,763**	**$2,712,000**	**$11,020,687**	**$16,866,561**	**$24,591,660**	**$6,761,477**
Cost per ton processed ($/ton)	**$19**	**$176**	**$132**	**$34**	**$113**	**$87**	**$84**	**$49**

(1) Integrated Pricing means use of existing scales, roads, and other MRF infrastructure, as applicable.

(2) IWT assumes 100% diversion, with no resulting residuals or residual disposal costs.

(3) CWT and IES specified capital repair & replacement costs were included with maintenance and repair costs.
The same is assumed for Arrow, although not specifically stated as so in the RFI response.

- **Development and Construction Costs.** Development, design and construction costs estimated by the technology suppliers, on a unit-price basis, range from approximately $70,000 to $241,000 per tpd of facility capacity, as follows:

Technology Supplier	Unit-Price Cost ($/tpd of Design Capacity)
Arrow	$70,000
CWT	$175,000
IES	$124,000
IWT (1 line)	$241,000
IWT (2 lines)	$203,000
IWT (3 lines)	$182,000
NTech Environmental	$137,000

  Overall, the development, design and construction costs on a unit-price basis appear reasonable. Arrow, which has the least technically-complex process (anaerobic digestion), has the lowest cost on a unit-price basis. Economies of scale are demonstrated in IWT's unit-price capital costs, with the smaller, 1-line facility showing a 33% increase in unit price compared to the larger, 3-line facility. For comparison, conventional waste-to-energy facilities would be expected to have unit-price costs ranging from approximately $150,000 to $200,000 per tpd of facility capacity.

- **Completeness of Development and Construction Costs.** Based on the technology evaluations presented in Section 5, some of the technologies may require the purchase of emission reduction credits to offset facility emissions. Specifically, three of the technology suppliers (IES, IWT and NTech Environmental) are expected to require the purchase of NOx emission reduction credits. These credits would be an initial, one-time project cost, and were not included in the estimated of development and construction costs. Also, two of the technology suppliers (Arrow and NTech Environmental) did not include the application of NOx controls in their estimated development and construction costs, which are expected to be required for the on-site generation of electricity. The cost impact, as applicable to each technology supplier, of purchasing emission reduction credits for NOx and installing control equipment, is addressed in the economic sensitivity analysis (Section 8.4).

- **Operating Costs.** Operating costs estimated by the technology suppliers range from approximately $19 to $176 per ton of waste processed as shown below. These costs include labor, maintenance and other operating costs, as itemized in Table 8.2-2, but are *exclusive* of debt service on capital costs and *exclusive* of project revenues. It is important to note that these costs *do not* represent the prospective tipping fees, which are calculated figures that take into consideration total costs and revenues. The projected tipping fees for each technology supplier are shown in Table 8.3-2. Overall, estimated operating costs appear reasonable.

Technology Supplier	Unit-Price Operating Cost ($/ton of Waste Processed)
Arrow	$19
CWT	$176
IES	$34
IWT (1 line)	$113
IWT (2 lines)	$87
IWT (3 lines)	$84
NTech Environmental	$49

For comparison, new conventional waste-to-energy facilities that employ modern combustion technology would be expected to have unit-price operating costs on the order of $50-$70 per ton of waste processed or higher, depending upon the scale of a facility. This range is representative of costs at operating waste-to-energy facilities, including facilities in Southern California based on information provided by the County Sanitation Districts.

- **Residue Disposal Costs.** Residue disposal costs are a component of estimated operating costs, described above, and appear reasonable based on the underlying assumptions specified by the technology suppliers and the typical, current costs in the region. Landfill gate fees in the area currently range from approximately $30 to $40 per ton, with cost for transfer and disposal somewhat higher (total cost is approximately $40 to $50 per ton). Arrow and NTech Environmental both assumed residue haul and disposal costs equivalent to approximately $37 per ton, and CWT assumed a very similar cost of approximately $40 per ton. IES assumed a higher residue disposal cost of $56 per ton, but its cost is higher because its proposal is to "tip" the residue at the host MRF/TS to simplify operations, at that facility's gate fee, rather than haul and dispose the residue on its own.

- **Energy Prices.** With the exception of CWT, the technology suppliers produce electricity and generate significant revenue from the sale of electricity. The estimated energy prices were generally in the range of $0.07 - $0.08 per kilowatt hour (kWh), and were reported to be based on other recent energy sale agreements with Southern California Edison (exclusive of renewable energy credits). Arrow used a conservative estimate of $0.05/kWh, and IES assumed a small percentage of its electricity sales would be retail sales at $0.11/kWh. In May 2007, Southern California Edison (SCE) published a new power contracting initiative called the "SCE Biomass Program", which is offering to contract with biomass projects of 20 MW of less. The offer is expected to remain open until December 31, 2007, or the date on which SCE has signed contracts totaling 250 MW, whichever comes first. Contract terms range from 10 to 20 years, with energy rates ranging from approximately $0.08/kWh to more than $0.09/kWh. While the energy prices specified by the technology suppliers were reasonable, SCE's initiative is a good indicator of potential future pricing. Therefore, application of a uniform electricity sale price of $0.08/kWh has been completed as a sensitivity analysis (see Section 8.4).

While the energy prices used in the evaluation are exclusive of renewable energy credits, a primary driver for utilities to purchase electricity is to meet state requirements for procuring eligible renewable energy resources. The California Energy Commission (CEC) has published a Guidebook that describes the requirements and process for certifying eligible renewable energy resources for California's Renewable Portfolio Standard (RPS) (CEC-300-2007-006-CMF, March 2007). CEC defines eligible renewable energy resources by renewable resource or fuel, and for certain resources, also requires consideration of the specific technology used. Generation facilities that use municipal solid waste, which is identified as a renewable resource or fuel, qualifies as eligible for California's RPS. However, facilities that use MSW in a conversion process must meet additional requirements for RPS eligibility which, depending on the technology employed, may include the following:

- The technology does not use air or oxygen in the conversion process, except ambient air to maintain temperature control;

- The technology produces no discharges of air contaminants or emissions, including greenhouse gases.

- The technology products no discharges to surface or groundwaters of the state;

- The technology produces no hazardous waste.

RPS eligibility would need to be determined on a case-by-case basis for specific project offers made by technology suppliers.

- **Secondary Product Prices.** With the exception of IES, which proposes to generate only electricity as a product, the technologies generate various secondary conversion products that are generally unique to their processes. Individual technology suppliers used a variety of sources in estimating prospective prices for these secondary products, and provided supporting information for the price estimates. It was acknowledged that pricing would be confirmed as individual projects are more fully defined. Price assumptions and related revenue estimates for the secondary products appear reasonable, with only two possible uncertainties:

- Arrow assumed that the compost produced, while usable, would not find a "buying" market, and assumed the material would be provided free-of-charge to end users (e.g., for landfill daily cover material). There is uncertainty that Arrow would find a long-term, stable market for a high volume of compost generated from MSW, even if it were provided at no cost.

- NTech Environmental assumed it would generate almost $2.5 million annually from the sale of oil generated by its plastic-to-oil conversion process, based on a sale price of approximately $2.00 per gallon of oil. There is uncertainty that NTech would generate this revenue, due to uncertainties identified in the technology evaluation regarding the plastic-to-oil process as well as the estimated price of the oil.

Both of these uncertainties have been addressed in the sensitivity analysis (Section 8.4).

- **Recyclable Prices.** Two of the technology suppliers, Arrow and NTech Environmental, plan to recover recyclables prior to the conversion process. These two technology suppliers have assumed different unit prices for recyclables. However, NTech Environmental has not accounted for any revenue from the sale of recyclables in the determination of its tipping fee. Arrow has accounted for revenue of almost $1.8 million, annually, from sale of recyclables, based on pricing that is conservative considering current market pricing conditions. While Arrow and NTech Environmental have both taken a conservative approach in pricing recyclables, with different specific price assumptions, a sensitivity analysis was not conducted because it is not certain that higher prices would translate to a lower tipping fee.

- **Financing Assumptions.** Assuming private-to-private transactions, each technology supplier applied its own financing assumptions, including debt-to-equity ratios, interest rates and other costs of capital, and financing-related "soft costs." For example, Arrow and IES both assumed debt-equity ratios of 70/30, NTech Environmental assumed a 75/25 ratio, IWT assumed an 87/13 ratio, and CWT indicated that the initial demonstration facility might be financed 100% with equity. Similarly, the technology suppliers assumed varying debt interest rates, between 6% and 8%. Notwithstanding such differences, the assumptions applied by the technology suppliers are reasonable, recognizing that market conditions and project specifics will dictate the financing approaches ultimately applied and the resulting costs. Due to their project-specific and company-specific uniqueness, the various costs and assumptions for the different technology suppliers cannot readily be normalized through a sensitivity analysis. In addition, financing structures and costs will be influenced if projects become eligible for State or Federal financial assistance, such as grants, or if they can use tax-exempt private activity bonds for portions of their financing. The effects of financing with tax-exempt, private activity bonds have been addressed in Section 8.4.

8.3 ECONOMIC ANALYSES AND MODELING

Using the cost and price information provided by the technology suppliers, as reviewed in Section 8.2, economic modeling was conducted to independently estimate tipping fees. In reviewing the analyses, it should be noted that:

- The purpose of the analyses was to determine whether the estimated tipping fees provided by the technology suppliers were internally consistent (i.e., to verify there was consistency among the technical and operational parameters presented in the responses and the operational and output results described) and, therefore, achievable assuming the reasonableness of their assumptions.

- The modeling exercise was intended to evaluate “Year 1” tipping fee estimates, assuming that all costs and prices would be comparably affected by inflation over the terms of the projects.

The tipping fees resulting from these analyses were then compared to the estimates provided by the technology suppliers to determine whether independent analyses would confirm the estimates. Also, analyses were performed, where appropriate, to identify elements of individual projects that might be particularly sensitive to outside influences (see Section 8.4, Sensitivity Analyses).

The analyses were conducted for the specific demonstration projects suggested by the technology suppliers. For Arrow, IES and NTech Environmental, these were single project concepts that would be integrated with existing MRF infrastructure (i.e., "integrated pricing" that assumed use of existing scales, roads, and other site infrastructure, to reduce project development costs). For IWT, the analyses included three project concepts - 1-unit, 2-units and 3-units, in all cases priced as a stand-alone project (i.e., "greenfield pricing"). For CWT, the analyses included two project concepts - greenfield pricing (as originally proposed) and integrated pricing. In reviewing the analyses, it should be noted that CWT's concept for integrated pricing was submitted late in the review process, and without sufficient opportunity or supporting information for assessment of the reasonableness of the integrated pricing assumptions. Therefore, while included for informational purposes, CWT's integrated pricing is not carried forward through the economic analyses.

The results of the economic analyses are shown in Table 8.3-1. The table first includes facility descriptive information, such as design capacities, annual availabilities, and annual throughputs. It also describes the types of waste that would be accepted for processing by each technology supplier, and indicates whether the pricing is based on a stand-alone, greenfield project or a project integrated with a MRF/TS through the intended use of existing, common-application site infrastructure such as scales, roads and other assets. The table then presents development, design and construction cost estimates, financing-related costs, operating cost estimates, and projected revenues. Finally, the table presents two tipping fee estimates, the first resulting from the independent modeling and the second as presented by each technology supplier.

The economic analyses show that the tipping fees for the prospective projects are internally consistent and achievable with the costs and revenues estimated by the technology suppliers, with the exception of CWT's greenfield pricing project. Excluding this project, the independent determination of tipping fees was within 5% of the tipping fees estimated by the technology suppliers. In several cases (i.e., IES and IWT), the tipping fees estimated from the independent model were nearly identical to the tipping fees estimated by the technology supplier (less than 1% difference), showing their calculations were internally consistent with the cost information provided. For CWT, the independently-determined tipping fee for a greenfield project was significantly higher than that projected by the company. However, in its RFI response, CWT projected a loss of $17.2 million dollars for a demonstration-scale, greenfield project. The independent determination of a higher tipping fee for CWT's greenfield project is consistent with CWT's projection of a loss for that project.

TABLE 8.3-1 SUMMARY OF PROJECT ECONOMICS

	Arrow	CWT	CWT	IES	IWT (1 unit)	IWT (2 units)	IWT (3 units)	NTech
Facility Data								
Design Capacity (tpd)	300	200	200	242.5	312	623	935	413
Annual Availability (%	91.0%	70.0%	70.0%	90.0%	85.6%	85.6%	85.6%	91.4%
Annual Waste Throughput (tpy)	100,000	51,100	51,100	79,661	97,350	194,700	292,050	137,790
Pricing Basis								
Greenfield (GP) or Integrated (IP) Pricing(1)	**IP**	**GP**	**IP**	**IP**	**GP**	**GP**	**GP**	**IP**
Waste Type(s) Accepted	MSW MRF Residue	MSW MRF Residue ASR, FOG Used Oil	MSW MRF Residue ASR, FOG Used Oil	MRF Residue (2)	MSW MRF Residue	MSW MRF Residue	MSW MRF Residue	MSW MRF Residue
Estimated Development & Capital Costs								
Development, Design & Construction Costs	$20,922,000	$35,000,000	$33,500,000	$30,142,000	$75,225,000	$126,446,000	$170,425,000	$56,594,060
Financing-Related Costs	$6,276,600	Included above	Included above	Included above	$9,850,000	$16,800,000	$22,700,000	$7,498,713
Grant Funding	$0	$0	$0	$0	$0	$0	$0	$0
Total Capital Cost/Total Financing	$27,198,600	$35,000,000	$33,500,000	$30,142,000	$85,075,000	$143,246,000	$193,125,000	$64,092,773
Estimated Annual Costs								
Annual Debt Service/Capital Recovery	$3,276,893	$4,111,087	$3,934,897	$2,152,600	$9,672,000	$16,399,000	$22,166,000	$5,927,921
Year 1 O&M Costs (Inc. Profit)	$4,899,513	$8,999,684	$6,749,763	$5,582,000	$11,020,687	$16,866,561	$24,591,660	$8,263,558
Total Year 1 Costs	$8,176,406	$13,110,771	$10,684,660	$7,734,600	$20,692,687	$33,265,561	$46,757,660	$14,191,479
Estimated Annual Revenues								
Total Year 1 Revenues	$3,026,350	$8,396,505	$8,396,505	$3,280,146	$7,948,379	$19,586,459	$29,393,297	$6,324,953
Estimated Net Year 1 Costs	$5,150,056	$4,714,266	$2,288,155	$4,454,454	$12,744,308	$13,679,102	$17,364,363	$7,866,526
Tipping Fee Provided in Response	**$50.00**	**$46.60**	**$46.60**	**$56.00**	**$130.86**	**$70.58**	**$59.23**	**$55.00**
Confirmation of Tipping Fee as Calculated(3) (4)	**$51.50**	**$92.26**	**$44.78**	**$55.92**	**$130.91**	**$70.26**	**$59.46**	**$57.09**
Difference	**($1.50)**	**($45.66)**	**$1.82**	**$0.08**	**($0.05)**	**$0.32**	**($0.23)**	**($2.09)**

(1) Integrated Pricing means use of existing scales, roads, and other MRF infrastructure, as applicable.

(2) IES could accept post-recycled, mixed MSW with additional front-end processing.

(3) CWT's original response did not assume any grant support, but subsequently CWT estimated Federal grant funding of $10 million.
With a $10 million grant, the calculated tipping fee for a CWT greenfield project (GP) would be $69.27 and for an integrated project (IP) would be $21.79.

(4) CWT presented its tipping fee as a weighted number, but also provided by-category estimates of $60/ton for MSW, $60/ton for shredded residue, and $20/ton for fats, oils, grease and used oil.

The tipping fees estimated by the technology suppliers, and other related information extracted from the detailed Table 8.3-1, are summarized below for ease of reference.

Table 8.3-2. Tipping Fees Estimated by Technology Suppliers and Related Information

Technology Supplier(1)	Design Capacity (tpd)	Development, Design and Construction Costs	Year 1 O&M Costs	Tipping Fee Estimate ($/ton)
Arrow (IP)	300	$20,922,000	$1,913,625	$50.00
CWT (GP)	200	$35,000,000	$8,999,684	$46.60(2)
IES (IP)	242.5	$30,142,000	$2,712,000	$56.00
IWT (GP)				
1 Line	312	$75,225,000	$11,020,687	$130.86
2 Lines	623	$126,446,000	$16,866,561	$70.58
3 Lines	935	$170,425,000	$24,591,660	$59.23
NTech (IP)	413	$56,594,060	$6,761,477	$55.00

(1) IP means integrated pricing (i.e., use of existing infrastructure) and GP means greenfield pricing (i.e., a stand-alone project).

(2) The economic modeling showed that CWT's estimated tipping fee would not be achievable, which is consistent with CWT's determination that the project would incur a substantial annual loss.

As previously noted, the tipping fees estimated by the technology suppliers and summarized in Table 8.3-2 were confirmed by modeling as achievable based on costs and revenues estimated by the technology suppliers, with the exception of CWT's estimated tipping fee. Because CWT's project would result in a substantial annual loss using the tipping fee estimated by the company, the project has not been carried forward in the economic analyses. In addition, IWT's single-unit (1 line) project, which has an estimated and confirmed tipping fee of approximately $131 per ton, is not competitive for the LA area and has also not been carried forward in the economic analyses. With the exclusions noted above, the tipping fees estimated by the technology suppliers and confirmed by modeling as achievable fall in the range of approximately $50 to $70 per ton. In comparison, current waste disposal costs in the region vary considerably based on location, extent of MRF processing, and long-term disposal agreements. Current landfill gate fees for MSW range from approximately $25 to $35 per ton. Costs including transportation and additional processing (as indicated by gate rates at MRF/TSs) are somewhat higher, ranging from approximately $40 to $50 per ton.

The Puente Hills Landfill is the largest operating landfill in the United States at 13,200 tpd, and a dominant force in setting market prices in the Los Angeles County area. The Puente Hills Landfill will close in 2013, and the Sanitation Districts of Los Angeles County will develop a system for long haul by rail from the Puente Hills MRF, adjacent to the Landfill, in order to compensate for a fraction of the disposal capacity no longer available upon closure of the landfill on October 27, 2013. This "waste-by-rail" system is estimated to be operational by 2011 and will direct waste to the Mesquite Landfill, several hundred miles from Los Angeles. The Sanitation Districts estimate the cost for rail haul from the Puente Hills MRF at approximately $75/ton, requiring a ramped increase before the Landfill closes in order to prevent a sudden spike in cost and provide for a levelized rate.

The Sanitation Districts projects this “levelized” gate fee (i.e., tipping fee) at Puente Hills for rail haul and disposal will be approximately $45 per ton in 2013, which corresponds with the potential initial operating year for a conversion technology facility ($50 to $70 per ton). Five years thereafter (i.e., by 2018) the gate fee for rail haul and disposal is expected to be approximately $70 per ton, and within ten years (i.e., by 2023) the gate fee is expected to be over $100 per ton. These prices are expected to reflect overall market conditions.

The estimated tipping fees for the conversion technologies compare favorably with projected costs for haul and disposal in the immediate future, and are estimated to be directly cost competitive with landfill disposal within 5-10 years. On a life cycle basis (e.g., over 20 years of operation), the conversion technologies could be less costly than rail haul and disposal. However, in the initial years of conversion technology operation (e.g., up to the first five years of operation in the scenario presented above) there may be a need to "bridge" the economic gap, if any, in order to make up the difference between those new facility costs and prevailing transfer and landfill disposal prices until such time as market waste disposal fees equal those for conversion technologies. As described in Section 10, many alternatives could be considered to meet this need.

As was previously noted, the estimated tipping fees are based on cost and pricing estimates provided by the technology suppliers that are considered preliminary estimates, based upon the best information available at the time the estimates were made. While the cost and pricing estimates provide a reasonable, planning-level estimate of costs, all technology suppliers acknowledged that their estimates would be subject to further refinement as individual projects become better defined. For example, actual costs would be affected by the following factors:

- actual site conditions experienced;
- final energy customer negotiations and pricing;
- construction market conditions at the time of development; and,
- environmental requirements (for example, the need to purchase emission reduction credits (e.g., NOx offsets).

To assess the economic impact of key, potential changes, sensitivity analyses were conducted.

8.4 SENSITIVITY ANALYSES

Sensitivity analyses were performed to determine the impacts on tip fees of certain contingencies, such as changes in key assumptions and/or potential adjustments to project configurations or pricing assumptions specific to selected technology suppliers. These analyses can be useful in identifying areas of particular economic sensitivity among the potential projects. Based on the review and evaluation of cost and pricing assumptions presented in Section 8.2, including the contingencies identified in that section and the reasonableness of conducting analyses for such contingencies, the following sensitivity analyses were conducted:

- the application of a uniform electric power sales price ($0.08/kWh) for all projects generating electricity;
- the need to purchase emission reduction credits for NOx, and the need to provide additional NOx control equipment, as applicable;
- technology-specific sensitivities for sale of secondary products with identified uncertainties; and,
- the effect of private-activity bond financing.

As described in Section 8.2, application of common assumptions to all technology suppliers as part of a "normalization" of the tipping fee estimates has not been conducted, except where specifically warranted due to expected commonality or the presence of an unexpected (or uncertain) assumption. For example, all of the technology suppliers that generate electricity are expected to be able to sell that electricity for a similar price. While most assumptions were similar for sale of electricity, one assumption was conservatively low. Therefore, a sensitivity was conducted applying a uniform power sales price. On the other hand, certain other cost assumptions differed (e.g., residue haul and disposal costs, financing assumptions), but were reasonable and within a similar range with differences specific to the particular project. Sensitivities were not applied to make such assumptions uniform.

The results of the sensitivity analyses follow.

8.4.1 Uniform Electric Power Sales Price

With the exception of CWT, all of the technology suppliers would generate electricity for sale. The individual technology suppliers each applied different electric power sales price assumptions to arrive at their estimated revenues and tipping fees. In order to put all technology suppliers on a common footing for this key economic factor, a sensitivity analysis using a uniform price for all technology suppliers was conducted, assuming a power sales price of $0.08/kwh for all electric power sold. This price was selected as reasonable, based on other recent energy sale agreements with Southern California Edison (SCE) as well as SCE's current offering for standard contracts for biomass projects (see Section 8.2). Table 8.4-1 shows the impact of this sensitivity analysis.

Table 8.4-1 Impact of Power Sale Price on Estimated Tipping Fee

Technology Supplier	Original Power Sales Price ($/kWh)	Original Tipping Fee Estimate ($/ton)	Possible Tipping Fee ($/ton) at Power Sales Price of $0.08/kWh
Arrow	$0.0500	$50.00	$43.95
IES	wholesale: $0.0800 retail: $0.1100	$56.00	$57.94
IWT – 2 Lines	$0.0790	$70.58	$69.41
IWT – 3 Lines	$0.0790	$59.23	$58.60
NTech Environmental	$0.0700	$55.00	$51.03

8.4.2 NOx Offset Purchase Requirement

As described in Section 5 of this report, some of the projects being considered might be required to purchase NOx offsets to obtain permits to construct (IES, IWT and NTech Environmental). In comparison, the project proposed by Arrow was determined to likely not require NOx offsets (assuming the application of necessary air pollution control equipment).

Recently, the South Coast Air Quality Management District (SCAQMD) recorded NOx offsets transactions on the order of $55,000 per pound per day of NOx emissions. This transaction cost equates to approximately $300,000 per ton per year of NOx emissions. Offset purchases are one-time transactions at the inception of a project and therefore are treated in this sensitivity analysis as a capital cost component. Since none of the technology suppliers itemized the cost of NOx offsets, the amount of offsets required specifically for each technology have been estimated and applied as a capital cost, to assess the tip fee sensitivity to their purchase. Table 8.4-2 shows the potential order of magnitude impacts for estimated NOx offset purchases for each of the technology suppliers.

Table 8.4-2. Impact of NOx Offset Purchases on Estimated Tipping Fee

Technology Supplier	Estimated NOx Offset Purchase (1)	NOx Offset Purchase Cost (2)	Original Tipping Fee Estimate ($/ton)	Possible Tipping Fee ($/ton) with NOx Offsets (3)
Arrow	0	0	$50.00	$50.00
IES	5 tons	$1.5 million	$56.00	$57.40
IWT - 2 Lines	10 tons	$3.0 million	$70.58	$71.47
IWT - 3 Lines	15 tons	$4.5 million	$59.23	$60.67
NTech Environmental	10 tons	$3.0 million	$55.00	$56.71

(1) Based on estimated NOx emissions (see Section 5).
(2) Based on estimated cost of $300,000 per ton of offsets required.
(3) Does not include any cost of financing.

In completing the NOx offset sensitivity analysis, air pollution control equipment proposed by the technology suppliers was reviewed (see Section 5). A determination was made that applicable control equipment was proposed for IES and IWT, but that additional air pollution control equipment would likely be required for permitting for both Arrow and NTech Environmental. Without such additional controls for these technology suppliers, estimated NOx emissions would be higher than shown, which would result in correspondingly higher costs for the purchase of NOx offsets. In order to evaluate the potential impact of additional air pollution control equipment likely required for permitting, a sensitivity analysis was conducted for Arrow and NTech Environmental. In the absence of a detailed, project-specific technical assessment or specific pricing information, the analyses assumed a capital cost increase of 5%. This additional 5% contingency, which does not include any cost of financing, is assumed to provide a sufficient margin to cover equipment costs considering the type of equipment expected to be required for each technology and the order-of-magnitude costs for such equipment. The results are as follows:

- For NTech Environmental, the tipping fee required with additional capital costs of 5% would be $56.62 rather than $55.00, an increase of $1.62 per ton. This cost impact would be additive to that for NOx offsets, since additional air pollution control equipment would be required to achieve the estimated NOx emissions. Considered together, the impact on the tipping fee estimated by NTech Environmental could be an increase of $3.33 per ton.

- For Arrow, the tipping fee required with additional capital costs of 5% would be $53.14 rather than $50.00, an increase of $3.14 per ton. The addition of air pollution control equipment is estimated to result in NOx emissions below the threshold that would require the purchase of offsets, so there is no cumulative effect for Arrow.

8.4.3 Technology-Specific Sensitivities for Product Sales

Two technology-specific sensitivities were conducted, associated with products that represented a potentially significant source of revenue and were identified to have a greater level of uncertainty in Section 5 (Technology Review). These products are the digestate (compost) generated by Arrow and the oil product produced by NTech Environmental:

- Arrow assumed that the compost produced, while usable, would not find a "buying" market. Specifically, Arrow assumed that the compost would be provided free-of-charge to end users, with transportation costs incurred by Arrow. A sensitivity analysis was performed to determine the impact of the situation under which the compost would need to be disposed of, with both transportation and disposal costs incurred by Arrow. In this event, the tipping fee for a project might be $55.98 rather than the $50.00 estimated by Arrow, an increase of $5.98/ton. The ability to sell the compost, rather than give it away, would have a positive impact on project economics. However, due to the uncertainty of securing a long-term, high-volume, stable market for the compost, it is reasonable to not assume a positive value for this product.

- NTech Environmental proposes to recover plastics through front-end separation. Some of the recovered plastic would be sold to secondary markets as a traditional recyclable material, and the rest would be used to generate oil using the Royco plastic-to-oil conversion technology. NTech assumed revenues from the sale of oil at the equivalent of approximately $2.00 per gallon of oil sold, but did not provide a source for this assumed sale price. The sale price assumed by NTech is significantly higher than that assumed by CWT (approximately $1.19 per gallon), which is the one other technology supplier that would generate oil as a product. CWT's estimate was based on its experience selling renewable diesel in Missouri and adjacent states. Given the uncertainty of NTech's oil conversion technology performance (including the quantity of plastic in the feedstock and the amount that would be recycled versus converted to oil), uncertainty regarding product characteristics, and lack of a source from NTech to verify market conditions at this time, a sensitivity analysis that assumed a price at 50% of the original assumption was performed. This single assumption was applied to account for all of the factors as a whole, such as reduced prices and/or reduced production. This sensitivity had the effect of reducing revenues from the sale of oil and indicating a potential tipping fee of $64.02 rather than the $55.00 estimated by NTech Environmental, an increase of $9.02/ton.

8.4.4 Effect of Private Activity Bond Financing

As mentioned previously, the ability of the projects to use tax-exempt private activity bonds for portions of their financings might reduce costs. A sensitivity analysis was performed to determine what, if any, per ton savings might be achievable. IWT had already assumed the use of private activity bonds, so it was not included in the analysis.

The impact of the use of lower-cost private activity bonds on per ton costs for any single project will be conditioned by project-specific factors such as that project's capital costs, the amount of debt assumed (based on the assumed debt-to-equity ratio) and the annual MSW throughput planned. The projection of specific potential savings compared to the per ton capital costs estimated by the technology suppliers is not possible because individual technology suppliers used differing techniques to calculate and present their estimated costs. They did not appear to apply actual costs such as annual debt service (i.e., the principal and interest on any loans or bonds used to finance a project), but rather based their estimates on accounting and tax considerations (which, for their business and project planning purposes, is appropriate). However, it was possible to estimate a range of potential savings.

Generally, the use of tax-exempt private activity bonds might result in cost savings of between $2.00 per ton and $4.00 per ton, depending upon a project's capital cost, the debt-to-equity ratio assumed and planned facility throughput.

8.4.5 Summary of Sensitivity Analyses

Based on the sensitivity analyses that were conducted, the key contingencies are as follows:

- **Arrow.** The most significant contingency for Arrow is the potential impact on the tipping fee should the compost require disposal. Under this circumstance, the tipping fee could potentially increase by approximately $6 per ton.

- **IES.** The most significant contingency evaluated for IES is the potential impact on the tipping fee associated with the purchase of NOx offsets. Under this circumstance, the tipping fee could potentially increase, but by approximately $2 per ton or less.

- **IWT.** IWT's tipping fee could potentially increase with the purchase of NOx offsets, but it could potentially decrease with a higher power sale price. The sensitivities for IWT showed an impact of not much more than approximately $1 per ton under all circumstance that were evaluated.

- **NTech Environmental.** The most significant contingency for NTech Environmental is the potential impact on the tipping fee should the estimated revenue from the sale of oil be less than estimated (due to quantity of oil generated and/or reduced sale price). Under the circumstance of a 50% reduction in revenue, the tipping fee could potentially increase by approximately $9 per ton. The need for additional NOx controls and offsets could impact the tipping fee additionally by approximately $3 per ton.

Therefore, based on the economic analyses conducted for this study, the contingency that could have the greatest impact on estimated tipping fees would be the estimated revenue associated with the generation and sale of products. However, for the sensitivity analyses that were conducted, the potential tipping fees remained within the overall range of approximately $50 to $70 per ton.

SECTION 9
PROJECT FINANCING AND FUNDING OPPORTUNITIES

9.1 INTRODUCTION

As part of Phase II activities, project financing and funding opportunities for a conversion technology demonstration project were addressed. Specifically, research was conducted in late 2006 to identify grants and funding opportunities from public and private sources, and the possibility of financing through the issuance of bonds or special appropriations was investigated. As described in Section 9.2, limited grants and related public funding opportunities were identified, and this resulted in a heightened emphasis on private project financing approaches.

In addition to information requested from the technology suppliers as part of the RFI regarding financing plans, bankers and financial advisors teamed with the various technology suppliers were asked to provide input on project financing issues and concerns. Information was solicited from in-person meetings with Morgan Stanley and Goldman Sachs, representing three technology suppliers, and through other project communications with the remaining bankers.

9.2 FUNDING OPPORTUNITIES

9.2.1 Summary

The Phase II study included research into potential State and/or Federal funding assistance in the form of grants, loans, loan guarantees and bonding. The research efforts and findings were summarized by Holland & Knight in a memorandum dated December 22, 2006, which is provided in its entirety in Appendix E. Key portions of the memorandum are excerpted and described in this Section. The purpose of the research was to develop an initial data base of potential funding sources, and to set the stage for the possible eventual pursuit of funding opportunities once one or more defined projects have been selected for County support. Such project definition is necessary to have sufficient information and detail to support funding applications.

The research indicated that there are limited public funding opportunities, both in number of solicitations and amounts of funding available. In addition, funding opportunities have generally been focused on the development of fuels (e.g., ethanol and biodiesel) from non-municipal sources (e.g., agricultural waste). The technologies considered acceptable under this study and recommended for further consideration for the next step of this Phase II project (see Section 10), have the potential to generate renewable fuels for off-site use. However, all of these technology suppliers currently plan to convert their intermediate fuel products into electricity. Therefore, recent funding opportunities identified are not yet applicable because a specific project has not been identified. Public funding opportunities are constantly changing, with several recurring solicitations, and should be monitored as projects begin to take shape with defined sites, selected technologies, and other established technical, business and financial terms.

Private activity bonds (tax-exempt bonds which under certain conditions can be used to finance privately-owned and/or operated facilities) could be used to finance a project. The structure of the bond issuance would depend on whether the government or a private party owned a project. Another financing option is Federal or State special appropriations. Although the research indicates that there were few opportunities on the federal level in fiscal year 2006, the fact that some of these opportunities were directed at projects similar to those being considered in this Phase II process shows that there may be some potential for such funding.

Below is a brief discussion of each of the available categories of funding (public sources, private sources, bonds, special appropriations).

9.2.2 Public Sources

Research of public funding sources included, among others, the US Department of Energy, US Environmental Protection Agency, California Energy Commission Public Interest Energy Research, and the California Integrated Waste Management Board. Several public funding opportunities were identified and are summarized in Appendix E. Some of the opportunities researched were determined to be not applicable to the projects being considered; others had no solicitations at the time the research was conducted, but should be monitored for future activity. For example, two funding sources that should be monitored are: (1) California's Biomass Research and Development Initiative, which awarded $17.5 million to 17 projects in 2006, and has reportedly appropriated funds for future fiscal years, but there are currently no active solicitations, and (2) the California Pollution Control Financing Authority's Sustainable Communities Grant and Loan Program, which is being structured to provide grants and no-interest loans of up to $500,000 per applicant.

Among the federal sources researched, the Advanced Energy Initiative ("AEI"), which falls under the Department of Energy's Loan Guarantee Program, might be one of the more viable future opportunities. AEI currently offers up to $2 billion in loan guarantees for up to 80 percent of the project cost of a facility. The use of a Federal loan guarantee enables a sponsor to finance a project by borrowing from conventional lending sources, since the risk to the lender of non-repayment is substantially reduced through the guarantee. The prospective projects must be consistent with the purpose of the AEI program, which is to encourage early commercial use of new or significantly improved technology in energy projects. Eligible technologies must be mature enough to assure dependable commercial operation and must be able to generate sufficient revenue to provide a reasonable prospect of payment of the loan obligation. Projects intended solely to demonstrate feasibility of a technology, on any scale, are not eligible.

In February 2007, USDOE announced several grant awards under its latest (2006) solicitation. Unlike guaranteed loans, grant awards do not require repayment. The awards were for cellulosic ethanol projects covering primarily agricultural feedstocks, but also including solid waste (including BlueFire Ethanol, Inc.'s Southern California acid hydrolysis process and BRI's waste gasification/fermentation process). Assuming future funding by Congress, this program may have application in the future for a project in Southern California and should, therefore, be monitored.

As described in Appendix E, among the State sources researched, the California Energy Commission's Public Interest Energy Research ("PIER") Environmental Area Team's Biofuels Research Development & Demonstration program offers a comparably higher level of potential grant funding than other State sources (including the California Integrated Waste Management Board). The total funding available through the program's most recent solicitation was $3 million, with a maximum $1 million per proposal/project. Eligible projects must produce a transportation fuel (e.g., ethanol, biodiesel). Applicants must present a team with demonstrated commercialization capability.

9.2.3 Private Sources

Research of private funding sources included several representative venture capital firms, funds, individuals and groups. The funding opportunities among these appear to be primarily geared towards equity investments in companies rather than the funding of discrete projects. Based upon market experience, it is expected that the technology suppliers will invest their own capital for the equity portion of the project financings, or look to "third-party" (unrelated, independent) investors for equity.

9.2.4 Bonds

Tax-exempt municipal bonds were researched as a financing option, for either public or private ownership models, and potential issuers were identified:

- **Government Ownership.** Should a governmental entity choose to own a project, it could be financed using tax-exempt bonds. The governmental entity could issue general obligation bonds or revenue bonds. General obligation bonds are secured by the full faith and credit taxing power of a government. Revenue bonds are secured only by the revenues generated by a project, for example, tipping fees and electricity sales revenues. Given statutory debt limits and the desire to preclude local tax impacts, it is most likely that a California governmental entity would issue revenue bonds. Any operating agreement entered into between the governmental owner and a private operator would have to meet the requirements of a "qualified management contract" under Federal tax law. These requirements control the term of any operating contract and the manner in which the operator's fee is paid.

  Another option for a government-owned solid waste facility is private activity bonds, a type of tax-exempt bond which under certain circumstances can be used to finance projects such as those contemplated by this study. Generally, under Federal tax law, the amount of private activity bonds that can be issued in any state in any one year is limited (this is called the "volume cap"), and projects can only use such bonds if they receive an "allocation" of volume cap from the State (i.e., State approval of the financing). With private activity bonds for governmentally-owned facilities, however, no allocation of State volume cap is required and the contract entered into between the governmental owner and a private operator does not have to meet the requirements of a "qualified management contract".

- **Private Ownership.** If a project is to be privately owned, it may still be financed with tax-exempt debt. The debt issued would be private activity bonds. Unlike a governmentally-owned facility, because the project would be privately owned it would have to receive an allocation of volume cap. Each State has a certain allocation of volume cap, which regulates the volume of private activity bonds that may be issued within the State. In California, volume cap allocation is administered by the California Debt Limit Allocation Commission. Any such private activity bonds issued for a project would be issued by a conduit issuer and secured entirely by the project (i.e., they would be revenue bonds). In California, projects such as those contemplated by this study generally appear to be eligible for financing under the State's cap, although specific eligibility and the amount of cap available could not be determined until a specific project was defined and an allocation applied for.

- **Potential Issuers.** Even though a project would be privately owned, private activity bonds would be issued for the project by an agency that is normally empowered to issue bonds. Potential issuers could include: (i) a County agency such as the Los Angeles County Sanitation District or the Los Angeles County Public Works Authority (which issues revenue bonds); (ii) statutorily-enabled joint powers authority issuers, including California Statewide Communities Development Authority (which issue bonds the proceeds of which are lent to private parties); (iii) on the state-wide level, the California Pollution Control Authority and the California Infrastructure Bank (both issue bonds for projects such as those proposed under this Phase II process). Examples of the later for solid waste projects include the California Pollution Control Financing Authority's $30 million issuance for a solid waste project by Republic Services, Inc. in March 2006 and the California Statewide Community Development Authority's $25 million Solid Waste Revenue Bonds (February 2003).

9.2.5 Special Appropriations

A project could be financed by special appropriations, either on a Federal or State level. Although the research completed in December 2006 indicated there were few opportunities on the federal level in fiscal year 2006, the fact that some of the opportunities were directed at similar projects being considered under this Phase II process shows that there may be some future potential for such funding. Any special appropriations would require strong support from the County and State delegations. They would encounter possible competition from other projects and other communities, and the success of any special appropriations efforts would be heavily influenced by the legislative climate at the time.

9.3 PROJECT FINANCING CONSIDERATIONS

Considering the limited opportunities and timing constraints for Federal and State funding (e.g., grants, loan guarantees, "earmarks"), technology suppliers were requested to provide private financing approaches as part of the RFI. This was done within the RFI responses.

In addition to the information provided by the technology suppliers, the bankers and financial advisors teamed with the various technology suppliers were asked to provide input on project financing issues and concerns. Information was solicited from Morgan Stanley (representing IES and IWT) and Goldman Sachs (representing CWT) during meetings in New York City in May 2007. Information was solicited from New Century Finance (representing NTech Environmental) by telephone and email. Arrow, in cooperation with CR&R, gathered and provided information from their banker and financial advisor (Investec Bank, based in Australia). The input provided by the bankers and financial advisors is summarized below, including general observations, criteria required for project financability, and discussion of the most important issue identified by the bankers: waste supply and tipping fees.

9.3.1 Criteria for Financing

There was a consensus among the bankers and advisors that the financability of any project would require addressing the general areas of risk listed below. These are typical of virtually any municipal waste project that is intended to be financed on a ”project finance” basis (e.g., where there is no general credit of a government or of a corporate sponsor securing the debt used to finance the project; the project is revenue-based and the repayment of debt is not guaranteed by a single party, whether public or private).

Areas of risk to be addressed:

- Assurance of construction completion (quality, schedule and cost)
- Control of the site
- Technology performance and long-term access to technical support
- Available and suitable waste supply and associated tipping fee revenue
- Operations and maintenance expense volatility
- Terms and conditions of energy and materials sales contracts (“off-take contracts”), especially those for energy sales, whether electric power or fuels
- Long-term capital repair and replacement costs
- Long-term project viability (including resistance to potential negative impacts of outside influences and potential competition over time)
- Experience, financial capabilities and track records of sponsors/participants

Bankers will rely heavily on such standard credit requirements in order to finance projects For example, Morgan Stanley specifically cited the solid waste project criteria developed by Standard & Poor’s, one of the major agencies that provide credit ratings on debt financings, as principal guidelines for financing. Standard & Poor’s criteria address the types of risks listed above. The bankers saw little feasibility in attempting to structure projects which would not closely track established risk-related industry practice in the U.S.

The participating bankers who have direct experience in California believe that the projects would likely be eligible for tax-exempt financing under the State's private activity bond volume cap. The ability to use low-cost, tax-exempt financing (as was assumed by at least one technology supplier) would reduce capital-related costs and enhance the economic feasibility of any of the projects.

9.3.2 General Observations and Analysis

The following observations are based upon input from the bankers:

- Given that they each represent individual technology providers, all bankers expressed comfort with the manageability of risks associated with the technology, its construction and operation, and, recognizing the strength of the California market for both electric power and "green" electric power, were comfortable with the ability to execute appropriate electric power sales agreements with major utilities.

- The preferred structure for the sale of energy output is the sale of electric power under a long-term contract to a substantial purchaser, such as a large regulated utility or power aggregator. Such a power sales arrangement would not require governmental participation (i.e., the arrangement could be between a project and a purchasing utility, with no County or municipal involvement).

  The eligibility of electric power from any of the potential facilities to earn renewable energy credits would enhance project economics and enhance the attractiveness to major utilities of purchasing the power. (However, under current regulations the electricity that would be generated by at least one of the projects would not be eligible for such credits because of the use of oxygen in the process. An amendment to current State statutes is needed to assure that electric power generated by these facilities would be eligible for these credits.)

  Energy sale to a non-utility purchaser (such as a large industrial facility) would be feasible, assuming the creditworthiness of the purchaser. This type of arrangement might require additional credit support. The principal benefit of such an arrangement would be the ability of the project to charge higher "retail" prices for the electricity it produced, since it would be selling such power directly to a customer. It would not be locked into the lower "wholesale" prices that a utility would normally pay. Even the sale of a portion of a project's power output on such a retail basis would benefit its economics.

- State or federal loan guarantees would benefit any project; however:

  - the application of a loan guarantee might preclude the use of tax-exempt debt for financing, which would increase a project's cost of capital (generally, since tax-exempt debt is considered to be already "Federally subsidized" due to its tax-exempt nature, a second layer of "subsidy", such as a loan guarantee, is not allowed); and

- timing considerations and delays in processing and approval may obviate the value of any guarantee.

While the bankers identified the numerous issues above that need to be addressed as a financing is being structured, there was a consensus among them that these are resolvable at the project level by applying industry standard approaches (e.g., proven technology, demonstrated environmental benefits, experienced constructors and operators, strong off-take contracts, corporate guarantees, security instruments such as bonds and insurance coverage). However, as discussed below, waste supply guarantees and supporting project tipping fees are essential.

9.3.3 Waste Supply

The most important issue identified by the bankers is a guaranteed, suitable waste supply provided at a tipping fee sufficient to support a project. There was a consensus among the bankers that a guaranteed waste supply would be critical to the financability of any project. In that regard, the following points were made by the bankers:

- **Totally Private Transactions.** Totally private-to-private transactions, which do not include any public sector involvement in the assurance of waste supplies and the payment of tipping fees, might be feasible subject to the creditworthiness of the major private parties. A constraint is that the technology suppliers and MRFs/TSs identified as potential participants might not have the financial capacity of the larger, more traditional regional and national waste management firms. For example, any private party would need to be rated, using standard national credit rating agency criteria, as "investment grade." Notwithstanding their real successes as established Los Angeles-area business, the MRFs/TSs may not meet rating agency criteria and, as companies still in development modes, the technology suppliers also may not meet such criteria. In addition to the financial capacity of private parties, such creditworthiness would include the "quality" of any waste disposal contracts they hold (dollar value, term, assignability, conditions, etc.). Such contracts might need to be amended to make them consistent with financing arrangements (i.e., term, assignability, default provisions).

  Also, any private-to-private transaction would need to be "bankruptcy remote" – meaning that the bankruptcy of any party would not adversely affect the ability of the project to continue operating. While this may seem a particularly conservative position, the potential bankruptcy of any major private participant - - and the impact of such on a project - - is always a major concern of bankers and lenders regarding private transactions, and any project would need to be insulated against this circumstance. One technique would be to have assignable waste supply contracts that would not be terminable or cancelable in the event of the bankruptcy of a major participant.

- **"Merchant Projects".** Very few "merchant projects" (those without long term waste contracts from creditworthy waste sources such as major waste management companies or public agencies) have been financed. While there is no industry standard, and some degree of merchant risk might be acceptable, there is a consensus among the bankers that most of the waste supply needed would have to be assured under long-term contracts with public entities. A frequently stated standard is that waste must be under contract in an amount that will assure at least minimal economic viability of a project; this could be 70%, or more, depending upon project specific circumstance.

- **Government-Based Projects.** In the bankers' terminology, "governmental risk" is conventionally acceptable. Generally, a waste management project that includes the assurance of long term waste supply and payment of tipping fees through a contract from a governmental entity(ies) is financable.

- **Institutional Context.** The institutional context in which the projects would be developed offers some benefit. State requirements to divert at least 50% of waste from landfills and County policies to divert even more through techniques such as conversion technologies create incentives and a supporting environment for the projects. However, these indirect supports will not substitute for strong, enforceable waste supply contracts from "creditworthy parties" such as governmental entities.

Based upon the above considerations, all of the bankers agreed that the proposed transactions could be financed if the waste supplies were assured by the public sector, as follows:

- The preferred approach would be to have the predominant volume of waste supply delivered and tipping fees paid by one public sector agency, under contract for the full term of a financing.

- Other options include waste supply delivered and tipping fees paid by a private company(ies) with either:

  - some form of governmental step-in/back-stop arrangement that will make up waste supplies and tipping fee payments in the event of a short-fall from the private company(ies), or

  - public sector contracts (such as those from individual municipalities) assigned to the project, locked in for the full term of financing.

9.3.4 Supporting Tip Fees

Waste disposal costs vary considerably based on location, extent of MRF processing, and long-term disposal agreements. Current landfill gate fees for MSW in the Los Angeles area range from approximately $30 to $40 per ton. Costs including transportation and additional processing (as indicated by gate rates at MRF/TSs) are somewhat higher, ranging from approximately $40 to $50 per ton.

The Puente Hills Landfill is the largest operating landfill in the United States, at 13,200 tpd, and a dominant force in setting market prices in the Los Angeles area. The Puente Hills Landfill will close in 2013, and the Sanitation Districts of Los Angeles County will develop a system for long haul by rail from the Puente Hills MRF, adjacent to the Landfill, in order to compensate for a fraction of the disposal capacity no longer available upon closure of the Landfill on October 27, 2013. This “waste-by-rail” system is estimated to be operational by 2011 and will direct waste to the Mesquite Regional Landfill, several hundred miles from Los Angeles. The Sanitation Districts estimate the cost for rail haul from the Puente Hills MRF at approximately $75/ton, requiring a ramped increase before the Landfill closes in order to prevent a sudden spike in cost and provide for a levelized rate.

The Sanitation Districts projects this “levelized” gate fee (i.e., tipping fee) at Puente Hills for rail haul and disposal will be approximately $45 per ton in 2013, which corresponds with the potential initial operating year for a conversion technology facility ($50 to $70 per ton). Five years thereafter (i.e., by 2018) the gate fee for rail haul and disposal is expected to be approximately $70 per ton, and within ten years (i.e., by 2023) the gate fee is expected to be over $100 per ton. These prices are expected to reflect overall market conditions.

As shown in Section 8 of this report (Project Economic Analysis), the tip fees needed to support a conversion technology project might range from approximately $50 to $70 per ton. Therefore, the estimated tipping fees for the conversion technologies compare favorably with projected costs for haul and disposal in the immediate future, and are estimated to be directly cost competitive with landfill disposal within 5-10 years. On a life cycle basis (e.g., over 20 years of operation), the conversion technologies could be less costly than rail haul and disposal. However, in the initial years of conversion technology operation (e.g., up to the first five years of operation in the scenario presented above) there may be a need to "bridge" the economic gap, if any, in order to make up the difference between those new facility costs and prevailing transfer and landfill disposal prices until such time as market waste disposal fees equal those for conversion technologies. As described in Section 10, many alternatives could be considered to meet this need.

9.3.5 Volume Caps

As described in this section of the report, tax-exempt, private activity bonds will likely be the least costly form of debt that could be used in a private project financing. As discussed in subsection 9.2.3, above, to secure such financing, tax law requires that the project financing secure an allocation of volume cap from the State, administered by the California Debt Limit Allocation Commission. County advocacy for a project may help secure an allocation.

SECTION 10
SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

10.1 INTRODUCTION

This section includes the following subsections:

- Summary of findings
- Recommended Next Steps – Competition for Selection of Project(s)

10.2 SUMMARY OF FINDINGS

As described in this report, the Task Force, its Subcommittee, and the Los Angeles County Department of Public Works have been working to facilitate the design, construction and operation of a conversion technology demonstration facility(ies) in Southern California, to demonstrate the capabilities and benefits of conversion technologies, and to forge permitting and legislative pathways for future projects. This report describes Phase II of the County's project facilitation activities. Key activities of Phase II included: (1) verification and evaluation of technology supplier qualifications; (2) verification and evaluation of technology capabilities (including technical, environmental and economic factors); and (3) evaluation of candidate MRF/TS sites and verification of their ability and willingness to partner with a technology supplier. Phase II activities also included identification of: project funding opportunities and financing approaches; financing requirements; and County incentives needed or helpful to facilitate project development. Tables 10.2-1 and 10.2-2 identify, respectively, the technology suppliers and sites recommended to participate in the next step of the Phase II process. It should be noted that the listing is alphabetic, and the ordering does not signify any ranking or preference. Key findings are as follows:

1. **Technology Readiness and Reliability.** Four of the five technology suppliers have demonstrated the technical capabilities of their conversion technologies with MSW (Arrow, IES, IWT and NTech Environmental) and are "ready" for application as part of a conversion technology demonstration project in Southern California. It should be recognized, however, that each of these technology suppliers would be incorporating one or more new aspects into its design concept, such as the unique integration of pre-processing equipment and/or other facility components. Also, specific waste characteristics, waste receiving and separation requirements, State and local regulatory requirements, and specific product markets will need to be addressed in an application of these conversion technologies in Southern California.

   CWT has demonstrated its depolymerization technology with agricultural waste, but has not yet demonstrated its technology with MSW. Additional development work is necessary for application of CWT's technology to MSW (particularly for processing MRF residuals and post-recycled MSW). CWT was not recommended for further consideration for this project because its technology is not yet demonstrated for MSW, although, CWT’s technology may be applicable to other waste streams. CWT's technology may be suitable for consideration in a future phase of Los Angeles County's project development activities (Phase III).

Table 10.2-1. Technology Suppliers Recommended for Next Step of Phase II
(Listed Alphabetically)

Technology Supplier	Technology Type
Arrow Ecology and Engineering (Arrow)	Anaerobic Digestion
International Environmental Solutions (IES)	Pyrolysis
Interstate Waste Technologies (IWT)	Pyrolysis / High Temperature Gasification
NTech Environmental (NTech)	Low Temperature Gasification

Table 10.2-2. MRF/TS Sites Recommended for Next Step of Phase II
(Listed Alphabetically)

MRF/TS Facility	Location
Del Norte Regional Recycling and Transfer Station	Ventura County (Oxnard)
Perris MRF/Transfer Station	Riverside County (Perris)
Rainbow Disposal Company, Inc. MRF(1)	Orange County (Huntington Beach)
Robert A. Nelson Transfer Station and MRF	Riverside County (Unincorporated)

(1) The Rainbow Disposal MRF was evaluated under this project exclusively in partnership with IES.

2. **MRF/TS Site Suitability.** Four sites were found to be technically and environmentally suitable for co-location of a conversion technology project: Del Norte Regional Recycling and Transfer Station (Oxnard); Robert A. Nelson Transfer Station and MRF (Riverside County Unincorporated); Perris MRF/Transfer Station (Perris); and Rainbow Disposal Company, Inc. MRF (Huntington Beach). Community Recycling/Resource Recovery, Inc. MRF/TS in Los Angeles was limited by available space and is faced with an active LEA Cease & Desist Order that may pose a constriction for project development at this site. The Community Recycling site was not recommended for this project because of those constraints. However, Community Recycling has access to a larger site, which may be suitable for consideration in a future phase of Los Angeles County's project development activities (Phase III).

   With only one exception, the MRF/TS sites have continued to express a willingness and ability to partner with a technology supplier and participate in Los Angeles County's conversion technology demonstration project. The only exception is the Del Norte Regional Recycling and Transfer Station in Oxnard (Ventura County), which has not yet made a commitment to continue to participate in the County's project. As the only publicly-owned MRF/TS under consideration, the Del Norte site requires a more formal and lengthier process for making a project commitment. In addition, the City of Oxnard has received and is evaluating a project offer that could result in development of the land adjacent to the MRF/TS, which was identified for location of a conversion technology facility. The future of Oxnard's participation in the County's project is uncertain.

3. **Corporate and Team Resources.** The teams assembled include technology suppliers and experienced team members in key roles such as finance, design and construction, and operations, and are capable of developing a project.

4. **Financial Resources.** Although in most cases, technology suppliers have not been in business in the U.S. market long enough to have built extensive U.S. project inventories or financial track records, the inclusion of major experienced financial, engineering and construction and/or operations team members, and their teaming with MRF/TS owners, will enhance their overall financial resources and capability, providing sufficient resources for project development and operations. In particular, these teaming arrangements will strengthen the ability to provide design, construction, operations and performance guarantees, and the taking of risks associated with these types of guarantees.

5. **Diversion Potential.** The conversion technologies have the potential of achieving significant diversion of MRF residue and post-recycled MSW from landfill disposal, ranging from approximately 87 percent to 100 percent by weight of the waste received, provided reliable markets can be identified for secondary products.

6. **Conversion Capability, Marketable Products.** The technologies have the capability of recovering recyclables, converting waste into intermediate fuel products (e.g., biogas, syngas, steam, biodiesel), efficiently using the fuel products on-site for power generation, and producing secondary material products. On-site power generation is currently the proposed alternative due to strong market demands for electricity, particularly from renewable energy sources.

7. **Environmental Soundness.** The technologies are expected to be permittable in Southern California, meeting applicable environmental standards. Appropriate air pollution controls will be required. The fuel gas (e.g., biogas, syngas) can be collected and cleaned prior to use for power generation, as necessary for permitting. Phase II addressed three key pollutants: nitrogen oxides (NOx); dioxins; and greenhouse gas (GHG) emissions.

    - NOx is a criteria air pollutant of concern as established by the U.S. EPA. NOx was selected as a key indicator of environmental acceptability of conversion technologies because ground level ozone (smog) is one of the most significant pollution issues in Southern California, and NOx is the most significant pollutant generated by conversion technologies that contributes to smog. The U.S. EPA classifies the Los Angeles South Coast Air Basin as being a severe non-attainment area for ozone, a precursor to smog. Smog poses a threat to humans because it can irritate the respiratory system and lead to severe respiratory health problems. The conversion technologies evaluated would apply control technologies to reduce NOx emissions, and would have potential, controlled NOx emissions that are significantly lower than the Federal requirements for large municipal waste combustors (i.e., approximately 10 times less).

    - Dioxin was selected as a key indicator of environmental acceptability of conversion technologies, because it is a toxic air pollutant of great public concern. Potential dioxin emissions from conversion technologies are expected to be very small compared to Federal requirements for large municipal waste combustors (i.e., approximately 10 to >100 times less).

    - Greenhouse gases are those gases in the atmosphere that increase global warming. Conversion technology facilities have the potential to significantly contribute positively towards the State's Global Warming Solutions Act goals. These technologies achieve significant diversion from landfill disposal and convert organic waste material into renewable energy, fuels and other products, resulting in a net reduction in greenhouse gas emissions.

    - The net generation of emissions can be reduced when considering the life-cycle impact of conversion technologies. By design, conversion technologies offset emissions from other sources, including the transportation of waste to remote disposal that is no longer necessary, as well as the combustion of fossil fuels offset by the generation of renewable energy in the form of electricity or green fuels. Co-location of conversion technology facilities with MRFs maximizes this transportation reduction of residual solid waste. When factoring in diversion of materials from disposal as well as offsets from transportation and energy production, conversion technologies are likely to reduce net emissions.

8. **Estimated Tipping Fees.** The tipping fees estimated by the technology suppliers, and reviewed in this study, fall in the range of $50 to $70 per ton, excluding IWT's single-unit, 312-tpd project, which is not considered economically viable. Sensitivity analyses (conducted to determine the impacts on tipping fees of certain contingencies) do not result in a significant change to the overall tipping fee range.

9. **Competitiveness of Estimated Tipping Fees.** As noted above, tipping fees needed to support a conversion technology project range from approximately $50 to $70 per ton. While these estimated tipping fees may be competitive with the future tipping fees associated with rail haul and landfill disposal, they are greater than current waste disposal costs in Los Angeles County. To support financing and successful project development and operation, there may be a need to "bridge" this economic gap, if any, until such time as market waste disposal fees equal those for conversion technologies.

   Many alternatives could be considered to help meet this need, including one or more of the following:

   - funding provided by the Sanitation Districts, consistent with the conditions of the Puente Hills Landfill C.U.P.;
   - funding provided by BFI, consistent with the conditions of the Sunshine Canyon C.U.P;
   - funding provided by the cities in Los Angeles County and the County itself;
   - development of public waste supply agreement (or private agreement with public “back stop”) with supporting tip fees;
   - increasing the amount of the project financing to provide surplus funds to “subsidize” initial tip fees being paid;
   - instituting a ramped tipping fee (i.e., a structured annual increase that is kept in place until the prices charged cover the cost incurred, similar to the funding subsidy formulated by the CSD for the Waste by Rail Project);

- instituting a “green fee” to be paid by MRF/TS customers for waste processed at the conversion technology facility;

- eliminating the Solid Waste Management Fee (currently $0.86 per ton) for waste originating in Los Angeles County going to the conversion technology facility, to provide a reduced tip fee for waste delivered to the conversion technology facility;

- increasing the Solid Waste Management Fee (currently $0.86 per ton) imposed on each ton of solid waste being disposed to provide a dedicated funding source for promoting development of conversion facilities;

- providing tax incentives that may result in lower facility construction or operating costs; and

- successful acquisition of State and Federal grants to augment other funds as described above.

The level of support needed and alternatives to address needed support would require evaluation in the next step of this process (see Section 10.3), when firm, competitive offers from the project developers are made, and proposed tip fees and project-specific market conditions are known.

10. **Financing Approach.** Given the experience and corporate and team resources of the technology suppliers, and assuming waste supplies would be provided or assured by a public entity or credit-worthy private source with assignable public contracts at a sufficient tipping fee for the term of financing, the technology suppliers could structure financable projects applying customary U.S. solid waste market project financing techniques. However, specific means for providing or assuring the waste supply need to be developed, as does a means of providing a supporting tipping fee. Tax-exempt, private activity bonds would most likely be the least-costly means of private project financing. County support may be needed to secure allocation of "volume cap" from the State for such financing (see discussion in Section 9.2.4).

    State and Federal funding opportunities are limited, but could be used to assist in project development and/or project financing. Securing such funding is competitive and requires project definition.

10.3 RECOMMENDED NEXT STEPS – COMPETITION FOR SELECTION OF PROJECT(S)

Although substantial evaluation work has been completed, resulting in selection of acceptable technologies and sites for one or more demonstration facilities for Southern California, formal project offers have not yet been presented. As a next step, it is recommended upon approval from the County Board of Supervisors that the Task Force, Subcommittee and Department of Public Works establish a competition to solicit formal, site-specific offers from the acceptable technology suppliers in partnership with the acceptable MRF/TS sites. Such a process would establish a defined mechanism by which one or more projects would be selected to receive County support to further facilitate project development activities.

The competition would not be a formal procurement process, and it would be open only to the technology suppliers and sites identified in this report as "recommended". The process would differ from a procurement in its formality and the extent of detail requested, both of which would be streamlined. However, the competition would still require clear project definition and commitments on the part of the development team making the offer, including a tipping fee and project guarantees, and it would need to meet standards set by the Task Force, the Subcommittee and the Department of Public Works. In return, the selected project(s) would be offered County support, to facilitate development activities. Potential options for support are described below, and ultimately must be selected and approved by the County before being formally offered.

The advantage of the competition is that it would allow the marketplace to establish the most beneficial pairing of sites and technologies, a process most appropriate for a privately developed project, and it would encourage the development of site-specific projects that meet the objectives of the County, the Task Force and the Subcommittee. In this way, specific offers would be evaluated to enable selection of the best project(s) as offered by a team that includes a technology supplier and site, rather than selection of a preferred technology and site for which a partnership has not yet been established or may not be possible, and a project that is not yet defined. The competition would also strengthen the County's negotiation position as a project facilitator.

The competition would be initiated with issuance of a "letter of invitation" to the recommended technology suppliers and MRF/TS sites, outlining the standards and incentives and other elements of the competition. A time limit would be set for project offers to be made. Approximately 3 to 4 months is recommended, to allow time for the technology suppliers and MRF/TS owners and operators to explore partnership opportunities and develop site-specific project offers. Upon receipt of project offers, the Task Force, Subcommittee and Department of Public Works would review, evaluate and rank the offers and select one or more projects to recommend receiving the support of the County of Los Angeles. Support activities would be negotiated with the project development teams, based on ranking and selection of project(s). As proposed, this competition would allow the County to support more than one project, perhaps with the highest level of benefits offered to the highest-ranked offer.

Standards set for the competition would include those that promote the overall objectives and goals of the project. Suggested standards could include the following:

Project Standards

- The project must be of a certain minimum size; e.g., 100 tons per day.
- The project must be capable of achieving operation by a specified date.
- The project must be capable of sustained operation at a market-competitive tip fee, if not initially, over the term of operation.
- The project must be designed to process MRF residuals and/or post-recycled municipal solid waste, and must have the potential to divert at least 75% (by weight) of this waste from landfill disposal.
- The project must have the ability to capture the gas produced and to generate electricity or a fuel product (e.g., biogas, synthesis gas, oil) and must have a defined use for the electricity and/or fuel product.
- The project must have the ability to capture and pre-clean the intermediate gas as necessary to meet permit requirements.
- The project must provide a permitting plan that demonstrates a reasonable chance of successful permitting.
- The project must provide a financing plan and assurance from the intended financing party that financing can be accomplished.
- The project must have a marketing plan for all products intended to be recovered and marketed, including power and secondary products, with provision of letters of intent to purchase from intended customers of key products.
- The project must be structured to provide for disclosure of non-proprietary project information to the County for public release, including technical, environmental and economic information, to promote the development of future projects.
- The project developer must offer a commitment to develop a “flagship facility”, to encourage and facilitate public tours, and public education programs.
- The project developer must provide assurance of its commitment to ensuring project success

The County could consider offering support to meet those needs essential to project development and other support activities that can facilitate project development. A suggested listing of such benefits is presented below. In addition to selecting specific support levels, or offering tiered levels of support based on rankings of proposed project offers, the County may wish to offer a menu of options to the facilities, and evaluate the project offers submitted based on the level of support requested in the offer.

Essential Support Activities for Private Project Development

- Provide for public waste supply agreements, or provide for public "back stop" to guarantee private waste supply agreements for the term of financing.

- Provide economic incentives in the form of a "bridge" that closes the gap, if any, between needed conversion technology tipping fees and market waste disposal fees, until such time as market waste disposal fees are sufficient to support a conversion technology project (see Section 10.2, finding number 9).

- In addition, if private activity tax-exempt bond financing is sought, lend County support to qualify for "volume cap" for such financing.

Other Support Activities to Facilitate Private Project Development

Develop Information, Facilitate Information Exchange

- Continue the development of information on technology suppliers and make the information available to MRF/TS site owner/operators.

- Continue the development of site information and make the information available to technology suppliers.

Funding Opportunities

- Continue to track and identify potential funding sources (e.g., grants, low interest loans, etc.) from state and federal sources to assist in payment of project development costs, construction costs and operating costs. Apply for and secure available State and Federal grants (or assist project developers in doing so). Assist the facility developer in applying for and obtaining low interest loans available from the State or Federal Government. Consistent with the CUP issued for Puente Hills Landfill, Public Works will request that CSD consider funding a pilot conversion technology facility.

Legislative Efforts

- Continue State legislative efforts to foster change in the solid waste management hierarchy in order to place conversion technologies within the context of beneficial uses rather than disposal.

- Continue State legislative efforts to ensure all conversion technologies that generate electricity are eligible to receive renewable energy credit.

Promote Beneficial Use of Products, Product Sales

- Assist site owner/operators and technology suppliers in identifying markets for products and in negotiating power or fuel sales agreements.

- Promote the use of more difficult-to-market products, such as compost and aggregate, by educating County and State departments that may use such products and integrating incentives or requirements for purchasing and use of such products into procurement practices for County and State projects. Support payment for testing services to develop engineering specifications for products and establish quality of products.

Foster Project Support with Municipal Leaders and General Public – Public Outreach

- Sponsor meetings and forums to encourage information exchange between technology suppliers, site owners/operators, municipal officials in which sites are located, State and Federal agencies, environmental and other advocacy groups and the general public to gain support for the project.

- Provide County “endorsement” of the project(s) to add credibility for purposes of public acceptance, permitting, financing, and publicity.

- Provide and reinforce public education efforts regarding the project, including publicizing the project, maintaining web and e-communications regarding the project, and seeking additional media coverage as appropriate.

Facilitate Permitting

- Assist the project in permitting efforts by making staff available to help in identifying permits needed, obtaining information needed for permit applications, helping the project get priority at agencies in scheduling for permit review and receiving reasonable consideration concerning applicability/interpretation of regulatory requirements.

Facilitate Design/Construction

- During facility design, assist the project by helping to obtain design related information available at the County and support "green" building design.

- During facility construction, assist the project in obtaining information on local suppliers of materials and services.

Support Operations and Commercialization of Technology

- Once the facility is operational, participate in facility testing and data exchange for engineering performance and environmental data.

- Continue County promotional support during facility operation to promote facility attributes and enhance public awareness. Serve as a “reference”, if requested by the facility developer, to expand the demonstration facility or to enhance the developer’s efforts to develop other facilities in or outside of the area.

10.4 SCHEDULE

The recommendation of this report is that, upon approval by the Board of Supervisors, the Task Force, Subcommittee and Department of Public Works establish a competition to solicit formal, site-specific offers for selection of one or more conversion technology demonstration projects for County support. Upon selection of a project(s) and negotiation of associated support activities to be provided by the County, the project would proceed to permitting, design and construction, and startup. The goal is to implement a project with expedited permitting by December 2011, as summarized in Table 10.4-1. More detailed, project-specific schedules would be requested as part of the recommended competition.

Table 10.4-1. Preliminary Project Implementation Schedule

Implementation Step	Time to Complete	Projected Completion
Initiate Competition (Issue Letter of Invitation)		Fall 2007
Offers Submitted	4 months	January 2008
Review, Evaluate and Rank Offers	3 months	April 2008
Selection of Project(s) for County Support	1 month	May 2008
Negotiate Support Activities, Other Agreements	3 months	August 2008
Permitting/Conceptual Design (1)	18 months	February 2010
Detailed Design/Construction	18 months	August 2011
Startup	4 months	December 2011

(1) Assumes permitting can be achieved with an amendment to the existing MRF/TS Solid Waste Facility Permit and an amendment to the non-disposal facility element.

Prepared for:

**The County of Los Angeles
Department of Public Works
and
Los Angeles County Solid Waste Management Committee
/Integrated Waste Management Task Force's
Alternative Technology Advisory Subcommittee**

Submitted by:

**Alternative Resources, Inc.
1732 Main Street
Concord, MA 01742
(978) 371-2054**

ARI

**For more information, please visit
www.SoCalConversion.org**