

Commonwealth 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
Market Potential Assessment Final Report**

Project No. 1.1 Program Planning and Analysis

Task 1.1.7 Final Report

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

Prepared By:

Itron
1104 Main Street, Suite 630
Vancouver, WA 98660

Legal Notice

This report was prepared as a result of work sponsored by the California Energy Commission (Commission). It does not necessarily represent the views of the Commission, its employees, or the State of California. The Commission, the State of California, its employees, contractors, and subcontractors, make no warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the Commission nor has the Commission passed upon the accuracy or adequacy of the information in this report.

December 2003

Table of Contents

1 Introduction	1-1
1.1 Overview of Commonwealth PIER Program Planning and Analysis Project.....	1-1
1.2 Market Potential Assessment Objectives	1-2
1.3 Report Organization	1-5
2 Overview of Analytic Methodology	2-1
2.1 Introduction.....	2-1
2.2 Definition of Relevant Terms	2-1
2.3 Technical Potential	2-2
2.4 Financial Analysis.....	2-2
<i>Prototypical Project Financial Performance</i>	<i>2-3</i>
<i>Required Project Financial Performance</i>	<i>2-5</i>
<i>Calculation of Economic Potential</i>	<i>2-6</i>
2.5 Market Potential Model Overview.....	2-6
3 Building-Integrated Photovoltaic Market Potential.....	3-1
3.1 Introduction.....	3-1
3.2 Development of Prototypes	3-1
3.3 Estimates of Technical Potential	3-2
3.4 Analysis of Economic and Market Potential	3-2
<i>Data Sources.....</i>	<i>3-3</i>
<i>Analytic Methodology</i>	<i>3-4</i>
<i>Economic and Market Potential Results</i>	<i>3-15</i>
4 Dairy and Food Processing Waste Market Potential	4-1
4.1 Introduction.....	4-1
4.2 Key Issues.....	4-1
4.3 Development of Prototypes	4-2
4.4 Estimates of Technical Potential	4-5
4.5 Analysis of Economic and Market Potential	4-5
<i>Data Sources.....</i>	<i>4-6</i>
<i>Analytic Methodology</i>	<i>4-6</i>
<i>Economic and Market Potential Analysis Results.....</i>	<i>4-12</i>
5 Wastewater Treatment Plant Biogas Market Potential	5-1
5.1 Introduction.....	5-1
5.2 Key Issues.....	5-1
5.3 Development of Prototypes	5-2
5.4 Estimates of Technical Potential	5-3
<i>Existing WWT Distributed Generation Facilities</i>	<i>5-3</i>
<i>Remaining WWT Biogas Technical Potential</i>	<i>5-4</i>
5.5 Analysis of Economic and Market Potential	5-6
<i>Data Sources.....</i>	<i>5-6</i>
<i>Analytic Methodology</i>	<i>5-7</i>

<i>Economic and Market Potential Results</i>	5-11
6 Landfill Gas Market Potential	6-1
6.1 Introduction	6-1
6.2 Key Issues	6-1
6.3 Development of Prototypes	6-2
6.4 Estimates of Technical Potential	6-2
6.5 Analysis of Economic and Market Potential	6-3
<i>Data Sources</i>	6-4
<i>Analytic Methodology</i>	6-4
<i>Economic and Market Potential Results</i>	6-6
7 Biogas and BI-PV Market Potential Summary	7-1
7.1 Summary of Technical, Economic, and Market Potential	7-1
7.2 Summary of Combined Market Potential by Resource	7-6
7.3 Summary of Key Economic and Market Drivers	7-9
7.4 Conclusions	7-11
Appendix A Tables of BI-PV Results	A-1
Appendix B Tables of Biogas Results	B-1

List of Tables

Table 2-1: Inventory/Technical Potential Task Reports	2-2
Table 2-2: Description of Low-, Expected-, and High-Potential Scenarios	2-4
Table 2-3: Financial Parameter Type by Technology and Parameter	2-4
Table 2-4: Illustration of Market Potential Model	2-7
Table 3-1: Public and Private Sector Nonresidential BI-PV Technical Potential	3-2
Table 3-2: Characteristics of PV Composite Profile	3-3
Table 3-3: Current Available Nonresidential PV System Costs	3-4
Table 3-4: BI-PV Potential - Scenario Financial Parameters	3-6
Table 3-5: Summary of Future PV System Costs (Real 2002 \$)	3-7
Table 3-6: Average Current Value of PV Electric Energy (Real 2002 Cents/kWh)	3-8
Table 3-7: Market Penetration Rates Assumed for BI-PV	3-14
Table 3-8: BI-PV Identified Projects	3-15
Table 3-9: Expected BI-PV Economic and Market Potential	3-16
Table 3-10: Low BI-PV Economic and Market Potential	3-18
Table 3-11: High BI-PV Economic and Market Potential	3-18
Table 4-1: Dairy and Food Processing Waste Biogas Technical Potential	4-5
Table 4-2: AD System Installed Capital Costs by Prototype	4-7
Table 4-3: Estimated Values of Generated Electricity	4-8
Table 4-4: Expected Case Dairy Biogas Economic and Market Potential	4-13
Table 4-5: Economic Performance Distribution for Public Agency-Owned Dairy CAD (IRR %)	4-16

Table 4-6: Expected Case Food Waste Biogas Economic and Market Potential	4-16
Table 4-7: Low Case Dairy Biogas Economic and Market Potential	4-21
Table 4-8: Low Case Food Waste Biogas Economic and Market Potential	4-21
Table 4-9: High Case Dairy Biogas Economic and Market Potential	4-22
Table 4-10: High Case Food Waste Biogas Economic and Market Potential	4-22
Table 5-1: Projected WWT Biogas-Fueled Generation within the Mini-grid	5-4
Table 5-2: Mini-grid WWT Biogas Technical Potential	5-6
Table 5-3: Estimated Values of Natural Gas and Generated Electricity	5-9
Table 5-4: Expected Case IRR Results	5-10
Table 5-5: WWT Biogas Incremental Economic and Market Potential – Expected Case	5-12
Table 5-6: Low WWT Economic and Incremental Market Potential	5-14
Table 5-7: High WWT Economic and Incremental Market Potential	5-14
Table 6-1: LFG Technical Potential	6-3
Table 6-2: LFG Electricity Prices	6-5
Table 6-3: LFG Gross Economic Potential	6-6
Table 6-4: Expected LFG Market Potential	6-7
Table 6-5: Low LFG Market Potential	6-9
Table 6-6: High LFG Market Potential	6-10
Table 7-1: Expected Scenario Potential – Biogas and BI-PV Resources	7-2
Table 7-2: Low Scenario Potential – Biogas and BI-PV Resources	7-4
Table 7-3: High Scenario Potential – Biogas and BI-PV Resources	7-5
Table 7-4: Expected Market Potential by Resource	7-7
Table 7-5: Low Market Potential by Resource	7-8
Table 7-6: High Market Potential by Resource	7-9
Table A-1: Representative BI-PV Market Potential Model Formulas	A-1
Table A-2: Total Private & Public Sector Non-Residential BI-PV Market Potential (Expected Potential)	A-2
Table A-3: Private Sector Non-Residential BI-PV Market Potential (Expected Potential)	A-3
Table A-4: Public Sector Non-Residential BI-PV Market Potential (Expected Potential)	A-4
Table A-5: Total Private & Public Sector Non-Residential BI-PV Market Potential (Low Potential)	A-5
Table A-6: Private Sector Non-Residential BI-PV Market Potential (Low Potential)	A-6
Table A-7: Public Sector Non-Residential BI-PV Market Potential (Low Potential)	A-7
Table A-8: Total Private & Public Sector Non-Residential BI-PV Market Potential (High Potential)	A-8
Table A-9: Private Sector Non-Residential BI-PV Market Potential (High Potential)	A-9
Table A-10: Public Sector Non-Residential BI-PV Market Potential (High Potential)	A-10
Table B-1: Representative Biogas Market Potential Model Formulas	B-1

Table B-2: Total Landfill Gas Potential (Expected Case).....	B-1
Table B-3: Total Landfill Gas Potential (High Case).....	B-2
Table B-4: Total Land Fill Gas Potential (Low Case).....	B-2
Table B-5: Total Wastewater Treatment Biogas Potential (Expected Case).....	B-3
Table B-6: Total Wastewater Treatment Biogas Potential (High Case).....	B-4
Table B-7: Total Wastewater Treatment Biogas Potential (Low Case).....	B-5
Table B-8: Total Food Processing Waste Biogas Potential (Expected Case).....	B-6
Table B-9: Total Food Processing Waste Biogas Potential (High Case).....	B-7
Table B-10: Total Food Processing Waste Biogas Potential (Low Case).....	B-8
Table B-11: Total Dairy Waste Biogas Potential (Expected Case).....	B-9
Table B-12: Total Dairy Waste Biogas Potential (High Case).....	B-10
Table B-13: Total Dairy Waste Biogas Potential (Low Case).....	B-11

List of Figures

Figure 1-1: Commonwealth Renewables Mini-grid Map.....	1-3
Figure 2-1: Cumulative Hurdle Rate Distribution for Generation Projects.....	2-5
Figure 3-1: Forecasted Average Values of PV Electric Production.....	3-9
Figure 3-2: Green Tags Values Assumed for BI-PV (Real 2002 \$).....	3-11
Figure 3-3: Expected Scenario - BI-PV Market Potential.....	3-16
Figure 3-4: BI-PV Expected Scenario - Economic Potential versus Cumulative Market Potential.....	3-17
Figure 3-5: Cumulative BI-PV Market Potential by Year and Scenario.....	3-19
Figure 4-1: Expected Case Dairy Biogas Market Potential.....	4-17
Figure 4-2: Dairy Economic Vs. Cumulative Market Potential – Expected Case.....	4-18
Figure 4-3: Expected Case Food Waste Biogas Market Potential.....	4-19
Figure 4-4: Food Waste Economic Vs. Cumulative Market Potential – Expected Case.....	4-20
Figure 4-5: Dairy Biogas Market Potential Scenarios.....	4-23
Figure 4-6: Food Waste Biogas Market Potential Scenarios.....	4-24
Figure 5-1: WWT Biogas Incremental Market Potential – Expected Case.....	5-12
Figure 5-2: WWT Economic Potential versus Cumulative Market Potential – Expected Case.....	5-13
Figure 5-3: WWT Biogas Incremental Market Potential by Scenario.....	5-15
Figure 6-1: Expected LFG Market Potential.....	6-8
Figure 6-2: LFG Economic Potential versus Cumulative Market Potential.....	6-8
Figure 6-3: LFG Market Potential Scenarios.....	6-10
Figure 7-1: Expected Scenario Potential – Biogas and BI-PV Resources.....	7-3
Figure 7-2: Low Scenario Potential – Biogas and BI-PV Resources.....	7-4
Figure 7-3: High Scenario Potential – Biogas and BI-PV Resources.....	7-6
Figure 7-4: Expected Market Potential by Resource.....	7-7
Figure 7-5: Low Market Potential by Resource.....	7-8
Figure 7-6: High Market Potential by Resource.....	7-9

1

Introduction

This report summarizes the methods and findings of a study to assess the market potential for non-residential renewable distributed generation, utilizing biogas and building-integrated photovoltaics (BI-PV) within the Chino Basin located southeast of Los Angeles in Southern California. Regional Economic Research, Inc., a wholly owned subsidiary of Itron, Inc. (Itron/RER), conducted the study for the California Energy Commission (Commission) under Contract No. 500-00-036. This assessment comprises one element of the broader Commonwealth Energy Biogas/PV Renewable Mini-Grid Program (Program) being administered through the Commission's Public Interest Energy Research (PIER) Renewables group. The overall purpose of the broader PIER Program is to increase the market opportunities, the available technologies, and the affordability of renewable energy options in California.

1.1 Overview of Commonwealth PIER Program Planning and Analysis Project

The Commonwealth Program's initial research, development and demonstration activities include two parallel efforts to help refine the Program strategy and direction: 1) Program Planning and Analysis (Project 1.1), and 2) Building-Integrated Photovoltaics (BI-PV) Testing and Evaluation (Project 3.2). The primary objectives for the Commonwealth PIER Project 1.1, Program Planning and Analysis effort, are to:

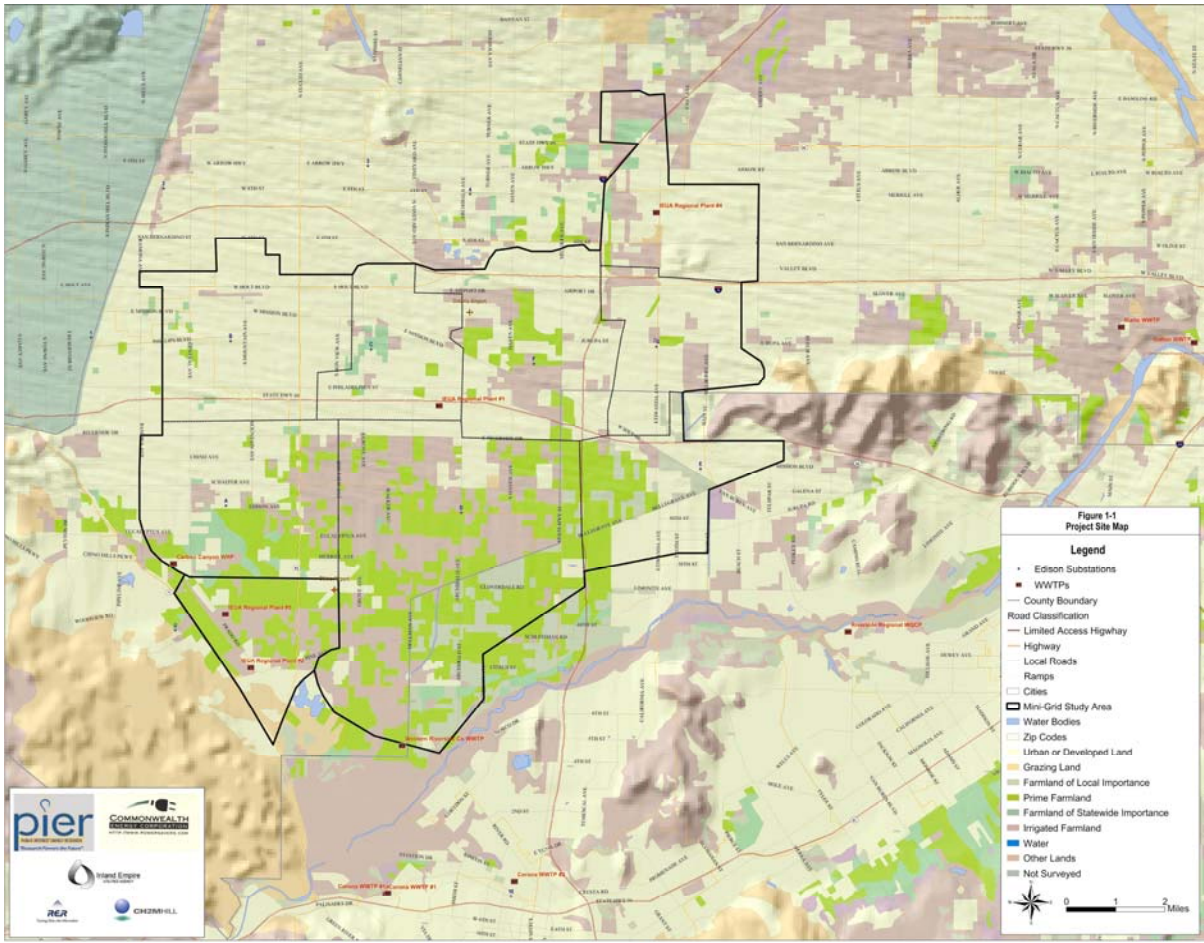
- Define the initial Program study area,
- Inventory the study area's potential photovoltaic and biogas resources to assess the potential of such resources and to help identify potential demonstration projects,
- Identify a mini-grid, on which the potential distribution impact of the development of such resources can be assessed,
- Conduct power flow studies to identify and quantify the benefits of various levels of renewable energy penetration on the local electric distribution system,
- Identify and prioritize individual demonstration projects, and
- Identify net cost savings and benefits that would accrue by developing complementary resources.

A multidisciplinary team led, by Itron/RER and supported by CH₂M Hill, Renewable Energy Development Institute (REDI) and Zaininger Engineering Company (ZECO), is responsible for meeting these program-planning objectives. CH₂M Hill is responsible for undertaking the various biogas resource inventory assessments. Electric system characterization and data development, power flow and other studies related to the mini-grid are being undertaken by ZECO. As mentioned above, the nonresidential BI-PV resource assessment documented in this report is being performed jointly by the REDI and Itron/RER.

1.2 Market Potential Assessment Objectives

This report focuses on the assessment of existing and future biogas and non-residential BI-PV market potential in the subject area, which is in the Chino Basin located east-southeast of Los Angeles. The boundaries of the Commonwealth PIER Renewables Program “mini-grid” encompass area in the southwest portion of San Bernardino County and the northwest portion of Riverside County. Initial specification of a *preliminary* mini-grid boundary was previously completed under Task 1.1.1 of the Program. A map outlining the geographical area of the Commonwealth Renewables electric distribution system mini-grid is included in Figure 1-1.

Figure 1-1: Commonwealth Renewables Mini-grid Map



The general goals of this market potential assessment are to:

- Develop an understanding of the renewable distributed generation resources that could be expected to contribute to electric grid support, both currently and over the 10 year planning period, and
- Provide renewable distributed generation market potential information to the T&D power flow expansion case modeling effort.

The specific objectives of this Task 1.1.7 market potential assessment include:

- Estimate the economic potential (in MW) for each Commonwealth Program biogas and BI-PV resource in 2003, 2007 and 2012 within the mini-grid, and
- Estimate the market potential (in MW) for each biogas and BI-PV resource in 2003, 2007 and 2012 within the mini-grid.

The specific biogas resources examined in this effort include landfill gas, agricultural (dairy) and food processing waste digester gas, and wastewater treatment digester gas. The non-residential BI-PV systems evaluated under this assessment include rooftop, curtain wall, awning, and parking/shade structure applications. The resulting market potential estimates for these biogas and non-residential BI-PV resources feed into the power flow modeling in Task 1.1.9b of the Program Planning and Analysis Project, which are necessary in order to quantify the grid impacts. The prior estimation of biogas technical potential was completed under Task 1.1.2, Task 1.1.3, and Task 1.1.4 of the Program.

Translation of the previous estimates of biogas and BI-PV technical potential under Tasks 1.1.2 through 1.1.5 into estimates of market potential are documented here under this Task 1.1.7 deliverable of the Commonwealth PIER Renewables Mini-grid Program. The scope of this market potential assessment was limited to maintain focus on areas that are most germane to the Commonwealth PIER Program. Therefore, only *non-residential* market applications within the Commonwealth Program mini-grid area are considered in this assessment.

1.3 Report Organization

Section 2 of this report provides a general overview of the methodology used in the assessment of market potential. The introductory overview includes a description of issues surrounding the market conditions that affect the adoption of biogas and BI-PV renewable distributed generation systems. Sections 3 through 6 provide descriptions of the BI-PV, dairy and food waste, wastewater treatment, and landfill gas resource market potential assessments, respectively. Within each of these sections, major issues are addressed surrounding the economic and market conditions that affect the adoption of the three biogas and the nonresidential BI-PV renewable generation systems. Section 7 provides a summary of the overall results of this market assessment.