

Commerce Energy Biogas/PV Mini-Grid
Renewable Resources Program

***Making Renewables Part of an Affordable and
Diverse Electric System in California***

Contract No. 500-00-036

**BI-PV and Biogas Project
Measurement & Evaluation (M&E) Plans**

Project No. 1.1 Program Planning and Analysis

Task 1.1.13 Deliverable

Prepared For:
California Energy Commission
Public Interest Energy Research Renewable Program

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Table of Contents

1 Project 2.1 – Enhanced Landfill Gas Production Using Bioreactors: Measurement & Evaluation Plan	1-1
1.1 Project 2.1 Goals and Objectives	1-1
1.2 Project 2.1 M&E Plan Objectives	1-3
1.3 Project 2.1 M&E Work Plan	1-3
A. <i>In-depth Interviews of Key Stakeholders</i>	1-3
B. <i>Analysis of the Stakeholder Interviews</i>	1-4
C. <i>Final Report Preparation</i>	1-4
<i>Deliverables</i>	1-4
<i>Draft Report Outline</i>	1-4
<i>M&E Implementation Schedule – Project 2.1</i>	1-4
2 Project 2.2 Measurement & Evaluation Plan: Optimization of WWT Anaerobic Digestion Project.....	2-1
2.1 Project Goals and Objectives	2-1
2.2 Project 2.2 M&E Plan Objectives	2-3
<i>Pilot Performance</i>	2-3
<i>Technology Transfer</i>	2-3
<i>Market Impact</i>	2-4
2.3 Project 2.2 M&E Work Plan	2-4
A. <i>Project Performance M&E</i>	2-4
B. <i>Technology Transfer M&E</i>	2-6
C. <i>Market Impact M&E</i>	2-7
<i>Deliverables</i>	2-7
<i>Draft Report Outline</i>	2-7
<i>M&E Implementation Schedule – Project 2.2</i>	2-8
3 Project 3.1 Measurement & Evaluation Plan: Dairy Waste to Energy Project.....	3-1
3.1 Project Goals and Objectives	3-1
3.2 Project 3.1 M&E Plan Objectives	3-2
<i>Pilot Performance</i>	3-3
<i>Technology Transfer</i>	3-3
<i>Market Impact</i>	3-3
3.3 Project 3.1 M&E Work Plan	3-3
A. <i>Project Performance M&E</i>	3-4
B. <i>Technology Transfer M&E</i>	3-6
C. <i>Market Impact M&E</i>	3-7
<i>Deliverables</i>	3-7
<i>Draft Report Outline</i>	3-8
<i>M&E Implementation Schedule – Project 3.1</i>	3-8
4 Project 3.2 - BI-PV Testing and Evaluation Project: Measurement & Evaluation Plan.....	4-1
4.1 BI-PV Testing and Evaluation Project Goals and Objectives	4-1
4.2 Project 3.2 M&E Plan Objectives	4-2
<i>Selection Criteria</i>	4-3

<i>Pilot Performance</i>	4-3
<i>Technology Transfer</i>	4-4
4.3 Project 3.2 M&E Work Plan.....	4-4
<i>Deliverables</i>	4-8
<i>Draft Report Outline</i>	4-9
<i>M&E Implementation Schedule</i>	4-9

List of Figures

Figure 2-1: Project 2.2 M&E Schedule..... 2-8
Figure 3-1: Project 3.1 M&E Schedule..... 3-8

List of Tables

Table 2-1: Environmental Benefits 2-5
Table 2-2: Engineering and Economic Metrics 2-5
Table 3-1: Environmental Benefits 3-5
Table 3-2: Engineering and Economic Metrics 3-5

1

Project 2.1 – Enhanced Landfill Gas Production Using Bioreactors: Measurement & Evaluation Plan

This section provides the measurement and evaluation (M&E) plan for the Enhanced Landfill Gas Production Using Bioreactors project (i.e., Project 2.1) under the Commerce Energy PIER programmatic contract. The project's primary goals were focused on increasing methane-biogas production from bioreactor landfills, while effectively addressing regulatory and facility operator concerns with the selected landfill's design and operational modifications.

On October 14, 2004, the Project 2.1 team members, Technical Advisory Committee and Energy Commission staff jointly agreed to halt all activity on the bioreactor project. The Energy Commission subsequently issued a stop work order for the project. The TAC members and PIER program staff agreed that an abbreviated evaluation effort was warranted for the bioreactor project due to the many difficulties encountered during the development stages.

1.1 Project 2.1 Goals and Objectives

The overall stated goals of the proposed Commonwealth Biogas/PV Mini-Grid Renewable Resource Program relevant to Project 2.1 include:

- Develop and implement an approach for tailoring resource development to the specific needs and resources of local areas, or mini-grids, and
- Improve the generation capacity and affordability of renewable energy produced from new solid waste landfills in California

The goals of Project 2.1 (Enhanced Landfill Gas Production Using Bioreactors) include:

- Advance the state of knowledge for using bioreactors at landfills to increase landfill gas production and improve the characteristics of the waste to accelerate reclamation
- Work with environmental regulators to develop and implement and strategy for developing bioreactors while meeting applicable groundwater and other environmental standards

- Establish the economic and environmental benefits of the use of landfill bioreactors

The main objectives of the (original) Project 2.1 (prior to the proposed modification to one bioreactor) were to:

- Develop a conceptual design for two types of landfill bioreactors
 - MSW or organic waste landfill bioreactor (First Bioreactor)
 - MSW or organic waste landfill bioreactor supplemented by food or animal waste (Second Bioreactor)
- Develop environmental documentation to satisfy regulators
- Quantify greenhouse gas and pollution reduction benefits
- Develop two types of landfill bioreactors
 - MSW or organic waste landfill bioreactor (First Bioreactor)
 - MSW or organic waste landfill bioreactor supplemented by food or animal waste (Second Bioreactor)

The planned outcomes from the initial project (before revisions to include a single large commercial demonstration at the Mid-valley Landfill site) are briefly discussed below. The primary outcome of project 2.1 will be the successful design, construction and operation of two bioreactor pilot projects. One bioreactor will be designed to use municipal solid waste (MSW) and source-separated organic waste materials; the other will be designed to use MSW or source-separated organic waste materials along with animal waste. Performance metrics will include measurement of changes in methane production; estimation of direct reductions in CH₄ emissions and indirect reductions in other criteria air emissions associated with displaced conventional generation; and assessment of changes in lifecycle costs of generation from landfill gas. It is anticipated that the cumulative incremental gas production from both of these pilot reactors will be in the range of 1 to 5 MW.

In addition to demonstrating the feasibility of developing these bioreactors, two reports will be developed. One report will summarize the regulatory issues that were addressed and satisfied in the course of developing this project. This report will include guidelines to be used on future projects and a methodology for calculating the economic value of environmental benefits of the project. The second report will summarize the engineering work done to design and install the reactor and present pertinent installation, operation, and maintenance costs. Project lifecycle costs will be presented incorporating engineering issues as well as the value of environmental benefits presented in the first report.

1.2 Project 2.1 M&E Plan Objectives

As a result of the stop work order, the focus of the M&E activity for this project therefore includes the documentation of the key reasons that the project did not move forward to final design and construction from each key stakeholder's perspective. In addition, it is important to gain a better understanding of how the next landfill bioreactor demonstration project could be designed, permitted, and developed/operated to improve the likelihood that the technology will be successfully demonstrated on a large commercial scale and if successful, subsequently transferred and integrated into the California waste management market.

1.3 Project 2.1 M&E Work Plan

The M&E scope is abbreviated relative to the other completed Commerce Energy projects, and incorporates a review of each of the completed tasks/deliverables included in the bioreactor project up to the point that the decision was made not to proceed with the project. The abbreviated M&E effort for this project includes three components: 1) In-depth interviews with key regulatory, policy, developer and technology stakeholders; 2) analysis of the stakeholder interviews; and 3) final report preparation.

A. In-depth Interviews of Key Stakeholders

The first task includes development of an interview guide and holding subsequent in-depth interviews with key regulatory, policy, developer and technology stakeholders that were associated with the project up through the time it was halted. Itron senior staff, including the Director of Renewables and Supply-side Services will be responsible for conducting a minimum of seven in-depth interviews for the bioreactor project M&E effort. Where feasible, these interviews will be conducted in-person. The remaining interviews will be completed via the telephone.

Evaluation topics to be addressed during the in-depth interviews include:

- Identification of the key technical and cost risks of the project from each stakeholder perspective
- Identifying the key benefits of the project from each stakeholder perspective
- Determine the primary reasons why the project had such difficulty proceeding from each stakeholder perspective
- Gain a better understanding of what changes to the project might be needed from the interviewees' perspective in order for a commercial bioreactor project to be successful in the future.

B. Analysis of the Stakeholder Interviews

Itron will compile and analyze the information collected from the interviews and assess the main factors led to the failure of the current Commerce Energy bioreactor project. Based on the available information collected during the interviews, the M&E team will then determine what is needed to ensure that the next bioreactor project will have a reasonable chance for a successful design, development and commercial operation.

C. Final Report Preparation

Itron will prepare a draft report for CEC review and approval and a final M&E Report to document the objectives, process employed, and outcomes of this abbreviated Project 2.1 M&E effort.

Deliverables

Draft Report: Upon the completion of the above activities, Itron will submit a Draft Report to the CEC Contract Manager. This report will follow the Draft Report Outline provided below.

Final Report: Upon receipt of CEC Contract Manager's review comments, Itron will prepare a Final M&E Report for Project 2.1.

Draft Report Outline

- 1 Introduction**
 - 1.1 Goals and Objectives of Project 2.1
 - 1.2 Relationship of this project to the overall goals of the Commonwealth PIER Program
 - 1.3 Organization of the Report
- 2 Abbreviated Approach to Landfill Bioreactor Project Evaluation**
 - 2.1 Review of Commonwealth bioreactor project development events
 - 2.2 Evaluation goals and objectives of this Project
 - 2.3 Abbreviated Project Evaluation approach
- 3 Stakeholder Interview Results**
- 4 Conclusions and Recommendations**

M&E Implementation Schedule – Project 2.1

Interviews will be conducted with selected stakeholders during February 2006. Itron will prepare and submit a Draft Project Evaluation Report by March 10th.

2

Project 2.2 Measurement & Evaluation Plan: Optimization of WWT Anaerobic Digestion Project

This section presents the Measurement and Evaluation (M&E) plan for the Enhanced Energy Recovery through Optimization of Anaerobic Digestion and Microturbines project (Project 2.2). Project 2.2 of the Commonwealth Biogas/PV Mini-Grid Renewable Resource RD&D Program focuses on enhanced wastewater treatment (WWT) biogas production and optimized energy conversion. In addition, the Project seeks to demonstrate ways that such installations can add value through improved destruction of wastewater solids, enhanced destruction of pathogens, decreased reliance on purchased energy from the grid, improved local air quality, and by providing benefits to the local electrical grid.

Essential to this project is an M&E plan to ensure the success of the overall program and project level goals and objectives. This plan defines the distinct M&E task objectives, specific performance metrics, data collection plans, analysis techniques, and the M&E implementation schedule. In addition, the Plan also addresses the effectiveness of the programmatic aspects (linkages) between this project in achieving goals, as well as any linkages to the other PIER-funded Renewables Programs that are being implemented over the same time frame.

2.1 Project Goals and Objectives

The overall stated goals of the proposed Commonwealth Biogas/PV Micro-Grid Renewable Resource Program relevant to Project 2.2 include:

- Develop and implement an approach for tailoring resource development to the specific needs and resources of local areas, or mini-grids, and
- Improve the affordability of renewable energy produced from digester gas at sewage treatment plants.

The specific objectives of this project are to:

- Increase and optimize digester gas production through ultrasound (mechanical hydrolysis) processes.

- Develop and optimize cost effective gas cleanup systems.
- Evaluate and quantify environmental benefits that result from using microturbines at sewage treatment plants fueled by biogas.
- Evaluate performance and cost during operation so sewage treatment plants have greater certainty on cost and reliability of using microturbines.

The first outcome will be to develop and optimize digester gas production improvement processes (thermal hydrolysis and ultrasound). The focus will be on the evaluation of the systems, their impact on gas production, and their cost effectiveness. An evaluation of the digester gas production and quality as well as bio-solids reduction rate and dewatering characteristics will be presented. The installation and operating costs for the systems will be established for full-scale facilities. The cost-effectiveness evaluation will include the overall installation and operating cost compared to the benefits of improved gas production and reduces biosolids mass for disposal/reuse. A detailed evaluation and quantification of environmental benefits for each of the systems will also be developed.

For the gas cleanup processes, at least three gas cleaning systems will be defined and optimized. It is anticipated that one of these systems will involve hydrogen sulfide removal, gas drying, and siloxane removal. A second system will likely involve gas drying and siloxane removal. A third system, with parameters not yet defined, will also be formulated. The installed and operating cost for each of these systems will be determined for the full project lifecycle.

A detailed evaluation and quantification of environmental benefits for each of the systems described above will also be developed. These will be presented in the context of the Capstone microturbine. A comparison to the existing conditions will be included in this assessment. The expected outcome will be to increase gas production by 10% to 20% at an existing wastewater treatment plant, which ranges in size from 1 to 50 gpm. Also on this project, the Contractor will seek to improve the efficiency and cost-effectiveness of biogas cleaning systems used on microturbines, but in this part of the project it may make more sense to test the work at an existing facility rather than install new generation. The expected cumulative generating capacities resulting from this project is expected to range from 60kW to 1 MW.

The results of this work will be documented in a report that evaluates the cost and effectiveness of the various gas cleanup systems for each of the microturbines considered. The economics of the systems will be evaluated based on the value of electricity produced and waste heat recovered and used at the sewage treatment plant. Various alternatives will be compared by examining the net present value of different systems and the rate of return based on funds utilized.

Results from this project will be documented in periodic reports and topical papers, presentations at technical conferences, and made available on the Internet accessible through the Commonwealth Program website.

2.2 Project 2.2 M&E Plan Objectives

This M&E plan defines for the above distinct project objectives, specific performance metrics, data collection plans, analysis techniques, and the M&E implementation schedule. The M&E Plan objectives are intended to provide an objective means to determine how well Project 2.2 met its stated goals and objectives.

This M&E Plan focuses on the following WWT enhanced digester gas to energy systems issues:

- Were the pilot system performance and reliability testing criteria appropriate and sufficiently comprehensive? The focus is on evaluation of environmental, economic and process efficiency/energy production performance.
- Were the Technology Transfer Effectiveness goals met?
- How well did the Project perform in meeting its mini-grid as well as statewide market impact goals?

Pilot Performance

Iron will evaluate the performance of the effectiveness of enhancing energy recovery at the host facilities, as indicated by the specific performance metrics. The primary emphasis here will be on the increased output of energy, the effects on cost-effectiveness, and the environmental impacts relative to conventional approaches. Initially developed estimates of environmental and economic performance will be compared to those based on actual pilot project results. Data on these aspects of performance will have been collected and analyzed by the project team under Task 2.2.5, and these results will be further assessed.

An evaluation will be conducted on how effectively the test sites were monitored for performance. This will include an assessment of how well designed the monitoring system was in capturing all relevant aspects of system performance, how well the monitoring was executed, and how thoroughly the performance data were analyzed and evaluated.

Technology Transfer

Iron will assess the extent to which the learning and system advancements accomplished at the wastewater treatment enhanced digester pilot test facilities were effectively transferred to the Commonwealth team members and to other key participants in the WWT digester supply channel and program/project development community. Part of this assessment will address

the effectiveness with which the project team worked with the Technical Advisory Committee and Program RPAC.

Market Impact

Also, Itron will assess the likely impacts of the advancements stemming from the project on market acceptance of wastewater biogas generation in the mini-grid area(s) as well as in the state as a whole. This assessment will be based upon an assessment of the relative cost-effectiveness of the demonstrated technology relative to conventional technologies, as well as the extent to which it mitigates some of the non-cost barriers to market acceptance.

2.3 Project 2.2 M&E Work Plan

The M&E work scope includes an independent review of each of the Tasks included in the Project 2.2 *Enhanced Energy Recovery through Optimization of Anaerobic Digestion and Microturbines* work plan. Itron will critically evaluate the process and the outcome of all of the activities within the project work plan with regard to how successfully the work plan was carried out and how the tasks contributed to the overall Project goals and objectives.

A. Project Performance M&E

Itron to perform:

- Review system evaluation plan vs. actual system evaluation methods.
- Assess conclusions and results – based on interviews with TAC for their opinion.
- Evaluate test facility (e.g., ability to test all stated performance criteria)
- Assess communication and working relationship with TAC and RPAC – interview TAC and RPAC members.

Review System Evaluation Plans: Itron will compare the original systems evaluation plans with the actual evaluation methods used. This comparison will document any discrepancies or inconsistencies between the original and actual plans and will explain or justify the discrepancies.

Assess Conclusions and Results: Telephone interviews will be conducted with the TAC members. They will be interviewed to get their opinions on the systems tested relative to other potential systems. The TAC members will be asked to give their opinions on how valuable the pilot test results are in demonstrating the viability and feasibility of widespread similar installations. Any hindsight modifications to the evaluation program will be noted.

Performance information will be collected and presented for the environmental measures shown in Table 2-1 below. The economic and engineering information will be presented in a similar format as shown in Table 2-2.

Table 2-1: Environmental Benefits

Environmental Benefits	Potential (Assuming Design Specifications)	Existing WWT Digester	Situation With Enhanced Digester and Gas Cleaning
Electricity Production (kWh/year)			
CO ₂ equivalent of kWh reduction (ton/Year)			
CO ₂ emissions avoided by fuel displacement (ton/year)			
No _x emissions avoided by fuel displacement (ton/year)			
SO ₂ emissions avoided by fuel displacement (ton/year)			
Other			

Table 2-2: Engineering and Economic Metrics

Engineering/Economic Consideration	Existing WWT Digester	With Enhanced Digester and Gas Cleaning
Electricity Consumption		
Total Capacity (MW)		
Avg. Annual Cost (\$)		
Capital Cost (\$)		
Annual O & M (\$/year)		
Environmental Benefits (\$)	N/A	
Total Life Cycle Cost (\$)		
Rate of Return (percent)	N/A	

Initially developed estimates of environmental and economic performance will be compared to those based on actual pilot project results to make a determination of performance.

Evaluate Pilot Test Facility: Itron will evaluate how well the pilot test facilities and demonstration test results will serve the overall objectives of the Project and the CE Mini-grid Program. In telephone interviews among the TAC and RPAC members, Itron will

assess the working relationship between the Project Team and TAC / RPAC members. Itron will also document the lessons learned by the CE Project Team and the Project 2.2 TAC and RPAC members in connection with the Enhanced Energy Recovery pilot program.

The evaluation will also assess how effectively the test site was monitored for performance. The design of the monitoring system will be examined to determine how successful the monitoring was in capturing all relevant aspects of system performance, how well the monitoring was executed and how thoroughly the performance data were analyzed and evaluated. An examination of the monitoring system and project documentation, including project reports, will be used in this assessment.

B. Technology Transfer M&E

Itron will assess how valuable “lessons learned” and “tech advancements” are to: a) the team, b) to the key industry supply channel players, and c) to third party project developers and potential host system owners.

Itron will assess how well “lessons learned” and “tech advancements” have been transferred to: a) to the key industry players and b) to third parties project developers and potential host system owners. The assessment will be conducted using the following measures:

- Identify and contact appropriate staff of federal agencies with WWT digester gas to energy expertise such as NREL, DOE, National Labs, etc. These contacts will be interviewed to ascertain their awareness of the pilot project and their opinions of its technology transfer and market impact relevance. A total of three to five experts will be interviewed.
- Review the reports, trade publication articles, and conference presentations developed as a part of, or a result of the Pilot Program. The content of these publications, conference presentations, and workshops will be reviewed and summarized with a view toward the degree to which they have increased acceptance of enhanced biosolids to biogas recovery systems.
- Interview other team members and other WWT digester system owners and developers to determine how well the lessons learned from the program have been transferred and the level of awareness about the program within the industry. A total of three to five WWT operators and two to three WWT digester system A&E firms and biogas microturbine project developers will be interviewed. Itron will also determine the degree to which institutional barriers such as contracting and inspection issues, and economic feasibility issues have been addressed by the project.

C. Market Impact M&E

Itron will also evaluate the market development impacts resulting from the pilot projects. Examining whether the targeted demonstrations were successful will assess likely market impacts. These include:

- Demonstration of the technical and economic feasibility of ultrasound processes;
- Demonstration of the technical and economic feasibility of optimized gas cleaning systems; and
- Demonstration of methodology to quantify the value of environmental benefits from using Microturbines (vs. internal combustion engines) at sewage treatment plants.

The impacts will be judged on the resulting cost-effectiveness of the demonstrations as well as their effectiveness in mitigating non-cost barriers. This assessment will be qualitative in nature as there are no clear quantitative measures of success. A judgmental assessment of the demonstrations will be requested during interviews with RPAC, TAC, CEC staff, and other industry stakeholders. Specific attention will be given to the impacts on the local mini-grid as well as the statewide market impacts.

Deliverables

Draft Final Report: Upon the completion of the above tasks, Itron will submit a Draft Final Report to the CEC and Project 2.2 TAC members. This report will follow the Draft Report outline described below.

Final Report: Upon receipt of CEC staff's and TAC member's review comments, Itron will prepare a Final Report

Draft Report Outline

1 Introduction

- 1.1 Purpose of the Enhanced Energy Recovery through Optimization of Anaerobic Digestion and Microturbines pilot
- 1.2 Relationship of this program to the overall goals of the Commonwealth PIER project.
- 1.3 Organization of the report

2 Pilot Performance, Economic/Financial and Project Design M&E

- 3.1 Environmental Evaluation
- 3.2 Economic Assessment
- 3.3 Engineering Assessment

3 Evaluation of Technology Transfer Activities

- 3.1 Evaluating Transfer Effectiveness
- 3.2 Market Impacts M&E

4 Assessment of Market Impacts

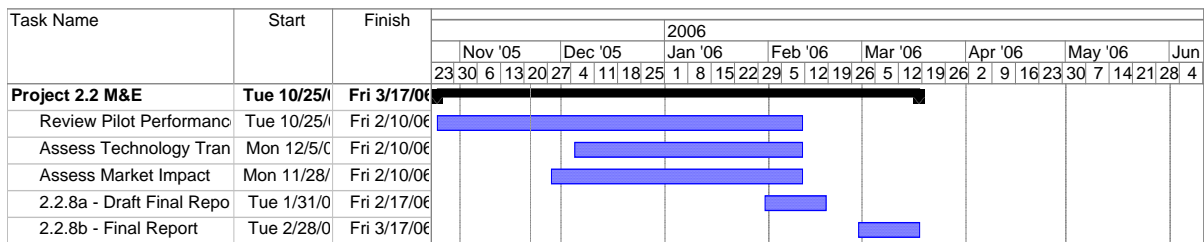
- 4.1 Mini-Grid Impacts
- 4.2 Statewide Impacts

5 Summary and Conclusions

M&E Implementation Schedule – Project 2.2

The schedule of M&E tasks and associated deliverables is illustrated in Figure 2-1 below.

Figure 2-1: Project 2.2 M&E Schedule



3

Project 3.1 Measurement & Evaluation Plan: Dairy Waste to Energy Project

This report presents the Measurement and Evaluation (M&E) plan for the Dairy Waste to Energy Project (Project 3.1). Project 3.1 of the Commonwealth Biogas/PV Mini-Grid Program focuses on the economical conversion of dairy waste to energy. In addition, the Project seeks to demonstrate ways that such facilities can add value through reducing groundwater and air pollution and by providing distributed generation benefits to the local electrical grid.

Essential to this project is an M&E plan to ensure the success of the overall program and project level goals and objectives. This plan defines the distinct M&E task objectives, specific performance metrics, data collection plans, analysis techniques, and the M&E implementation schedule. In addition, the Plan also addresses the effectiveness of the programmatic aspects (linkages) between this project in achieving goals, as well as any linkages to the other PIER-funded Renewables Programs that are being implemented over the same time frame.

3.1 Project Goals and Objectives

The overall stated goals of the proposed Commonwealth Biogas/PV Mini-Grid Program relevant to Project 3.1 are:

- Develop and implement an approach for tailoring resource development to the specific needs and resources of local areas, or mini-grids, and
- Improve the economics of producing energy from animal waste.

The specific goals of Project 3.1 are to:

- Develop technologies that can be used to maximize the energy recovery from animal waste,
- Develop and evaluate different pilot projects that will include facilities at existing treatment plants and at individual and clusters of dairies, and

- Evaluate and test the effectiveness of low and high technologies developed in North America and Europe for the collection processing and energy recovery of animal waste.

The specific objectives of this project are to:

- Assess and evaluate technologies available for the conversion of animal waste to energy including European manure digestion technologies (food waste co-digestion selected – both with bio-solids and with dairy waste),
- Select Sites for animal waste to energy pilot plant(s),
- Design, construct and operate pilot plant(s), and
- Summarize and evaluate economic and environmental costs and benefits associated with developing an animal waste to energy facilities.

The Dairy Waste to Energy Project will generate process flow diagrams (which integrate the selected process advancements into the selected site) and preliminary facilities location plans depicting the conceptual layout of the pilot plant, the pilot plant test protocol Plan, performance specifications, site drawings, and one (or more) operating pilot plant(s) ranging in size from 60 kW to 5 MW, with quarterly plant operating reports that document performance and needed modifications throughout the project. Results from this program will be documented in periodic reports and topical papers, presented at technical conferences, and made available on the Internet accessible through the Commonwealth Program website.

3.2 Project 3.1 M&E Plan Objectives

This M&E plan defines for the above distinct project objectives, specific performance metrics, data collection plans, analysis techniques, and the M&E implementation schedule. The M&E Plan objectives are intended to provide an objective means to determine how well Project 3.1 met its objectives and goals.

This M&E Plan focuses on the following dairy waste to energy systems issues:

- Were the pilot system performance and reliability testing criteria appropriate and sufficiently comprehensive? The focus is on evaluation of environmental, economic and engineering performance.
- Were Technology Transfer Effectiveness goals met?

- How well did the Project perform in meeting its Market Impact goals?

Pilot Performance

Itron will evaluate the performance of the effectiveness of enhancing energy recovery at the host's treatment facilities, as indicated by the specific performance metrics listed and developed under the (original) Task 3.1.6. The primary emphasis here will be on the increased output of energy, the effects of program advancements on cost-effectiveness, and the environmental impacts relative to conventional approaches. The evaluation will assess how effectively the test sites were monitored for performance. Initially developed estimates of environmental and economic performance will be compared to those based on actual pilot project results. The evaluation will include examining how well designed the monitoring system was in capturing all relevant aspects of system performance, how well the monitoring was executed and how thoroughly the performance data were analyzed and evaluated.

Technology Transfer

Itron will assess the extent to which the technology application advancements accomplished at the host facilities were transferred to other team members, as well as to others in the renewable energy community. The evaluation will assess the extent to which the learning and system advancements accomplished at the dairy waste to energy host facilities were effectively transferred to the Commonwealth team members and to other key participants in the dairy waste to energy supply channel and project development community. Part of this assessment will address the effectiveness with which the project team has worked with the RPAC.

Market Impact

Also, Itron will assess the *likely impacts* of the advancements stemming from the project on market acceptance of dairy waste generation within the mini-grid area(s) as well as throughout the state as a whole. This activity will be based upon an assessment of the relative cost-effectiveness of the demonstrated technology relative to conventional technologies, as well as the extent to which it mitigates some of the non-cost barriers to market acceptance.

3.3 Project 3.1 M&E Work Plan

The M&E work scope includes an independent review of each of the Tasks included in the Project 3.1 work plan. Itron will critically evaluate the process and the outcome of all of the activities within the dairy waste to energy work plan with regard to how successfully the work plan was carried out and how the tasks contributed to the overall Project goals and objectives.

A. Project Performance M&E

Itron to perform:

- Review system evaluation plan vs. actual system evaluation methods,
- Assess conclusions and results – interview TAC for their opinion,
- Evaluate test facility (ability to test all stated performance criteria), and
- Assess working relationship with TAC and RPAC – interview TAC and RPAC members.

Review System Evaluation Plans: Itron will compare the original systems evaluation plans with the actual evaluation methods used. This comparison will document any discrepancies or inconsistencies between the original and actual plans and will explain or justify the discrepancies.

Assess Conclusions and Results: Telephone interviews will be conducted with the TAC members. They will be interviewed to get their opinions on the systems tested relative to other potential systems. The TAC members will be asked to give their opinions on how valuable the pilot test results are in demonstrating the viability and feasibility of widespread similar installations. Any hindsight modifications to the evaluation program will be noted.

Performance information will be collected and presented for the environmental measures shown in Table 3-1 below. The economic and engineering information will be presented in a similar format as shown in Table 3-2.

Table 3-1: Environmental Benefits

Environmental Benefits	Potential (Assuming Design Specifications)	Existing (Pre-Project) Situation	With Manure and Food Waste Co- digestion and Gas Cleaning
Electricity Production (kWh/year)			
CO ₂ equivalent of kWh reduction (ton/Year)			
CO ₂ emissions avoided by fuel displacement (ton/year)			
No _x emissions avoided by fuel displacement (ton/year)			
SO ₂ emissions avoided by fuel displacement (ton/year)			
Other Environmental Benefits			

Table 3-2: Engineering and Economic Metrics

Engineering/Economic Consideration	Existing (Pre-Project) Situation	With Manure and Food Waste Co- digestion and Gas Cleaning
Electricity Consumption		
Total Capacity (MW)		
Avg. Annual Cost (\$/yr)		
Capital Cost (\$)		
Annual O & M (\$/year)		
Environmental Benefits (\$)	N/A	
Total Life Cycle Cost (\$)		
Rate of Return (percent)	N/A	

Initially developed estimates of environmental and economic performance will be compared to those based on the implemented pilot project results to make a determination of performance.

Evaluate Pilot Test Facility: Itron will evaluate how well the pilot test facilities and demonstration test results will serve the overall objectives of the Project and the CE Mini-grid Program. In telephone interviews among the TAC and RPAC members, Itron will

assess the working relationship between the Project Team and TAC / RPAC members. Itron will also document the lessons learned by the CE Project Team and the Project 3.1 TAC and RPAC members in connection with the Enhanced Energy Recovery pilot program.

The evaluation will also assess how effectively the test site was monitored for performance. The design of the monitoring system will be examined to determine how successful the monitoring was in capturing all relevant aspects of system performance, how well the monitoring was executed and how thoroughly the performance data were analyzed and evaluated. An examination of the monitoring system and project documentation, including project reports, will be used in this assessment.

B. Technology Transfer M&E

Itron will assess how valuable “lessons learned” and “tech advancements” are to: a) the team, b) to the key industry supply channel players, and c) to third-party project developers and potential host system owners. The assessment will be conducted using the following methods:

Itron will assess how well “lessons learned” and “tech advancements” have been transferred to: a) to the key industry players and b) to third parties project developers and potential host system owners. The assessment will be conducted using the following measures:

- Itron will identify and contact appropriate staff of federal agencies with dairy-waste digester gas to energy expertise such as NREL, DOE, National Labs, etc. These contacts will be interviewed to ascertain their awareness of the pilot project and their opinions of its technology transfer and market impact relevance. A total of two to three experts will be interviewed.
- Itron will review the reports, trade publication articles, and conference presentations developed as a part of, or a result of the Pilot Program. The content of these publications, conference presentations, and workshops will be reviewed and summarized with a view toward the degree to which they have increased acceptance of centralized dairy-waste biosolids to biogas recovery systems.

- Itron will interview other team members and other dairy-waste digester system owners and developers to determine how well the lessons learned from the program have been transferred and the level of awareness about the program within the industry. A total of two to three dairy-waste digester operators and two to three dairy-waste digester system A&E firms will be interviewed. Itron will also determine the degree to which institutional barriers such as contracting issues, inspection issues, and economic feasibility issues have been addressed by the project.

C. Market Impact M&E

Itron will also evaluate the market development impacts resulting from the pilot projects. By examining whether the targeted demonstrations were successful, likely market impacts will be assessed. The expected market impacts include:

- Demonstration of the technical and economic feasibility of centralized anaerobic digester (CAD) technology for dairy waste to energy; and
- Demonstration of methodology to quantify the value of environmental benefits from CAD.

The impacts will be judged on the resulting cost-effectiveness of the demonstrations and their effectiveness in mitigating non-cost barriers. This assessment will be qualitative in nature as there are no clear quantitative measures of success. A judgmental assessment of the demonstrations will be requested during interviews with appropriate RPAC, all TAC and CEC PIER Renewable Program staff, and other industry stakeholders. Specific attention will be given to the impacts on the local mini-grid, as well as the statewide market impacts.

Deliverables

Draft Final Report: Upon the completion of the above tasks, Itron will submit a Draft Report to the CEC Contract Manager and to the Project 3.1 TAC members. This deliverable will follow the Draft Report outline described below.

Final Report: Upon receipt of CEC staff's and TAC member's review comments, Itron will address reviewer comments as appropriate and submit a Final Report to the CEC Contract Manager.

Draft Report Outline

1 Introduction

- 1.1 Purpose of the Dairy Waste to Energy project
- 1.2 Relationship of this project to the overall goals of the Commonwealth PIER program.
- 1.3 Organization of the report

2 M&E of Pilot Performance Finance and Development M&E

- 3.1 Environmental Assessment
- 3.2 Economic Assessment
- 3.3 Engineering Assessment

3 M&E of Technology Transfer Activities

- 3.1 Evaluating Technology Transfer Effectiveness

4 M&E of Market Impacts

- 4.1 Mini-Grid Impacts
- 4.2 Statewide Impacts

5 Summary and Conclusions

M&E Implementation Schedule – Project 3.1

The review of the project performance can begin after Task 3.1.5 is nearly complete. This task marks the end of the *test operation* of the facility. The review of performance, the assessment of the technology transfer and the assessment of the market impact can be conducted simultaneously.

Figure 3-1: Project 3.1 M&E Schedule

Task Name	Start	Finish	2006																													
			Nov '05			Dec '05			Jan '06			Feb '06			Mar '06			Apr '06			May '06			Jun '06								
			23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	5	12	19	26	5	12	19	26	2	9	16	23	30	7	14
Project 3.1 M&E	Tue 10/25/05	Fri 3/17/06																														
Review Pilot Performance	Tue 10/25/05	Fri 2/10/06																														
Assess Technology Transfer	Mon 12/5/05	Fri 2/10/06																														
Assess Market Impact	Mon 11/28/05	Fri 2/10/06																														
3.1.9a - Draft Final Report	Tue 1/31/06	Fri 2/17/06																														
3.1.9b - Final Report	Tue 2/28/06	Fri 3/17/06																														

4

Project 3.2 - BI-PV Testing and Evaluation Project: Measurement & Evaluation Plan

This document presents the Measurement and Evaluation (M&E) Plan for the Commerce Energy Biogas/PV Mini-Grid Renewable Resource RD&D Program Building-Integrated Photovoltaic Testing and Evaluation Project (Project 3.2). In general terms Project 3.2 focuses on advancing PV system integration and establishing a path forward to develop a basic PV system rating procedure that can be used by the PV industry. Essential to this process is an M&E plan to ensure the success of the overall program-level and project-level goals and objectives. This plan provides the project objectives, specific performance metrics, data collection plans, analysis techniques, and the implementation schedule. This Plan also addresses the effectiveness of the programmatic aspects (or linkages) between this project in achieving its goals, as well as any linkages to the other PIER-funded Renewables Programs that are being implemented over the same time frame.

4.1 BI-PV Testing and Evaluation Project Goals and Objectives

The overall stated goals of the proposed Commerce Energy Biogas/PV Micro-Grid Renewable Resource Program relevant to Project 3.2 are:

- To develop and implement an approach for tailoring resource development to the specific needs and resources of local areas, or mini-grids;
- To demonstrate the use of proper system and components integration to enhance the performance of photovoltaic systems; and
- To demonstrate and update the application of a *performance evaluation rating system* for building integrated systems; and to improve the transfer of this information on system and module performance to consumers and the supply channel stakeholders; and

The specific goals of Project 3.2 are to:

- Address the existing gap between future third-party certified PV component and system performance results and currently available information from manufacturers,

- Provide an independent comparative evaluation of PV systems relevant to Project 3.3 (large systems testing) and the Energy Commission's Emerging Renewables Buydown Program (small systems testing),
- Provide useful decision-making information to PV industry stakeholders and potential purchasers and users on those PV systems, and
- Improve the quality of systems installed through the Commerce Energy Program (i.e., Project 3.3 - Note: this goal is no longer directly applicable, given the stop-work issued by the Commission for Project 3.3) and through directed training.

The specific objectives of Project 3.2 include:

- Select, procure, install, and evaluate three large PV systems (for use in implementing Project 3.3 BI-PV on Public Buildings) and three small PV systems,
- Determine whether flaws, weak points, poor design features, etc. exist and where appropriate, offer suggested remedies or improvements,
- Evaluate system/component selection, ease of installation, performance, other issues that may impact life-cycle costs,
- Characterize initial performance, monitor and report on system performance for 12 months,
- Develop recommendations for BI-PV system specifications and purchases, and;
- Demonstrate and refine the application of a *Performance Evaluation Rating System* for building integrated systems; and improve the transfer of system and module performance information to consumers and supply channel stakeholders.

For the system design element of this project, performance will be evaluated through comparisons of the performance of three selected building integrated commercial PV system designs generally applicable to major publicly-owned facilities. The Commerce Energy PV Testing and Evaluation Project will procure and install selected PV systems and modules, perform extensive engineering and initial performance evaluations, and monitor the performance of installed modules and systems on a side-by-side basis for a minimum of 12 months. Results from this program element will be documented in periodic reports and topical papers, presented at technical conferences and at on-site training (workshops), and made available in real-time via the Internet and accessible through the Commerce Energy Program website.

4.2 Project 3.2 M&E Plan Objectives

This M&E plan defines for the above distinct project objectives, specific performance metrics, data collection plans, analysis techniques, and the M&E implementation schedule. In addition, the plan also addresses the effectiveness of the programmatic aspects (linkages)

between the projects in the Commerce Energy Program in achieving their goals, as well as any identified linkages to the other PIER-funded Renewables Programs that are being implemented over the same time frame.

This M&E Plan focuses on the following BI-PV systems issues:

- System selection criteria (applicability to nonresidential markets, scale up, eligibility for CEC Buydown/CPUC Self-Generation Incentives Programs),
- System performance and reliability testing criteria, and
- Technology Transfer effectiveness, including recommendations for a National Systems Performance Standard.

Outside of the PIER Program Team's use of the testing system results, there are no direct market impacts expected from this performance-testing project. Therefore, unlike the other Program projects, the M&E plan for Project 3.2 does not contain a plan for measuring and evaluating market impacts.

Selection Criteria

The focus of the selection criteria will be commercial building-integrated PV systems relevant to the Commerce Energy Biogas/PV Renewable Energy Affordability RD & D Program and the California Energy Commission PIER Program. At least three sample PV systems will be purchased and evaluated by Endecon Engineering (now BEW). Selection of sample systems will be based on such factors as:

- Relevance of the system to other activities within the program, such as a forthcoming procurement,
- Relevance of the system to California's CEC Emerging Renewables/CPUC Self-Generation Incentive Programs,
- Availability of prior testing data and system changes made since prior evaluation(s),
- Key system components that have not been previously evaluated, and
- Information from other sources, such as our verification monitoring and troubleshooting work with the Commission's Emerging Buydown Program systems.

Pilot Performance

While the major components are being evaluated, Endecon Engineering will review the documentation for code compliance, installation issues, ease of installation, quality of design, etc. This evaluation plan shall encompass the operational performance of the testing facility, the reported usefulness of the results to potential users (including key Commerce Energy

Team members), and the effectiveness with which the project team has worked with the Project's Technical Advisory Committee (TAC).

Technology Transfer

This evaluation plan includes the assessment of the extent to which the learnings and system advancements accomplished at the BI-PV pilot test facilities were effectively transferred to the Commerce Energy team members and to other key participants in the PV supply channel and program/project development community. In addition, Itron will review the appropriateness and applicability of the Project's plans to provide recommendations for a National PV Systems Rating Performance Standard. Another aspect of the technical transfer assessment will address the effectiveness with which the project team worked with the Project 3.2 TAC, Program RPAC and other PIER Renewables Programmatic contract teams.

4.3 Project 3.2 M&E Work Plan

The M & E work scope shall include a review of the criteria used for selection of the pilot system location and equipment, preparation of plans to test the performance of the pilot systems, and the plans for using the results of the BI-PV pilot program as a vehicle for technology transfer. The results of this evaluation effort for Project 3.2 will be presented to the Energy Commission Contract Manager through the submittal of a draft and final M&E reports.

A. Review of Selection Criteria

In its review of BEW's selection criteria, Itron shall perform the following activities:

- Conduct literature search to identify any independent prior testing or evaluation of BI-PV components and/or systems
- Interviews w/ TAC members,
- Interviews w/ Energy Commission staff,
- Interviews w/ Endecon/BEW project staff, and
- Assess appropriateness and completeness of Selection Criteria for this Project and from a programmatic perspective.

Literature Search: Itron will conduct a literature search to identify and retrieve the results of previous testing of the PV components selected for the BI-PV systems. The search will include an online search as well as contacts with the equipment manufacturer's representatives, as needed. The results of any previous tests will be briefly summarized. Literature sources will be documented. Any implications of the results of this search will be passed along to BEW/Endecon.

Interviews with Project 3.2 TAC Members: Itron will conduct telephone interviews with all TAC members to review the selection criteria and the choice of components and systems. These discussions will be open-ended and intended to allow the interviewees a chance to comment on the entire large and small system configurations, including any relevant locational considerations.

Interviews with CEC staff: Itron will conduct telephone interviews with appropriate CEC to review the selection criteria and the choice of components and systems. These discussions will be open-ended and intended to allow the interviewees a chance to comment on the entire large and small system configurations, including any relevant locational considerations.

Interviews with BEW-Endecon: Based on the above input, Itron will conduct telephone interviews with BEW/Endecon to provide feedback and to obtain clarification about issues raised in the interviews and literature search.

Appropriateness of Section Criteria: Itron will assess the above input in the context of a careful review of the programmatic purposes to determine whether the BI-PV Components and Systems selection criteria are best suited to the overall program. The applicability of the systems to the CEC Emerging Buydown Program and the CPUC's Self-Generation Incentives Program will also be evaluated by the M&E team.

B. Review of Test Plans and Pilot Performance Evaluation

The test plans and pilot performance measurement and evaluation protocols will be reviewed by Itron with select input from BEW, as follows:

- Review System Evaluation Test Plan vs. actual Project 3.2 system evaluation methods,
- Assess conclusions and results – interview TAC for their opinion, literature review of other systems reports and case studies,
- Interview other team members (e.g., Commerce and REDI) for usefulness of the testing results,
- Interview several system integrators and/or installers concerning the testing results,
- Evaluate test facility (ability to test all stated performance criteria), and
- Assess working relationship with TAC and RPAC – interview TAC and RPAC members.

Review System Evaluation Plans: Based on the results of the activities completed in Section A above, Itron will compare the original System Evaluation Test Plans with the

actual evaluation methods selected. This comparison will document any discrepancies or inconsistencies between the original and actual plans and will explain or justify the discrepancies.

TAC and Team Member Interviews: Telephone interviews will be conducted with the TAC, other team members (CE, REDI). The TAC will be interviewed to get their opinions on the literature review of other systems and how they feel these systems compared to others studied. Team members will go over test results and be asked to give their opinions on how valuable the pilot test results are in demonstrating the viability and feasibility of widespread similar installations. Any hindsight modifications to the evaluation program will be noted.

Integrator/Installer Interviews: The system integrator/installers will be selected from the Energy Commission list of installers active within the Self-Generation Incentive Program. Seven interviews are planned to be completed. The installers interviewed will not include the installers selected for the mini-grid test site. System Integrators/Installers will be selected from those who:

- Have experience in installing BI-PV systems of a comparable size to the test site installations,
- Have successfully participated in the CPUC SGIP or the CEC's Buydown Program, and
- Distributed among the three utility service areas as follows:
 - Three from the PG&E area
 - Three from the Edison/SCG area
 - One from the SDG&E area.

The interviews will be conducted in person or via telephone by Itron staff. The interviewers will first brief the interviewees on the purpose of the CE PIER program and the interview itself. They will then be briefed on the specifics of the types of installations in the pilot program, the equipment used, the installation and testing process and the test results. They will be invited to comment on all of these aspects of the pilot sites and to relate their experiences with similar situations. They will be solicited to provide feedback on the installations and results of the 3.2 testing program in terms of its demonstration value for similar BI-PV installations. They will be asked to give their opinion on how effectiveness of Project 3.2 Testing and Evaluation, and how it might have been improved.

Itron will evaluate how well the planned test facilities will serve the overall objectives of the program. In telephone interviews among the 3.2 TAC members, Itron will assess the quality of the working relationship between BEW and the TAC members. Itron will also document

the key lessons learned by TAC members in connection with the BI-PV testing and evaluation program.

C. M&E of Technology Transfer Activities

Itron will assess the BI-PV Testing & Evaluation Project in terms of effectively transferring the lessons learned from this project to other Commerce Energy team members, and to other participants in the PV supply channel and development community. The emphasis of this part of the project review will be focused on how effective the pilot program has been in addressing the economic and institutional barriers to acceptance of BI-PV systems, particularly in the public sector and in the commercial/institutional markets.

Itron will assess how well “lessons learned” and “advancements in determining system performance” have been transferred through the efforts of Project 3.2 to PV stakeholders including: a) the CE Team, b) to the key industry supply channel players, and c) to third party project developers and potential host system owners. The assessment will be conducted using the following measures:

- Itron will identify and contact appropriate staff of federal agencies with BI-PV expertise, such as NREL, DOE, National Labs, etc. These contacts will be interviewed to ascertain their awareness of the program and their opinions of its technology transfer relevance.
- Itron will quantify the number of trade publication articles, consumer publication articles, conference presentations, workshops conducted as a part of, or as a result of the CE Program. The M&E Team will review and summarize the content of these publications and conference presentation with a view toward the degree to which they have increased acceptance of BI-PV systems on public facilities.
- Itron will interview other team members and other PV system manufacturers and installers to determine how well the lessons learn from the program have been transferred and the level of awareness about the program with the industry. We may also determine the degree to which institutional barriers such as contracting issues, building and inspection issues, and economic feasibility issues have been addressed by the Program.
- Itron will compile the number of visits to relevant pages of the Program website. The number of hits for this website will be compared with other comparable PV-related websites to benchmark the number of site visits to the Program site versus other comparable sites.
- Itron will review the appropriateness and applicability of the Project’s plans with respect to the ability of the program’s intentions to provide recommendations for a National Systems Rating Performance Standard.

Deliverables

Draft Final Report: Upon the completion of the above tasks, Itron will submit a Draft Final Project M&E Report to the CEC contract manager. This report will follow the Draft Report outline described below.

Final Report: Upon receipt of CEC staff's review comments, Itron will submit the Final Project 3.2 M&E Report.

Draft Report Outline

1 Introduction

- 1.1 Purpose of the BI-PV Testing and Evaluation pilot program
- 1.2 Relationship of this program to the overall goals of the Commerce Energy PIER project.
- 1.3 Organization of the report

2. Review of Project Selection Criteria

- 2.1 Literature Review
- 2.2 TAC Interviews
- 2.3 CEC PIER Staff Interviews
- 2.4 BEW/Endecon Interviews
- 2.5 Appropriateness of Selection Criteria

3 Review of Test Plans and Pilot Performance Evaluation

- 3.1 Code Compliance and design and installation issues
- 3.2 Selection and Evaluation Plan review
- 3.3 Interview results
- 3.4 Test Program Evaluation
- 3.5 Assessment of working relationships

4 Evaluation of Technology Transfer Activities

- 4.1 Data on Website Activity
- 4.2 Evaluating Information Transfer Effectiveness

5 Summary and Conclusions

M&E Implementation Schedule

Literature search and interviews will be conducted with selected stakeholders during the month of February 2006. Itron will prepare and submit a Draft Project Evaluation Report to the CEC Contract Manager by March 10th.