California Integrated Waste Management Board
Session Summary:
Emerging Technology Forum
April 17-18, 2006
International Experience in Emerging Technologies

The purpose of this session was to provide some insight into foreign conversion technology policy, planning, and permitted processes and some of the experiences implementing non-combustion energy generating technologies overseas.

Brief summary of presentation by Rick Diederich prepared by CIWMB staff

Rick Diederich is President and CEO of ILS (Innovative Logistics Solutions, Inc) – Partners. ILS-Partners is a California-based company that uses ultra-high temperature gasification technology developed and commercialized by Pyromex A.G., a Swiss Corporation.

Mr. Diederich's presentation was entitled, "Pyromex Ultra-High Temperature Technology Development." He began by discussing environmental factors that led to development of the Pyromex Ultra-High Temperature technology, including Germany and other European Community countries in the mid 1980's tightening legislation regarding landfilling and incineration, and investigating and evaluating alternative waste elimination methods. He described how Pyromex developed a commercial scale demo facility that operated in Switzerland from 1989 to 1992, and how new legislation by the European Community in 1993 made full scale commercialization and facility permitting impossible. He explained how Pyromex engineers and scientists in response to the new legislation developed a high temperature gasification prototype to meet the new requirements. He reviewed some of the development objectives pursued by Pyromex in designing the new gasification technology, such as targeting non-recyclable waste streams, eliminating all toxic residue from the process, eliminating any combustion (dioxins or furans), and maximizing the generation of synthetic gas. He then identified a number of the characteristics associated with ultra-high temperature gasification, including operational temperatures between 1200 and 1700 degrees Centigrade; thermal decomposition in an oxygen free environment; minimal amount of inert, non-leachable residue; no ash, no char, no tar, no emissions and no stack; and the most efficient and cost effective means of converting waste to energy.

Mr. Diederich said the European Union continues to expand and implement stringent regulations regarding limiting landfill and recycling. He noted that many EU countries have additional environmental and emission standards, with Germany having the most stringent standards in the world. He added that the EU is developing strict end-of-life regulations for most manufactured products. He provided examples of municipal solid waste legislation, such as Switzerland, the Netherlands, France and Denmark banning the landfilling of combustible solid waste.

He said that Pyromex gasification technology was part of a two-year European study that was funded by the Energy, Environment and Sustainable Development Committee in Brussels, which found Pyromex gasification met all environmental standards and is well suited for waste elimination and generation of clean energy from non-recyclable organic waste. He added that the study concluded that the technology has the potential to become a major contributor to the hydrogen economy.

Mr. Diederich said current German permitting allows a wide range of waste types to be accepted, including farming and animals waste, plastic waste, fly-ash from power plants, waste from car recycling, medical waste, and shredder waste.

He concluded his presentation by saying the EU is serious about the environment and emissions, they have moved legislatively beyond classifying gasification as an incineration technology, and they have a willingness to accept new technologies that meet or surpass new standards.

Brief summary of presentation by Henrik Harmssen prepared by CIWMB staff

Henrik Harmssen is a senior engineer at Waste Solutions Ltd in Dunedin, New Zealand, where he deals with design and construction of anaerobic treatment plants for a wide range of different waste streams in various countries.

Mr. Harmssen's presentation was entitled, "Turning Muck into Money – Wastes as a source of energy and valuable products." He began by saying between 1995 and 2003, the production of waste in EC member countries grew by about 2% per year. He added in 1995, 204 million tons were generated (457 kg/person/per year), which grew to 243 million ton per year in 2003 (574 kg/person/year). He said at the same time, the amount of waste landfilled decreased by about 10%, the amount incinerated remained roughly the same, but the amount recycled nearly doubled from 42 to 82 million tons.

He added that during this time, the EC Landfill Directive of 1999 stipulated a reduction of the organic fraction in landfills to near zero by 2005. He said the organic wastes that were the focus of the directive are degradable wastes (organic fraction of household wastes and gardening wastes from the private sector; and wastes from landscaping and commercial kitchens and food processing industry from the commercial sector). He said sludgy, mechanically easily to handle materials found their way to agricultural derived biogas plants. Household organic waste was collected in Bio Bins and used by composting facilities. He noted that over time the ingredients of the compost changed to wetter, structureless components like kitchen waste with higher nitrogen content, which created odor and leachate problems He said two approaches were used to deal with these problems: 1) enhance composting facilities by turning them into compost factories with artificial ventilation, full enclosure (buildings, tunnels), treatment of exhaust air and automated turning; and 2) have a anaerobic digestion plant for the more unstructured materials and a compost plant for the woody structured materials. He added that if possible the waste stream is separated "at the gate" and directed to different parts of the plant, the structured waste being composted and the wet part going to digestion. He observed that during the "boom time," around 1994 to 1998, 32 to 35 suppliers of more or less different anaerobic process designs were on the market in Germany.

He added there has been a lot of discussion on energy balance. He observed that composting does not generate any usable energy, but instead requires an influx of energy; whereas anaerobic digestion produces energy in the form of methane gas that can be used to generate electricity. He gave several mass balance examples.

Mr. Harmssen concluded his presentation by saying that anaerobic digestion is the keystone for energy efficient waste management. He added that synergistic effects in integrated waste management systems contribute to energy efficiency systems. He said the integration of agriculture with waste management is a cost-effective strategy; the utilization of the products and the operational experience with this kind of materials may contribute to a project's success. He ended by recommending that different wastes should be kept separate as much as possible, the waste to be treated must be well known, and the operator must have the control over the wastes.

Brief summary of presentation by Arnold Klann prepared by CIWMB staff

Arnold Klann is the President and Chief Executive Officer for both Arkenol, Inc. and ARK Energy. Arkenol is an affiliate of ARK Energy, is a technology and project development company that focuses on construction and operation of biorefineries that utilize concentrated acid hydrolysis technology to convert various forms of biomass into high-value chemicals and transportation fuels.

Mr. Klann began his presentation by saying that a plant in Japan is using the Arkenol concentrated acid-hydrolysis system to produce ethanol. He said the idea isn't new and it has

been known for over 100 years that acids act as catalyst to convert ("hydrolyze") cellulose and hemicellulose into simple sugars. He added the Germans used this simple procedure in 1914 to produce alcohol fuels and chemicals from wood to supply their war efforts. He said during the same period, a similar plant was operating in Oregon. He noted that the technology fell out of use after World War II because it couldn't compete with low cost petroleum.

Mr. Klann said in 1989 there were no commercial plants converting cellulose into simple sugars, when Arkenol began researching several technologies to develop thermal hosts for proposed power plant projects and determined that the concentrated acid hydrolysis process could be made economically viable. He added that it took 12 years before the idea could be deployed as a pilot project in the City of Orange, California. He said the pilot plant was used to test equipment and feedstock, and operated for five years from 1992.

He then discussed Arkenol's permitting experience in California for a Sacramento ethanol project in the late 1990's. He said over $17 million was spent in California to license the ethanol plant and power plant together, which was fully licensed by the California Energy Commission. He added that what killed the project was it didn't meet the requirements for non-recourse project financing – growers were not considered financeable and the ethanol market was uncertain at the time.

Mr. Klann said in 2000 Arkenol licensed JGC Corporation to construct a plant in Japan. He added the new plant is located adjacent to an existing ethanol plant and has been in operation since 2002. He said the biomass facility is a fully integrated, concentrated acid-hydrolysis system that uses waste wood chips as feedstock.

Mr. Klann identified some of the driving forces that can lead to the commercialization of biomass to ethanol, including an increasing population and amount of waste generated, increasing fossil fuel prices, move to green chemistry, greenhouse gases reduction goal, and increasing problem building new or expanding existing landfills. He said the current paradigm is shifting the strategy for the ethanol industry, such as the real cost for oil approximately $250 per barrel, a shortfall of 40 billion gallons of liquid fuel today, and one ton of rice straw producing 90 gallons of ethanol.

Mr. Klann invited everyone to view a presentation on the Arkenol concentration acid hydrolysis process at Arkenol's Web site: www.arkenol.com.

Summary of presentation by Yair Zadik prepared by CIWMB staff

Yair Zadik is Co-CEO of ArrowBio Ecology, Ltd., and is in charge of business development, marketing, and the ArrowBio Plant operational team.

Mr. Zadik's presentation was entitled, "The ArrowBio Process: An Experienced Clean Treatment for MSW." He began with a chart diagramming the of the ArrowBio process at the plant in Tel-Aviv, Israel. After shredding, the incoming unsorted municipal solid waste (MSW) goes through water-based presorting process to remove contaminants to the bio-treatment process such as metals, glass, plastic, sand and other inert debris. The extracted recyclable materials are sent for recycling. Biomass material is then sent through a primary bio-treatment process (an acidogenic reactor). When that is completed, the material is sent to a secondary bio-treatment process (a methanogenic reactor), in which biogas and an effluent are extracted. The biogas is used to make electricity (and heat as a byproduct), and the effluent is recycled back into the shredder to be used in the initial sorting process. The resulting digestate is used for soil improvement. All of these processes are controlled through a computerized control system.

Mr. Zadik's presentation includes several photos of the plant and its equipment, which he went through step by step. He also showed photos of extracted recyclable and the resulting soil

amendment, as well as agricultural test plants. He described the process as an environmentally friendly treatment method to manage and recover resources from unsorted or sorted MSW via a watery sorting process ("a watery MRF") and a classical watery anaerobic treatment (UASB).

Mr. Zadik provided several testimonial statements from Australia regarding the ArrowBio system, and one chart provided from a United Kingdom source showed that the ArrowBio plant had a much better biogas recovery rate per ton of MSW than several other facililities. He indicated that the water conservation and production of a soil amendment are important considerations in desert areas such as Israel, and the small footprint is also popular.

In closing, Mr. Zadik offered the following parameters as a thought process when evaluating MSW treatment processes:

- What feedstock is it handling now? Ism it mixed MSW or not?
- What is the quality of the products?
- What is the tipping fee it works with?
- Does it have a commercial plant receiving waste from random garbage trucks?

Answering these questions for ArrowBio, he said that:

- ArrowBio receives mixed MSW, on a daily basis.
- ArrowBio has data that shows clean and non-contaminated products.
- ArrowBio works with a few tens of dollars per ton.
- ArrowBio works in a commercial site, receiving random mixed waste every day.