RP-5 Renewable Energy Project

Quarterly Technical Report

October 1, 2002 – December 31, 2002

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Date Report Submitted: January 30, 2003

DOE Award No. DE-FC26-02NT41475

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ABSTRACT

This is the second quarterly technical report for the RP-5 Renewable Energy Project. The report summarizes the work progress, effort and activities that took place during the period of October 1, 2002 to December 31, 2002. The report has been prepared in accordance with the Department of Energy (DOE) Guidelines.

This technical report covers all meetings and discussions that were conducted in order to follow up on potential renewable energy technologies that were identified in the previous report; the technologies were analyzed for their feasibility, suitability and cost effectiveness for this project. This report covers the one-day conceptual design kickoff meeting that took place on November 4, 2002. The meeting was held to discuss the practicality and implementation of potential innovative technologies. Following the kickoff meeting, Inland Empire Utilities Agency (IEUA) and CH2M Hill, the Public Interest Energy Research (PIER) Consultant, held a meeting on December 2, 2002 to discuss the Conceptual Design Report outline and contents in order to clearly present each selected technology along with its evaluation, cost effectiveness and justification. A conference call also took place between the PIER Consultant and IEUA on December 13, 2002, to discuss the overall scope of work for this project.

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INTRODUCTION

Work on the RP-5 Renewable Energy Project continued through this report period with a prime objective being to expedite various project activities and start innovative technologies selection and implementation. As it was stated in the first report for the third quarter of Year 2002, innovative technologies identified therein will be technically and commercially evaluated before final selection.

In order to put this approach into prospective, a one-day conceptual design kickoff meeting was held on November 4, 2002 at the Inland Empire Utilities Agency (IEUA) headquarters building. Experts, engineers and innovative industry representatives with many years of experience, all participated in this meeting to follow up on previous discussions and decisions that were made during the Energy Charrette (see prior technical report for details). Most of these experts participated in the Energy Charrette meeting, which set the goals and expectations for this important project.

The conceptual design kickoff meeting concentrated on potential technologies that might be considered for this project. The meeting included experts' presentations and recommendations. Discussions covered major systems such as biogas gasification and cleaning, Stirling engines and organic Rankine cycles, along with other systems that will be described in the Executive Summary. The information obtained from the kickoff meeting will be used as a basis for technologies selection and implementation.

IEUA and the PIER Consultant held another meeting on December 2, 2002 to discuss the conceptual design report's approach and contents, and its logical relation between the RP-5 Renewable Energy Project and the State of California's Energy Commission's Public Interest Energy Research (PIER) Program. The PIER program activities are logically tied, in most areas, to the conceptual design activities. The PIER Consultant is doing most of the conceptual design work under the PIER Program, which will provide a portion of the matching funds for this project. Currently, IEUA and the PIER Consultant are working on the scope of work and design effort for this project.

IEUA has established communications with Stirling Energy Systems and FlexEnergy to discuss and host their innovative power generation equipment.

IEUA has started working on a demonstration project for the Photovoltaic (PV) Carport Port System at the new headquarters building. IEUA issued a request for information to invite interested vendors for bidding. IEUA is also discussing the installation of PV panels on the roof of the Headquarters Building and at Regional Plants: RP-1 and RP-4.

EXECUTIVE SUMMARY

Major project activities in this period include expanded discussions on previous Energy Charrette decisions and recommendations, conceptual design kickoff meeting, conceptual design report, and deciding on the overall project scope of work.

Following the Energy Charrette, which was discussed in the first technical report, IEUA decided to hold a conceptual design kickoff meeting to follow up on innovative technologies presented in the Energy Charrette, and to focus on the pros and cons of each technology and its practicality. The kickoff meeting covered the following major systems:

- Biogas gasification and cleaning;
- Stirling engines;
- Organic Rankine cycles;
- Flexible microturbines;
- Bio-Reactors; and,
- Thermal ice storage.

The meeting was divided into two sessions: the morning session, which covered technology presentations; and the afternoon session, which dealt with feasibility and implementation. The following is a summary of the key points of each technology as presented by technology experts:

Biogas gasification and cleaning:

- Tested gasification systems have had a mixed success rate in the waste area;
- Receiving and handling of materials into the system is a challenging task;
- Problems in gasification systems include high alkalinity of the ash, silica formation, oils and tars, and siloxane;
- Most manure gas cleaning systems are not commercially available;
- Some of the above problems can be minimized by blending fuel with other fuels such as wood waste;
- Biomass fuel characterization is very important prior to developing any preliminary design using this technology.

Stirling Engines:

- The main reasons for using Stirling engines include efficiency and adaptability to various exhaust heat streams;
- Stirling engines can be used for primary power generation and as a bottoming cycle utilizing waste heat for power generation;
- Temperature consideration is very important for the bottoming cycle application;
- The primary disadvantage of Stirling engine is its lack of commercial availability;
- Stirling engines require fewer major components;
- Innovative approaches also include running Stirling on manure/digester gas or a mixture of digester and natural gas; partial funding for this item is available from the PIER II grant.

IEUA is currently discussing Stirling engine implementation and the possibility of inclusion of this technology in the RP-5 Renewable Energy Project, if it is found they will be cost effective when evaluated in the conceptual design report.

Organic Rankine Cycle:

- Similar to steam Rankine cycle but uses Pentane instead of steam;
- Exhaust heat from IC engines is used to heat the intermediate fluid media which in turn heats the Pentane that drives the turbine;
- The technology has been used extensively in geothermal applications but it has never been used on IC engines exhaust;
- The technology has been used in Europe and other countries, but not in the U.S.
- Heat to power efficiency ranges between 10-12%.

Flexible Microturbines:

- The flexible microturbine is a modified Capstone C-30 microturbine;
- The flexible microturbine will run on Btu fuel gas as low as 15 Btu (2% methane);

- NOx emissions are less than 1 ppm due to catalytic combustion technology;
- No pre-compression of gas is needed;
- Moisture content and variable Btu content are not a concern;
- Could be used to scrub areas and systems such as composting facilities, clarifiers, dewatering facilities, etc. if 2% methane is available in the air in that area;
- Flexible microturbine technology is to be factory tested soon;
- Flexible microturbine technology is supported by California Energy Commission (CEC) and Department of Energy (DOE) through its National Renewable Energy Lab (NREL).
- Funding for project is available from CEC and DOE grants.

IEUA has invited FlexEnergy, the developer of the flexible microturbine technology, to further discuss this technology for possible implementation at IEUA's facilities.

Bio-Reactors Technology:

- Biological conversion system using a biofilm array inside a reactor;
- Used primarily on green waste for digester gas production with a heating value of 750 Btu/scf;
- Technology has the potential to be used on manure;
- Bacteria are not removed with sludge which typically occurs with most anaerobic digestion systems.
- Residual material from the process is better in quality than Class A Biosolids.

IEUA is planning to follow up on bioreactor technology for possible future implementation at IEUA's facilities.

Thermal Ice Storage:

- The system stores the chill during off-peak hours and uses it during peak hours for significant power cost savings;
- Propane could be used as a refrigerant and as a coolant as well;
- An innovative approach would be to use the thermal ice storage system in conjunction with existing absorption chillers for higher performance.

A complete Conceptual design kickoff meeting summary is included in this report in Appendix A. The following major activities took place after the conceptual design kickoff meeting which are summarized as follows:

IEUA/ CH2M Hill (PIER Consultant) December 2, 2002 Meeting:

- Discussion of the conceptual design scope of work;
- Discussion prioritizing a list of projects under the PIER Program and the relation with the RP-5 Renewable Energy Project;
- Discussion regarding how much of the conceptual design work will be done under the PIER Program;
- Discussions defining the conceptual design report approach and contents;
- IEUA has divided the project technologies into three groups:
 1. Conventional Systems such as IC engines with short payback period;
 2. Additional systems for higher efficiency with possible long payback period; and,
 3. Additional experimental systems with no payback.
- IEUA submitted a letter to the PIER Consultant summarizing IEUA understanding and expectations of the conceptual design activities including study, evaluation and report. See attachment in Appendix B.
- The PIER Consultant is to evaluate technologies technically and economically;
- The PIER Consultant is to explore and investigate energy efficiencies improvement at other IEUA plants besides RP-5
- The PIER Consultant is to submit the conceptual design report by the end of January 2003.

IEUA/ PIER Consultant December 13, 2002 Conference Call and Subsequent Discussions:

- Discussion of overall project scope of work;
- Conducting preliminary site visit;

Other Activities:

- IEUA has contacted some IC engine-generator sets and bottoming cycles equipment manufacturers for technical information and data.
- IEUA has prepared a general layout drawing reflecting the anticipated cogeneration building size and location in the RP-5 Plant.
- IEUA is working on the design of the cooling water system supplying water to the absorption chillers.
- IEUA is discussing with vendors and respective PV PIER consultants the potential installation of photovoltaic (PV) system on the Headquarters Building and other location at RP-1 and RP-4 for power generation. The PV project will be funded, coordinated and completed through the PIER Program.
- PV Carport System
 - Selected vendors were invited to bid on the PV Carport System demonstration project;
 - The PV system generates between 1-3 kW power for solar energy;
 - The CEC provides rebates for up to 50% of the system cost;
 - System installation will start as soon as a successful vendor is selected.

EXPERIMENTAL

The RP-5 Renewable Energy Project throughout the conceptual design and research phase, and through the preliminary design phase, will continue to use standard research methods and equipment such as computers, phones, etc. The methods and steps that have been utilized in this project include, but are not limited to the following:

- Manufacturers' survey, communications, literatures, catalogues, etc.;
- Technical workshops;
- Communications with leading experts;
- Communications with environmental control agencies;
- Manufacturers' plant visits;
- Evaluation of specific factory test results for selected equipments;
- Feed back from owners of existing installations;
- Economic evaluation;
- Life Cycle analysis; and,
- Payback calculations.

RESULTS AND DISCUSSION

Although the Conceptual Design Report has not been finalized yet, however, the RP-5 Renewable Energy Project has progressed significantly as many parallel activities have taken place during this report period. These activities have defined the course and the scope of work of the project, and set the stage for equipment selection and practical implementation in the near future. Project specific details such as electrical load estimate, engine-generator sets preliminary sizing, conceptual general layout of the Cogeneration Building, and finalizing the innovative technologies evaluation table; all of these important activities reflect the noticeable progress of the project.

CONCLUSION

The RP-5 Renewable Energy Project is moving ahead as planned and anticipated. The project's main highlights are summarized below:

- Project is on schedule
- Project is on budget
- Project scope of work is being discussed
- Major power generation equipment are being sized
- PIER Conceptual design report is near completion by the PIER Consultant
- Flex microturbine and Stirling engines technology is being sought
- Installation of PV power generation system at several IEUA facilities is being discussed

Appendix A

Summary of Conceptual Design Kickoff Meeting

A meeting was held at Inland Empire Utilities Agencies (IEUA) headquarters on Monday, November 4, 2002, to review energy technologies applicable to the RP-5 Renewable Energy Project. A variety of experts were drawn together and the relative merit of various technologies were considered. This summary presents the agenda, list of attendees, key points made during the presentations, and the results of the group discussion held during the meeting.

Agenda

Inland Empire Utilities Agency RP-5 Renewable Energy Project Conceptual Design Kick-off Meeting Held on Monday, November 4, 2002

Morning Session

Introduction

Purpose of Meeting

RP-5/ PIER Program Relationship

Gasification Systems

Biogas Cleaning

Stirling Engines

Ethanol Fuel

Organic Rankine Cycles

Micro-Turbines

Thermal Ice Storage

Others

Lunch Break (Discussion to Continue)

Afternoon Session

Identification of Application Opportunities

Department of Energy (DOE) Grant and Related Projects Under Consideration

Commonwealth Energy PIER Program and Related Potential Projects

Round Table Discussion

Waste Sludge Gasification and Cleaning

Stirling Engines

Rankine Cycles

Microturbines

Thermal Ice Storage

Ethanol Fuel (Waste Food)

Overall System Recommendations

Closing Remarks

Attendees

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Presentation Highlights

Eliza Jane Whitman, Supervising Civil Engineer

Eliza Jane Whitman welcomed invitees and provided an overview of the meeting. She explained that the meeting was a continuation of previous efforts, including the energy charette held earlier this year. She also explained that the meeting was to be a planning session for future activity being planned by the Agency. The planning effort was focused on activity to be conducted under both the California Energy Commission funded Commonwealth Energy Public Interest Energy Research (PIER) Program and the RP-5 Renewable Energy Project to be funded by IEUA, DOE, and PIER.

She then provided more detailed background information on energy work completed by IEUA to date. This included:

- A general description of IEUA generation projects conducted at several of their plants
- Ongoing work at RP-5, including work on the new headquarters and adjacent facilities
- An overview of the PIER Program planning and analysis activities currently being completed
- A description of the types of projects anticipated to be included under the DOE Grant for the RP-5 Renewable Energy Project

Neil Clifton, Manager of Energy, Engineering and Construction Department

Neil Clifton also welcomed meeting participants and provided additional background information on IEUA facilities. He explained that RP-5 is presently a 15-million-gallon-per-day -per-day (mgd) plant to be expanded to 48 mgd. This expansion is planned to handle the rapid growth that is occurring in the IEUA service area. He also explained that to the west of the RP-5 complex there is undeveloped land where floodplain and wetlands considerations will restrict future development. IEUA is currently planning uses for this area. He cited the example of recreational areas near the proposed headquarters building.

Mr. Clifton explained that a relatively unique situation exists in the IEUA service area because of several factors. First, this area has had a long history of agricultural use and some of the waste material from the dairies presents waste management challenges and energy production opportunities. Second, the rapid growth occurring in the area means that there will be a need to improve the infrastructure for both managing wastewater and serving future power needs. Finally, and very significantly, the current rate structure in the area makes expensive renewable energy projects cost effective where they would not otherwise *be* cost effective.

Mr. Clifton also explained that one of the biggest challenges the agency faces is how to do business given the uncertainty of future activities. He indicated that all planners see the area eventually urbanizing and replacing existing agricultural operations, but whether this will occur in five to ten years—or forty to fifty years—is unclear. IEUA’s challenge is to develop energy projects that make sense in the short term, but also will be applicable in the future.

Mr. Clifton stated that one of the important decisions the agency will need to make is whether to develop multiple small generation systems or to develop one or two larger systems. Because these power generation systems will be serving several different loads, it may make sense to have more disbursed generation. He also pointed out, however, that you can get improved efficiencies and economies of scale with a more centralized system.

Mr. Clifton then reviewed some of the loads in the area of the RP-5 Renewable Energy Project. He said that initially there was a load of 1.5 megawatts (MW) for facilities in the area, plus another 400 kilowatts (kW) for the headquarters building presently under construction. Further, he pointed out that under Title 22, IEUA is required to have a 2000-kW backup generation in the plant before it can be operational. It is not clear at this time whether two (2) 1,400-MW generators will be installed for this project or if other generator set combinations may be considered. All gas engines will be fueled by a combination of biogas and natural gas. Presently, enough digester gas is produced at RP-2 to generate approximately 500 kW, and the manure-to-energy facility produces a comparable amount of gas. It is expected that this level of gas production will be the same or increase slightly in the future. This increase is expected recognizing that, over time, the manure operation may produce less gas as dairy operations leave the area. This decrease will be offset, however, by the anticipated increase in digester gas produced at RP-5.

Mr. Clifton pointed out other factors that should be considered in the planning process. These include IEUA’s partially implemented distribution system connecting their facilities. The IEUA plan is to have their facilities interconnected using a 12-kilovolt (kV) line. This system is partially completed in the RP-2 and RP-5 area. He identified two other facilities, at RP-4 and Carbon Canyon, where there are loads but no digester gas. This situation exists because there are no digesters at these facilities. Additional information he provided included the fact that IEUA has installed lean burn engines, and the South Coast Air Quality Management District requires that generation run on 70 percent or greater biogas to avoid the more stringent emission limitations that exist for natural gas-fired generation.

Summary of Technical Presentations

A number of experts presented technical information regarding a variety of technologies that might be applicable on the RP-5 Renewable Energy Project. The presentations have been copied onto a compact disc (CD) and are available in their entirety. The following summaries present key points made in each presentation. The key points are summarized by speaker.

David Tillman

Dave Tillman's presentation addressed two topics. These were biomass gasification and gas cleanup. The highlights of each of these topic presentations are summarized below.

Gasification

It is very important to characterize the biomass fuel prior to developing any preliminary designs for using this technology. The high alkalinity of the ash, inorganic matter, and fume particles is a major concern with manure-based gasification system. Several projects have failed because of slagging and silica formation. Dave suggested that efforts should focus on selecting the right technology once a detailed fuel characterization is completed. He also pointed out that some problems encountered with manure-type fuels can be minimized with fuel blending. Wood waste such as pallets and certain other debris might be good blending sources. He stated that particular care had to be given to material receiving and handling systems. He did, however, indicate that in spite of the challenges, several technologies looked promising. One in particular, Prime Energy, seemed appropriate.

Gas Cleanup

Dave made the following points regarding gas cleanup:

- Hot gas cleaning is not a commercial option;
- Ceramic Candles are not yet commercial; and,
- Cold gas cleaning has been demonstrated as being the closest to commercial viability. A good example of this is the Polk County Project.

F. Michael Lewis

Michael Lewis addressed gasification, pyrolysis, gas cleaning, and other technologies. A summary of the key points in his remarks follows:

- Gasification has been used sporadically in the U.S. for many years. It was widely used in Germany and Europe in the 1940s because of the unavailability of other fuel sources;
- In the waste area, gasification has been tested in many applications but has had mixed success;
- One of the best examples of a successful gasification project in the waste area is in Southern California at Hyperion;
- Michael agreed with Dave Tillman that ash is a major concern and it is important to know the origin and characteristics of the fuel;
- Tars and oils are also a key challenge in gasification systems and dealing with them may be the most cumbersome;
- NOx emissions are generally lower for gasification systems, but an important consideration can be the fuel-bound nitrogen in some of the biomass fuels;
- In general, gasifying materials to use for steam production works well where gasification to run turbines is more problematic. Gasification to run internal combustion engines is an intermediate challenge;
- Increasingly, siloxane has become a problem in some of the waste fuels;
- An important potential benefit of locating a gasification plant near a wastewater treatment plant is the availability of water;
- Some of the gas cleaning systems, although necessary for efficient energy production, can be costly. Michael cited a project where activated carbon had to be changed biweekly.

David Parry

David Parry addressed the potential use of Stirling Engines as both primary generation and as part of a bottoming cycle. He explained that the reasons for considering the Stirling technology include its efficiency, its adaptability to other systems, and the fact that it is well-suited for locations at wastewater treatment plants where water is available. He indicated that the primary disadvantage of this technology is its lack of commercial availability.

David explained that it is important to consider the temperature carefully, as it affects the efficiency of the Stirling engine. He also indicated that using the Stirling engine as a bottoming cycle is appealing because it adds capacity without additional fuel cost. He compared the Stirling engine to the Organic Rankine Cycle in a bottoming application. He characterized the comparison as:

- Similar efficiencies;
- Stirling engines can be staged for higher efficiency;
- Stirling engines have the potential for lower costs; and,
- Stirling engines are not commercial, while the Organic Rankine Cycle has been commercially demonstrated.

He also described the key attributes of the Stirling engine as a prime mover. He noted the following:

- Stirling engines require less gas treatment than IC engines or turbines;
- Compression is not required; and,
- Heat recovery is built in to the Stirling cycle.

Gerard Rodriquez

Gerald Rodriquez is a representative of Stirling Energy Systems (SES). He explained the following:

- SES's main product is a solar concentrator with a Stirling engine;
- The Stirling engine can also be used in standalone applications; and,
- The technology was developed by McDonald-Douglas.
- SES formed in the late 1990s buying rights from McDonald-Douglas and from California Edison;
- The collector has been tested and run for 25,000 hours, achieving a peak efficiency of 24.9% with a 95% availability;
- It has over 250 MWH on sun generated energy;
- SES is teamed with Kockums Stirling Engines, who produced a 75-kW engine used on submarines. The life of this engine is long; it requires limited maintenance and is very quiet; and,
- SES's objective on the RP-5 project would be to complete a demonstration project with blended biogas and natural gas and establish technical and economical parameters for successful commercialization of these dual fuel systems. SES has a full-service team ready to support this effort.

Dan Schochet

Dan Schochet represented the ORMAT Company and provided information on their organic Rankine Cycle technology. A summary of his key points is presented below.

- A key feature of the technology is its direct drive of the generator; there is no gear box involved;
- The overall electrical conversion efficiency is about 10 to 12 percent;
- The technology has been used extensively in geothermal applications;
- The technology has been used in hundreds of applications in Europe, but not in the U.S.;
- The technology has been well-suited for remote, low-maintenance, and low-cost operations;
- A 200-kW unit application would cost approximately \$1,500 to \$3,000 per kW.
- Standard unit size is 250 kW;
- Locating this technology at a wastewater treatment plant could reduce costs because of the availability of water for cooling;
- For a 2-MW system with a 400 degree (F or C) temperature???, an approximately 350-kW system could be developed;

- Although the technology has not been used in California, ORMAT has met with the California Energy Commission staff and will be working with them so that some incentives will be available for using the technology in the future. ORMAT anticipates that their standard design will meet safety requirements. Additional cost to make the system explosion proof at RP-5 should be minimal because current systems operate in refineries where safety requirements are strict;
- The ORMAT business model involves parent company doing process design with local engineering firm handling site work and installation; and
- Approximately 700 megawatts of this technology has been installed, of which 10 megawatts has been bottoming cycle applications. There has been little activity in the U.S. to date.

Overall, this technology has been used successfully in Europe. Key barriers in the U.S. include:

- Plant owners typically aren't interested in projects of only a few megawatts;
- Unlike geothermal applications, most projects considered in the U.S. have been looking for a three- to four-year payback; and,
- There is inertia to overcome related to adopting any new energy technology.

David Parry – Ethanol

David Parry explained that typically 60 percent of solids go to biogas at wastewater treatment plants, and at dairies, approximately 40 percent of the solids are converted to biogas. Ethanol production is another alternative for using this material. In addition, other feed-stocks could be used. He also cited a California Energy Commission report prepared in August 1999 suggesting that other processes could be used. He encouraged the consideration of a pilot plant integrated with anaerobic digestion. This would involve ethanol production first, followed by anaerobic digestion. This could be used for bio-solids, dairy manure, and food waste.

Edan Prabhu

Edan Prabhu described the flex microturbine technology. It operates on low British thermal unit (Btu) gas (as low as 15 Btu) at atmospheric pressure. Its emissions of NO_x are less than 1 part per million (PPM). It uses the Capstone technology but focuses on low Btu fuels that are not used by others. The biggest challenge relates to the compressors in the system.

Overall, FlexEnergy is looking for a demonstration project using gas with a heating value of 100 Btu/scf for the first unit, with plans to go to lower Btu gas in the future. The flow rate of their system is 400,000 Btu/hr, and a gas cleaning system is required. Like the Capstone unit, the technology can be easily grid connected. The key component in this system is the catalytic combustor installed in the microturbine. Because this is a new

technology, they are looking for a demonstration project and would not be willing to provide warranties typically associated with commercial technologies. They also need to have siloxanes at levels below detection limits.

Dan Aiken – VogtIce

Dan Aiken talked about a thermal energy storage for space conditioning technology. He explained that it has been used in a variety of applications, from cooling turbines for large-scale energy production to uses at individual dairies. Other applications involve load leveling. Additional key points made by Dan Aiken included:

- Systems have been installed in Gilroy, California; South Carolina (using propane); and Santa Ana;
- Types of coolants that can be used include ammonia, propane, and R22;
- A particularly innovative approach would be to use waste heat in an absorption chiller in conjunction with this technology;
- Important research activity could also be conducted using propane as a coolant; and,
- Operations and maintenance costs can be significant on these projects.

James McElvaney

James McElvaney described a biological conversion system used primarily on green waste. It uses a bio-film array inside a reactor. This process avoids removing bacteria with the sludge as typically occurs with most anaerobic digestion systems. This technology is being developed in Los Angeles County based on a technology tested in Hawaii. Gas with a heating value of approximately 750 Btu/scf is expected. This technology has the potential to be used on manure. It is important, however, to get a chemical analysis of the manure with particular emphasis on salt content. The residual material from this process is better in quality than Class A bio-solids. James also reviewed the economics of the L.A. County project, indicating that waste would be taken at \$25/ton, while the material coming out of the system (which would have a moisture content of 50%) would be sold for \$75/ton.

Action Items

- Determine whether the emission limits for NO_x are 9 or 30 PPM (IEUA)
- Look into methane produced at composting facilities for potential flex turbine application (IEUA)
- Send fuel analysis protocol to IEUA so their lab can conduct the analysis (Tillman)
- Send STM information to IEUA (Kitto)

- Provide electronic copy of presentation to IEUA (McElvaney)
- Send electronic copy of consolidated presentations to Jamal (Kitto)

Group Discussion Comments

In the afternoon session, an overview of the DOE and PIER programs, as well as a description of the existing IEUA facilities, was provided to the meeting participants. This overview formed the basis for the subsequent group discussion. The purpose of the group discussion was to identify the relative merit of the various technologies discussed in the morning session in light of the opportunities for their use as a part of the PIER and DOE Programs. All attendees participated in the discussion and a variety of topics were addressed. A summary of the key points discussed is presented below. The discussion was structured so that general topics were discussed at the outset of the session. After the general discussion, individual technologies were discussed. The results of those discussions are presented below.

GENERAL TOPICS

The availability of large quantities of water at the treatment plants is an important resource that could make a variety of technologies feasible. This resource should be assessed so its value can be maximized.

The Bio-converter system looks promising, but it is not clear that it can work on dairy manure. Additional work would be required to determine its applicability and cost to a manure, as opposed to a green waste, system.

The potential use of waste heat to dry bio-solids and manure sludge to reduce its composting or disposal costs should be investigated.

Several attendees noted that the twin roll process is highly effective and should be considered for use in projects at IEUA facilities.

An excellent contact on a dairy waste to energy project is the Mason-Dixon dairy in Gettysburg PA. On that project, a plug flow digester fed by waste from 2,000 dairy cows has been running successfully. The digester is slug loaded and serves the dairy's electrical requirements. Burt Wainright is the point of contact at the dairy.

GASIFICATION

Traditional gasification of manure is difficult because of salts, ash, and other constituents in the feedstock.

Consideration should be given to pyrolysis (low temperature) that can produce a fuel for an IC engine.

Careful fuel characterization is necessary before any gasification process can be seriously considered. Such characterization should include detailed chemical analysis, not just the determination of the methane content. In addition to fuel characterization, it is also important to know how the fuel gas would be used (e.g., turbine, IC engine, boiler).

Fuel blending could be a key to the successful deployment of any gasification process. It needs to be determined if other potential feed-stocks, such as urban wood waste, are available.

A key challenge in the gasification process is the handling of the salts in the ash. Process alternatives should be sought to reduce or eliminate the salts.

Potential use of gasification ash as flowable fill should be considered.

Gasification will likely be a long-term option, as much additional work needs to be done before this technology can be deployed on the corral dried waste.

STIRLING ENGINES

This technology offers the promise of bringing an innovative technology to a project in the IEUA area. The technology, which has been known for a long time, has had limited application in the field.

It was suggested that using this technology as the prime mover at the 75-kW scale warrants additional consideration.

Developing a Stirling Engine system as a prime mover system poses two significant challenges. First, a new burner would have to be developed. This could take more than a year. Second, the technology itself has experienced relatively little use and using it on biogas could be challenging.

Using a Stirling Engine as bottoming cycle has long-term potential, but challenges exist in using it in the near term in such applications.

Another option that may have merit is to consider fuel switching between biogas and natural gas with a Stirling Engine so output can be maximized at the times it has the most value.

It was also suggested that using a Stirling engine as a converter of waste heat and cool liquid to produce electricity is a good concept applicable in wastewater treatment plant settings at IEUA.

ORGANIC RANKINE CYCLE

This technology is proven, particularly in geothermal applications, but deployment at wastewater treatment plants in the U.S. would be a significant advancement.

Consideration should be given to using this cycle in conjunction with a solar converter.

The primary near-term application of this technology would be as a bottoming technology enhancing electrical output of the plant. Given the current cost of power, this looks promising in the near term.

The potential use of water available at plants for cooling at wastewater treatment plants offers potential for this technology that should be examined.

Discussions have been initiated between ORMAT and the California Energy Commission to have this technology identified as an emerging technology. This could be helpful in securing the Commission's interest in using this technology on the Commonwealth Energy PIER program.

ORMAT representatives said that the Energy Commission was having a workshop on December 3, 2002, about innovative technologies and those in attendance might want to consider attending the workshop to support the technology.

Consideration should also be given to using the Rankine Cycle at RP-4 given the potential size of loads at the plant.

A standard 250-kW system appears to be a good size for a variety of applications at IEUA.

FLEX MICROTURBINE

Flex Microturbine just won a grant from the Energy Commission under their targeted biogas solicitation. They are looking for a host site for this project and believe there is good potential to use this at an IEUA facility.

An important consideration in looking at potential sites for using this technology is to obtain good information on the quantity and quality of gas produced. Flex Microturbine would like to monitor the gas produced at the site where their system could be deployed.

Technology is best suited for locations where low Btu gas is available. This technology, which is really more of an air cleaning technology than an energy generation technology, is well suited for such applications.

It was suggested that this technology should be considered for use where low Btu gas is available. Suggested locations include places where off gases can be found. Locations along pipes transporting waste to wastewater treatment plants are examples of possible

locations where gas can be collected. Such locations should be identified for potential use with this technology. A suggested location that was signaled out as one worth considering is at RP-1. There is a project presently being initiated to collect gas at this location and then destroy it. Such a location might be a good location for this technology.

Consideration should be given to using off gases at the proposed composting facility at RP-4. The use of this technology could reduce odors, reduce the amount to be spent on bio-filters, and produce some energy.

There is another potential application for this technology in Orange County where a large static pile system is being used and where odor control from the off gases is a concern.

THERMAL ICE STORAGE

A key consideration in deploying this technology is the degree to which it is innovative. It is a commercial technology in a number of commercial building applications.

Key considerations that would make this technology applicable for the PIER and DOE program would be new aspects of this technology such as its use with pentane as a coolant, or to use the existing absorption chiller as a condenser to cool the ice system refrigerant.

Appendix B

January 16, 2003

Bill Kitto
Manager of Energy and Utility Programs
CH2M Hill
825 NE Multnomah, Suite 1300
Portland, OR 97232-2146

Dear Bill:

The following is a summary of our understanding and expectations that IEUA has for the Conceptual design study and report.

IEUA understands that CH2M Hill will be working on some of the activities through the PIER funded grant.

It is our understanding that through the PIER program activity, CH2M Hill will be conducting a review of technologies and evaluating their viability and cost effectiveness. The summary report to PIER will include pros and cons for each technology, project costs, reasons why the technology should be selected as a project and the benefits that could come from the technology. The report to PIER will include a summary which prioritizes the projects.

What IEUA is asking for is beyond the scope of what is being done in PIER and is as follows:

- Attend additional meetings at IEUA for additional input and education of the technologies being researched.
- Payback calculations for each technology associated with increased energy efficiency.
- A report that summarizes each of the technologies and provides the manufacturers and assumptions CH2M Hill made in reference to the energy efficient system.

In addition, this report will include all information provided to PIER, including:

2.2 Enhanced Energy Recovery Through Optimization of Anaerobic Digestion and Microturbines

The energy efficiency technologies that we understand are innovative for review under the Enhanced Energy Recovery Through Optimization of Anaerobic Digestion. Aspects of this task include the following:

1. Pentane Turbine

2. Steam Turbine
3. Stirling Engine
4. Stirling Pump
5. Ceramic Heads (or lining) for IC engines internal parts.
6. Supplemental duct firing upstream of bottoming cycle heat recovery unit (evaluation shall cover both cases; performance with and without duct firing).
7. Grease and Oil

All of these technologies can provide additional energy recovery to the system and all of these technologies will be added to generation systems that are powered from methane gas generated from anaerobic digestion as practicable.

In addition, IEUA will work with CH2M Hill to find a site location for gas cleaning and blending with existing IEUA microturbines, or the 2% methane microturbines, if they are located at our site.

In addition to looking at enhanced anaerobic digestion, we understand research related to dairy waste to energy will be conducted. As the goals and objectives indicate for the dairy waste to energy task, maximizing energy recovery in the system is one of the main tasks. It is understood by the Agency that for this task there is a separate conceptual design report and prioritization list that will be going to the PIER TAC. The items that CH2M Hill will be researching and summarizing include: the pros and cons for each technology, project costs, reasons why the technology should be selected as a project, the benefits that could come from the technology, and a summary which prioritizes the projects.

The energy efficiency technologies that we understand are innovative for review under the Dairy Waste to Energy. Aspects of this task are as follows:

1. Combining and mixing food processing waste with dairy waste.
2. Thermophilic digester pilot.
3. Digestion project at West Valley MRF.
4. Gasification
5. Propane refrigerant thermal ice storage.

Bill, if you have any questions regarding this, please give me a call.

Sincerely,

Eliza Jane Whitman, P.E.
Supervising Civil Engineer

EJW:lk

cc: Martha Davis
Neil Clifton
Jamal Zughbi