Technical Report

September 2000 • NREL/TP-550-25283

A Market Assessment of Residential Grid-Tied PV Systems in Colorado

Barbara C. Farhar, Ph.D.
Timothy C. Coburn, Ph.D.

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393

NREL is a U.S. Department of Energy Laboratory
Operated by Midwest Research Institute • Battelle • Bechtel

Contract No. DE-AC36-99-GO10337

September 2000 • NREL/TP-550-25283

A Market Assessment of Residential Grid-Tied PV Systems in Colorado

Barbara C. Farhar, Ph.D.
Timothy C. Coburn, Ph.D.

Prepared under Task No. PV00.8201

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393

NREL is a U.S. Department of Energy Laboratory
Operated by Midwest Research Institute • Battelle • Bechtel

Contract No. DE-AC36-99-GO10337

Available electronically at http://www.doe.gov/bridge

Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: reports@adonis.osti.gov

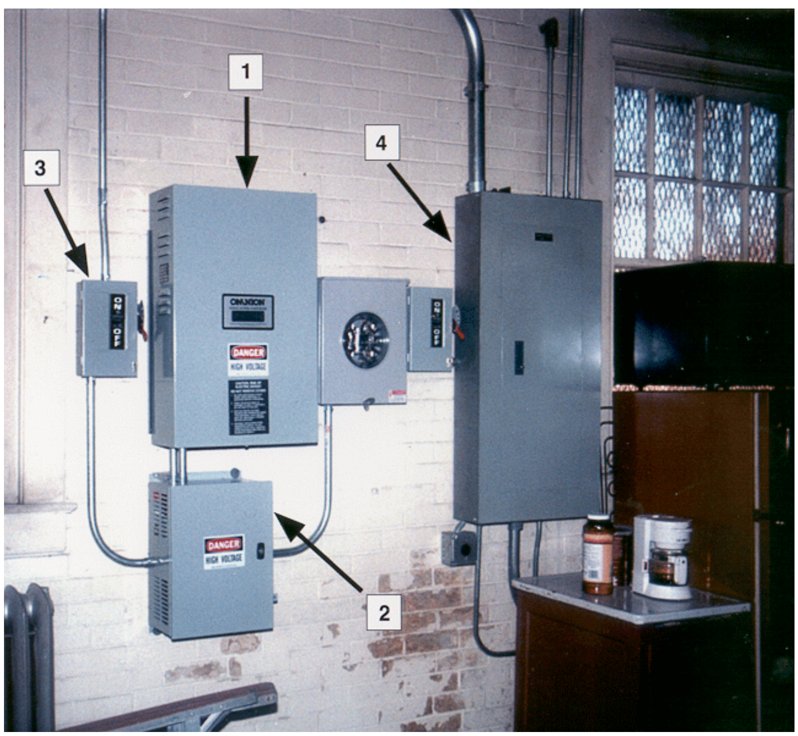
Available for sale to the public, in paper, from:
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

Printed on paper containing at least 50% wastepaper, including 20% postconsumer waste

PV panel installation on Evergreen home in Public Service Company of Colorado Parade of Homes, 1996

PV shingles installation at Southface Energy and Environmental Resource Center, Atlanta, Georgia, 1996

PV panel installation on private residence in Gardner, Massachusetts



Standard equipment for a household PV system. For example, this is the equipment for the PV installation at the Governor's mansion: (1 and 2) inverter, and (3) service disconnect switch. The equipment was installed near the existing household breaker box (4).

Contents

Page

List of Tables vii
List of Figures xi
Acknowledgments xii
Executive Summary xiv

Chapter 1. Introduction 1

Chapter 2. Guiding Ideas of the Study 3
Literature Review 3
Rate of Adoption 3
Characteristics of Innovation Adopters 5
Innovation Attributes 6
Stages in the Adoption of Innovations 7
"Next Tiers" 9
Operationalizing the Model 9
Study Hypotheses 10
Interpretation of Data 12

Chapter 3. Descriptive Findings: Knowledge, Favorability, Benefits, Barriers, and Information 13
Familiarity and Favorability 13
Knowledge and Behavioral Intention 15
Perceived Benefits of GPV Adoption 15
Perceived Barriers to GPV Adoption 19
Information Needs 21
Information Sources 23

Chapter 4. Descriptive Findings: Product Attributes 27
Preferred System Features 27
Preferred PV Suppliers 29
Appearance/Performance Trade-offs 30
Excess Electricity and Net Metering 31

Chapter 5. Descriptive Findings: Willingness to Pay for GPV Systems and Favorability Toward Using GPV 34
System Size/Price Tradeoffs 34
Scenarios for GPV System Purchase 35
Payment Preferences 43
Policy Preferences on GPV Subsidies 44
Favorability toward Using GPV on One's Own Home 45
Changes in Favorability after Considering GPV Benefits and Costs 46

Page

Chapter 6. Data Reduction 50
Factor Analysis of Perceived Benefits 51
Factor Analysis of Perceived Barriers 53
Factor Analysis of Product Attributes 54
Factor Analysis of Information Needs 56
Factor Analysis of GPV Information Sources: Individuals, Groups, and Organizations 57
Factor Analysis of GPV Information Sources: Channels 59
Factor Analysis of Lifestyles and Values 59
Further Discussion 60

Chapter 7. Market Segmentation 61
Approach to Segmenting the Prospective Market 61
Important Data Considerations 62
The Criterion Variables 63
Description of the Criterion Clusters 63
The Predictor Variables 65
Description of the Predictor Clusters 66
Linking the Predictor and Criterion Clusters 68
Establishing the Next Tiers of Market Development 71

Chapter 8. The Size and Composition of the GPV Market 74
Composition of the GPV Market 74
Estimating the Market Size 77
Market Sensitivity to System Size and Cost Trade-offs 79
Market Sensitivity to Alternative Financing Options 80
Market Response to Full Subsidization of Systems 81
Threshold Values 82

Chapter 9. Detailed Characteristics of Near-Term Purchasers 85
Two Types of Early Adopters of GPV 85
A Comparison of Highly Likely (HL) Pacesetters and Highly Likely (HL)
Steady Positives 85

Chapter 10. Validating Study Hypotheses 90
Dependent Variables 90
Independent Variables 90
Hypothesis Testing Approach 90
Results of Hypothesis Testing 91
Discussion of Hypothesis Testing Results 96

Chapter 11. Findings, Conclusions, and Discussion 100
Some Specific Findings of the Study 100
Caveats to Market Size Estimates 101

Page

Developing a Successful GPV Product 102
Developing a Successful Marketing Strategy 102
The Market Impacts of Institutional Intervention and Advocacy 102
An Overall Conclusion 104

Chapter 12. Recommendations and Summary Remarks 105
PV System Marketers (Utility Companies, PV Manufacturers, and Homebuilders) 105
Lenders 106
State Policy Makers 106
State and Local Energy Offices 107
Interested Parties and Consumers 108
Final Summary Remarks 108

Bibliography 109

Appendixes

A. Respondent Characteristics (Demographics, Values and Lifestyles, and Other Variables) 111
B. Research Approach 127
Questionnaire Construction 128
Sampling 129
Response Rate and Margins of Error 130
Data Collection 132
Reasons for Nonresponse 132
Data Coding and Reconciliation 133
Representativeness of the Study's Respondents 134
Statistical Analysis 137
C. Base n’s, Means, Standard Deviations, and Coefficients of Variation for Scaled Responses . . 139
Descriptive Statistics 140
D. Detailed Factor Analysis Results 148
E. “Positive” Response Patterns on All Study Variables Relative to Tier Membership 157
F. “Positive” Response Patterns on All Study Variables Relative to Highly Likely Predictor Clusters 170
G. Relationship of Cluster Matrix Membership and Membership in the Tiers to the Sample as a Whole 184
H. Experience with Efficiency and Renewables by Market Tiers 190
I. Differences Between *Highly Likely* and *Highly Unlikely* Criterion Clusters on the Basis of Percentages of Highly Important Ratings Assigned to Relative Advantages, Product Attributes, and Barriers 193
J. Colorado Homeowner Questionnaire on Home-Based PV Systems Tied to the Utility Grid 198

List of Tables

Page

Guiding Ideas of the Study

1. The Study's Dependent Variables 10
2. The Study's Independent Variables 11

Descriptive Findings: Knowledge, Favorability, Benefits, Barriers, and Information

3. Favorability toward GPV Being More Available 14
4. Perceived Sources of Electricity in Colorado 16
5. Perceived Benefits of GPV System Purchase 18
6. Potential Barriers to GPV System Purchase 20
7. Information Needs 22
8. Individuals, Groups, and Organizations Preferred as PV Information Sources 24
9. Preferred GPV Information Communication Channels 26

Descriptive Findings: Product Attributes

10. Preferred System Features 28
11. Preferred Source of GPV System Purchase 30
12. Appearance/Performance Trade-offs 31
13. Net-Metering Options 32

Descriptive Findings: Willingness to Pay for GPV Systems and Favorability to Using GPV

14. System Size/Price Trade-offs 36
15. Estimates Used in Purchase Scenarios 37
16. Net Amounts Willing to Pay More per Month for a Very Small GPV System 38
17. Net Amounts Willing to Pay More per Month for a Medium-Sized GPV System 39
18. Net Amounts Willing to Pay More per Month for a Very Large GPV System 41
19. Likelihood of Purchase of a No-Added-Cost GPV System 43
20. Level of Choice (in Percent) by GPV Payment Options 44
21. Preferred Forms of Subsidy 45
22. Favorability toward the Idea of Using PV on One's Own Home 46
23. Comparison of Responses on Favorability toward GPV 48
24. Changes in Favorable Opinions toward GPV 49

Market Segmentation

25. Criterion Cluster Variable Scores 64
26. Percentage Allocation of Respondents to Criterion Clusters 65
27. Factor Scores of Predictor Variable Clusters 68

Page

28. Percentage Allocation of Respondents to Predictor Clusters, with Descriptive Characteristics 69
29. Predictor Cluster Membership in Criterion Clusters 70
30. Designation of the Market Tiers 72

The Size and Composition of the GPV Market

31. Selected Demographic Characteristics of Respondents Included in the Tiers 76
32. Values and Lifestyle Characteristics of Respondents Included in the Tiers 77
33. Other Characteristics Related to GPV Adoption Exhibited by Respondents Included in the Tiers 78
34. Low and High Market Size Estimates for Various System Sizes and Monthly Cost Alternatives 81
35. Low and High Market Size Estimates for Various Financing Options 82

Detailed Characteristics of Near-Term Purchasers

36. Comparative Responses of *HL Pacesetters* and *HL Steady Positives* Relative to Selected Perceived Benefits 86
37. Comparative Responses of *HL Pacesetters* and *HL Steady Positives* to Selected Perceived Barriers 87
38. Comparative Responses of *HL Pacesetters* and *HL Steady Positives* Relative to Selected Product Attributes 88
39. Comparative Responses of *HL Pacesetters* and *HL Steady Positives* Relative to Values and Lifestyles 88

Validating Study Hypotheses

40. The Study's Hypotheses and Results of Hypothesis Testing on Attitudes, Knowledge, and Preferences 92

41. The Study's Hypotheses and Findings on Demographics 95

Appendix A: Respondent Characteristics (Demographics, Values, and Lifestyles, and Other Variables)

A-1. Gender 116
A-2. Age 116
A-3. Marital Status 117
A-4. Annual Household Income before Taxes 117
A-5. Household Composition 118
A-6. Rural or Urban Location 118
A-7. Occupation 119
A-8. Educational Attainment 120
A-9. Geographic Locale 121

A-10. Political Orientation 121
A-11. Primary Heating Fuel 122
A-12. Likelihood of Moving 122
A-13. Utility Company 123
A-14. Lifestyle and Values 124
A-15. Experience with Efficiency and Renewables 126

Appendix B: Research Approach

B-1. Margins of Error for Selected Dependent Variables 131
B-2. Reasons for Nonresponse 133
B-3. Comparison of Distributions of Percentages of Households Living in Various Geographic Areas of Colorado 135
B-4. Comparison of Distributions of Percentages of Households Using Various Fuels as Their Primary Heating Sources 136
B-5. Comparison of Distributions of Percentages of Households Served by Various Utilities/Energy Providers 137

Appendix C: Base n's, Means, Standard Deviations, and Coefficients of Variation for Scaled Responses

C-1. Variables with High Standard Deviations 142
C-2. Statistics 143

Appendix D: Detailed Factor Analysis Results

D-1. Perceived Relative Advantages 149
D-2. Product Attributes 150
D-3. Perceived Barriers 152
D-4. Information Needs 153
D-5. Information Sources 154
D-6. Information Channels 155
D-7. Values and Lifestyles 156

Appendix E: "Positive" Response Patterns on All Study Variables (Including Demographics) Relative to Tier Memberships

E-1. "Positive" Response Patterns on All Study Variables Relative to Tier Membership 158

Appendix F: "Positive" Response Patterns on All Study Variables (Including Demographics) Relative to Highly Likely Predictor Clusters

F-1. "Positive" Response Patterns on All Study Variables Relative to *Highly Likely* Predictor Clusters 171

Page

Appendix G: Relationship of Cluster Matrix Membership and Membership in the Tiers to the Sample as a Whole

G-1. Likelihood to Purchase a No-Added-Cost GPV System (Scenario D), Cluster Matrix Members versus Entire Sample 186
G-2. Likelihood of Looking for More Information on GPV Cluster Matrix Members versus Entire Sample 186
G-3 System Size/Price Trade-offs, Cluster Matrix Members versus Entire Sample 187
G-4. Favorability toward Using GPV on One's Own Home, Cluster Matrix Members versus Entire Sample 187
G-5. Likelihood to Purchase a No-Added-Cost GPV System (Scenario D), Members of Tiers versus Entire Sample 188
G-6. Likelihood of Looking for More Information on GPV, Members of Tiers versus Entire Sample 188
G-7. System Size/Price Trade-offs, Members of Tiers versus Entire Sample 189
G-8. Favorability toward Using GPV on One's Own Home, Members of Tiers versus Entire Sample 189

Appendix H: Familiarity and Experience with Efficiency and Renewables of Respondents Assigned to the Different Market Tiers

H-1. Nature of Experience with Energy Efficiency and Renewable Energy Equipment by Tiers . . . 191
H-2. Familiarity with Energy Efficiency and Renewable Energy Equipment by Tiers 192

Appendix I: Differences between *Highly Likely* and *Highly Unlikely* Criterion Clusters on the Basis of Percentages of Highly Important Ratings Assigned to Relative Advantages, Product Attributes, and Barriers

I.1 Comparisons of *Highly Likely* and *Highly Unlikely* Criterion Clusters on the Basis of the Percentages of Respondents Rating Selected Relative Advantages as Highly Important 195
I-2. Comparisons of *Highly Likely* and *Highly Unlikely* Criterion Clusters on the Basis of the Percentages of Respondents Rating Selected Product Attributes as Highly Important 196
I-3 Comparisons of *Highly Likely* and *Highly Unlikely* Criterion Clusters on the Basis of the Percentages of Respondents Rating Selected Barriers as Highly Important 197

List of Figures

		Page
1.	The Bell-Shaped Frequency Curve and the S-Shaped Cumulative Curve for an Adopter Distribution	4
2.	Examples of Diffusion Curves	5
3.	Model of the Innovation-Adoption Decision Process	8
4.	Net Incremental Monthly Amounts Respondents Are Willing to Pay for a Very Small GPV System (Cumulative)	39
5.	Net Incremental Monthly Amounts Respondents Are Willing to Pay for a Medium-Sized GPV System (Cumulative)	40
6.	Net Incremental Monthly Amounts Respondents Are Willing to Pay for a Very Large GPV System (Cumulative)	42
7.	Initial Favorability toward Systems Being Available to Colorado Residents and Later Favorability toward the Idea of Using GPV on One's Own Home	48
8.	Distribution of Respondents in the Criterion Clusters	65
9.	Distribution of Respondents in the Predictor Clusters	66
10.	Percentage of Cluster Matrix Respondents in Tiers	73
11.	Percentages of Respondents in All Tiers Represented by Each Respective Tier	75
12.	Estimate of Near-Term Market Size, Very Small GPV System (7%–15% of Electricity)	83
13.	Estimate of Near-Term Market Size, Medium-sized GPV System (50% of Electricity)	83
14.	Estimate of Near-Term Market Size, Very Large GPV System (100% of Electricity)	84

Acknowledgments

The Colorado Office of Energy Conservation and Management (OEC) and the National Renewable Energy Laboratory's (NREL's) STEP-2 Program partnered to fund this research. The OEC funded the research at the University of Colorado, Boulder. Program managers were Marc Roper, then of OEC, and Carol Tombari, then of NREL's State and Local Programs Office. Professor Dennis Mileti, chair, and Steve Graham, staff assistant, Department of Sociology, University of Colorado, Boulder, provided encouragement and administrative support to the project. Ron Judkoff and Sheila Hayter of NREL's Center for Buildings and Thermal Systems extended themselves in support of the project. Many colleagues in the energy and utility communities expressed interest in the study.

The authors would like to acknowledge other key contributors to the quantitative phase of this study:

Jan Buhrmann, Ph.D., U.S. Environmental Protection Agency, Denver
Elizabeth Sheff, graduate student, Department of Sociology, University of Colorado, Boulder
K. L. Berry, Matrix International, consultant, data analysis
Direct Marketing Designs, Inc., and The Polk Company, sampling frame, sampling, and mailing services
Alexander's Data Services, Inc., data entry and cleaning
David Lillie, User Interface Services, data base integrity
Rochelle Watters, NREL, project coordination and support, manuscript preparation
Erica Henningsen, NREL, manuscript preparation
University of Colorado Printing Services, printing services
University of Colorado Mail Room, mail handling

The authors acknowledge David Crawford, Kay Vernon, and Susan Sczepanski for editing and manuscript preparation.

Executive Summary

This research began in response to a decision by the Colorado Governor's Office of Energy Conservation and Management (OEC) and Colorado utility companies to consider making residential grid-tied photovoltaic (PV) systems available in Colorado. The idea was to locate homeowners willing to pay the costs of grid-tied PV (GPV) systems without batteries—$8,000 or $12,000 for a 2- or 3-kilowatt (kW) system, respectively, in 1996. These costs represented two-thirds of the actual installed cost of $6 per watt at that time and assumed the remainder would be subsidized.

The National Renewable Energy Laboratory (NREL) and OEC partnered to conduct a market assessment for GPV technology in Colorado. The study encompassed both qualitative and quantitative phases. The qualitative phase focused on identifying residential customers willing to pay certain amounts for a GPV system and to explore their reasons for wanting to become involved with the technology. The quantitative phase was designed to gather data on GPV from a probability sample of Colorado homeowners. The ultimate objective of the quantitative phase was to develop estimates of the size of the GPV market among Colorado homeowners.

Owning homes with GPV systems to power them is a new idea—an innovation. Hence, the diffusion-of-innovations tradition—an established theory of social and technological change—formed the basis for this research on homeowner response to GPV technology. The adoption of innovations, such as using residential GPV to provide all or part of a home's electricity, is a process occurring over time. Much research has focused on the perceived attributes of innovations that affect their rate of adoption, and on the characteristics of innovation adopters. Attributes determining how quickly innovations will spread include: relative advantage; compatibility with social values, past experiences, and needs; complexity; trialability; and observability.

Researchers have generally categorized populations into five types according to how quickly they adopt innovations. The leading edge of adopters is called "innovators" (about 2.5% of a population). Next, a group of about 13.5% is defined as "early adopters." Early adopters are also frequently "opinion leaders" who serve as an important social catalyst to shift the penetration of innovations from the select few to the "early majority" (34%).

Using this model as a foundation, the quantitative phase of the present study was designed to measure perception about GPV, and to establish homeowner characteristics (such as demographics, environmental values, and opinion leadership) relevant to potential early adoption of the technology.

Research Approach

The qualitative phase of this study resulted in the report: *Public Response to Residential Grid-Tied PV Systems in Colorado: A Qualitative Market Assessmen*t (Farhar and Buhrmann 1998). The qualitative work greatly supported and informed the quantitative phase of the study, for which two specific questionnaires were developed: one on grid-tied PV systems and the other pertaining to renewable energy, environmental concerns, and utility restructuring. The results of the second questionnaire are reported in Farhar and Coburn (1999). In all, the first questionnaire was administered as a conventional mail survey to a probability sample of 6,088 Colorado single-family homeowners drawn at random from across the state. The survey was designed in such a way as to permit categorization of homeowners in Colorado in the various stages of the GPV adoption-decision process, thus permitting estimates of market sizes. The study's dependent variables included willingness to pay for GPV, favorability toward the idea of using GPV on one's own home, and likelihood of seeking further information about GPV.

A total of 3,001 respondents completed questionnaires. Because the sampling frame unavoidably contained undeliverable addresses, townhouse owners, and others not qualified to be respondents, the number of qualified respondents was lower than the number of questionnaires mailed. The overall response rate was approximately 60%. Findings are generalizable to all Colorado single-family owner-occupied households (some 624,000 in all).

Such a large sample was used in order to capture an anticipated small "signal" from homeowners interested in purchasing GPV systems; that is, the prior assumption was that only a few homeowners would be interested in GPV purchase at today's market prices. In fact, the findings indicate a much higher positive response to grid-tied PV than anticipated, despite the costs of the technology presented in the questionnaire.

Descriptive Findings: Knowledge, Favorability, Benefits, Barriers, and Information

A majority of 68% of survey respondents favor GPV being made more widely available to Colorado residents. Respondents know little about GPV, as would be expected. While familiarity and favorability toward GPV are somewhat correlated, there is clearly more favorability than familiarity. At first blush, respondents tend to favor GPV without knowing much about it.

Important perceived benefits of GPV make it seem advantageous compared with conventional energy sources. A bare majority of homeowners (52%) know that coal is Colorado's primary power source, making it less likely that homeowners would attribute as many environmental advantages to PV ownership as they would if they were more aware of the extent of coal use. The survey asked about the importance of 23 potential benefits of GPV. The highest-scoring benefits were divided between long-term environmental benefits, including conserving natural resources, and homeowner financial benefits, including reducing electricity bills right away and long-term savings. Factor analysis resulted in three major dimensions: environmental benefits, financial advantages, and pacesetting advantages of adopting GPV. PV marketing messages should cover these three themes.

The survey presented respondents with 18 potential concerns regarding, or potential barriers to, PV system purchase. Barriers could reduce the perceived relative advantage of buying and owning a GPV system. Initial system cost and maintenance costs are key concerns. Homeowners also care about the reputability of PV manufacturers and vendors. Factor analysis resulted in two components: (1) feasibility of PV systems and reliability of PV providers, and (2) local conditions that might be problematic, such as codes or covenants prohibiting PV adoption, what friends and neighbors might say, or the amount of space needed at one's home for a PV system.

The survey explored 15 potential information needs and 24 information sources concerning GPV system purchase. Homeowners need information about concerns and benefits of PV ownership. The top-scoring information needs were savings on utility bills; amount of electricity the PV system will produce; and battery costs, maintenance, and disposal. Factor analysis was performed on the information-needs variables, resulting in three important components: PV product available to customers, financial aspects of PV system purchase and ownership, and benefits of PV use to the community and the world. GPV system marketers should address each of these major themes.

The *utility company* is the highest rated potential supplier of GPV systems and, for that reason alone, the utility company is an important, even authoritative, information source on GPV. The study's query on information sources had two parts: (1) individual, groups, and organizational sources of information on GPV, and (2) information channels, such as broadcast media or workshops. Both were factor analyzed, with the following results. The highest rated sources of PV information were *people who already own PV systems* and *utility companies*. *PV manufacturers and suppliers* were also a somewhat highly rated source. Three dimensions of information sources were defined: (1) government agencies, (2) local building businesses (such as home builders, local contractors, and home supply stores), and (3) friends and other trusted sources (including environmental organizations).

The highest rated kinds of information are those which give people a chance to see, touch, and experience PV technology, and to talk with those who have already lived with a PV system. Other than these sources, channels requiring people to spend time and money are less highly rated. Print media are more highly rated than broadcast media. These information channels appear to fit well with the technological nature of GPV systems.

Descriptive Findings: Product Attributes

GPV's feasibility for use now is an important attribute. Homeowners rate PV system warranties and durablity as very important. They rate financial incentives, such as rebates or tax credits, to help them purchase a system as highly important, as well as battery options to provide power during a power outage. The potential to keep computers running during an outage appears to be an important attribute in addition to other basic necessities such as heat, refrigeration, and lighting.

Descriptive Findings: Willingness to Pay for Residential GPV and Favorability to Using GPV

Data were obtained on four possible scenarios related to obtaining a GPV system, including one scenario that involved no added cost. Larger percentages of respondents than expected are hypothetically interested in paying for various-sized PV systems, with the most interest expressed in systems providing half or all of a household's electricity. About three-quarters of respondents say they would, at least hypothetically, be interested in paying at least something more per month for grid-tied PV. Eleven percent prefer a PV system that provides 100% of a household's electricity at a one-time cost of between $14,000 and $28,000, depending on how much electricity the household uses. Approximately 40% of Colorado single-family homeowners comprise the minimum market for a no-added-cost grid-tied PV system.

When asked about subsidies for GPV, more than one-third of this self-described politically conservative sample call for a federal income tax credit to support GPV. Twelve percent say they are opposed to all subsidies. Seventy percent say they would be likely to purchase a subsidized GPV system whose net cost is no higher than what they are currently paying for electricity.

The most popular financing option for GPV system purchase is to pay for a system through the utility bill. Equally popular as second choice are financing through a home mortgage or by paying a PV manufacturer or supplier.

After responding to several questions on potentially positive and negative aspects of GPV ownership, respondents were asked to consider the idea of using PV on their own homes. A majority of 57% indicate favorability; 25% are neutral; 11% are unfavorable; and 6% don't know. Initially favorable respondents tend to remain favorable to the idea of GPV ownership, even after considering realistic market costs.

Segmenting the GPV Market

In an attempt to reconcile attitudes regarding GPV system features, benefits, and barriers with stated intention to pursue GPV purchase, parallel analyses were conducted using the statistical technique of cluster analysis. A cluster analysis was conducted using the survey's attitudinal data in factor form, and a second cluster analysis was conducted using the survey's outcome variables. The two statistically satisfactory cluster solutions were then crosstabulated in an effort to identify the numbers of homeowners who not only say they would pursue GPV purchase but whose attitudes regarding GPV system features, benefits, and barriers are consistent with their stated intention.

Size and Composition of the GPV Market

The analyses indicate that 16% of the surveyed homeowners simultaneously occupy the two most conceptually receptive predictor clusters *and* the *Highly Likely* (to purchase GPV) criterion cluster. This 16% can be considered the core market for near-term GPV purchase because of the congruence of their receptive attitudes toward GPV *and* their stated intentions of pursuing GPV purchase.

When the projected "next-tier" customer groups were analyzed according to their hypothetical willingness to pay for GPV systems, it was found, not surprisingly, that as net system cost increases, willingness to pay (WTP) declines, especially beyond $50 per month for either a 50% or a 100% GPV system. The size of the immediate market under the 100% system scenario at $100 per month net cost is estimated to be a minimum of about 5,000 Colorado homeowners. At $125 a month net increase in cost for a 100% PV system, the market size is estimated to be a minimum of about 1,300 homeowners.

Conclusions and Recommendations

A market for residential grid-tied PV systems exists in Colorado today. That market is substantial enough for companies to successfully market PV systems to Colorado homeowners. These systems will have to be custom-designed to fit varied customer needs and preferences and different architectural styles and roof surfaces.

In September 1999, Public Service Company offered its customers GPV systems that can be net metered in the price range of $8,000 for a very small system to $45,000 for a 100% system with emergency back-up. These costs are markedly higher than those used in this study to estimate market size in Colorado. Higher costs will slow market acceptance of GPV systems.

Without question, utility practices and government policies will affect the rapidity of GPV uptake, although a few homeowners will go ahead with GPV system purchase regardless of utility or government action. If the State of Colorado or the federal government were to implement substantial financial incentive policies to foster GPV adoption, the size of the potential market for PV residences would increase. Those interested in purchasing a PV system highly subsidized by the government—despite their political conservatism—comprise an estimated 6% of Colorado households living in single-family dwellings. Subsidized systems could be made available, for example, through systems benefits charges in connection with utility restructuring.

Aside from substantial legislative intervention on behalf of GPV, utilities will make or break this market. They (and by extension, their contractors) are not only an authoritative source of information about GPV, but they also control net metering policies (unless the state Public Utilities Commission decides to take a favorable and binding stand on net metering). Net metering appears to be one of the most crucial factors in providing financial advantages to homeowners adopting GPV. Many homeowners need to feel that they will break even financially at some point in the future—even if it is in the distant future—before they would purchase GPV. In addition, utilities could stimulate the GPV market by offering their customers financing for GPV system purchase—the means of paying for GPV that homeowners appear to prefer most.

Colorado's homeowners appear ready to learn more, inform themselves, and actively purchase GPV systems. The present situation is highly advantageous to Colorado's institutions—primarily its state government and its utility companies, and also its home builders—if they are ready to move forward on GPV technology.

Chapter 1
Introduction

The Colorado Governor's Office of Energy Conservation and Management (OEC) has played an important role in developing governmental policy in Colorado relative to renewable energy. In 1996, a consortium of Colorado utility companies, OEC, and other organizations successfully competed for a federal grant to subsidize the cost of installing 50 grid-tied photovoltaic systems in the state. Utilities were faced with the problem of finding 50 buildings whose owners were willing to pay $8,000 or $12,000 for a 2- or 3-kW system, respectively, in 1996—the planned costs of GPV systems without batteries.[1] This reflected an installed system cost of $6 per watt with a $2 per watt federal/utility subsidy. Customers were asked to consider paying two-thirds of actual installed system cost ($4 per watt).

The National Renewable Energy Laboratory (NREL) and OEC teamed with the University of Colorado at Boulder to examine customer interest in residential GPV as a utility service option in Colorado. NREL had reason to believe that at least a small market for residential GPV existed (Farhar-Pilgrim and Unseld 1982; Farhar 1993, 1994a, 1994b, 1996; Farhar and Houston 1996). The result of this collaboration led to the initiation of a statewide study of Colorado homeowners.

The study was intended to help OEC better understand electricity customer views of residential GPV systems from business and policy standpoints and to assess the size of the residential market for GPV technology. The market assessment also was intended to help Colorado utilities and the PV industry determine the roles they could play in offering PV systems and in designing PV products that would best meet the needs of their customers.

The study was designed in two phases:

1. *Qualitative pilot work, involving focused, open-ended interviewing of a purposive sample of interested candidates for the PV systems.* The purpose was to identify residential customers willing to pay certain amounts for GPV and to explore their reasons for wanting to participate in implementation of the technology.

2. *A survey of a probability sample of residential electricity customers.* Based on the pilot research, a survey was developed to assess the interest in renewables among single-family homeowners and to estimate the potential size of the residential market for GPV systems in Colorado.

The qualitative phase of this study resulted in the report *Public Response to Residential Grid-Tied PV Systems in Colorado: A Qualitative Market Assessment* (Farhar and Buhrmann 1998). The qualitative interviews comprised a beginning point for answering questions about the GPV market because it identified potential customers and explored their motivations and preferences. Interviews were also conducted with 25 homeowners who had no interest whatsoever in GPV to ascertain the reasons for their lack of interest.

The present report documents the results from the quantitative phase of the study. The text of the report consists of 12 chapters encompassing various aspects of the study from model conceptualization through data analysis and interpretation, and then to establishment of findings, conclusions, and recommendations.

---

[1] Prices used in the survey are higher (see Chapter 5).

Specific topics include the following:

- The market assessment's guiding ideas
- Descriptive findings, including initial familiarity with, and favorability toward, GPV systems in Colorado; perceived benefits of GPV system use; perceived barriers to such use; information needs about GPV; and preferred information sources
- Favorability toward the idea of using GPV at one's own home
- The GPV product attributes most important to homeowners
- Willingness to pay for GPV systems under several hypothetical scenarios
- Data reduction and identification of key variables
- Market segmentation
- The size and composition of the potential market for residential GPV systems
- Validating the study hypotheses
- Conclusions, discussion, and recommendations.

Although the details of survey development and questionnaire design are certainly important, the focus of this report is on the research findings and their implications for GPV technology in Colorado. Readers interested in the developmental stages of the study involving survey operations are referred to Appendix B, which contains a thorough treatment of these aspects.

In addition to documenting the results of the quantitative phase of the study, the objective for preparing this report is to educate and enlighten policymakers, corporate strategists, local business people, and the general public about the prospects for GPV technology in Colorado. It is hoped that the information provided here will serve to stimulate increased interest in adoption and proliferation of this and similar innovations as the state moves more closely toward an energy-efficient and environmentally stable economy.

Chapter 2
Guiding Ideas of the Study

Literature Review

National poll data show that, since 1979, majorities of the U.S. public have exhibited a marked preference for renewable energy and energy efficiency when cost is not mentioned, and majorities indicate a hypothetical willingness to pay more for environmental improvement and protection, including use of renewable electricity (Farhar 1996; 1999). Therefore, NREL had reason to believe customers would be interested in GPV (Farhar 1993; Farhar 1994a, 1994b; Farhar and Houston 1996).

Chapter Highlights

- The concept of diffusion of innovations guided the research
- Grid-tied PV (GPV) is an innovation that was not available to homeowners at the time of the survey
- Adoption of innovations such as residential GPV depends on social conditions, personal characteristics, and the attributes of PV perceived by homeowners
- Most of the population was expected to know little about GPV
- A "next tiers" analysis was planned to describe the size and composition of the GPV market.

As is the case with other technologies, adoption of GPV systems for home use is a process expected to occur over time. Each household is hypothesized to fall along a continuum from never having heard about GPV systems to readiness to purchase a GPV system. At the time the present study was initiated, most homeowners knew little about GPV systems and certainly not enough to evaluate the potential of GPV for their households.

Favorable attitudes toward GPV are expected to precede behavioral intention, which, in turn, is expected to precede purchase of a GPV system and ultimate adoption of GPV. Favorability to GPV is hypothesized to be affected by a homeowner's knowledge and information sources, perceived benefits of GPV, concern about the risks of purchasing GPV, perceived feasibility of GPV technology, product attributes made available to customers, and business and policy preferences. In the present study, therefore, data have been collected from Colorado homeowners on these variables for purposes of characterizing attitudes toward the technology and for making estimates of the current size and composition of the likely markets for residential GPV systems.

Rate of Adoption

GPV is an innovation, and the market diffusion of innovations develops over time. A large body of empirical research has shown that the adoption of an innovation usually follows a normal bell curve. If the cumulative number of adopters is plotted, the result is an S-shaped curve. Figure 1 shows the bell-shaped curve for an adopter distribution and an S-shaped curve showing the data on a cumulative basis (Rogers 1995).

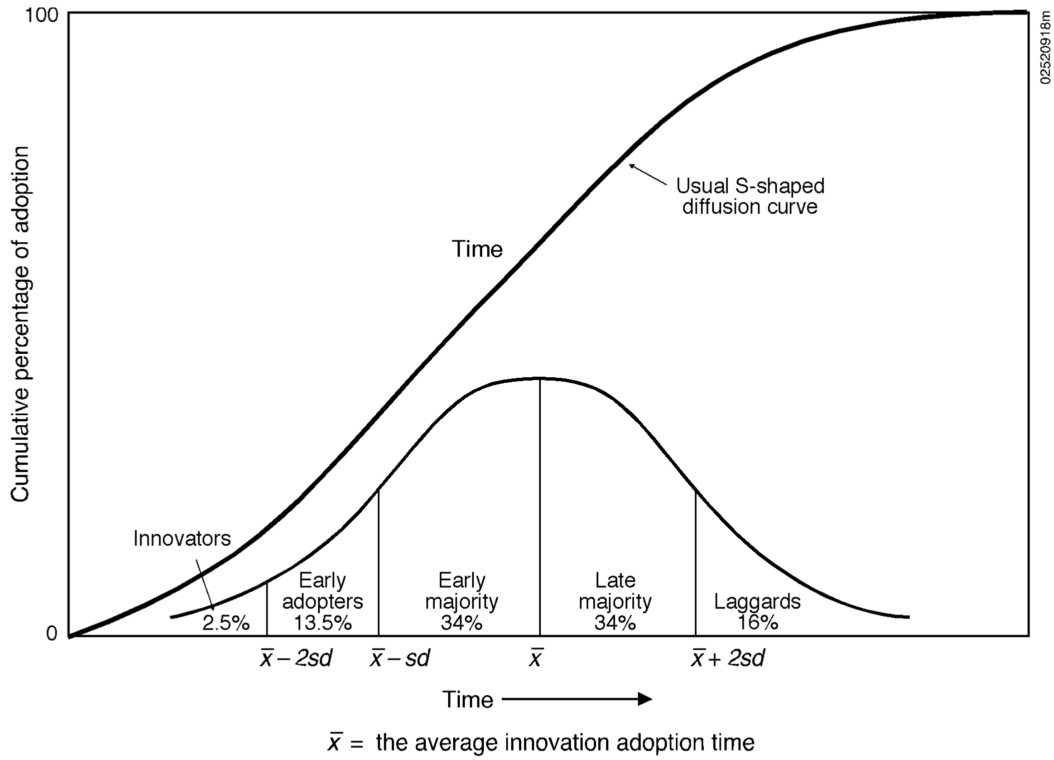


Figure 1. The Bell-Shaped Frequency Curve and the S-Shaped Cumulative Curve for an Adopter Distribution

Source: Adapted from Rogers (1995)

The product diffusion process is classically launched by "innovators" and "early adopters." Gradually, the number of adopters builds until saturation is reached. The length of time this process takes varies by the complexity of the innovation and its perceived relative advantage, among other factors. For example, the Internet began in 1969 as ARPANET with only a handful of users. By 1981, it became BITNET, used by 14 universities. After the University of California at Berkeley joined BITNET in 1982, critical mass was achieved and the number of nodes doubled every 6 months. As of mid-1993, there were 15 million Internet connections, a number that was doubling annually at that time.

Innovations take varying lengths of time for adoption. Innovations that can be adopted by individuals can reach saturation within a few months to a few years. Innovations requiring organizational and community change, such as kindergarten, can take as long as 50 years to reach saturation. Figure 2 shows rates of adoption of three different innovations over time.

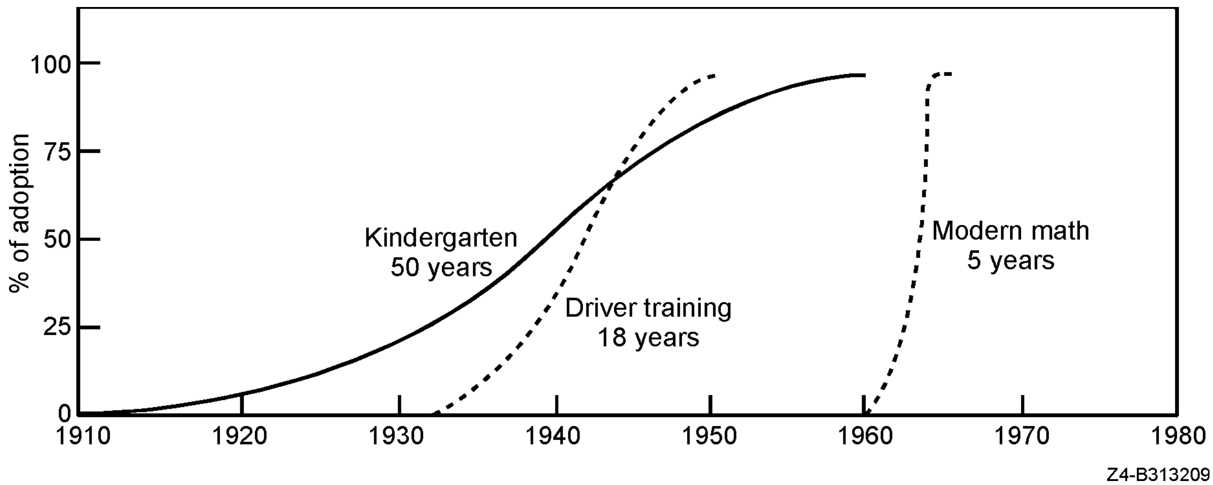


Figure 2. Examples of Diffusion Curves

Source: Adapted from Rogers and Shoemaker (1971)

Characteristics of Innovation Adopters

The population is distributed along a bell curve, with time to adoption as the *y* axis (Figure 1). The first 2.5% of the population to adopt are "innovators." Next, a group of approximately 13.5% is defined as "early adopters"— those who benefit from the experience of innovators, maximizing their advantages in adopting the innovation while minimizing their risks. Early adopters are also frequently "opinion leaders" who catalyze shifts in the innovation's penetration from the select few to the "early majority" (34%). Gradually, the "late majority" (34%) adopts the innovation, for not doing so would leave them in a worse position relative to everyone else. Finally, the "laggards" (16%) get around to adopting. When most people have adopted an innovation, the market is said to be "saturated" (Rogers 1995).

Innovators tend to be venturesome and members of social groups of like-minded individuals. They tend to control substantial resources, have complex technological knowledge, and tolerate uncertainty in outcomes. *Early adopters* are well integrated into local communities and tend to be people to whom others look for advice before adopting an innovation. The *early majority*—the most numerous adopter category—are more deliberate than the first two groups, taking longer to adopt new ideas. The *late majority* are skeptical of new ideas and cautious about adopting them. They tend not to adopt until others have done so. *Laggards* are the last in the social system to adopt an innovation; they are more oriented to their local areas than they are cosmopolitan and may be less well integrated in social networks. Their resources are relatively limited, and their caution is often financially necessary (Rogers 1995, pp. 263-267).

Some demographic characteristics of earlier adopters as compared with later adopters are as follows (Rogers 1995, p. 269):

- Earlier adopters tend to have higher levels of formal education.
- They tend to have higher socioeconomic status.
- They have a great degree of upward social mobility.
- They control larger units (such as companies).
- They are no different in age from others.

Innovativeness tends to be linked with wealth, yet wealth does not explain innovative behavior. Many wealthy people are not innovators.

Innovation Attributes

From 49% to 87% of the variance in rate of adoption can be explained by five attributes: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability.

Relative Advantage

The perceived relative advantage of an innovation is positively related to its rate of adoption. Relative advantage is "the degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers 1995, p. 212). Often, the relative advantage of an innovation is expressed in terms of economic and prestige advantages. When prices decrease rapidly, or when a great deal of value is added, or both, a rapid rate of adoption is encouraged.

Compatibility

The perceived compatibility of an innovation is positively related to its rate of adoption. Compatibility is "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (Rogers 1995, p. 224). Innovations may be compatible or incompatible with sociocultural values and beliefs, with other ideas, and with the adopter's needs. If PV water pumping in a village causes a disruption of the patterns of sociability among women, even though it assists in reducing the amount of their manual labor, it could be rejected.

Complexity

The perceived complexity of an innovation is negatively related to its rate of adoption. Complexity is "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers 1995, p. 242). The first adopters of home computers loved technological gadgets; many were engineers with extensive mainframe experience. But most people had difficulty using personal computers and had to join computer clubs, take courses, obtain help from friends, or find other means to cope with the difficulties their computers posed. This slowed down the rate of adoption. Eventually, personal computers became more user friendly and, by 1994, about 30% of households owned one.

Trialability

The more the innovation can be tried out, the faster its rate of adoption. Trialability is "the degree to which an innovation may be experimented with on a limited basis" (Rogers 1995, p. 243). If new ideas can be tried out without too much risk, uncertainty can be dispelled. The perceived trialability of an innovation is positively related to its rate of adoption. Early adopters are more concerned with trialability than are later ones.

Observability

The perceived observability of an innovation is positively related to its rate of adoption. Observability is "the degree to which the results of an innovation are visible to others" (Rogers 1995, p. 244). The effects of some ideas are readily observable; the effects of others are difficult to discern. The observability may include how visible adoption is to others, thereby conferring status on the adopter, or showing that the innovation indeed "works." Observability may also include the ability to actually see the effects of the innovation.

Other Factors

Assuming that an innovation may be perceived as having characteristics desirable for adoption, other factors come into play that can accelerate or impede decisions to adopt. These include the following:

- The availability of the innovation through regular organizational channels.
- Sufficient consumer understanding about the innovation to make a purchase decision.
- Sufficient salience—purchase is important enough to be at or near the top of a household's action list.
- Adequate support systems for customers, preferably provided by the organization from which the innovation was purchased, and also access to friends or others who understand the innovation.
- The financial wherewithal to purchase the innovation, or a financing arrangement to make a purchase possible.

Stages in the Adoption of Innovations

To help explain the potential market for renewable electricity in Colorado, it is useful to understand the innovation-adoption decision process. Figure 3 shows a widely accepted model of the decision process that was an underpinning of this research.

Social conditions and the characteristics of decision makers affect the dynamic innovation-adoption process, which moves through stages.

1. The *knowledge stage* refers to individuals, households, and organizations (called market "actors") who have heard about the innovation. They might be interested because of prior experience, professional interest, business interest, interest in technology, social pressure, and social values. At the end of this stage, an actor may be eager to know more, be disinterested, be opposed, or somewhere between.

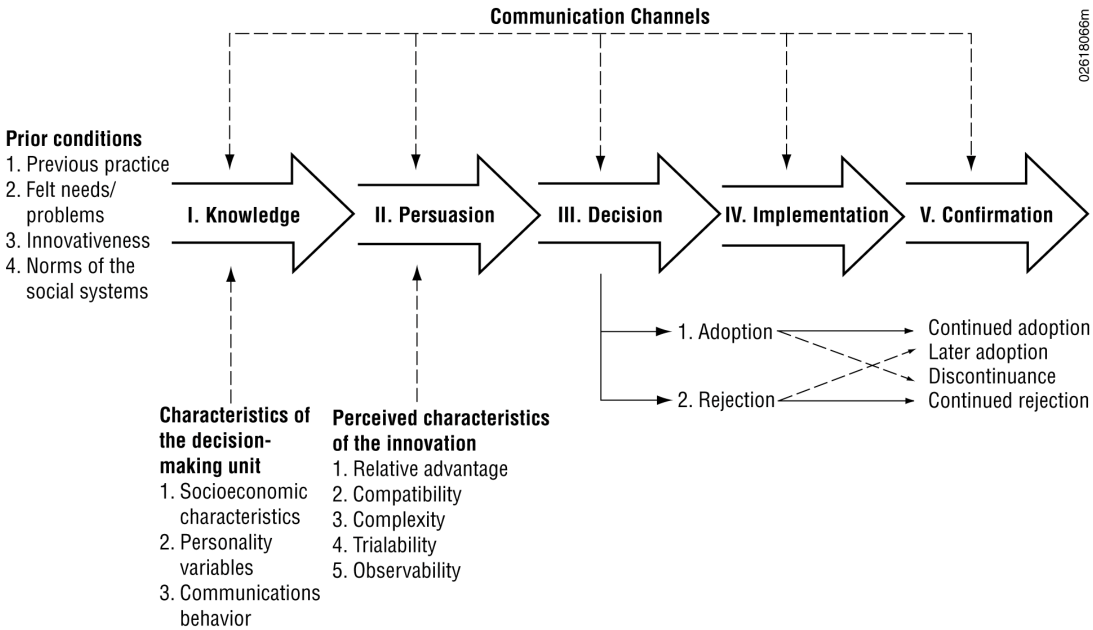


Figure 3. Model of the Innovation-Adoption Decision Process

Source: Diffusion of Innovations, 4th Edition by Everett M. Rogers (p. 163). Copyright © 1995 by Everett M. Rogers. Copyright © 1962, 1971, 1983 by The Free Press. Reproduced with the permission of The Free Press, a division of Simon & Schuster, Inc.

2. The *persuasion stage* refers to the aware actor's exposure to more information about the innovation, how it works, how much it costs, who is using it and with what results, who is for and who is against it, and how it might fit in with the actor's own situation. By the end of this stage, an actor has formed a stronger favorable or unfavorable attitude—a position—toward the innovation, both in terms of its general use and its specific relevance to the actor. It is possible for actors to be generally favorable to the new idea but unfavorable to their own involvement with it.

3. If favorable to becoming involved, the actor moves to the next stage of the process: the *decision stage.* During this stage, the actor decides to become involved with the innovation and makes plans to acquire it within the foreseeable future. The actor's "behavioral intention" is to use the innovation. If no major obstacles intervene, the actor will probably pass to the next stage.

4. In the *implementation stage*, the actor purchases or otherwise implements the innovation. This stage is not yet considered full adoption because the actor could later reject the innovation if negative experiences ensue. Once the implementation stage has been reached, the last stage inevitably follows.

5. In the *confirmation stage*, the actor lives with the positive and negative consequences of implementation. After a time, the actor decides whether the choice is satisfactory. If problems arise during this stage, actors try to resolve them. Cognitive dissonance could help explain a propensity to feel satisfied with purchase decisions; however, regret about the decision could also occur.

Continuance or discontinuance of the adoption decision made in the decision stage is the end result of the process.

"Next Tiers"

This model of the innovation adoption decision process is dynamic, yet surveys are cross-sectional, measuring changing awareness, attitudes, and practices at given points in time. How, then, does the dynamic model relate to a static measurement of Colorado homeowners on adoption of GPV technology?

Members of the relevant population can be conceived as falling along a continuum from unawareness of an innovation to actual adoption or discontinuance. For estimating near-term market size, the question is: how many individuals are in the latest stage of the process? A measurement of the numbers of the population at any one stage of the process permits inferences to be drawn about the shape of the GPV diffusion curve across time. Such inferences, and resulting estimates of market size, would permit more accurate business planning, marketing communication, policy decisions that effectively target the desires of the public, and forecasting of the demand for GPV and of the amount of electricity it can produce. Further, if it can be learned *why* people are at various stages, it can be anticipated how to inform, educate, devise policies for, and market to the relevant segments in the population.

The study was designed in such a way as to permit the categorization of the respondent population in the various stages of the adoption-decision process. Hypothetically, at least, most people would currently be unaware of GPV or, if they are exceptional, they would fall into the *knowledge* and *persuasion* stages. Although *standalone* PV systems have been available in Colorado for many years, PV systems *tied to the utility grid* have only recently become available.[1] Therefore, it was expected that most people would be unaware of the possibility of purchasing a GPV system for their homes. Only a handful of homeowners were expected to be in the *decision* stage. No respondents could have been in the *implementation* stage.

Because the population can be segmented into groups, or "tiers," according to where households fall along the GPV decision process, consumers in the *decision* stage can be considered the group most likely to adopt GPV in the near-term—the "next tier" or "Tier 1." The group in the *persuasion* stage would be in Tier 2, but these households are not likely to adopt for some time.[2] Households in the *knowledge* stage are even further from action, and they comprise Tier 3. Those unaware, along with those who have decided against GPV for their homes, comprise Tier 4—these are households unlikely to adopt GPV anytime in the foreseeable future.

Operationalizing the Model

Assuming the diffusion-of-innovations model to be appropriate, a survey about GPV was conducted using a scientifically selected sample of Colorado homeowners. The survey questionnaire included questions that were intended to measure the attributes of GPV as an innovation, summarized as follows:

---

[1] In fact, GPV systems were not available to the public at the time the quantitative survey supporting this study was undertaken.

[2] The length of time of their progression toward a GPV purchase decision depends on several exogenous variables, including the marketing efforts of utility companies and others and the number of GPV systems already installed.

- *Relative advantage*—perceived benefits, product attributes, and risks associated with GPV adoption
- *Compatability*—lifestyle and values
- *Complexity*—barriers and information needs
- *Trialability*—product attributes on feasibility and performance and information sources
- *Observability*—visibility of GPV system and its performance.

In addition, data were collected on the characteristics of innovation adopters, including standard demographic characteristics such as age, educational attainment, gender, and household composition.

Study Hypotheses

Dependent Variables

The study has four dependent variables related to stages in the decision process. Table 1 shows the study's major dependent (criterion) variables and the ways in which they were operationalized.

Table 1. The Study's Dependent Variables

Variables	Measurements
Favorability to GPV	• Favorability to making it available to Colorado residents • Favorability to the idea of using it on one's own home
System size/price trade-offs	Preferences for smaller, less expensive systems or larger, more expensive systems
Willingness to pay for GPV	• Likelihood of purchase of a no-added cost PV system • Willingness to pay net electricity cost increases for small, medium, and large systems
Behavioral intention	Likelihood of looking for more information on GPV

Source: Constructed by the authors.

Independent Variables

The study's independent (predictor) variables include a number of factors that are hypothesized to affect a homeowners' position in the GPV adoption process. Table 2 shows these variables, the ways in which they were operationalized in the study, and their hypothesized relationship to likelihood of GPV purchase.

Table 2. The Study's Independent Variables

Variables and Hypotheses	Measurements
Perceived relative advantage of GPV adoption *Hypothesis*: The higher the perceived relative advantage of GPV, the more likely is near-term GPV purchase.	• Rated importance of 23 perceived benefits • Perceived fuel source of electricity in Colorado (PV could be considered advantageous as compared with coal)[3]
Perceived feasibility of GPV *Hypothesis*: The higher the perceived feasibility of GPV, the more likely is near-term purchase.	• Perceived importance of 21 product attributes • Preferences for paying for system • Preferred source of GPV system
Perceived barriers *Hypothesis*: The more important the perceived barriers to GPV adoption, the less likely is near-term purchase.	Rated importance of 18 potential problems
Knowledge *Hypothesis*: The more knowledge, the more likely is near-term purchase.	• Familiarity with GPV • Knowledge to make an informed decision • Familiarity with efficiency and renewables technologies
Information *Hypothesis*: The more interest in information, the more likely is near-term purchase.	• Rated importance of 15 information needs • Rated importance of 24 information sources
Policy preferences *Hypothesis*: The more favorable to a GPV subsidy, the more likely is near-term purchase.	Subsidy preference and how to pay for PV
Compatible lifestyle and values *Hypothesis*: The more compatible GPV is perceived to be with personal values and lifestyles, the more likely is near-term purchase.	• Environmental values • Early adopter characteristics

[3]Respondents were asked the primary fuel sources of electricity in Colorado (coal-burning). The hypothesis is that, if homeowners know that coal-burning is the source of most electricity, they might be more favorable toward GPV for electricity production.

Table 2. The Study's Independent Variables (cont'd.)

Hypotheses	Variables
Demographics *Hypotheses*: Men are more favorable* than women heads of household. Younger homeowners are more favorable than older ones. Married homeowners are more favorable than single ones. Married homeowners with children are more favorable than other household types. There is no difference in favorability by area of residence. There is no difference in favorability by geographic locale. More highly educated homeowners are more favorable than others. Homeowners in professional and managerial occupations are more favorable than others. Higher income homeowners are more favorable than others. Liberal homeowners are more favorable than conservative homeowners. There is no difference in favorability by primary heating fuel used. The less likely the respondent is to move in the near-term, the more favorability toward GPV. ________________________ *The term "favorable" used in this section of the table refers to likelihood of near-term purchase.	• Gender • Age • Marital status • Household composition • Rural, town, or city resident • Geographic locale of Colorado • Educational attainment • Occupation • Annual income • Political orientation • Primary heating fuel • Likelihood of moving

Source: Constructed by the authors.

Results of hypothesis testing are presented in Chapter 10.

Interpretation of Data

Throughout the questionnaire, respondents were frequently asked to rate benefits, barriers, information needs, and other variables relative to GPV in their perceived importance on 1-10 scales. For other variables, they were asked to rate the likelihood of their taking an action, again using 1-10 scales. Still other questions asked directly about respondent preferences. At times, highly rated responses (usually 9-10 on a 1-10 scale) are interpreted in the text as "preferences." Appendix J presents the questionnaire's exact item wordings.

Chapter 3
Descriptive Findings: Knowledge, Favorability, Benefits, Barriers, and Information

The survey asked how familiar respondents are with GPV, their attitudes toward it, benefits they perceive from its adoption, problems and concerns about purchasing it, their information needs about PV, and information sources they prefer. Means and frequencies of responses to these questions are discussed in this chapter.

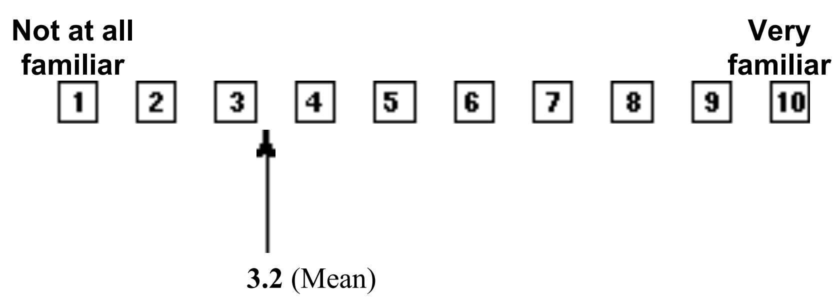
Familiarity and Favorability

> **Section Highlight**
>
> Initial familiarity and favorability: survey respondents tend to be favorable without knowing much about GPV systems.

Because it was expected that few people would have knowledge of GPV systems, especially because such systems had not been on the market in Colorado at the time of the survey, respondents were asked about their familiarity with the concept. To provide background, a page with four pictures of GPV systems was provided in the questionnaire package.[1] A brief description of PV systems was also provided as a prelude to the first question in the survey:

Electric utilities in Colorado are considering the addition of renewable resources as one of the sources from which your electricity is generated. One way to get electricity from renewable resources is from individually owned solar systems called photovoltaic or PV systems that are tied to the utility grid.

*These **grid-tied PV systems**, as they are called, consist of solar panels that can be placed on or near your home, or they can be integrated into the structure of your home such as PV shingles on the roof. **(See the enclosed pictures.)** The PV system converts sunlight directly into electricity. Your home will still be connected to the electric utility grid, enabling you to send the excess electricity your grid-tied PV system can generate during the day to the utility, and to receive electricity from the utility when your PV panels are not generating all the electricity you require. On a scale of 1 to 10, how familiar are you with these grid-tied PV systems?*

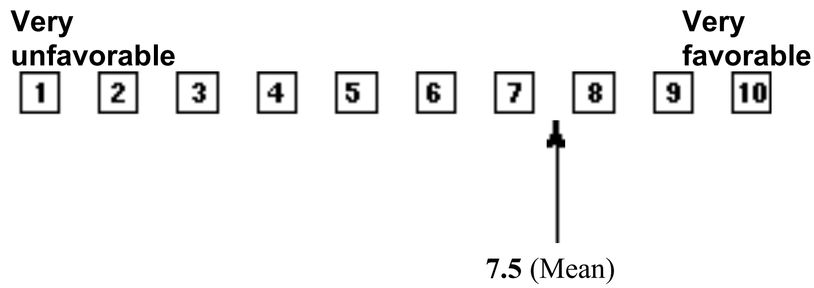


The survey responses indicate clearly that Colorado homeowners have very little knowledge of GPV systems. On a 10-point scale, where 1 = Not at all familiar and 10 = Very familiar, the mean familiarity is 3.2, with only 10% expressing strong 8,9,10 familiarity with GPV.

---

[1]This picture page is included at the front of this report.

The second survey question asked respondents: *"Without knowing any more than you do right now about grid-tied PV systems, on a scale of 1 to 10, how favorable are you to these systems being available to Colorado residents?"*



In response to this question, 68% responded in the favorable range (7-10 on the 10-point scale). A plurality of 44% indicate a strong positive response (9-10 on the scale). With a mean favorability rating of 7.5, and with 59% of the ratings being 8, 9, or 10 (subsequently called 8,9,10 ratings), Colorado homeowners clearly favor greater availability of GPV. However, 33% express a less than clear positive regard for GPV availability (ratings of 1-6), and 12% express unfavorability (ratings of 1-4) (Table 3).

While *familiarity* and *initial favorability* are somewhat correlated, there is clearly more favorability than familiarity. At first blush, respondents favor GPV without knowing much about it.

Table 3. Favorability toward GPV Being More Available

Response categories (1-10 scale)	**Making PV More Available %**
Very favorable (9-10)	44
Favorable (7-8)	24
Neutral/mixed (5-6)	21
Unfavorable (3-4)	6
Very unfavorable (1-2)	6
Don't know	6
Total	101*
Base n	2353

*Percentages do not add to 100 because of rounding.

Source: Constructed by the authors.

Knowledge and Behavioral Intention

Following the question on favorability toward the idea of using GPV on their own homes, respondents were asked whether they knew enough about grid-tied PV systems to make an informed decision about buying a system. As would be expected, knowledge levels are low; the mean score is 3.3 with only 10% of respondents assigning strong 8,9,10 ratings.

To measure behavioral intention—whether homeowners are likely to take action about GPV—the questionnaire asked how likely respondents would be to look for more information about PV in the near future, on a 1-10 scale, with 1 being not at all likely and 10 being very likely. The mean response is 5.4 with 26% assigning 8,9,10 ratings.

Perceived Benefits of GPV Adoption

Section Highlights

- The survey asked about 23 potential benefits
- Important perceived benefits of GPV make it seem advantageous compared with conventional energy sources
- A bare majority know that coal is Colorado's primary power source

Perceived Relative Advantage

The perceived advantage of an innovation, relative to the accepted way of doing things, has been shown to increase its rate of adoption. Relative advantage means that the new way of doing things—in this case, including GPV in Colorado's energy mix—offers advantages over other approaches or over simply maintaining the status quo.

A basic question is the extent to which people are aware of the current way in which electricity is produced. To test people's knowledge on this situation, the survey asked:

From which source do you think most of the electricity used in Colorado is currently produced?

Only slightly more than half of the respondents know Colorado's current primary source of electricity. A majority of respondents is aware that most electricity in Colorado is produced from coal (52%). However, 48% have an incorrect perception, believing that most comes from natural gas (27%), hydropower (12%), oil (6%), and other sources such as nuclear, solar, or wind. Of course, the source of electricity varies by utility company. For example, 50% of the electricity in the City of Fort Collins comes from hydropower, while 98% of Public Service Company's electricity comes from coal. Still, the question addressed electricity used in the state as a whole (Table 4).

Perceived Benefits of Using GPV

The qualitative research conducted prior to this survey indicated that homeowners interested in purchasing GPV mentioned the following reasons for their interest, categorized as altruism, environmental concerns, economic and financial benefits, and values (Farhar and Buhrmann 1998, pp. 13-20):

- Have a standing interest in renewables or technology
- Want to create/expand the PV market
- Believe PV use has positive environmental impacts and avoids the negative impacts of other electricity sources
- Perceive an opportunity to act locally

- Value self-sufficiency
- Want to educate others about PV
- Want financial breakeven over 20 years.

Table 4. Perceived Sources of Electricity in Colorado

Electricity source	%
Coal	52
Natural gas	27
Hydropower	12
Oil	6
Nuclear	1
Solar	1
Wind	--*
Other	1
Totals	100
Base n	2441

*Less than 0.5%.

Source: Constructed by the authors.

Such ideas, along with others frequently mentioned, were encompassed by the questionnaire. Specifically, respondents were asked the following question about the perceived benefits of GPV.

> *Listed below are some possible benefits of using a grid-tied PV system. On a scale of 1 to 10, please indicate how important each benefit would be to you if you were considering purchasing this kind of a system for your home.*

Not at all important									Very important
1	2	3	4	5	6	7	8	9	10

Table 5 summarizes findings on the importance of these benefits if respondents were considering purchasing a GPV system for their homes. The table lists the mean score from the primary sample for each of 23 potential benefits, as well as three associated response percentages: "10" on a 1-10 scale, with 1 = "Not at all important" and 10 = "Very important"; the percentage of respondents assigning 8, 9, 10 ratings; and the percentage of respondents assigning ratings of 7, 8, 9, 10. This data arrangement shows the percentages giving each potential benefit the greatest importance (a 10 rating), strong importance (an 8, 9, 10 rating), or, simply, importance (a 7, 8, 9, 10 rating). Benefits are listed in the table from high to low according to the sizes of their mean scores.

Seven of the 23 potential benefits of using GPV systems receive mean importance ratings of 8.0+, and five of the seven receive 8, 9, 10 ratings by at least 75% of respondents. The seven potential benefits receiving the highest scores, on average, are divided between *long-term environmental benefits* (4), including *conserving natural resources*, and *homeowner financial benefits* (3), including *reducing electricity bills right away* and *long-term savings*. A GPV marketing campaign focused on these seven benefits may increase homeowner interest and purchasing.

In a second group are five potential benefits with mean importance of 7.5 to 7.8. The percentage of respondents assigning the strong 8,9,10 ratings ranges from 59% to 68%. This second group of benefits focuses largely on *energy self-sufficiency* and *financial gain*.

A third group of three potential benefits has average scores ranging from 7.2 to 7.4. The percentage of respondents assigning 8,9,10 ratings ranges from 54% to 57%. Two of these focus on *GPV benefits for Colorado*'s economy, whereas the third focuses on *increased energy diversity*.

The remainder of the potential benefits receive lower average scores. The least important potential benefits are *profitable for utility companies* (14% rating this 8,9,10) and *being first on the block to have a PV system* (8% rating this 8,9,10).

Given that marketing and public information campaigns can communicate only a limited number of potential benefits, the first group of benefits should form the hub of marketing communications, especially advertising. The second and third groups are unlikely to add persuasiveness unless they can be seen as amplifying those in the top group. For example, *good for Colorado's economy* is probably a no-added-gain message, while *increased energy diversity* may amplify *conserve natural resources*.

Table 5. Perceived Benefits of GPV System Purchase

Potential system benefits	Mean*	%10	%8,9,10	%7,8,9,10
Result in long-term energy cost savings	8.5	50	78	86
Help reduce air pollution and acid rain in our area	8.5	49	78	84
Conserve natural resources	8.4	46	77	85
Benefit future generations	8.4	49	75	82
Reduce electricity bills right away	8.3	50	73	82
Help protect the environment	8.3	45	75	82
Increase resale value of home	8.0	40	69	79
Help reduce global warming	7.8	44	68	75
Have electricity during a power outage	7.8	37	66	76
Sell excess electricity back to utility company	7.7	39	62	71
Pay for itself over system lifetime	7.7	37	61	72
Increase self sufficiency	7.5	33	59	70
Increase diversity of energy sources	7.4	26	57	70
Help create jobs for Colorado	7.3	26	55	68
Good for Colorado's economy	7.2	24	54	68
Encourages others to replace gas and coal use	6.8	22	49	62
Feels good to do this	6.3	20	40	51
Increase awareness of household energy use	6.0	15	35	46
An opportunity to make a difference in community	5.9	13	32	44
Help to create and expand PV market	5.3	11	27	38
A new technology to enjoy	5.0	10	24	33
Profitable for utility companies	3.9	6	14	20
First on block to have PV system	2.8	5	8	10

*See Appendix C for base n's, means, standard deviations, and coefficients of variation for each item.

Source: Constructed by the authors.

Perceived Barriers to GPV Adoption

As markets become more familiar with GPV systems, questions arise about potential concerns if one were to become the owner of such a system. Many such concerns were raised during the qualitative interviews conducted prior to the survey, expressed either as questions people have about owning and operating a GPV system or problems that need to be resolved. For advocates of renewables, these concerns are not significant enough to preclude them from saying they want to purchase a system. However, for homeowners not currently dedicated to the use of renewables, such concerns—if they remain unaddressed or unresolved—could be an impediment to GPV system purchase.

Section Highlights

- The survey asked about 18 potential concerns or barriers to PV system purchase
- Barriers could reduce the perceived relative advantage of buying and owning a GPV system
- Perceived operating reliability of PV systems and reliability of PV providers are important
- Initial system cost and maintenance costs are key concerns
- Homeowners care about the reputation of PV manufacturers and vendors
- A concern is whether the utility company will continue service and support to GPV purchasers

Concerns about the Risk of Adopting GPV

Even among respondents in the qualitative study deeply interested in purchasing GPV systems with estimated costs of $8,000 or $12,000, enthusiasm is moderated by a degree of caution. Most respondents express some concerns. Economic and financial concerns are mentioned frequently, including concern about high initial system cost, fair pricing for electricity purchased by the utility, and whether the utility company would continue its involvement with GPV once they had purchased their systems.

Other concerns include how vulnerable PV systems would be to weather extremes, uncertainties about system longevity, system efficiency in converting sunlight to electricity, and the quality of PV power. Health and safety concerns are also mentioned frequently, including such issues as potential roof damage during system installation, grid-surge effects on the system, danger to utility linemen, and the potential for vandalism. Other issues include liability or liability insurance, the need for battery recycling, and the amount of space required for a PV system (Farhar and Buhrmann 1998). All these issues were encompassed by the questionnaire.

Perceived Barriers

The questionnaire asked respondents to rank on a scale of 1-10 the importance of 18 potential concerns or barriers to PV system purchase.

> *Here is a list of conditions you might see as problems with grid-tied PV. For each condition on the list, please indicate on a 1 to 10 scale, how important a concern it would be for you, if you were thinking about adding PV to your home.*

Not at all important									Very important
1	2	3	4	5	6	7	8	9	10

Table 6 summarizes findings on the importance of these potential concerns if respondents were considering purchasing a GPV system for their homes. The table lists the mean score for each of 18 potential concerns about owning a GPV system, as well as three associated response percentages: "10" on a 1-10 scale, with 1 = "Not at all important" and 10 = "Very important"; the percentage of respondents assigning strong 8, 9, 10 ratings, and the percentage of respondents assigning ratings of 7, 8, 9, 10. This data arrangement shows the percentages giving the potential concern the greatest importance (the 10 rating), strong importance (an 8, 9, 10 rating), or, simply, importance (a 7, 8, 9, 10 rating). Entries in the table are organized from high to low according to the size of the mean scores.

Table 6. Potential Barriers to GPV System Purchase

Perceived barriers to purchase	**Mean***	**%10**	**%8,9,10**	**%7,8,9,10**
Operating reliability of PV system	9.3	64	93	97
Amount of electricity produced by the PV system	9.2	59	91	95
Initial cost of PV system	9.1	64	89	94
Dependability and reputability of PV manufacturer	9.1	59	89	95
Expense of maintaining a PV system	9.0	58	87	94
Dependability and reputability of PV vendor	9.0	57	87	93
Utility company might stop service and support	8.8	58	83	88
Possible damage to system by storms, vandalism, etc.	8.8	53	82	89
Amount of time needed to maintain PV system	8.8	50	83	91
Getting PV system covered under home insurance	8.6	49	80	88
Safety of PV system power	8.5	53	78	83
Effect on property taxes	8.5	47	76	85
Suitability of my site for a PV system	8.5	46	76	85
System could become outdated technologically	8.3	45	73	81
Effect on resale value of home	8.3	43	74	83
Amount of space needed for PV system	8.3	41	73	83
Codes or covenants that might prohibit it	7.7	42	65	72
What friends and neighbors might say	3.7	7	14	18

*See Appendix C for base n's, standard deviations, and coefficients of variation for each item.

Source: Constructed by the authors.

Of the 18 potential GPV problems or concerns, only one receives an average score low enough to make it seem unimportant—*what friends and neighbors say*.[2] A group of six concerns receives average scores of 9 or more—representing the issues of most concern. The percentage of respondents assigning ratings of 8, 9, 10 to each of these items ranges from 87% to 93%. This group focuses on manufacturer and vendor *dependability and reliability* and on initial and ongoing *cost or cost-benefit*; e.g., initial cost and amount of electricity produced.

A second group of seven items receives average ratings of between 8.5 and 8.8. The percentage of respondents assigning an 8, 9, 10 rating to these issues ranges from 76% to 83%. These items included *homeowner maintenance time spent*, *possible system damage*, *system safety*, and *the possibility that service and support by the utility could be stopped*. Two concerns focus on financial impact—*insurance coverage* and the potential *effect on property taxes*, and one focuses on GPV's physical requirements—*suitability of my site*.

A third group of three concerns receives average ratings of 8.3. The percentage of respondents assigning 8, 9, 10 ratings to these concerns ranges from 73% to 74%. A financial concern is expressed in *effect on home resale*, another concern focuses on *potential system obsolescence*, and the third concern involves GPV's physical requirements—*amount of space needed*.

Information Needs

Section Highlights

- The survey asked about 15 information needs
- Information needs are related to concerns and benefits of PV ownership
- Most important information needs are savings on utility bill; amount of electricity produced; and battery costs, maintenance, and disposal

In the qualitative pilot study, respondents said they need a good deal of information on these innovative systems to make a final decision about purchasing one. The types of information needs mentioned most frequently were:

- Technical information about the PV system
- Durability of the PV system
- How much electricity a system would produce
- System installation
- Warranties
- Maintenance
- Financial aspects of PV system ownership.

Many other points of information were also mentioned (Farhar and Buhrmann 1998, p. 25). However, respondents in the qualitative pilot study said little about their preferred sources of information on GPV systems.

Again, building on the findings from the qualitative pilot work, the questionnaire asked respondents to rate the importance of 15 specific kinds of information, using a 1-10 scale, that could be important to them in making a decision to purchase a GPV system for their home.

[2] However, this concern differentiated among respondents—see the discussion on perceived barriers in Chapter 6.

Assume that you were considering purchasing a grid-tied PV system. On a 1 to 10 scale, how important would the following information be to you in making your decision?

Not at all important **Very important**

1 2 3 4 5 6 7 8 9 10

Table 7 summarizes the findings regarding importance of these information needs. Mean scores for each of the 15 kinds of information are presented, along with the associated percentages of respondents who assign a rating of "10" on a 1-10 scale, the percentages assigning 8,9,10 ratings, and the percentages assigning 7,8,9,10 ratings. This data arrangement shows the percentages giving the information needs the greatest importance (a 10 rating), strong importance (an 8,9,10 rating), and, simply, importance (a 7,8,9,10 rating). Information needs are listed in the table from high to low according to the sizes of their mean scores.

Table 7. Information Needs

Types of information needed	Mean*	%10	%8,9,10	%7,8,9,10
Savings on utility bill	9.0	59	88	93
Amount of electricity PV system will produce	9.0	57	90	95
Battery costs, maintenance and disposal	9.0	56	87	93
General basic information on PV for home	8.7	56	80	86
Payback period for PV system purchase	8.6	48	81	89
Financial incentives to help pay for PV system	8.6	48	80	87
Buyback rates for excess electricity	8.5	45	77	86
Options available (e.g., maintenance agreements, warranties)	8.5	45	76	85
Government policies and programs on PV and utility restructuring	8.3	42	73	82
Sizes and brands of PV systems available	8.3	41	73	84
Technical information on how the system works	7.9	38	65	75
Description of system components	7.8	35	63	75
Financing available from utility company for PV system purchase	7.7	37	65	73
Benefits to my community and state	7.3	27	53	66
Benefits to the nation and world	7.0	27	51	62

*See Appendix C for base n's, means, standard deviations, and coefficients of variation for each item.

Source: Constructed by the authors.

All 15 information needs receive mean scores of 7 or higher, indicating that all are important to the respondents. Information needs may also be interpreted as factors driving a decision on GPV purchase or as concerns about purchasing a PV system. A top group of four specific information needs receives mean scores of 8.7 or higher. This is a group of *must know/must have* purchase decision drivers or concerns, three of which are largely financial concerns—*utility bill savings*, *amount of electricity produced*, and *battery costs, maintenance and disposal*. The fourth need—*general PV information*—focuses on information gathering.

A second group of information needs includes six strong purchase decision elements or concerns. These six receive mean scores of between 8.3 and 8.6, and between 73% and 81% of respondents rate them 8,9,10. Three of the elements again represent financial concerns—*payback period*, *financial incentives*, and *buyback rates for excess electricity*. The other three are more focused on information gathering, whether it be *available options*, *size and brand availability*, or *government PV policies and programs*.

The last group of five information needs receives mean scores of between 7.0 and 7.9. This group contains two technical factors—*technical information* and *description of system components*. *PV financing from the utility* is also in this group, as are two altruistic elements—*benefits to community and state* and *benefits to nation and world*. Individuals may feel their GPV system purchase will be beneficial to others, but it is either unlikely to be a true driver of the purchase or people assume that these benefits are inherent in a GPV purchase and need no further information about them. This is interesting because early adopters of GPV—interviewed in qualitative research—most often mention altruistic reasons for GPV investment. In this regard, early adopters could have somewhat different motivations than homeowners in general.

Information Sources

Because GPV systems had not been offered to Colorado homeowners prior to the survey, no single group or organization could lay claim to being the major source of expertise on PV. However, homeowners could regard utility companies as highly knowledgeable about PV electric systems, particularly systems tied to the utility grid. On the other hand, some customers might not trust their utility companies to be unbiased sources of information about PV because they do not trust the utility company or because GPV could be seen as harming a utility's interests.

Section Highlights

- Those trusted to provide information include PV system owners, utility companies, and PV manufacturers.
- Demonstration homes are the highest rated information source.

Gaining credible information from trusted sources is critical to any purchase decision. The reputability and credibility of any information source are essential to belief in the information conveyed and its subsequent effect on a purchase decision. In addition, people vary in the information channels they trust and rely on—some prefer the broadcast media, others the print media, still others scientific journals, and so on.

Respondents were asked to rank on a scale of 1-10 the likelihood of their using each of 24 different sources of information in making a decision to purchase a GPV system for their home. The response categories included individual, group, and organizational types of information sources, as well as various information channels.

Listed here are some sources of information about grid-tied PV systems. Please indicate how likely it is that you would contact or use each source for information.

Very unlikely 1 2 3 4 5 6 7 8 9 10 **Very likely**

Individuals, Groups, and Organizations

Table 8 summarizes findings on the likelihood of using types of individuals, groups, or organizations to obtain information about GPV. Mean scores for each of the 16 types of individuals, groups, or organizations are presented, along with the associated percentages of respondents who assign a rating of "10" on a 1-10 scale, the percentages assigning 8,9,10 ratings, and the percentages of respondents assigning ratings of 7,8,9,10. This data arrangement shows the percentages giving the types of individuals, groups, and organizations the greatest likelihood of use (the 10 rating), strong likelihood of use (an 8,9,10 rating), and, simply, likelihood of use (a 7,8,9,10 rating). The types of individuals, groups, and organizations are listed in the table from high to low according to the sizes of their mean scores.

None of the mean scores exceed 6.9, and the percentages of respondents rating these information sources as 8, 9, 10 is never higher than 52%. The indication is that respondents are neutral or only slightly inclined to use any of the 15 information sources. This result may be attributable to respondents' uncertainty as to who would have solid information on GPV, and to the fact that people might not believe it very likely that they would be contacting anyone for information on purchasing a system.

The sources of information about GPV most likely to be used, with mean scores higher than 6.5, are *people who already own PV systems* (with 52% of respondents assigning 8, 9, 10 ratings), *utility companies* (with 48% of respondents assigning 8, 9, 10 ratings), and *PV manufacturers and suppliers* (with 40% of respondents assigning 8, 9, 10 ratings). Strangely, *consumer protection organizations* receive a mean score of 5.9, and only 36% of respondents assign them an 8, 9, 10 rating. The remaining information sources receive lower mean scores.

Utility companies appear to have a relatively high degree of authority about GPV systems. If utilities favor and actively market such systems, consumers are likely to have much more confidence in the grid-tied systems than if utilities do not or if they come across to consumers as being negative toward GPV. Environmental organizations are unlikely to be considered credible PV information sources. GPV may be considered as a technological subject about which environmentalists may not be experts.

People seem to take a degree of comfort in an information source that could protect them from "scams" in connection with GPV purchase. Many people have failed to distinguish between the solar thermal systems of the early 1970s and today's GPV systems. They recall stories about unsavory business practices in marketing solar water-heating systems, especially the manner in which people were abandoned with their systems once their solar companies went out of business when the federal tax credits expired. Given this historical context, it is interesting that consumer protection organizations do not receive higher ratings, on average, as an information source on GPV likely to be used.

Table 8. Individuals, Groups, and Organizations Preferred as PV Information Sources

Potential sources of PV information	Mean	%10*	%8,9,10	%7,8,9,10
People who already own PV systems	6.9	24	52	63
Utility companies	6.8	19	48	60
PV manufacturers/suppliers	6.3	17	40	52
Consumer protection organizations	5.9	15	36	47
Public libraries	5.5	11	32	42
Friends, neighbors, acquaintances, and relatives	5.3	13	29	39
Home builders	5.3	9	27	38
Local contractors	5.3	9	27	38
Home supply stores	5.2	8	24	34
Environmental organizations	5.1	9	23	34
Colleges and universities	5.0	9	25	34
Federal government agencies and national labs	4.8	8	23	32
State and local governments	4.8	7	22	32
Financial institutions (banks, lenders)	4.6	7	19	26
Green power marketing companies	3.9	4	13	20
Lobbying organizations	3.0	2	5	9

*See Appendix C for base n's, means, standard deviations, and coefficients of variation for each item.

Source: Constructed by the authors.

Information Channels

Table 9 summarizes findings on the likelihood of relying on various information channels to obtain information about GPV if respondents are considering purchasing a GPV system for their homes. This set of questions measured preferences for obtaining PV information among various possible information channels. Mean scores for each of the eight types of information channels are presented, along with the associated percentages of respondents who assign a rating of "10" on a 1-10 scale, the percentages assigning 8,9,10 ratings, and the percentages of respondents assigning ratings of 7, 8, 9, 10. This data arrangement shows the percentages giving the information channel the greatest likelihood of use (the 10 rating), strong likelihood of use (an 8, 9, 10 rating), and, simply, likelihood of use (a 7, 8, 9, 10 rating). The types of information channels are listed in the table from high to low according to the sizes of their mean scores.

The top information channel (mean score = 6.9; 52% of respondents assigning it an 8, 9, 10 rating) is *a demonstration building or model home with PV*. No information channels receive mean scores higher than

6.9, indicating less than strong enthusiasm for any of the information channels. Nonetheless, a group of four channels receive mean scores between 6.2 and 6.5. Between 39% and 47% of respondents assign 8, 9, 10 ratings to these channels. This group includes *written materials—books, journals, and reports about PV*; *brochures*; and *magazines and newspapers*. *Events*, such as home shows and solar home tours where people can see and touch PV systems, are also part of this second group.

The information channels that people are apparently least likely to use include seminars and classes, the Internet, and the broadcast media. The mean scores for these items are less than 5.5.

Table 9. Preferred GPV Information Communication Channels

Potential PV information communication channels	Mean	%10*	%8,9,10	%7,8,9,10
Demonstration building or model home with PV	6.9	22	52	64
Books, journals, and reports about PV	6.5	16	47	59
Brochures	6.4	14	41	55
Events (home and garden shows, solar home tours)	6.3	16	43	54
Magazines and newspapers	6.2	13	39	52
Seminars, workshops or classes	5.4	11	31	40
The Internet	5.3	14	34	42
Radio and television	4.9	7	22	32

*See Appendix C for base n's, means, standard deviations, and coefficients of variation for each item.

Source: Constructed by the authors.

The best sources of information are those which give people observability and trialability—a chance to see, touch, experience, and talk with those who have already lived with a PV system. Other than these, channels requiring people to spend time and money are less likely to be used. Print media are more likely to be used than broadcast media. These preferred information channels appear to fit well with the technological nature of GPV systems.

Chapter 4
Descriptive Findings:
Product Attributes

Understanding the features that most homeowners would like to see in a GPV system is important to developing products and policies to which the market will positively respond. In the qualitative pilot study, respondents expressed an interesting variety of features and attributes they would like to see a PV system include (Farhar and Buhrmann 1998, pp. 23-24). The most frequently mentioned preferred features were:

- On-site or real-time feedback on system performance
- Net metering
- An option to own the PV system
- An option to pay the utility over time
- An option for the system to meet all or most of their electricity needs
- An option for the system to provide excess electricity, at least part of the time
- Equipment warranties
- A battery for emergency backup.

Chapter Highlights

- Consumers prize a PV system warranty and a 20-year system life.
- Rebates or tax credits for system purchase are important.
- A battery option to provide power during an outage is desired.
- One-third want PV system to blend into their homes.
- Consumers want net metering at retail rates.
- Utility companies, PV manufacturers, and local PV contractors are the most preferred PV system suppliers.

Many other attributes and features were also volunteered during the interviews (Farhar and Buhrmann 1998).

Preferred System Features

Building on these findings, the questionnaire asked respondents to rank on a scale of 1–10 the importance of 21 PV system features in making a decision to purchase one for their homes.

If you were considering obtaining a grid-tied PV system, on a 1 to 10 scale, how important would each of the following features be to you?

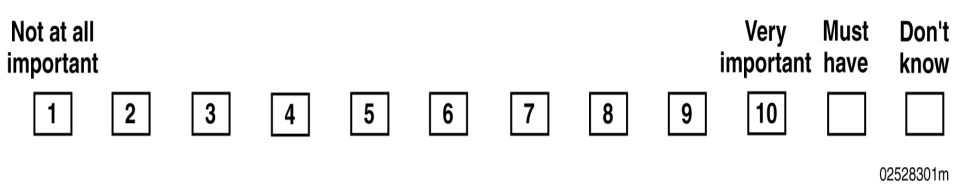


Table 10 summarizes the results. The mean score for each of the 21 system features is presented, as are three related percentages: the percentage of respondents rating the feature as 11 (“Must have”), the percentage of respondents assigning 8, 9, 10 ratings on a 1–10 scale, with 1 = “Not at all important” and 10 = “Very important"; and the percentage of respondents assigning ratings of 7, 8, 9, or 10. This data arrangement shows the percentages giving each product feature the greatest importance (the 11 "Must have" rating), strong importance (an 8, 9, 10 rating), or, simply, importance (a 7, 8, 9, 10 rating). The features are listed in the table from high to low according to their mean scores.

Table 10. Preferred System Features

System feature	Mean*	% Must have	%8,9,10	%7,8,9,10
Manufacturer-provided warranty on PV system	9.1	12	76	80
System lasts for at least 20 years	8.9	8	76	82
Rebates or tax credits for purchasing system	8.6	6	73	79
Battery to provide power during power outage	8.5	8	70	76
Way to measure how much electricity PV system produces	8.3	8	63	73
Battery to store excess power for use at night	8.3	7	67	75
Maintenance agreement at reasonable cost	8.3	7	67	75
Attractive-looking system	8.3	6	68	76
PV panels mounted flush with roof	8.0	4	66	76
Extended warranty at reasonable cost	8.0	7	61	69
Add-on or upgrade capability	8.0	5	63	74
System integrates in home, such as PV shingles and PV skylights	7.7	3	62	71
A guarantee electricity rates stay the same for 5 years	7.6	3	58	68
Produce more electricity than is needed at my home	7.5	4	54	65
Owning the PV system	6.6	3	41	52
PV system easily moved to next home	6.5	3	45	52
Financing system through utility	6.2	2	38	48
Option to do own installation	5.8	3	36	43
Pay for system up front rather than finance	5.5	1	27	35
Leasing, leasing with option to buy PV system	5.3	1	25	35
PV panels mounted on ground	4.8	1	22	29

*Mean calculated on a 1-11 scale, with 10 = Very important and 11 = Must have. See Appendix C for base n's, means, standard deviations, and coefficients of variation.

Source: Constructed by the authors.

Four of the 21 potential features have mean scores of 8.5 or more. Seventy percent or more of the respondents assign 8,9,10 ratings to each of these features. This indicates that consumers are likely to demand *a system warranty* and *a 20-year system life*. *Rebates or tax credits* for system purchases are also highly desired, as is a *battery to provide power during an electrical outage*.

A second group of four features have mean scores of 8.3. Between 63% and 68% of respondents assign 8,9,10 ratings to each of these features. This particular group focuses on *PV energy measurement*, *maintenance agreements*, *system attractiveness*, and *storage for excess capacity*. It is likely that the eight features in these two groups comprise the key features for a GPV system.

In addition to the eight features identified above, a third group of six have mean scores between 7.5 and 8.0. Four of these features can be considered corollaries of the first and second group's features—*available extended warranty*, *installation aesthetics* (including *flush-mounted panels* and *integrated PV systems*), and *upgrade availability* (to ensure system longevity). Also in the third group are *guaranteed electricity rate stability* and the *ability to produce more electricity than is needed*—both of which suggest a need for financial security (or gain). However, while the four features tied to the first and second groups are likely to guide a GPV purchase decision, the two financial features are likely to be less influential because they have no first or second group correlates.

The remaining features are of less importance; they have mean scores of 6.6 or less. Most of these focus on ownership or purchase options for GPV. None of them are likely to play a pervasive role in a GPV purchase decision. However, ownership is preferred to leasing, and utility financing is considered to be important. Ability to move a PV system if a homeowner moves to a new home is also a feature to which a majority of respondents assign a 7,8,9,10 rating.

Preferred PV Suppliers

Respondents were asked from whom they would prefer to purchase a GPV system. The question was:

Assume you made the decision to purchase a PV system for your home. On a 1 to 10 scale, how likely would you be to consider purchasing it from . . .? ***[For each source, please circle one response.]***

Not at all likely									Very likely
1	2	3	4	5	6	7	8	9	10

The choices listed were the utility company, local contractors, retail home improvement centers, PV manufacturers, and renewable energy/energy efficiency specialty suppliers. Responses are listed in Table 11 in order of the size of the mean score.

Table 11. Sources of GPV System Purchase

Sources of GPV system	Mean*	%10	%8,9,10	%7,8,9,10
Electric utility	7.45	25	61	67
PV manufacturer	6.45	12	42	51
Local area PV contractor	6.42	10	39	51
Renewable energy/energy efficiency specialty supplier	6.06	9	36	45
Retail home improvement center	5.53	8	29	37

*See Appendix C for base n's, means, standard deviations, and coefficients of variation for each item.

Source: Constructed by the authors.

All of these potential sources of GPV systems have mean scores toward the positive end of the scale. However, utility companies are the highest rated source of GPV (mean = 7.45), selected by 67% of the respondents as a likely source. Majorities of 51% also selected PV manufacturers (mean = 6.45) and local area PV contractors (mean = 6.42) as likely GPV sources. The lowest rated source is retail home improvement centers.

Appearance/Performance Trade-offs

The efficiency of any solar energy system is affected by the amount of sunlight to which the solar collector is exposed. In the case of GPV systems mounted flush with the roof, the system's potential for maximum performance could be attenuated by less-than-optimal roof pitch, house orientation, shading, and other factors. PV panels can be mounted on frames that hold them toward the sun at the optimum angle to maximize their performance. Yet, many people object to the appearance of such systems.

A question was included on the trade-off between system aesthetics and performance. Respondents were asked:

> *There may be trade-offs between how much electricity a PV system will produce and its appearance when it is installed on a house. Of the following options, please select the one that would appeal most to you, assuming you were thinking of purchasing a PV system.* ***[Please check only one response.]***

Table 12 presents findings on the responses. Thirty-one percent want a PV system to blend into their homes as much as possible, even if this would somewhat reduce the amount of electricity produced. Twenty-four percent want to maximize electricity production, even if the PV panels stick up at an odd angle from the roof of their home.

Table 12. Appearance/Performance Trade-offs

Response categories	%
I'd want the PV system to blend into my home as much as possible (such as PV shingles), even if this would somewhat reduce the amount of electricity produced	31
I'd want the PV system to maximize the electricity produced, even if it means that the panels stick up from my roof at an odd angle	24
I'd want the PV panels mounted flat on my roof, even if this would slightly reduce the amount of electricity they produced	19
I'd prefer a ground-mounted system not on my home	6
Don't know	20
Totals	100
Base n	2470

Source: Constructed by the authors.

Excess Electricity and Net Metering[1]

One of the possible benefits of GPV is the potential for selling excess electricity produced by a PV system back to the utility company. Sixty-two percent of the respondents indicate that this is an important benefit by rating it 8, 9, or 10 on a 10-point scale.

Later in the questionnaire, respondents were presented with the following question:

> *Because roof space on homes is limited, a grid-tied PV system would probably not produce more electricity than is consumed in your home. However, at certain times (such as in the middle of the day in the summer), the PV system could produce more power than a home is consuming. During these times, there are several options for what can happen to this excess electricity. On a scale of 1 to 8, how positive or negative are you to the following three options?*

Respondents were presented with these options:

- The utility automatically credits me for any excess electricity I put on the grid at the same rate the utility charges me for electricity.

- The utility credits me for any electricity I put on the grid at the same rate that the utility pays its other wholesale electricity providers.

- The utility takes the electricity and does not reimburse me, but donates the excess electricity I produce to assist low-income households.

[1]Net metering is discussed in more detail in Starrs (1996).

The first option represents net metering at full retail rate and is termed "Wants retail cost" in Table 13. If an electric meter runs forward when a household is using electricity from the utility grid and backward when a household is sending electricity from the PV system to the utility grid, in effect the utility is paying the customer full retail rate for any excess electricity generated by the customer's PV system. This would be, in Colorado, on the order of 8¢ per kWh. A variation of this is "net metering to zero" in which the utility in effect pays retail rate until breakeven, but pays the customer nothing extra for any excess electricity the customer's PV system produces.[2]

The second option represents a net-metering scheme in which the utility pays the customer avoided cost—that is, the cost the utility avoided having to pay for the electricity from another source—for any excess electricity generated by the customers PV system. This amount would be, in Colorado, on the order of 1.9¢ per kWh. This option is termed "Accepts avoided cost" in Table 13.

The third option, involving contributing any proceeds that might result from owning PV systems to lower-income households, was suggested by some respondents in the qualitative study, and was included in the questionnaire to determine how widespread such a sentiment might be among Colorado homeowners. This option is termed "Wants excess donated to low-income customers" in Table 13.

Table 13 shows the responses for each of these options.

Table 13. Net-Metering Options

Response options (1-8 scale)	Wants retail cost %	Accepts avoided costs %	Wants excess donated to low-income customers %
Positive (6-8)	84	21	22
Neutral/mixed (4-5)	7	27	25
Negative (1-3)	3	44	45
Don't know	6	9	8
Totals	100	101*	100
Base n	2424	2348	2344

*Percentages do not add to 100 because of rounding.

Source: Constructed by the authors.

Eighty-four percent of respondents rate "retail cost" net metering as positive. Three percent are negative toward the idea of retail-cost net metering; 6% percent don't know.

[2]This option is currently employed by Public Service Company of Colorado's *SolarSource* program.

Being paid avoided cost for net excess electricity production is not as popular. One in five (21%) are positive toward the utility reimbursing them for excess electricity at avoided cost. Homeowners may recognize that the utility company needs to make a profit. But 27% are neutral about this, and 44% are negative toward the idea. Nine percent don't know.

Although 45% are negative toward the idea of donating excess PV electricity to low-income consumers, 22% are positive toward this idea. One in four are neutral, and 8% don't know.

Chapter 5
Descriptive Findings:
Willingness to Pay for GPV Systems
and Favorability toward Using GPV

A critical question for any utility company, energy service company, or green power marketer is customer willingness to pay (WTP) for GPV systems. The survey measured interest in, and willingness to pay for, GPV system purchase as a major dependent variable of the study.

The survey asked about the size of a PV system that respondents might like to own while taking price into account. Also explored were stated willingness to pay for systems of three sizes as well as willingness to acquire a no-added-cost PV system. Respondents were asked how they would prefer to pay for a system. In addition, their views on subsidies for PV systems were elicited.

Chapter Highlights

- Preferences on PV system size/price trade-offs: preference for larger systems, even with higher costs
- Willingness to pay for various GPV products: 75% hypothetically willing to pay more for GPV system
- Likelihood of purchase: 70% say likely if no added cost
- Preferred methods of paying for GPV system: utility bill, then mortgage and PV manufacturer or supplier
- Preferred forms of subsidy: one-third say federal income tax credit; 12% say no subsidies.

System Size/Price Trade-offs

In the past 2 years, various people in the energy industry have speculated about the size of PV systems that customers would prefer. Some asserted that customers would prefer a small system that would power a large appliance, while others asserted that people were looking for a large system that would allow them to be net exporters of electricity.

One of the survey questions was designed to generate empirical information on this issue. The question asked about system size and price trade-offs, noting that the cost ranges presented were based on the installed cost of a PV system. These cost estimates were centered around an average home electricity consumption of 600 kWh a month at a cost of $45 a month.

The question was phrased:

> *PV systems can be sized to meet a variety of needs. Larger ones produce more electricity and are more expensive than the smaller ones. If you were to purchase a PV system outright for your home, which of the following sizes and price ranges would you prefer?* ***[Please check one response.]***
>
> *Note: The following cost ranges are based on the installed cost of a PV system. They are centered around an average home electricity consumption of 600 kWh a month at a cost of $45 a month. Remember that these costs are hypothetical. Electricity use varies considerably by household.*

Estimated one-time costs shown for these systems were as follows:

- *A very small system that powers one large appliance (such as a refrigerator) at a one-time cost of $2,500.*

- *A small system that provides 25% of your household electricity at a one-time cost of between $4,500 and $9,500, depending on your electricity usage.*

- *A medium-sized system that provides 50% of your household electricity at a one-time cost of between $8,500 and $16,500, depending on your electricity usage.*

- *A large system that provides 75% of your household electricity at a one-time cost of between $11,500 and $23,000, depending on your electricity usage.*

- *A very large system that provides 100% of your household electricity at a one-time cost of between $14,000 and $28,000, depending on your electricity usage.*

The question reminded respondents that the costs presented were hypothetical and that electricity use varies considerably by household.

The modal response to this question, as anticipated, is that Colorado homeowners would not purchase any of the GPV systems described (Table 14). The next most frequent response pertained to the purchase of a medium-size system that could provide half of a household's electricity, with a price tag between $8,500 and $16,500, depending on electricity usage. Eighteen percent of respondents say they would purchase a system of this size, if they were to purchase a PV system for their home. The third most frequent response pertained to the purchase of a system that provided 100% of a household's electricity, at a one-time cost of between $14,000 and $28,000. Eleven percent of respondents selected this option. These findings exhibit preferences among system sizes in the context of price ranges but should not be interpreted as intent to purchase GPV systems.

Scenarios for GPV System Purchase

To develop an accurate picture of stated willingness to pay for GPV systems, realistic prices for several different system sizes and plausible scenarios for purchasing GPV systems were used. Four different purchase scenarios were developed: (1) a very small system, (2) a medium-sized system, (3) a very large system, and (4) a system which people could purchase but for which they would pay nothing more than they were currently paying for electricity.

These scenarios were based on a realistic market price of each GPV system at the time of the survey, utility financing with an annual interest rate of 7%, a financing term of 20 years, average monthly usage of 600 kWh, and an average price per kWh of $0.076. Table 15 shows the variables for each of these systems for the different scenarios. The amount of electricity to be produced by the GPV system, and therefore saved on the monthly electricity bill, was subtracted from the monthly payment to yield a net monthly increase in the customer's electricity costs after purchasing the system.

Table 14. System Size/Price Trade-offs

System Size/Price Option	%
A very small system that powers one large appliance (such as a refrigerator) at a one-time cost of $2,500	1
A small system that provides 25% of your household electricity at a one-time cost of between $4,500 and $9,500, depending on your electricity usage	7
A medium-sized system that provides 50% of your household electricity at a one-time cost of between $8,500 and $16,500, depending on your electricity usage	18
A large system that provides 75% of your household electricity at a one-time cost of between $11,500 and $23,000, depending on your electricity usage	7
A very large system that provides 100% of your household electricity at a one-time cost of between $14,000 and $28,000, depending on your electricity usage	11
I would not purchase any of these systems	23
Other*	11
Don't know	22
Totals	100
Base n	2503

*Other responses include: price too high, depends on tax credits/relief/rebates, cost-to-benefit ratio is very poor, would have to be able to make payments, I'm too old to get my money back out of it, want lease option, build cost into utility bill, want a very large system for $2,500, would want to sell excess electricity back for credit, ability to produce extra electricity with upgrade capability, would need more information, would need to talk to others who have system, more competition in manufacturing to lower costs, would need assurance it would be in my home for a long time.

Source: Constructed by the authors.

Table 15. Estimates Used in Purchase Scenarios

System size (W)	Unit installed cost ($/W)	Installed cost ($)	Payment ($/mo.)	Electricity produced (kWh/mo.)	% of total	Value of electricity produced ($/mo.)	Increase in bill ($/mo.)
Very small (250 W)	$10	$2,500	$19.38	42	7%	$3.17	$16.21
Medium (1800 W)	$7	$12,600	$97.69	300	50%	$22.80	$74.89
Very large (3600 W)	$6	$21,600	$167.46	600	100%	$45.60	$121.86

Source: Constructed by the authors using data developed by Marc Roper, Colorado Office of Energy Conservation, 1998.

Very Small System

The first scenario presented was:

> *Suppose you would purchase a PV system that produces* ***enough electricity to power one or two large appliances****, like a refrigerator and a dishwasher. The system reduces the amount of conventional electricity you buy from your utility by* ***a small amount (say, 7% to 15%)****. Your utility provides financing for 20 years at a competitive interest rate of 7%, and your payment for the PV system would be listed separately as part of your utility bill. What is the most you would be willing to add to your current electricity bill to purchase this PV system?* ***[Please check one response.]***

More than one-quarter of respondents (26%) say they would pay nothing more for a very small GPV system; the remaining 74% say they would pay something more. The most frequently mentioned response is $10 per month more (by 21%). Selected next most frequently is $5 per month; the remaining amounts of $3, $8, $15, $20, and $25 per month more are selected by 7%–10% of respondents each. Table 16 presents the results.

Figure 4 shows the cumulative percentage of respondents willing to pay more for a very small GPV system. As would be expected, the percentage drops off as the cost increases.[1] Twenty-three percent indicate WTP the "actual" incremental system cost estimate of $15 based on the calculations provided by OEC.[2]

---

[1]Figure 4 and similar figures that follow display WTP responses as cumulative percentages. For example, in Figure 4, 75% of respondents indicate that they would be willing to pay *at least* $3 more for electricity from renewable sources. The cumulative curve is drawn to 100% at $0 to indicate that, in this case, some additional number of respondents that answered "zero" may have, if asked, been willing to pay some amount between $0 and $3.

[2]Respondents were not told the "actual" incremental amount per month more in the scenario questions.

Table 16. Net Amounts Willing to Pay More per Month for a Very Small GPV System

Response options	%
Nothing more	25
$3 more per month	10
$5 more	14
$8 more	7
$10 more	21
$15 more*	8
$20 more	7
$25 more	8
Totals	100
Base n	2447

*Actual net increase in bill was estimated to be $16.21 per month for a system of this size.

Source: Constructed by the authors.

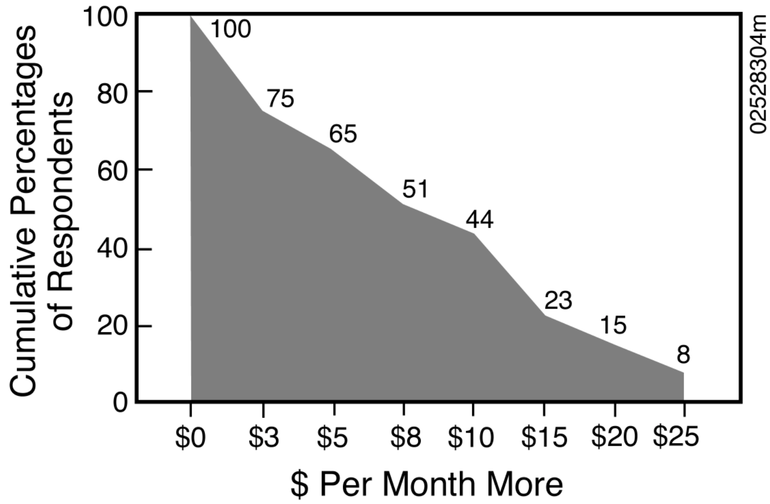
Medium-sized System

The second scenario presented was

> *Suppose you would purchase a PV system with the same arrangement as in Scenario A, except that the PV system produces* ***half of the electricity used in your household****. That is, the amount of electricity you buy from your utility is reduced by half. What is the most you would be willing to add to your current electricity bill to purchase this PV system?* ***[Please check one response.]***

Twenty-two percent of the primary sample say they would pay nothing more for a medium-sized GPV system (slightly less than the percentage unwilling to pay more for a very small system). The remaining 78% indicate that they would pay something more. The most frequently mentioned response is $25 per month more (by 25%). Mentioned next most frequently is $15 per month (by 17%). Sixteen percent select $50 per month more, and 15% indicate they would be willing to pay $20 per month more for the medium-sized system. The other amounts of $60, $70, and $80 per month more are selected by 1% to 3% of respondents each.

Only 2% indicate WTP the "actual" incremental system cost estimate of $70 based on calculations provided by the OEC.



Estimated Actual Cost: $15

Figure 4. Net Incremental Monthly Amounts Respondents Are Willing to Pay for a Very Small GPV System (Cumulative)

Source: Constructed by the authors.

Table 17 presents the results and Figure 5 shows the cumulative percentages.

Table 17. Net Amounts Willing to Pay More per Month for a Medium-sized GPV System

Response options	%
Nothing more	22
$15 more per month	17
$20 more	15
$25 more	25
$50 more	16
$60 more	3
$70 more*	1
$80 more	1
Totals	100
Base n	2440

*Actual net increase in bill was estimated to be $74.89 per month for a system of this size.

Source: Constructed by the authors.

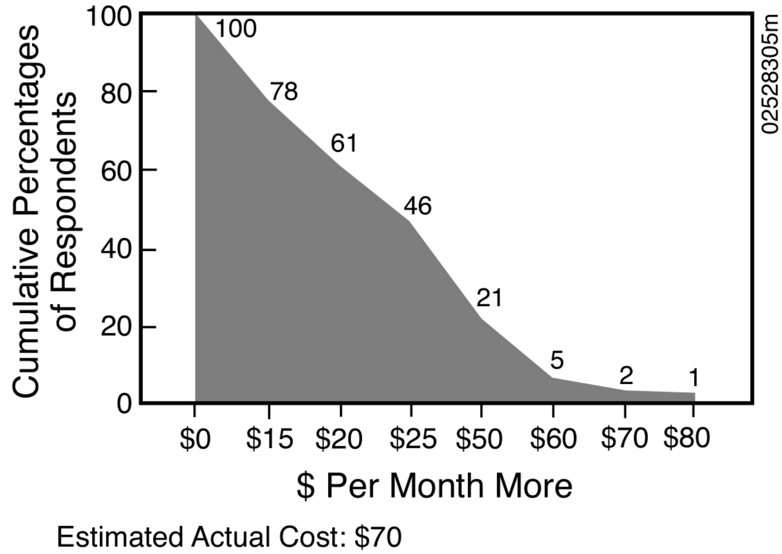


Figure 5. Net Incremental Monthly Amounts Respondents Are Willing to Pay for a Medium-sized GPV System (Cumulative)

Source: Constructed by the authors.

Very Large System

The third scenario presented was:

> *Suppose you would purchase a PV system with the same arrangement as in Scenario A, except that the PV system produces* ***100% of the electricity used in your household*** *. That is, on average you purchase no electricity from your utility because the PV system produces as much electricity as you use. The utility grid is your storage and backup. What is the most you would be willing to add to your current electricity bill to purchase this PV system?* ***[Please check one response.]***

Twenty-three percent of the primary sample say they would pay nothing more for a very large GPV system, slightly more than the percentage unwilling to pay more for a medium-sized system. The remaining 77% indicate that they would pay something more. The two most frequently selected responses (by 21% each) are $25 per month more and $50 per month more. Selected next most frequently is $75 per month more (by 12%). Ten percent select $100 per month more, and 9% indicate they would be willing to pay $60 per month more for the very large system. The amount of $125 per month more is selected by 2%, and $150 by 1%. Table 18 presents the results and Figure 6 shows the cumulative percentages.

Only 3% indicate WTP the "actual" incremental system cost estimate of $125 based on the calculations provided by OEC.

Table 18. Net Amounts Willing to Pay More per Month for a Very Large GPV System

Response options	%
Nothing more	23
$25 more per month	21
$50	21
$60	9
$75	12
$100	10
$125*	2
$150	1
Totals	99**
Base n	2446

*Actual net increase in bill was estimated to be $121.86 per month for a system of this size.
**Percentages do not add to 100 because of rounding.

Source: Constructed by the authors.

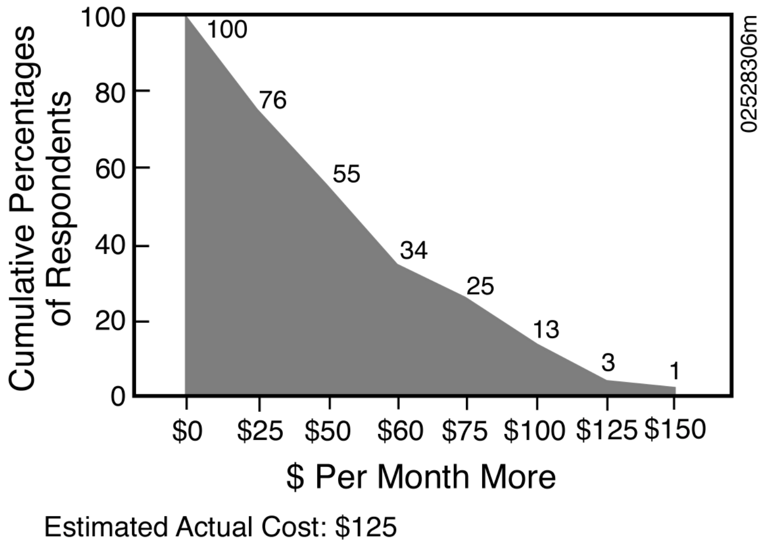


Figure 6. Net Incremental Monthly Amounts Respondents Are Willing to Pay for a Very Large GPV System (Cumulative)

Source: Constructed by the authors.

No-Added-Cost System

The fourth scenario presented was:

> *Assume subsidies became available or the price of PV dropped, and you could purchase a grid-tied PV system for your home from your utility company. The PV system portion of your bill and the electricity portion combined* ***would equal your current electricity bill.*** *On a 1 to 10 scale, how likely would you be to purchase the grid-tied PV system?* ***[Please check one response.]***

Seventy percent of the respondents say they would be likely to purchase a GPV system that adds no cost to their current electricity bill (7,8,9,10 on a 10-point scale). Eleven percent indicate that they would be neutral or unsure about purchasing such a system (5-6 on the scale), and 13% indicate that they would be unlikely to purchase a GPV system even if it cost nothing more on their utility bill. Table 19 presents the results.

Table 19. Likelihood of Purchase of a No-Added-Cost GPV System

Response categories (1-10)	%
Very likely (9-10)	47
Likely (7-8)	23
Neutral/unsure (5-6)	11
Unlikely (3-4)	4
Very unlikely (1-2)	9
Don't know	7
Total	101*
Base n	2468

*Percentages do not add to 100 because of rounding.

Source: Constructed by the authors.

Payment Preferences

Respondents were asked:

> *If you were thinking of buying a PV system, regardless of its cost, which way would you prefer to make the payment for the system?* ***[Please rank the following choices, with 1 for your first choice, 2 for your second choice, and so on.]***

Payment options listed were utility bill, home mortgage, payment to a PV manufacturer or supplier, or payment against a home equity loan or other personal financing.

Assuming they would buy a PV system, most respondents indicate they would prefer to pay for it via their regular *utility bill* (57% of first choices, 23% of second choices, totaling 80% of first and second choices). Two options occupy second position. Financing through *home mortgages* receives 17% of first choices, and 25% of second choices, for a total of 42%. Direct payment to a *PV manufacturer or supplier* is chosen by 12% for first choice and 33% for second choice, for a total of 45% selecting it as first or second choice. It appears to be a toss-up in preferences for these two options. Least popular is personal financing. Table 20 summarizes the responses.

Table 20. Level of Choice (in Percent) by GPV Payment Options

Payment options	1st choice	2nd choice	3rd choice	4th/5th choice
Utility bill	57	23	16	8
Home mortgage	17	25	25	23
PV manufacturer or supplier	12	33	26	30
Home equity or personal loan	9	18	32	39
Other	5	1	2	--*
Totals	100	100	101**	100
Base n's	2061	1003	798	746

*Less than 0.5%.
**Percentages do not add to 100 because of rounding.

Source: Constructed by the authors.

Policy Preferences on GPV Subsidies

The following question about subsidization was presented toward the end of the questionnaire:

> ***THINKING NOW ABOUT EVERYONE PAYING FOR GRID-TIED PV . . .***
>
> *Assume for the moment that all or part of the cost of grid-tied PV systems on homes are subsidized for a limited time to help introduce PV to consumers. Which way would you prefer to see this accomplished,* ***assuming that each option listed provided the same financial benefits to PV owners? [Please check the option you feel is best.]***

Responses presented include a slight increase in utility rates, a federal income tax credit for PV owners, a state income tax credit, government-subsidized low-interest utility financing, government subsidies to PV manufacturers, and opposition to all subsidies.

One-third choose a *federal income tax credit* as the best way to help introduce PV to consumers, if everyone were to help pay for grid-tied PV (Table 21). Twelve percent of the sample say they oppose all subsidies, and 18% don't know. Earlier experiences with solar tax credits for active solar energy systems may affect homeowner views toward subsidies, both positively and negatively.

Table 21. Preferred Forms of Subsidy

Forms of subsidy	%
Federal income tax credit	34
Low-interest financing	13
Slight increase in electricity rates	8
State income tax credit	8
Direct subsidies to PV manufacturers to reduce system cost	5
Other*	1
Opposed to all subsidies	12
Don't know	18
Total	99**
Base n	2425

*Other includes the following: slight rate increase combined with government subsidy; pay for itself through buyback of electricity; subsidies fine but no artificial price increases.
**Percentages do not add to 100 because of rounding.

Source: Constructed by the authors.

Favorability toward Using GPV on One's Own Home

Most respondents tend to be favorable toward using GPV on their own homes. After responding to several questions on potentially positive and negative aspects of GPV, respondents considered the idea of using it on their own homes. If respondents answered the questionnaire sequentially, which is a reasonable assumption, they would have considered the costs and benefits of GPV systems before they responded to a question on overall favorability to personally using GPV technology. The question was: *"Now that you have thought a little more about grid-tied PV for homes, on a 1 to 10 scale, how favorable are you about the idea of using it on your own home?"* A majority of 57% indicate favorability (7-10 on the 10-point scale); 25% respond in the neutral range; 11% are unfavorable; and 6% don't know. The mean response is 6.95 (Table 22).

Table 22. Favorability toward the Idea of Using GPV on One's Own Home

Response categories (1-10 scale)	Using GPV on Your Own Home %
Very favorable (9-10)	25
Favorable (7-8)	32
Neutral/mixed (5-6)	25
Unfavorable (3-4)	4
Very unfavorable (1-2)	7
Don't know	6
Total	99*
Base n	2475

*Percentages do not add to 100 because of rounding.

Source: Constructed by the authors.

Changes in Favorability after Considering GPV Benefits and Costs

Energy analysts have often stated they believe survey responses tend to be favorable to renewables because survey participants are not asked about price. Their hypothesis would be that, if people knew how much green power actually costs, they would be less favorable toward its use. For this reason, responses on favorability toward GPV before and after the questions on GPV systems costs—as well as questions on potential problems and concerns—were compared. This comparison is based on the assumption that respondents answered the questions in the order they were offered in the questionnaire.

Because GPV was still a hypothetical product at the time of the survey, completing the survey questionnaire probably was a learning experience for most respondents. It might have been their first opportunity to consider the potential benefits and costs of adopting this technology. A comparison of the responses to the question on favorability to the idea of making GPV available to Colorado residents (at the beginning of the questionnaire) and favorability to the idea of using it on one's own home (near the end of the questionnaire) could therefore be instructive in assessing whether favorability increases or decreases with exposure to more information.

The two questions on favorability were not identical, since the first was general, dealing with GPV systems being more available to Colorado residents, and the second was specific, asking about using GPV "on your own home." Because responses to the second question were expected to be more conservative, the findings on the way in which favorability tends to hold despite exposure to realistic information on costs are striking.

The opinions on favorability of some respondents apparently changed as they thought about GPV while they were in the process of completing the questionnaire. Figure 7 summarizes the before-and-after changes in favorability, which are different at a p-value of .0001. Seventy percent were initially favorable to the idea of systems being made available to Colorado residents, and 62% were favorable toward the idea of using GPV on their own homes. Ten percent were unfavorable to the idea of GPV systems becoming more widely available, and 11% were unfavorable to the idea of using GPV on their own homes.

Table 23 shows the percentages favorable and unfavorable to the two questions. Responses are positively correlated at R = .5987. Initially favorable respondents tend to remain favorable. A majority of respondents favor both the idea of having GPV systems available and the idea of using them on their own homes, even after they were presented with realistic size/price trade-offs for GPV systems, various payment scenarios, and possible problems. Of those initially favorable, 77% stay favorable; of those initially neutral or mixed, 29% become more favorable. Of those initially unfavorable, 57% (18% + 39%) become more favorable as a result of thinking about GPV. Furthermore, unfavorable respondents tend to become neutral or favorable (Table 24).

Some respondents remain unfavorable or become less favorable toward GPV after thinking it over. Among those respondents initially unfavorable, 44% remain unfavorable. Among those initially neutral/mixed, 20% become less favorable. Among those initially favorable, 22% (19% + 3%) become less favorable.

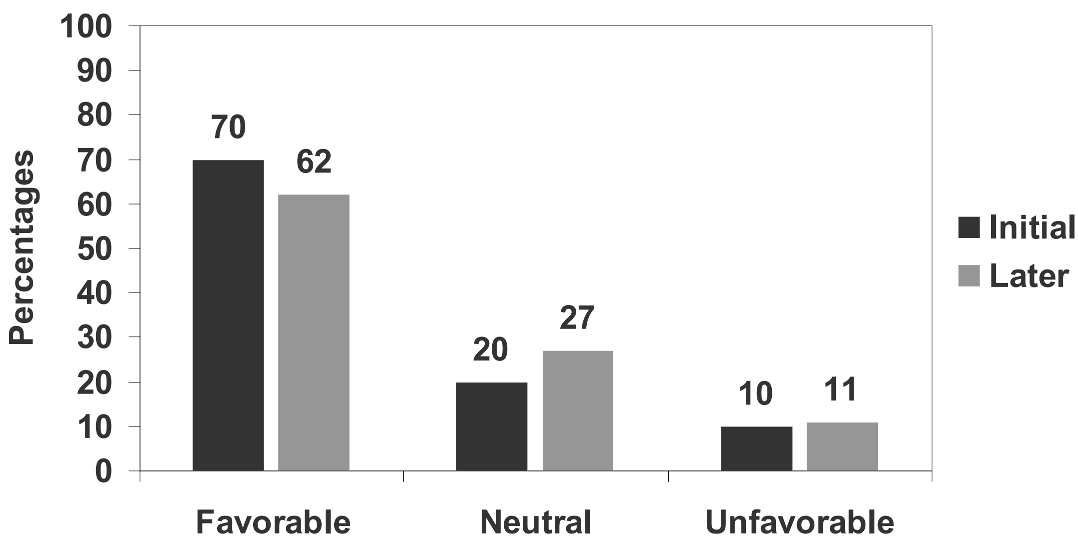
These findings support the idea that respondents tend to remain favorable toward the use of electricity from renewable sources, even when they are presented with information about high costs and potential problems.

Table 23. Comparison of Responses on Favorability toward GPV

Response categories (1-10 scale)	Making PV More Available %	Using GPV on Your Own Home %
Very favorable (9-10)	44	25
Favorable (7-8)	24	32
Neutral/mixed (5-6)	21	25
Unfavorable (3-4)	6	4
Very unfavorable (1-2)	6	7
Don't know	--*	6
Total	101**	99**
Base n	2353	2475

*Don't know was not a response category for this question.
**Percentages do not add to 100 because of rounding.

Source: Constructed by the authors.



Chi-square = 1362.549; d.f. = 81; p < .0001.

Figure 7. Initial Favorability toward Systems Being Available to Colorado Residents and Later Favorability toward the Idea of Using GPV on One's Own Home

Source: Constructed by the authors.

Table 24. Changes in Favorable Opinions toward GPV*

Response categories	Subsequently favorable	Subsequently neutral	Subsequently unfavorable
Initially favorable (7, 8, 9, 10 ratings)	77%	19%	3%
Initially neutral/mixed (5, 6 ratings)	29%	50%	20%
Initially unfavorable (1, 2, 3, 4 ratings)	18%	39%	44%

*Percentages add row-wise. Percentages do not add to 100 because of rounding.

Source: Constructed by the authors.

Chapter 6
Data Reduction

> **Chapter Highlights**
>
> - Perceived benefits of GPV adoption: environmental benefits, financial advantages, and personal satisfaction are the three major dimensions.
> - Perceived barriers to GPV purchase: feasibility of PV systems, reliability of PV providers, neighborhood concerns are the three major dimensions.
> - Product features: warranties, system performance, battery options, aesthetics, financing, and self-reliant ownership are the five major dimensions.
> - Factor analyses were performed on information needs; on individuals, groups, and organizations preferred as information sources; and on preferred information channels (such as media).
> - Three dimensions of information needs are PV product available, financial aspects, and benefits to the community and the world.
> - Three dimensions of individuals, groups, and organizations as information sources are: (1) government agencies, (2) local building businesses, and (3) friends and other trusted sources.
> - Two dimensions of information channels are activities (events, demonstrations, and classes) and media (including the Internet).
> - Two dimensions of values and lifestyles are environmental values and early adopter characteristics.

Many surveys provide vast amounts of information that cannot be usefully interpreted without some preliminary synthesis. Various statistical techniques are available for accomplishing the synthesis. Factor analysis is one such statistical technique by which several variables can be reduced to a smaller number of "factors" or "dimensions" by considering and identifying which of the original variables are similar to each other (Morrison 1976). In the context of survey research, factor analysis can be used to distill the total number of questions, items, or response variables comprising a survey instrument down to a smaller set of factors that more succinctly reflect the answers of all the respondents.

Each of the factors produced with factor analysis represents a weighted combination of some of the original variables. The numerical weights that are used in combining the variables to form factors are referred to as "factor loadings." Factor loadings may vary from -1.0 to +1.0. A positive factor loading for a contributing variable indicates it is positively associated with the overall factor. Similarly, a negative factor loading for a contributing variable indicates it is negatively associated with the overall factor.

The most important factors are determined to be those which collectively explain a high percentage of the variability in the data. These are often the factors for which the highest factor loadings are determined. A high positive factor loading from any variable or item indicates that the item helps to "define" the factor. In the survey context, the key definers are those variables that are truly able to differentiate respondents into different categories.

Once the most important factors have been determined, they can be used to compute a factor response, or "factor score," in much the same way that each original variable yields a response, value, or score. These factor scores can then be substituted for the values of the original variables in further analyses of the data.

Factor analysis was used to investigate many of the items and variables contained in the questionnaire for the present study.[1] A particular kind of factor analysis involving varimax rotation (Dillon and Goldstein 1984) was used. The results of all the factor analyses from the study and all the items used in them are contained in Appendix D, and discussion of the factors and their defining items is provided below.

Having determined the most important factors representing the study variables, factor scores for each of them were computed for every respondent, and the scores were subsequently standardized (by using the statistical Z-transformation). All standardized factor scores essentially range from -3.0 to +3.0. These standardized factor scores were ultimately used to help establish market segments of respondents having various likelihoods of embracing GPV technology.

Factor Analysis of Perceived Benefits

The 23 items on potential GPV benefits were factor analyzed. The items form three major dimensions: (1) environmental benefits, (2) financial advantages, and (3) pacesetting benefits of adopting GPV.

Environmental Benefits

The first dimension reflects environmental benefits. Items defining this dimension have to do with natural resource conservation, environmental protection, pollution reduction, benefitting future generations, and reducing global warming. These defining items and their factor loadings are shown below.

Factor One: Environmental Benefits
EV[2] = 6.457 and % of variance explained = 28.075

Key Definers	Factor Loading
It could conserve natural resources	.895
It could help protect the environment	.893
It could help reduce air pollution and acid rain in our area	.889
It could benefit future generations	.845
It could help reduce global warming	.828

Financial Advantages

The second dimension reflects financial advantages. Items defining this dimension include having free electricity once the system is paid for, reducing electricity bills now, selling excess electricity back to the utility company, increasing the resale value of the home, and self sufficiency. These items reflect a desire, or even an expectation, that purchase of a GPV system would have positive financial rewards. These items and their factor loadings are shown below.

[1]As noted previously, Appendix C presents, for the study's individual questions, base n's, means, standard deviations, and coefficients of variation for scaled responses.

[2]EV = eigenvalue, a numerical index of the importance of each factor.

Factor Two: Financial Advantages

EV = 4.410, % of variance explained = 19.175 and cumulative % of variance explained = 47.250

Key Definers	Factor Loading
It could result in long-term savings since electricity could be free once the system is paid for	.843
It could reduce my electricity bills right away	.821
I could sell excess electricity back to the utility company	.750
It could increase the resale value of my home	.723
It could pay for itself over its expected lifetime of twenty years or more	.698
It could increase my self sufficiency	.611

Respondents were asked to answer these questions about perceived benefits before they came to questions concerning their hypothetical willingness to pay for GPV at realistic system prices. To maintain and enhance credibility, those marketing GPV systems should make certain that customer expectations regarding costs and benefits are realistic.

Pacesetting Benefits

The third dimension reflects noneconomic motivations involving the pacesetting benefits of owning a PV system. These items pertain to the personal satisfaction provided by being first on the block with a new PV system, enjoying a new technology, and creating and expanding the PV market. The items defining this dimension and their factor loadings are shown below.

Factor Three: Pacesetting

EV = 4.298, % of variance explained = 18.687 and cumulative % of variance explained = 65.937

Key Definers	Factor Loading
I could be first on my block to have a PV system	.767
It could be a new technology to enjoy	.754
It could be profitable for utility companies	.721
It could help to create and expand the PV market	.699

Together, the above three dimensions (factors) concerning perceived benefits account for 66% of the variance in the responses. Both environmental benefits and financial advantages have high mean scores and could be important marketing messages for potential GPV purchasers. Although the mean scores for the pacesetting benefits dimension are lower than for the other two dimensions, this dimension contains altruistic elements that were mentioned frequently by potential early adopters of GPV in the qualitative interviews preceding the homeowner survey. Possibly, this dimension could be more important to the next most likely GPV adopters.

Factor Analysis of Perceived Barriers

The 18 potential barriers items were subjected to factor analysis to further reduce the data to a smaller, more manageable, and more succinct set of dimensions. The items form two dimensions: (1) the feasibility and reliability of systems and their providers and (2) neighborhood concerns.

Feasibility and Reliability of GPV Systems

The first dimension reflects respondent apprehension about a little-known technology and its technical uncertainty. Would a GPV system actually perform by producing enough electricity to make it worthwhile? Would a system perform reliably or would it break down frequently? Are the manufacturers and vendors solid corporate citizens or fly-by-night operators? These concerns may reflect previous experiences people have had and the stories they have heard about active solar thermal systems during the l970s and l980s. Items defining this dimension and their factor loadings are shown below.

Factor One: Feasibility of PV Systems and Reliability of PV Providers
EV = 6.732 and % of variance explained = 37.402

Key Definers	Factor Loadings
Operating reliability of PV system (need for repairs, maintenance)	.862
Dependability and reputability of PV manufacturer	.839
Performance of PV system (amount of electricity produced)	.807
Dependability and reputability of PV vendor	.806
Expense of maintaining the PV system	.751

Neighborhood Concerns

The second dimension reflects concern about neighborhood issues that could make a GPV purchase difficult. The items defining this dimension and their factor loadings are shown below.

Factor Two: Neighborhood Concerns
EV = 3.335, % of variance explained = 18.529 and cumulative % of variance explained = 55.931

Key Definers	Factor Loadings
Codes or covenants that might prohibit it	.718
What friends and neighbors might say	.682
Amount of space needed at my home for a PV system	.673

Together, these two dimensions (factors) concerning perceived barriers account for 56% of the variance in the responses. Items defining Factor One have higher mean scores relative to other items (Table 6). Items defining Factor Two had relatively low mean values. Interestingly, the high initial cost of a PV system, although an important barrier judging from the mean scores, does not define either one of these factors.

Factor Analysis of Product Attributes

Twenty-one potential product attributes that respondents might prefer in a GPV system were presented in the questionnaire and the results were factor analyzed. The items form five major dimensions: (1) warranties and system performance, (2) battery options, (3) aesthetics, (4) financing, and (5) self-reliance of PV system ownership.

Warranties and System Performance

The first dimension reflects concerns about warranties and PV system performance. This dimension relates to features that reduce the risk of PV purchase. Items defining this dimension and their factor loadings are shown below.

Factor One: Warranties and System Performance

EV = 4.631 and % of variance explained = 22.050

Key Definers	Factor Loadings
A manufacturer-provided warranty on the system	.780
A maintenance agreement at reasonable cost	.729
A system that lasts for at least 20 years	.703
A way to measure how much electricity the PV system produces	.678
An extended warranty on the installation	.672

Battery Options

The second dimension reflects extra features that appear to have special appeal: batteries to store excess power or to provide power during outages. Items defining this dimension and their factor loadings are shown below.

Factor Two: Battery Options

EV = 2.405, % of variance explained = 11.454 and cumulative % of variance explained = 33.505

Key Definers	Factor Loadings
A battery with which to store excess power for use at night	.762
A battery to provide emergency power during power outages	.743

Aesthetics

The third dimension relates to the appearance of the PV system on the customer's home. Items defining this dimension and their factor loadings are shown below.

Factor Three: Aesthetics
EV = 2.243, % of variance explained = 10.679 and cumulative % of variance explained = 44.183

Key Definers	Factor Loadings
A system that is integrated into my home, such as PV shingles or PV skylights	.792
PV panels that can be mounted flush with my roof	.781
An attractive-looking system	.643

Financing

The fourth dimension relates to financing the system through the utility company, leasing the system, or leasing with an option to buy. These items appear to be related to reducing the financial burden of initial PV system cost. The items defining this dimension and their factor loadings are shown below.

Factor Four: Financing the System
EV = 1.942, % of variance explained = 9.250 and cumulative % of variance explained = 53.433

Key Definers	Factor Loadings
Finance the system through the utility	.796
Leasing the PV system, or leasing with an option to buy	.789

Self-Reliance

The fifth dimension reflects some personal aspects of GPV system ownership. The items defining this dimension and their factor loadings are shown below.

Factor Five: Self-Reliant Ownership
EV = 1.936, % of variance explained = 9.217 and cumulative % of variance explained = 62.650

Key Definers	Factor Loadings
Paying for the system up front rather than financing it	.697
An option to do my own installation	.655
Owning the PV system	.531

Together, these five dimensions (factors) account for 63% of the variance in the responses. Items defining Factor One (features that reduce the risk of PV adoption) and Factor Two (a battery option) have the highest mean scores (Table 10). Items defining Factors Four (financing the system) and Five (self-reliant ownership) tend to have lower mean scores relative to other items. Nevertheless, these dimensions together help to describe the key attributes that would be desired in a GPV system. They are the major options that should be offered to prospective GPV homeowners to maximize market impact.[3]

Factor Analysis of Information Needs

The questionnaire contained another 15 items pertaining to information needs, and these were similarly factor analyzed. The items form three major dimensions, reflecting information on (1) the PV product available, (2) financial aspects of system purchase, and (3) benefits to the community and the world.

Information on PV Products Available

The first dimension reflects the need for information about PV products that would be available in the marketplace at any given time. Items defining this dimension and their factor loadings are shown below.

Factor One: Information on PV Product Available
EV = 4.256 and % of variance explained = 28.376

Key Definers	Factor Loadings
Technical information on how the system works	.816
Description of system components	.793
Options available, such as maintenance agreements and warranties on equipment and installation	.719
Sizes and brands of PV systems available	.684
Amount of electricity the PV system will provide	.654
Battery costs, maintenance, and disposal	.639

Financial Aspects of GPV Purchase

The second dimension reflects the need for information on ways to pay for a PV system and the expected costs and benefits of system ownership. Items defining this dimension and their factor loadings are shown below.

[3]Some external validity for these findings was acquired in a communication with a private GPV company representative who proposed that a battery option to provide power during outages is increasingly viewed as important by GPV system purchasers.

Factor Two: Information on Financial Aspects
EV = 3.724, % of variance explained = 24.828 and cumulative % of variance explained = 53.204

Key Definers	Factor Loadings
Availability of financial incentives to help pay for the PV system	.822
Availability of financing for the PV system from my utility company	.761
Savings on my utility bill	.699
Payback period for a PV system purchase	.690

Benefits to the Community and the World

The third dimension reflects needs for information about the benefits of residential GPV to the community, state, nation, and world. Items defining this dimension and their factor loadings are shown below.

Factor Three: Information on Benefits to the Community and the World
EV = 2.139, % of variance explained = 14.263 and cumulative % of variance explained = 67.466

Key Definers	Factor Loadings
Benefits to the nation and the world	.930
Benefits to my community and state	.920

Together, these three dimensions (factors) account for 67% of the variance in the responses. Mean scores on the items defining these factors range from the lowest (7.0) to the highest (9.0) (Table 7).

Factor Analysis of GPV Information Sources: Individuals, Groups, and Organizations

The questionnaire contained 16 items pertaining to the source from which information about GPV could be obtained. These 16 items were also factor analyzed, producing three major dimensions: (1) government agencies, (2) local businesses, and (3) sources trusted to provide a viewpoint not representing business and government.

Government Agencies

The first dimension reflects the influence of government agencies and educational institutions as information sources on PV. Items defining this dimension and their factor loadings are shown below.

Factor One: Government Agencies
EV = 4.079 and % of variance explained = 25.497

Key Definers	**Factor Loadings**
State and local government agencies	.861
Federal government agencies and national laboratories	.860
Colleges and universities	.796
Public libraries	.701

Local Businesses

The second dimension reflects the influence of local businesses, particularly those in the home construction and maintenance industries, as sources of information. Items defining this dimension and their factor loadings are shown below.

Factor Two: Local Businesses
EV = 3.669, % of variance explained = 22.933 and cumulative % of variance explained = 48.430

Key Definers	**Factor Loadings**
Local contractors	.860
Home builders	.849
Home supply stores	.661

Other Trusted Sources

The third dimension reflects likelihood of using personal contacts and environmental organizations as information sources. Items defining this dimension and their factor loadings are shown below.

Factor Three: Friends and Other Trusted Sources
EV = 2.827, % of variance explained = 17.669 and cumulative % of variance explained = 66.099

Key Definers	**Factor Loadings**
Friends, neighbors, acquaintances and relatives	.741
People who already own PV systems	.727
Environmental organizations	.681

Together, these three dimensions (factors) account for 66% of the variance in the responses. Surprisingly, utility companies and PV manufacturers do not emerge as a defining item for any of the factors. Utility companies and PV manufacturers are highly rated information sources by most respondents and they do not differentiate among respondents.

Factor Analysis of Information Sources: Channels

Finally, the questionnaire contained six items designed to reflect the actual likelihood of use of various information channels. The six items measuring the likelihood of use were factor analyzed, producing two major dimensions: (1) activities and (2) media.

Activities

The first dimension reflects attendance at or participation in various activities centered on the dissemination of GPV information. Items defining this dimension and their factor loadings are shown below.

Factor One: Activity Sources
EV = 3.017 and % of variance explained = 37.715

Key Definers	Factor Loadings
Event (such as home and garden show, solar home tour)	.855
Demonstration building or model home with PV	.850
Seminars, workshops, or classes	.808

Media

The second dimension reflects reliance on the media as sources of information about GPV. Items defining this dimension and their factor loadings are shown below.

Factor Two: Media Sources
EV = 2.780, % of variance explained = 34.744 and cumulative variance explained = 72.459

Key Definers	Factor Loadings
Radio and television	.816
The Internet	.776
Magazines and newspapers	.763

Together, these two dimensions (factors) account for 73% of the variance in the responses.

Factor Analysis of Lifestyle and Values

Prior research on adoption of solar energy has shown that voluntary simplicity lifestyles and environmental values can affect system purchase (Leonard-Barton 1978). Consequently, the questionnaire contained five items pertaining to lifestyle and values, which were factor analyzed to search for important relationships. This analysis yielded two major dimensions: (1) an early adopter dimension and (2) an environmental values dimension.

Early Adopter Characteristics

The first dimension reflects characteristics of early adopters (Rogers 1995). These include innovativeness and opinion leadership. Valuing self-sufficiency also factors with these characteristics.

Factor One: Early Adopter Characteristics
EV = 1.718 and % of variance = 34.360

Key Definers	Factor Loadings
Likes to experiment with new way of doing things	.767
Seen as an opinion leader	.758
Likes to be as independent as possible	.706

Environmental Values

The second dimension reflects environmental values. Items defining this dimension and their factor loadings are shown below.

Factor Two: Environmental Values
EV = 1.710, % of variance = 34.190 and cumulative % = 68.550

Key Definers	Factor Loadings
Willing to modify lifestyle to help environment	.894
Buys environmentally friendly products	.890

These items reflect two dimensions of values and lifestyles that are expected to be related to GPV adoption. Those with *early adopter* characteristics and those scoring higher on *environmental values* are expected to be more likely to purchase GPV systems early on.

Further Discussion

As suggested in this chapter, the key definers on these factors are those that *differentiate among respondents.* For example, utility companies are the second most trusted information source, yet their influence does not contribute to any of the factors. This is because utility companies are an information source on GPV that would be used by most respondents. Reliance on the utility company as an information source is so widespread that it is not a distinguishing factor. Similarly, concern about initial cost has a high mean score and does not differentiate among respondents.

Chapter 7
Market Segmentation

> **Chapter Highlights**
>
> - Sensitivity analysis was used to reduce the data set to the key variables for predicting market size and composition.
> - Standardized factor scores were used in the analysis.
> - Criterion variables were used to establish six clusters related to what respondents say they are likely to do (behavioral intention).
> - Predictor variables were used to establish seven clusters related to respondents' attitudinal inclination toward GPV.
> - Predictor and criterion clusters were cross tabulated.
> - Four "tiers" reflecting various stages of market development were identified based on the cluster crosstabulation matrix.

The next phase of this study was to segment the prospective GPV market and to identify those groups of individuals most likely to purchase the technology. The results of the foregoing analyses are used in this phase to accomplish the desired results.

Approach to Segmenting the Prospective Market

Sensitivity analysis was employed to identify the most important variables for use in estimating market size and composition. The sensitivity analysis was based on several multivariate statistical approaches, including correlation analysis, regression analysis, and cluster analysis.

Multiple regression analysis is a statistical modeling approach that facilitates the discovery of relationships among variables (Cohen and Cohen 1983; Kleinbaum and Kupper 1978). In the regression context, the objective is to determine which, if any, of a collection of "independent" variables can successfully "predict" the outcomes or values of a single "dependent" variable. In other words, the goal is to express the dependent variable as a weighted combination, or function, of some other set of predictor variables. Regression analysis is an effective means to identify the most important contributors to an overall experimental or observational response. It can be applied in various forms, either before or after other statistical tools (e.g., factor analysis).

For the present study, regression and stepwise regression analysis were employed for purposes of identifying the most significant contributors to "favorability toward using GPV on one's own home." As noted in the previous chapter, factor analysis was first used to reduce a large number of the survey variables to a more manageable set of important factors or dimensions. Numerous regression analyses were conducted in search of the best predictors. Using a sensitivity analysis approach, these regression runs were performed to shed light on the relationships among the variables both included in and excluded from the factor analyses.

A multivariate statistical approach used in many industries for market segmentation—that of cluster analysis—was selected as the method with which to identify the most likely purchasers of GPV technology and to achieve the categorization of individuals desired. Simply stated, cluster analysis is a numerical algorithm that sorts individual respondents into bins based on their "average closeness," where average closeness means the average of each individual's collective responses to one or more important questions. The important questions are determined through prior application of other statistical tools, and the number of clusters (groups, bins, categories, etc.) is optimized through sensitivity analysis.

Once the most important relationships among variables were determined, the conceptual model discussed in Chapter 2 was overlain onto the most important variables. For the present study, cluster analysis was used as the next sequential step to analyzing the survey data, with the ultimate goal of identifying those respondents who are most likely to be near-term adopters of GPV. Two separate sets of variables were used in sensitivity analyses using the cluster analysis technique—predictor variables and criterion variables (defined below).

The two sets are quite different in nature, but both were viewed as important. Consequently, it was determined that both sets of variables should be used, comparing the separate cluster analysis results using a process of crosstabulation. The goal of crosstabulation was to highlight groups of individuals who are inclined toward GPV purchase from both perspectives, thereby making the strongest possible case for any early-market-adopting segment, and for the next tiers of market development (defined in Chapter 8).

Ultimately, a set of four criterion variables and a set of seven predictor variables were determined to result in the best possible cluster analysis solution. As suggested above, numerous cluster analysis "runs" were conducted using these variables in a sensitivity fashion to determine the optimum number of clusters. The k-means clustering algorithm available in SPSS-8 was used to accomplish this task. After extensive evaluation, investigation, and comparison, the optimum number of clusters (groups, segments) based on the four criterion variables was determined to be six. The general make-up of these clusters is discussed below. The optimum number of clusters (groups, segments) based on the seven predictor variables was determined to be seven. The general make-up of these clusters is also discussed below.

Important Data Considerations

Three important data issues should be noted when interpreting the cluster analysis results. First, all variables were "standardized" as part of the analysis process to minimize any effects caused by scaling or measurement unit differences. "Standardization," or "normalization," is a conventional data transformation based on the mean and standard deviation of each variable. Standardization is required as part of the application of the k-means clustering algorithm. The resulting standard scores generally range from ± 3 (though they can be even greater), with the higher values in either direction indicating more weight, strength, or importance. Standard scores near zero have the least weight, strength, or importance.

Second, in order to be included in the cluster analysis, respondents must have provided answers to all four questions representing the criterion variables, and they must have had factor scores computed for all seven of the factors constituting the predictor variables. This restriction resulted in an overall increase in the number of "missing observations" for the cluster analysis phase of the survey investigation.[1]

Finally, during the course of the cluster analysis work, 10 respondents were determined to be outliers and were removed from further consideration. (These are the same 10 respondents discussed in Appendix B.) No further data edits were applied.

[1]The respondents included in the cluster analysis are a subset of all respondents.

The Criterion Variables

The first set of variables determined to be significant in measuring the immediacy of GPV purchase decisions consists of four items that closely reflect *actions likely to be taken* by homeowners. Henceforth referred to as the *criterion variables*, these variables are:

- Willingness to look for more GPV information
- Willingness to pay for no-added-cost GPV (Scenario D: Purchase subsidies available resulting in no added net monthly electricity cost)
- Preference for a system that provides all of a household's electricity (a "100% system")
- Favorability toward using GPV on one's own home.

Description of the Criterion Clusters

The cluster analysis based on the four criterion variables produced an easily interpretable six-cluster solution (henceforth referred to as the "criterion clusters"). A total of 1,651 respondents are included in this analysis. As would be expected, the six clusters vary clearly and predictably regarding the stated likelihood of their constituents to purchase a GPV system. For ease of examination, the criterion clusters are arrayed in Table 25 from one (1) to six (6) in descending order of their associated stated likelihood of purchase. The individual clusters are henceforth referred to as:

Cluster 1: Highly Likely
Cluster 2: Somewhat Likely
Cluster 3: Slightly Likely
Cluster 4: Slightly Unlikely
Cluster 5: Somewhat Unlikely
Cluster 6: Highly Unlikely

For each cluster, Table 25 also reports the average standardized ratings assigned by respondents to the questions representing the criterion variables.

Cluster 1 comprises the ***Highly Likely*** purchasers of GPV. For this cluster, the average standardized ratings for all four criterion variables are moderately to highly positive. Thirty-one percent of the survey respondents covered by the cluster analysis based on criterion variables fall into this category—the largest of the six groupings.

Cluster 2, comprising about 21% of the respondents covered by the cluster analysis based on criterion variables, can be considered ***Somewhat Likely*** GPV purchasers. For this group, the average standardized ratings on three of the four criterion variables—"willingness to look for more GPV information," "favorability toward using GPV on one's own home," and "willingness to buy a no-added-cost GPV system"—are all slightly to moderately positive (relative to the corresponding ratings associated with other clusters). The average standardized rating for this cluster on "preference for a 100% GPV system" is moderately negative.

Cluster 3, labeled ***Slightly Likely***, is characterized by having average standardized scores on the four criterion variables that are generally mixed, though leaning more toward the positive. For "preference for a 100% GPV system" and "willingness to buy a no-added-cost GPV system," the average standardized ratings are slightly to moderately positive. For "favorability toward using GPV on one's own home," the average standardized rating is close to zero—indicating neutrality; and for "willingness to look for more GPV information," the average standardized rating is slightly negative. The criterion with the highest average standardized rating associated with this cluster is "willingness to buy a no-added-cost GPV system"—indicating the households represented are legitimate prospects. This cluster represents about 21% of the survey respondents covered by the cluster analysis based on criterion variables.

Ten percent of the survey respondents covered in the cluster analysis based on criterion variables are included in a group labeled ***Slightly Unlikely***. The average standardized ratings of this group on "willingness to look for more GPV information," "favorability toward using GPV on one's own home," and "preference for a 100% GPV system" are all close to zero—indicating neutrality—and their average standardized rating on "willingness to buy a no-added-cost GPV system" is moderately to highly negative (relative to the corresponding ratings associated with the other segments).

Table 25. Criterion Cluster Variable Scores*

Criterion Variables	Cluster 1 Highly Likely n=513	Cluster 2 Somewhat Likely n=254	Cluster 3 Slightly Likely n=345	Cluster 4 Slightly Unlikely n=160	Cluster 5 Somewhat Unlikely n=220	Cluster 6 Highly Unlikely n=159
Percent who will definitely look for more GPV information	Very High 1.05	Hi Avg 0.44	Lo Avg -0.44	Avg 0.08	Very Low -1.00	Very Low -1.29
Percent who are very favorable to using GPV on their own homes	High 0.91	Hi Avg 0.36	Avg 0.08	Avg -0.05	Low -0.78	Very Low -1.82
Percent who are willing to buy a no-added-cost GPV system	High 0.64	Hi Avg 0.45	Hi Avg 0.42	Very Low -1.17	Avg 0.04	Very Low -2.06
Percent who prefer a 100% GPV system	High 0.83	Low -0.84	High 0.76	Avg 0.19	Very Low -1.11	Very Low -1.10

*Standardized scores with interpretation. 0 to ±.20=Avg, ±.20 to ±.50=Hi or Lo Avg, ±.51 to .99=High or Low, ±1.0+=Very High or Very Low. SPSS Quick Cluster required 26 iterations to arrive at these final cluster centers.

Source: Constructed by the authors.

Thirteen percent of the respondents included in the cluster analysis based on criterion variables comprise a segment labeled ***Somewhat Unlikely***. Even though the average standardized rating assigned by this group to "willingness to buy a no-added-cost GPV system" is close to zero—indicating neutrality—the average standardized ratings assigned to the other three variables—"willingness to look for more GPV information," "preference for a 100% GPV system," and "favorability toward using GPV on one's own home"—are moderately to highly negative (relative to the corresponding ratings associated with the other segments).

Clearly, Cluster 6, labeled ***Highly Unlikely*** because of the moderately to highly negative average standardized ratings assigned to all four criterion variables, should contain the fewest GPV purchasers. In fact, it would defy the data to find even one GPV purchaser among this group. The ***Highly Unlikely*** segment represents about 10% of the survey respondents covered by the cluster analysis based on criterion variables.

Table 26 and Figure 8 summarize percentages of respondents classified into the various criterion clusters, information that is also shown in the box. As previously noted, the ***Highly Likely*** cluster contains 31% of the survey respondents covered by the cluster analysis based on criterion variables, suggesting about one-third of the total group is strongly inclined toward GPV. Furthermore, the three clusters labeled ***Highly Likely***, ***Somewhat Likely***, and ***Slightly Likely*** comprise two-thirds of the total group, suggesting that the group as a whole is more inclined toward GPV than not.

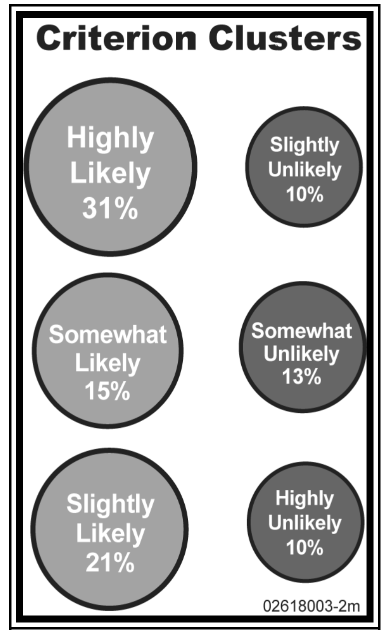


Figure 8. Distribution of Respondents in the Criterion Clusters

Table 26. Percentage Allocation of Respondents to Criterion Clusters

Criterion Cluster	Percentage in Cluster
Highly Likely (High or very high on all variables)	31
Somewhat Likely	15
Slightly Likely	21
Slightly Unlikely	10
Somewhat Unlikely	13
Highly Unlikely (Low or very low on all variables)	10

Source: Constructed by the authors.

The Predictor Variables

The second set of variables determined to be significant contributors to favorability toward using GPV on one's own home consists of seven items that closely reflect *attitudes likely to be held* by homeowners that would affect the immediacy of GPV purchase decisions. Henceforth referred to as the *predictor variables*, each of these seven variables is one of the factors derived through factor analysis. As noted in the previous chapter, these factors (dimensions) are composite in nature, each reflecting the multiple other items used to construct it. The seven predictor variables (factors) are:

- Warranty Reassurance—a system *feature* defined by the importance or requirement of a GPV system warranty, especially an extended warranty (Factor One, Product Attributes)[2]

- Self-Reliant Ownership—a system *feature* defined by the importance of the option to pay for the system up front and the option of GPV self-installation (Factor Five, Product Attributes)

- Environmental Benefit—a system *benefit* seen as an advantage to society, the factor being defined by the importance of conservation and protection of the environment associated with GPV use (Factor One, Perceived Advantages)

- Personal Financial Benefit—a system *benefit* that suggests responsible self-interest, defined by the importance of financial savings and financial gain realized through GPV use (Factor Two, Perceived Advantages)

- Pacesetter Benefit—a system *benefit* that reflects personal satisfaction defined by the importance of being the first on the block to own a PV system, enjoying a new technology, and helping to create the PV market (Factor Three, Perceived Advantages)

- Neighborhood Concern—a system *barrier* defined by apprehension about neighborhood codes and neighborhood talk, and by GPV system space requirements (Factor Two, Perceived Barriers)

- System Failure—a system *barrier* factor defined by apprehension that the GPV system will not perform as advertised in electricity production, operating reliability, or both (Factor One, Perceived Barriers).

Description of the Predictor Clusters

A cluster analysis of 1,547 survey respondents based on the seven predictor variables yielded a very interesting, theoretically reasonable seven-cluster solution (henceforth referred to as the "predictor clusters"). As in the case of the criterion clusters, the seven predictor clusters vary clearly and predictably regarding the attitudes of their constituents toward GPV. For ease of examination, the predictor clusters are labeled A through G and are arrayed in Table 27 in alphabetic order in terms of their probable, theoretical potential for GPV purchase. A hierarchical ranking is also assigned. The individual clusters are henceforth labeled as follows:

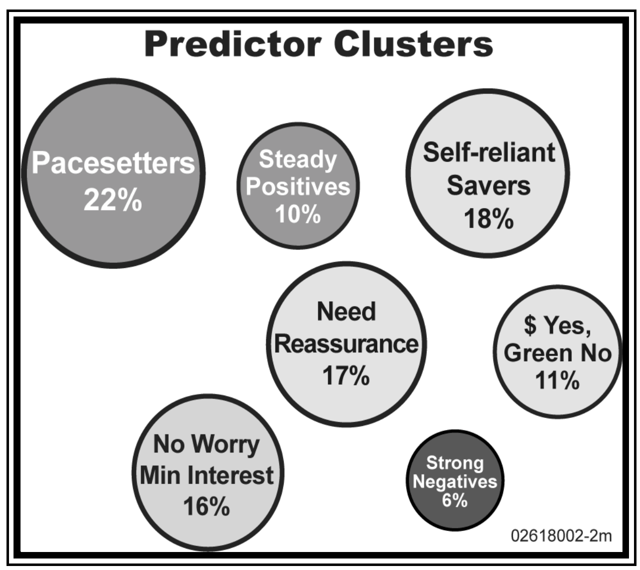


Figure 9. Distribution of Respondents in the Predictor Clusters

[2]See Chapter 6 for descriptions of these factors.

Cluster A: Pacesetters
Cluster B: Steady Positives
Cluster C: Self-Reliant Savers
Cluster D: $ Yes, Green No
Cluster E: Need Reassurance
Cluster F: No Worry, Minimum Interest
Cluster G: Strong Negatives

Table 27 also reports the average standardized scores on each of the original factors (predictor variables) for the respondents in each cluster. Table 28 summarizes the information on the predictor clusters and the percentage of respondents in each cluster, which is also presented in Figure 9. Fifty percent of the respondents covered by the cluster analysis based on predictor variables are included in the first three clusters.

Cluster A comprises the ***Pacesetters*** because of its strongly positive average standardized factor score on "pacesetting benefits." In addition, this cluster has slightly to moderately positive average standardized factor scores on all the other factors (predictor variables). Twenty-two percent of the respondents covered by the cluster analysis based on predictor variables are included in this group—the largest of all seven.

Cluster B is labeled ***Steady Positives.*** This group has slightly to moderately positive average standardized factor scores on four factors (predictor variables): "warranties and system performance," "self-reliant ownership," "environmental benefits," and "system feasibility." It has slightly negative average standardized factor scores on "financial advantages" and "pacesetting benefits," and a very strongly negative average standardized factor score on "neighborhood concerns." Of all the predictor clusters, Cluster B is seen as the segment that is second most positive toward GPV. These respondents are consistently, but not zealously, positive about the technology's benefits and features, and they have minimal concerns about the technology relative to their neighborhoods, such as code restrictions. Cluster B makes up about 10% of the survey respondents covered in the cluster analysis based on predictor variables.

Cluster C, ***Self-Reliant Savers,*** has moderately positive average standardized factor scores on "self-reliant ownership" and "financial advantages." On the other hand, it has a moderately negative average factor score on "pacesetting benefits," and slightly positive average factor scores on both "neighborhood concerns" and "system feasibility." Together, these last three findings may militate against GPV purchase—especially early purchase. This cluster represents about 18% of the survey respondents covered by the cluster analysis based on predictor variables.

Cluster D is labeled ***$ Yes, Green No.*** The defining characteristics of this group are the highly negative and moderately positive average standardized factor scores for "environmental benefits" and "personal financial benefits," respectively. This group comprises 11% of the survey respondents covered by the cluster analysis based on predictor variables.

Cluster E is comprised of those respondents who ***Need Reassurance***. For this cluster, the average standardized factor score is highly negative on "self-reliant ownership" and moderately positive on "warranties and system performance." While the average standardized factor scores on "environmental benefit" and "system feasibility" are moderately positive, they are moderately negative on "pacesetting benefits" and essentially neutral for the remaining factors (predictor variables). This cluster represents about 17% of the survey respondents covered by the cluster analysis based on predictor variables.

Cluster F is labeled ***No Worry, Minimum Interest*** because of its highly negative average factor score on "system feasibility," its moderately negative average factor scores on "warranties and system performance" and "financial advantages," and its mixed average factor scores on all other factors (predictor variables) ranging from slightly negative to neutral to slightly positive. This group of survey respondents—representing roughly 16% of those covered by the cluster analysis based on predictor variables—is not particularly motivated to purchase GPV systems.

Table 27. Factor Scores of Predictor Variable Clusters*

Predictor Factors	Cluster D $ Yes, Green No n=171	Cluster B Steady Positives n=161	Cluster A Pacesetters n=334	Cluster E Need Reassurance n=268	Cluster F No Worry, Min Interest n=238	Cluster G Strong Negatives n=90	Cluster C Self-Reliant Savers n=285
Warranties & System Performance	Avg 0.13	Hi Avg 0.21	Hi Avg 0.39	**High** 0.58	**Low** -0.64	**Very Low** -1.70	Avg 0.13
Self-Reliant Ownership	Hi Avg 0.24	Hi Avg 0.22	**High** 0.54	**Very Low** -1.22	Avg -0.16	Lo Avg -0.30	**High** 0.61
Environ-mental Benefits	**Very Low** -1.73	Hi Avg 0.49	Avg 0.14	Hi Avg 0.44	Avg 0.15	**Very Low** -1.20	Hi Avg 0.41
Financial Advantages	**High** **0.74**	Hi Avg -0.20	Hi Avg 0.30	Avg 0.09	**Low** -0.79	**Very Low** -1.30	**High** 0.54
Pacesetting Benefits	Lo Avg -0.39	Lo Avg -0.21	**Very High** 1.33	Lo Avg -0.45	Avg -0.03	Lo Avg -0.28	**Low** -0.57
Neighbor-hood Concerns	Lo Avg -0.22	**Very Low** -1.73	**High** 0.51	Avg 0.01	Avg 0.01	Avg 0.03	Hi Avg 0.26
System Feasibility	Avg -0.02	Hi Avg 0.27	Hi Avg 0.24	Hi Avg 0.35	**Very Low** -1.19	Lo Avg -0.24	Hi Avg 0.24
Hierarchical Ranks	Fifth	Second	First	Fourth	Sixth	Seventh	Third

*Standardized factor scores with interpretation. 0 to ±.20 = Avg, ±.20 to ±.50 = High or Low Avg, ±.51 to ±.99 = High or Low, ±1.0 or more = Very High or Very Low. SPSS Quick Cluster required 28 iterations to arrive at these final cluster centers.

Source: Constructed by the authors.

Cluster G, the ***Strong Negatives***, represents about 6% of the survey respondents covered by the cluster analysis based on predictor variables—the smallest of these seven segments, and clearly the one that is conceptually least likely to purchase GPV. The average standardized factor scores range from essentially zero (neutral) to highly negative on all seven factors (predictor variables).

Linking the Predictor and Criterion Clusters

As previously noted, in an effort to identify the percentage of homeowners most likely to purchase GPV in the near-term, as well as the sequential next tiers of likely purchasers, the predictor clusters were cross tabulated against the criterion clusters (Table 29). In essence, this crosstabulation attempts to match the attitudinal clusters regarding GPV with a level of stated intention of purchase, represented by the criterion clusters. It tests the attitudes respondents express toward GPV against their stated purchase intention.

Table 28. Percentage Allocation of Respondents to Predictor Clusters, with Descriptive Characteristics

Predictor Cluster	Percentage in Cluster	Description
Pacesetters	22%	Those individuals who are most passionate toward GPV. They are self-reliant and they zealously pursue involvement in innovation. However, they have some concerns about the prospects of local restrictions on GPV.
Steady Positives	10%	Individuals who generally endorse GPV, but who will not purchase without thorough consideration of all aspects of the technology. Steady and thoughtful, they are self-reliant, and they view GPV in terms of its environmental and financial advantages. They seek to limit the risk of participation through warranty reassurance, and they have few concerns about the prospects of local restrictions.
Self-Reliant Savers	18%	Individuals who are self-reliant and principally driven by the financial advantages of technology. They are inclined toward GPV, but are not likely to actively pursue a purchase. They are highly concerned about potential system failures.
Need Reassurance	17%	Individuals who are not very self-reliant. They recognize the environmental benefits of GPV technology, but they would not purchase without the reassurance of a system warranty.
No Worry, Minimum Interest	16%	Individuals who are not particularly motivated. They are not concerned about the reliability of GPV technology, but neither do they see much personal financial advantage of a purchase.
$ Yes, Green No	11%	Individuals who see few environmental benefits of GPV, and who would consider a purchase only if personal financial advantages could be guaranteed.
Strong Negatives	6%	Individuals who see few environmental benefits or financial advantages to GPV, whether or not the technology can be warranted.

Source: Constructed by the authors.

Clearly, homeowners most likely to purchase GPV will occupy both an attitudinally positive predictor cluster—that is, ***Pacesetters*** or ***Steady Positives***—and the ***Highly Likely*** criterion cluster.[3] The information given in Table 27 portrays the validity of this claim, but not its certainty (note, for example, that about 3% of the respondents in the ***Strong Negatives*** predictor cluster are also members of the ***Highly Likely*** criterion cluster).

[3]Chapter 9 more specifically describes the ***Highly Likely Pacesetters*** and ***Highly Likely Steady Positives***.

As described earlier, most Colorado homeowners are generally favorable toward GPV, a finding that is confirmed by the crosstabulation of clusters shown in Table 29. Seventy percent of the respondents occupy the three "likely" criterion clusters, with almost half of these being in the ***Highly Likely*** category.[4]

Table 29. Predictor Cluster Membership in Criterion Clusters*

	Predictor Clusters						
Criterion Clusters	**Pacesetters n=224**	**Steady Positives n=124**	**Self-Reliant Savers n=190**	**Need Reassurance n=169**	**$ Yes, Green No n=118**	**No Worry Min Interest n=171**	**Strong Negatives n=68**
Highly Unlikely n=78 7%	1%	5%	2%	6%	7%	9%	**47%**
Unlikely n=148 14%	7%	7%	14%	18%	**26%**	11%	**29%**
Slightly Unlikely n=98 9%	9%	4%	12%	5%	11%	14%	9%
Slightly Likely n=229 22%	15%	22%	24%	25%	25%	27%	9%
Somewhat Likely n=163 15%	17%	13%	15%	18%	18%	16%	3%
Highly Likely n=348 33%	**50%**	**50%**	34%	29%	14%	25%	3%
Total n=1064	100%	100%	100%	100%	100%	100%	100%

*SPSS crosstabulations produced a Chi-square value of 311.8, significant at the .0001 level.

Source: Constructed by the authors.

It could be argued that all members of the ***Highly Likely*** criterion cluster are equally strong candidates for GPV purchase. After all, each one stated strong intentions to pursue GPV purchase. Clearly, the 3% of respondents in the ***Strong Negative*** predictor cluster who are also in the ***Highly Likely*** criterion cluster must be viewed with suspicion, as should all other ***Strong Negative*** respondents expressing any likelihood of GPV purchase. Nothing about the attitudes of these individuals supports their stated purchase intentions.

It was earlier suggested that the ***Pacesetter*** cluster would comprise homeowners most likely to pursue GPV purchase, and its top-tier position is borne out by the fact that 50% of its constituents also fall in the ***Highly Likely*** criterion cluster. In fact, 82% of respondents in the ***Pacesetter*** cluster also fall in one of the three "likely" criterion clusters.

[4]Note that the total number of respondents reported in Table 29 is reduced to 1,064 because not all respondents answered all the same survey questions on which both sets of clusters were constructed, and the ones who did not answer all the questions did not have the standardized scores used in the cluster analysis. Data presented in Appendix G show that the respondents included in the cluster matrix represent the sample as a whole.

The ***Steady Positive*** cluster, determined to be the second most likely group to purchase GPV, appears to be a segment equal in stature to the ***Pacesetter*** cluster. Fifty percent of the respondents encompassed by the ***Steady Positive*** cluster also fall in the ***Highly Likely*** criterion cluster; and 85% of all ***Steady Positive*** respondents fall in one of the three "likely" criterion clusters.

At least one-fourth of three other predictor clusters—***Self-Reliant Savers, Need Reassurance,*** and, surprisingly, ***No Worry/Minimum Interest***—also fall into the ***Highly Likely*** category. In fact, approximately 70% of all respondents in each of these three predictor clusters fall in one of the three "likely" criterion clusters. Conceptually, some respondents in the ***No Worry/Minimum Interest*** cluster, with their apparent lack of GPV motivation, may well just have been taking the politically correct position that resulted in their occupying in the ***Highly Likely*** criterion cluster.

Finally, 14% of the ***$ Yes, Green No*** predictor cluster fall into the ***Highly Likely*** criterion cluster. A total of 57% of the respondents in this cluster fall into one of the "likely" criterion clusters.

Conceptually, the immediate market potential for GPV requires homeowners to be congruent in their attitudes and stated intention to purchase. Clearly, this constraint immediately narrows the market to the two predictor clusters that are most likely to purchase—***Pacesetters*** and ***Steady Positives***. The respondents included in the analysis who are simultaneously encompassed by the ***Pacesetters*** and ***Steady Positives*** predictor clusters and the ***Highly Likely*** criterion cluster should be considered prime candidates for GPV purchase. Such individuals possess attitudes that suggest they are receptive to GPV technology and they express a willingness to pursue actual purchase. Two-thirds of this group of prime candidates will be receptive to marketing campaigns emphasizing the pacesetting qualities of GPV purchase, whereas the remainder will be more attracted to a broad communication of GPV environmental benefits and financial advantages.

Establishing the Next Tiers of Market Development

Although the ***Highly Likely Pacesetters*** and the ***Highly Likely Steady Positives*** represent the individuals who are most likely to purchase GPV in the near term, it is reasonable to extend the boundaries of this market segment to include individuals from other criterion clusters who actually indicated likelihood of purchase—that is, those in the ***Slightly Likely*** and ***Somewhat Likely*** clusters. These individuals were grouped into a series of hierarchical tiers designed to reflect degrees of purchase likelihood as established in the analysis.

Table 30 shows the development of the tiers based directly on the information contained in Table 29. The first tier (Tier 1), shaded a light gray in the table, includes the ***Pacesetters*** and ***Steady Positives*** who say they are likely to purchase GPV (all three degrees of likelihood—Slightly Likely, Somewhat Likely, and Highly Likely—are included). The second tier (Tier 2), shaded a darker gray, includes respondents from the ***Self-Reliant Savers, Need Reassurance,*** and ***No Worry/Minimum Interest*** predictor clusters who indicated they are likely to purchase GPV. The third tier (Tier 3), shaded a yet darker gray, includes individuals from the ***$ Yes, Green No*** predictor cluster who indicate they are likely to purchase GPV. Finally, a fourth tier (Tier 4), illustrated by a solid light gray shading, includes individuals from the ***Strong Negatives*** predictor cluster who indicate they are *unlikely* to purchase a GPV system. These tiers are described in more detail in Chapter 8.

Table 30. Designation of the Market Tiers*

	Cluster No.	**3**	**2**	**7**	**4**	**1**	**5**	**6**
Clust. No.	**Criterion Clusters**	**Pacesetters n=224**	**Steady Positives n=124**	**Self-Reliant Savers n=190**	**Need Reassurance n=169**	**$ Yes, Green No n=118**	**No Worry Min Interest n=171**	**Strong Negatives n=68**
1	***Highly Unlikely 7%*** ***n=78***	1%	5%	2%	6%	7%	9%	**47%**
2	***Unlikely 14%*** ***n=148***	7%	7%	14%	18%	**26%**	11%	**29%**
3	***Slightly Unlikely 9%*** ***n=98***	9%	4%	12%	5%	11%	14%	**9%**
4	***Slightly Likely 22%*** ***n=229***	15%	22%	24%	25%	25%	27%	9%
5	***Somewhat Likely 15%*** ***n=163***	17%	13%	15%	18%	18%	16%	3%
6	***Highly Likely 33%*** ***n=348***	**50%**	**50%**	34%	29%	14%	25%	3%
	Total ***n=1064***	100%	100%	100%	100%	100%	100%	100%

*This table is identical to Table 29, but with the tier definition superimposed in terms of cell shading.

Source: Constructed by the authors.

The principal purpose of these tiers is to facilitate testing of the hypotheses on which the study is founded. However, the tiers also provide valuable insight into determining the most likely size and composition of the GPV market.

The formation of tiers had two purposes: (1) to show how those most likely to purchase differ from other homeowners (thus enabling a test of the study's hypothesis) and (2) to locate, within the sample, the respondents most likely to purchase GPV in the near-term. This enabled estimates of the size of the near-term market for GPV systems to be derived.

Figure 10 shows that 74% of the respondents in the cluster matrix (n = 1,064) are included in the four tiers shown in Table 28, and 26% are not included. Those excluded from the tiers have *inconsistent* attitudes and behavioral responses of two types: (1) respondents who are attitudinally predisposed toward GPV, but indicate they are unlikely to purchase a system and (2) respondents who are attitudinally opposed to GPV but indicate they are likely to purchase. The first type includes far more respondents (n = 273) than does the second type (n = 10).

The responses of these 10 respondents of the second type are considered anomalous. The responses of the first type of 273 respondents suggest that, although these homeowners are favorable toward GPV, they are unlikely to purchase a GPV system for reasons not measured by the questionnaire. For example, the questionnaire did not ask directly whether respondents felt they could afford a system, what their family obligations were, and what the status of their health was—all factors that could affect a household's GPV purchase decision.[5]

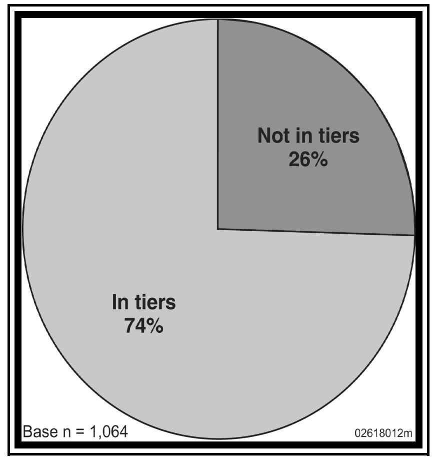


Figure 10. Percentage of Cluster Matrix Respondents in Tiers

[5] In Chapter 8, estimates of market size based on tier incumbents basically omit consideration of possible future GPV purchasers who, for a variety of reasons not measured specifically in this study, probably will not or cannot purchase a GPV system in the near-term or mid-term future.

Chapter 8
The Size and Composition of the GPV Market

In the final assessment, perhaps the most important part of this study is a determination of the size and composition of the GPV market. This chapter first addresses the notion of the likely market composition, and then proceeds to assess the market size.

Chapter 7 showed respondents were grouped into four tiers of market development. Figure 11 shows that most respondents within the tiers (85%) fall in either Tier 1 or Tier 2. This finding is a function of two facts: (1) the sample as a whole tends to be favorable toward GPV and (2) respondents included in the tiers analysis have indicated likely action (or inaction) *consistent* with their measured attitudes toward GPV (either for or against using GPV in their own homes).[1]

The four tiers originally defined in Table 30 do not encompass all the respondents included in the crosstabulation of the two cluster regimes, as shown in Table 29. The remaining respondents, as already noted, constitute a group for which a clear-cut definition could not be constructed.

Chapter Highlights

- Four distinct "market tiers" were identified from most to least likely to purchase a GPV system in the near term.
- Potential near-term GPV purchasers exhibit more environmentally friendly values and lifestyle choices than do others.
- Potential near-term purchasers also exhibit early adopter characteristics.
- Homeowners need to know a good deal more about GPV before they make a purchase decision.
- Estimated market sizes vary by system size and price.
- For a very small GPV system, the estimated market size ranges from 6,000 to 16,000 households, varying by cost (based on realistic market price estimates used in the study).
- For a medium-sized GPV system, the estimated market size ranges from 225 to 2,750 households, varying by cost.
- For a very large GPV system, the estimated market size ranges from 1,300 to 3,100 households.
- If GPV systems are made available at no net increase in the monthly cost of electricity because of subsidies, a market size of 40,000 households is estimated.
- Threshold values at or below which the market size increases dramatically, and above which market size drops off dramatically, are $10 net incremental cost per month for a 15% system, $50 for a 50% system, $100 for a 100% system (a lower threshold), and $50 for a 100% system (a higher threshold).

Composition of the GPV Market

To obtain the most detailed characterization possible of prospective GPV purchasers, the tiers of individuals developed in the previous chapter were analyzed on the basis of the study's key demographic variables. This analysis took the form of crosstabulating tier membership against the

[1] Chapter 7 presents a discussion on how the tiers were derived. The percentage of all respondents encompassed by the tiers is restricted as a result of crosstabulating the two cluster regimes. Not all respondents answered all survey questions involved in constructing the two different sets of clusters (see Tables 26, 28, and 29). See Appendix G for further discussion.

various demographic variables and performing Chi-square significance tests to assess the comparability of percentage distributions. For some of the variables, no statistically significant differences were found among the tiers. For example, all tiers were determined to be essentially identical on the basis of gender, marital status, size of the community of residence, and principal source of home heating fuel. On the basis of other variables, however, the tiers are considerably diverse, as indicated in Table 31.

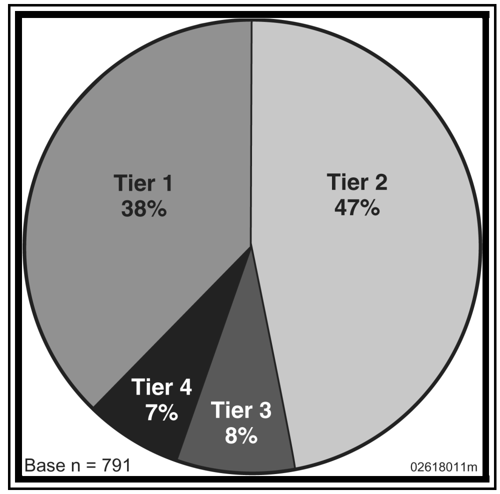


Figure 11. Percentages of Respondents in All Tiers Represented by Each Respective Tier

Based on the foregoing analysis, it is possible to descriptively name and characterize the four tiers originally identified in Table 30. These descriptions are presented below.

Tier 1: Early Adopters—those who say they will purchase and who will actually do so soon (38%)

Tier 1 homeowners are individuals who say that their purchase of a GPV system is likely or highly likely, assuming affordability, and whose overall attitudes toward GPV technology suggest they are likely to follow through in the immediate near term. This first tier contains a higher percentage of skilled workers than the other tiers (except for Tier 3), and the lowest percentage of college graduates among all tiers. A higher percentage of its members are Western Slope (Grand Junction and other areas west of the Continental Divide) residents than in other clusters. The dominance of political conservatives is relatively low in Tier 1.

The ***Early Adopter*** tier includes both innovators and early adopters. Ordinarily, this tier would be expected to comprise approximately 16% of a population (see Figure 1). But the tier's population, as a function of the broad favorability toward GPV expressed by survey participants and of the way the analysis was conducted, shows a greater representation of potential GPV adopters than would usually be expected—and greater than in the population of homeowners as a whole.

Tier 2: Mid-term adopters—those who say they will purchase but will wait until a later time (47%)

Tier 2 homeowners are individuals who say that their purchase of a GPV system is likely or highly likely, assuming affordability, but whose overall attitudes toward GPV suggest they are likely to wait until the technology has been adopted by the first tier. This second tier contains some of the most affluent, highly educated, and highest job positioned individuals, and it has a high percentage of residents from the Denver/Boulder area. Though still politically conservative, it is less so than Tiers 3 and 4.

Table 31. Selected Demographic Characteristics of Respondents Included in the Tiers

Characteristics of Respondents	Tier 1	Tier 2	Tier 3	Tier 4	All tiers	Statistical Significance*
Percent under the age of 50	62	66	70	48	63	p <.0001
Percent living in Denver/Boulder area	58	71	47	70	64	p <.001
Percent living in Grand Junction or other Western Slope areas	11	4	11	4	7	p <.001
Percent with a college degree or higher	47	69	58	55	59	p <.0001
Percent with annual incomes of at least $50,000	63	80	63	67	71	p <.002
Percent employed in professional or managerial positions	51	67	51	43	58	p <.0001
Percent who are retired	14	5	5	28	10	p <.0001
Percent who are skilled workers	14	8	17	4	11	p <.0001
Percent who claim to be conservative or liberal	42/28	40/31	64/11	69/13	44/27	p <.0001

*In all cases the size of the p-value indicates that there is at least one significant difference among the tiers.

Source: Constructed by the authors.

Tier 3: Late adopters—those who say they will purchase, but are the least likely to follow through (8%)

Tier 3 homeowners are individuals who say that purchase of a GPV system is likely or highly likely, assuming affordability, but whose overall attitudes toward GPV suggest they may not be motivated enough to follow through with a purchase commitment in the foreseeable future. This third tier contains higher percentages of women, younger residents, married couples with children, and skilled workers than the other tiers. High percentages of its members also say they are politically conservative.

Tier 4: Nonadopters—those who absolutely will not purchase (7%)

Tier 4 homeowners are individuals who say that purchase of a GPV system is unlikely to highly unlikely, either now or in the future. Their overall attitudes toward the technology are negative. This fourth tier contains high percentages of retirees, residents from the Denver/Boulder area, and political conservatives.

The distinctiveness of the individual tiers can be substantiated and validated by crosstabulating tier membership against other variables that were measured as part of the survey but which did not play a direct role in defining the tiers. Two such crosstabulations are shown in Tables 32 and 33.

Table 32 shows the percentages of respondents in each tier who indicate they possess each of five characteristics pertaining to values and lifestyles. As indicated in the table, there are significant differences among the tiers on the basis of all these characteristics. Tier 1 (***Early Adopters***), for example, is significantly different from the other tiers on the basis of all five characteristics. The members of Tier 1 are more likely to accept lifestyle modifications to help the environment, to buy environmentally friendly products even if they cost more, to be as independent and self-reliant as possible, to experiment with new ways of doing things, and to view themselves as leaders.

Likewise, Table 33 shows the percentages of respondents in each tier who indicate they possess other characteristics related to adoption of GPV technology. There are also significant differences among the tiers on the basis of all these additional characteristics, indicating the existence of varying attitudes. A significantly higher percentage, for example, of respondents in Tiers 1 (***Early Adopters***) and 4 (***Non-Adopters***) indicate they already know enough to decide whether or not to purchase a GPV system. (Presumably, among those indicating they know enough to decide, Tier 1 members already know enough to purchase, while Tier 4 members already know enough not to purchase.) A significantly higher percentage of respondents in Tier 1 indicate they would look for more information about GPV than in other tiers. A significantly lower percentage of those in Tier 4 indicate willingness to pay for a GPV system of any size than in other tiers. Finally, in Tier 1 a significantly higher percentage of respondents are favorable toward various net metering options, while in Tier 4 a significantly lower percentage is not. A higher percentage of Tier 1 respondents, for example, are willing to accept avoided cost for excess electricity and to donate excess electricity to low-income households. Curiously, a majority of Tier 4 respondents (most of whom have no interest in net-metering options) indicate they would prefer retail cost when it comes to selling excess electricity back to the utility grid.

Table 32. Values and Lifestyles Characteristics of Respondents Included in the Tiers

Characteristics of Respondents*	Tier 1	Tier 2	Tier 3	Tier 4	All Tiers	Statistical Significance**
Percent who would accept lifestyle modifications to help the environment	62	57	11	9	52	$p < .0001$
Percent who would buy green	58	52	17	13	48	$p <.0001$
Percent who are self-reliant	80	68	74	50	72	$p <.0001$
Percent who are innovative	78	65	44	29	65	$p < .0001$
Percent who are opinion leaders	63	62	55	39	60	$p < .002$

*Percentage of respondents giving highly positive responses of 9 or 10 (on a 10-point scale) to the associated survey questions.
**In all cases the size of the p-value indicates that there is at least one significant difference among the tiers.

Source: Constructed by the authors.

Other characteristics suggested by responses to the survey questions could also be considered. Note that, for purposes of completeness, Appendix E contains a crosstabulation of tier membership against every study variable (survey question).

Estimating the Market Size

Using the tiers identified in Table 30 and characterized above, both low and high estimates of market size were determined. In both cases, the only respondents included were those who indicate a willingness to pay *actual* *cost or more* under the three GPV system purchase scenarios.[2] The percentage of respondents included was further restricted to those indicating the highest likelihood of seeking more information about GPV (responses of 9 or 10 on a 10-point scale). Since at the time the questionnaire was administered GPV systems were not yet available for purchase in Colorado, respondents were not asked explicitly how likely they would be to purchase a system. Likelihood of looking for more information was deemed to be the best indicator of respondents' behavioral intention because it suggests an action mindset.

Table 33. Other Characteristics Related to GPV Adoption Exhibited by Respondents Included in the Tiers

Responses	Tier 1*	Tier 2	Tier 3	Tier 4	All Tiers	Statistical Significance**
Percent who believe they definitely know enough to decide	29	14	15	33	21	$p < .0001$
Percent who say they are familiar with GPV	31	19	24	22	24	$p < .005$
Percent who respond positively to the possibility of receiving retail price when selling excess electricity back to the utility grid	86	88	91	53	85	$p < .0001$
Percent who respond positively to the possibility of accepting avoided cost	41	27	31	16	31	$p < .0001$
Percent who respond positively to the possibility of donating excess electricity to low-income households	19	12	6	6	14	$p < .0001$

*Percentage of respondents giving highly positive responses of 9 or 10 (on a 10-point scale) to the associated survey questions.
**In all cases the size of the p-value indicates that there is at least one significant difference among the tiers.

Source: Constructed by the authors.

Such a high level of stringency in computing market size estimates was deemed necessary because people are more likely to *say* they will undertake, or pay for, something than to actually *do* it. The analytical restrictions were imposed to constrain the estimates of market size to levels more closely reflecting what homeowners will actually do.

A **high estimate** of market size can be based on the size of Tier 1, projecting the percentage of all survey respondents encompassed by Tier 1 to the entire population of single-family owner-occupied households in Colorado. This group (27.2% of all the respondents in the clustered market segments of Table 30 and 9.6% of all survey respondents) represents the most likely eventual adopters of GPV technology. Nonetheless, the statistical composition of Tier 1 still includes some respondents who will not make an immediate purchase, a near-term one, or even one at all.

[2] These scenarios are described in Chapter 5.

A **low estimate** of market size can be computed by projecting only the intersection of the ***Pacesetter*** and ***Steady Positive*** predictor clusters and the ***Highly Likely*** criterion cluster (denoted ***HL Pacesetters*** and ***HL Steady Positives***) to the population of single-family owner-occupied households. This group (174 of the respondents included in Table 30, representing 60% of the 289 in Tier 1, 16% of the 1,064 respondents in the clustered market segments, and 6% of all 3,001 survey respondents), delineates the subset of Tier 1-type households projected to have the highest likelihood of a near-term purchase, given system availability.

Because the process of crosstabulating the criterion and predictor clusters (described in Chapter 7) reduces the number of responses from 2,991 to 1,064, both high and low market size estimates are adjusted downward (using a multiplier of .3557, or 1064/2991) to accommodate the sampling disparity.

To assess how representative the members of the clusters, and of the tiers, are of the sample as a whole, Chi-square analysis was used to compare occupants of the cluster matrix and the members of the tiers with the sample as a whole on the study's key dependent variables. Appendix G presents the results of these analyses. In general, members of the cluster matrix are representative of the entire sample on the study's key dependent variables, but members of the tiers are, as expected, somewhat more favorable toward GPV than is the sample as a whole.

Market Sensitivity to System Size and Cost Trade-offs

Since system size and cost can directly affect market size, it is important to consider their effect on market size estimates. The survey responses provide information that can be used to evaluate market sensitivity to system size and cost trade-offs.

As discussed previously in Chapter 5, and indicated in Table 33, respondents were presented three different system size scenarios to consider:

- Scenario A: a small system that reduces conventional household electricity requirements by 7%-15% (henceforth referred to as the **very small,** or **15%,** system)

- Scenario B: a medium-sized system that reduces conventional household electricity requirements by half (henceforth referred to as the **medium-sized,** or **50%,** system)

- Scenario C: a large system, that produces all the electricity needed by a household (henceforth referred to as the **very large,** or **100%,** system).

The specific systems about which survey participants were asked to respond would be purchased through the local utility and would involve no purchase subsidies. Financing would be provided by the utility at 7% interest, amortized over a period of 20 years. Monthly payments would be listed separately as a line item on the purchaser's electricity statement or utility bill.

Survey participants were asked to respond to the three system size scenarios by indicating how much they would be willing to pay, in terms of a net incremental increase in their total monthly electricity bills, to purchase the system in question. For each size scenario, participants were presented with eight incremental dollar amounts from which to choose. Consequently, using the percentages of respondents who selected each of the various payment amounts as fractional multipliers, both the low and high market size percentages were further adjusted to reflect the desired sensitivity to size and cost. Table 34 contains selected results from this analysis, presenting both low and high adjusted estimates that encompass the range of the market size scenarios.

On the whole, the results presented in Table 34 indicate considerable strength in the projected market for GPV in Colorado, and this is true irrespective of system size. As expected, an increase in system cost has an overall detrimental impact on market size, but it in no way totally eliminates the demand (up to the levels tested). The low estimate market sizes range from approximately 200 households to about 14,000 households, depending on system size and cost. The high estimate market sizes range from about 1,500 households to about 31,000 households, again depending on system size and cost.

The most surprising result is the size of the projected market for very large systems—those designed to supply 100% of a household's electricity needs and which correspondingly involve higher net monthly costs. The evidence provided here suggests that, among the three size categories, the largest consumer base exists for such high-end systems, whereas the second largest consumer base exists for the smallest systems. The finding that demand for medium-sized systems—those designed to provide about 50% of a household's electricity needs—is apparently smallest among the three size categories is also somewhat surprising. These results imply that, not only does a viable market for the technology exist, but consumer demand is not dominated by small systems. Given an effective marketing campaign, homeowners in Colorado can be expected to purchase GPV systems in fairly robust numbers (depending, of course, on cost and marketing programs), with those numbers likely to be maximized by the availability of larger GPV systems.

Market Sensitivity to Alternative Financing Options

In addition to system size and cost, financing options are also likely to affect market response. As noted above, the specific systems presented in the survey questionnaire involve utility financing at 7% interest for 20 years. To assess market sensitivity to financing, the following three alternatives were considered:

Option 1: Subsidized low-interest loan (3% for 20 years)
Option 2: $3/watt buydown (8% interest for 10 years)
Option 3: System cost rolled into the home mortgage (7% interest for 30 years).

In cooperation with the Colorado Office of Energy Conservation and Management (OEC), monthly cost estimates were computed for each of the three system size alternatives. These amounts are shown in Table 35. Because survey participants were not specifically asked to consider these options, it is not possible to use the survey data to explicitly estimate market size in response to various GPV system financing alternatives. However, the monthly cost projections produced by OEC for the three system sizes under each financing alternative are very close in value to some of the dollar amounts respondents were asked to consider for the same-sized systems under the utility financing case (henceforth referred to as the *base case*). Table 35 shows this match-up of monthly costs under the three alternative financing options with the corresponding amounts respondents claim to be willing to pay for the same-sized system under utility financing. While survey respondents were not specifically asked to address the alternative financing options, conclusions about market size based on Table 34 could reasonably be extended to those situations because of the close match demonstrated in Table 35, assuming all possible financing options are equally acceptable to homeowners.

Table 34. Low and High Market Size Estimates for Various System Sizes and Monthly Cost Alternatives

System Size	Monthly Cost Alternative	Low Market Size Estimate*	High Market Size Estimate**
15% system (Very small)	$10 $15★ $20	12,218 8,219 5,998	25,998 15,994 11,551
50% system (Medium-sized)	$50 $60 $70★ $80	7,553 1,333 666 222	14,439 3,554 2,666 1,555
100% system (Very large)	$50 $75 $100 $125★ $150	14,439 8,664 4,665 1,333 1,111	30,656 15,772 8,886 3,110 1,777

*Low estimates: 624,000 multiplied by the percentage of ***HL Pacesetters*** and ***HL Steady Positives*** in clustered market segments (Table 30) who will look for more GPV information and who are willing to pay the specified monthly cost for the size of system in question, multiplied by .356.
**High estimates: 624,000 multiplied by the percentage that Tier 1 respondents represent of all respondents in clustered market segments (Table 30) who will look for more GPV information and who are willing to pay the specified monthly cost for the size of system in question, multiplied by .356.
★Actual net increase used in the OEC cost calculations.

Source: Constructed by the authors.

Market Response to Full Subsidization of Systems

Another possible option for obtaining GPV systems is to purchase them under a plan of full subsidies. Survey participants *were* asked to consider this possibility, and the percentage of respondents who rate their likelihood of purchase under such a plan as 9 or 10 on a 10-point scale was computed. The percentages of Tier 1 (***Early Adopter***) respondents and of ***HL Pacesetters*** and ***HL Steady Positives*** who indicate they are likely to look for more GPV information and to purchase such a system were used to compute high and low market estimates, respectively. These estimates are also shown in Table 35. As expected, the general provision of purchase subsidies, among all possible financing scenarios, is projected to yield a stronger market for GPV technology.

Table 35. Low and High Market Size Estimates for Various Financing Options

Financing options	System size	Calculated monthly cost ($)*	Cost under base case financing ($)	Low market estimate under base case financing	High market estimate under base case financing
Subsidized low-interest loan (3% for 20 years)	Very small Medium Very large	$10.70 $47.08 $85.43	$10 $50 $75	12,218 7,553 8,664	25,998 14,439 15,772
$3 per watt buydown (8% for 10 years)	Very small Medium Very large	$18.07 $64.56 $85.43	$20 $70 $75	5,998 666 8,664	11,551 2,666 15,772
Roll cost into 30-year mortgage (7% for 30 years)	Very small Medium Very large	$13.47 $61.03 $98.11	$15 $60 $100	8,219 1,333 4,665	15,994 3,554 8,886
No-added-cost (subsidized to breakeven cost)	Very small Medium Very large	N/A**	N/A	17,771	39,985

*Calculations provided by the Colorado Office of Energy Conservation and Management
**Size and cost are of no consequence where systems are subsidized to achieve breakeven cost.

Source: Constructed by the authors.

Threshold Values

The market response indicated in Table 35 is depicted in Figures 12, 13 and 14. In addition, the figures illustrate four important price thresholds among the potential likely buyers. Figure 12, representing very small GPV systems, shows an increase in the potential market size when the incremental cost of a system producing 15% of a household's electricity (a "15% system") diminishes to $10 a month.

Figure 13, representing medium-sized GPV systems, shows an abrupt increase in the potential market size when the incremental cost of a 50% system cost drops off to $50 a month. Although the actual incremental net cost is calculated as $70 a month, if system cost were partially subsidized —through the use of a systems benefit charge, for example—to reduce the monthly cost to $50 for a system providing one-half of a household's electricity, the market size could be expected to increase markedly.

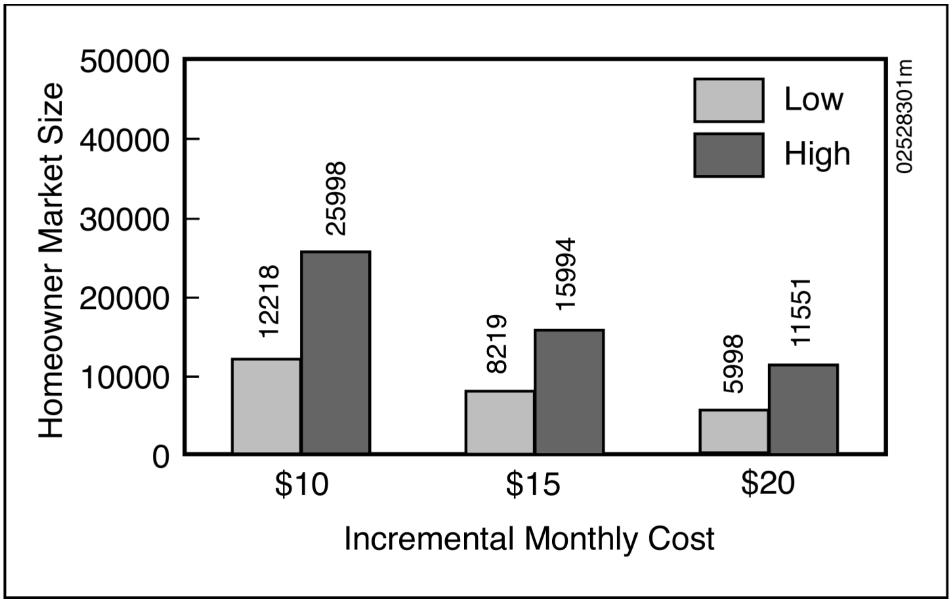


Figure 12. Estimate of Near-Term Market Size, Very Small GPV systems (7%–15% of Electricity)

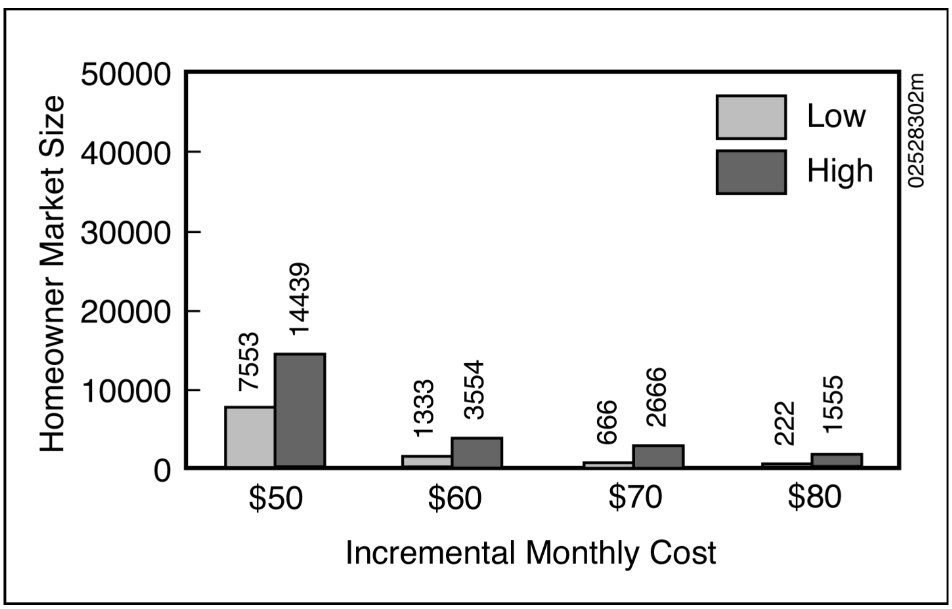


Figure 13. Estimate of Near-Term Market Size, Medium-sized GPV System (50% of Electricity)

Similarly, Figure 14 shows that the estimated market size for a GPV system providing 100% of a household's electricity at $100 net monthly increase in cost for electricity is markedly higher than the market size for such a system at $125 a month more, which is the actual estimated cost used in the OCE cost calculations. As would be expected, the lower the monthly cost, the higher the market size. Notably, however, the market for a 100% GPV system at $50 a month is almost as large as the market for a no-added-cost system (that is, a GPV system of unspecified size at breakeven cost).[3]

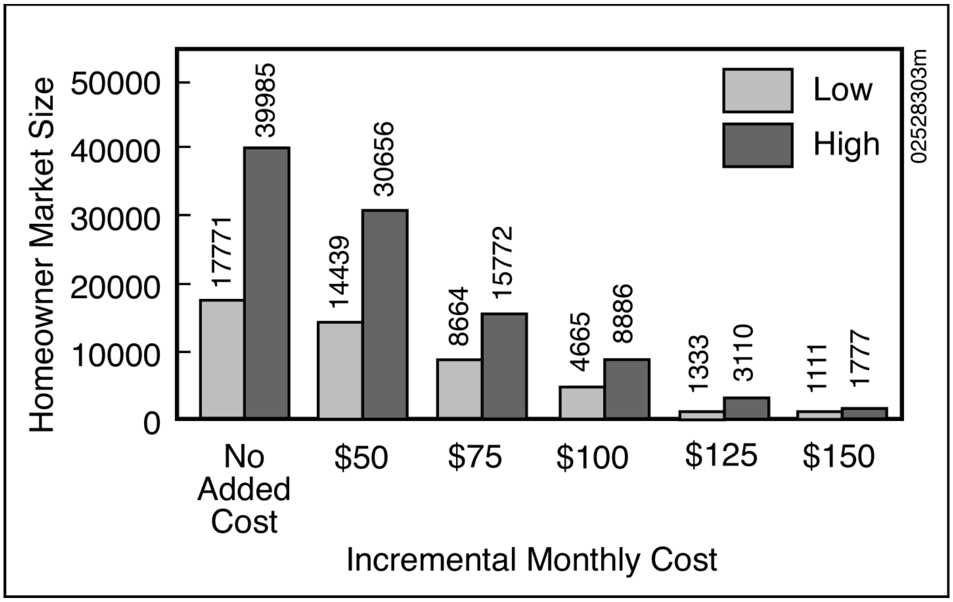


Figure 14. Estimate of Near-Term Market Size, Very Large GPV System (100% of Electricity)

Threshold values at or below which the market size increases dramatically, and above which market size drops off dramatically, are $10 for a 15% system, $50 for a 50% system, $100 for a 100% system (a lower threshold), and $50 for a 100% system (a higher threshold).

---

[3]The survey question on the no-added-cost GPV system did not address system size, but for comparison purposes it is shown in Figure 13.

Chapter 9
Detailed Characteristics of Near-Term Purchasers

Two Types of Early Adopters of GPV

Analysis has shown that a specific group of individuals constitutes the most likely near-term GPV purchasers. This group consists of the ***Highly Likely Pacesetters*** and the ***Highly Likely Steady Positives*** described in Chapter 7. The sidebar describes a real-life example of each of these two kinds of individuals.

Further analysis was conducted to determine how and whether these two types of projected near-term purchasers are different. This analysis permits potential marketers of GPV products who want to design marketing messages to tailor those messages more accurately. Selected results are discussed here, and Appendix F contains complete details. Appendix F, in fact, presents a comparison of all categories of homeowners who could be termed "highly likely to purchase" (the seven categories formed by crosstabulating membership in the ***Highly Likely*** criterion cluster with membership in the seven predictor clusters; see Chapter 7).

GPV Purchasers: The Human Face

Two Colorado homeowners who actually purchased GPV systems when they became available (after the data had been collected for this study) seem to represent the two types of early adopters.

The first adopter is an ***HL Pacesetter***. This man, perhaps in his 40s, lives in one of Colorado's Front Range communities (e.g., Denver, Boulder, Fort Collins, Colorado Springs). He purchased a 9 kW GPV system at a cost of $85,000. This purchaser owns a large home that also houses his business. He is also the owner of an electric car, and he planned to power his home, his business, and his automobile with the GPV system. As one of the initial adopters of GPV in Colorado, and as the purchaser of a system three times as large as a system that would power a typical Colorado residence, this GPV purchaser was a novelty. Stories about his purchase appeared in the local press and he appeared on the evening news. He said he believed that Colorado should move away from burning coal to produce electricity and GPV is the direction society should go in the future to provide clean electricity.

The second adopter is an ***HL Steady Positive***. This purchaser is a woman in her sixties living in one of Colorado's Western Slope communities. She is a widow who is reasonably comfortable financially, although not wealthy. She purchased a GPV system for her home quietly and without fanfare. She was concerned about the environment, and had arrived at a life-cycle stage when she was interested in creating her legacy. The GPV system purchase offered a way for her to take an action that increased the meaning of her life.

A Comparison of *Highly Likely (HL) Pacesetters* and *Highly Likely (HL) Steady Positives*

As would be expected, there are no statistically significant difference between ***HL Pacesetters*** and ***HL Steady Positives*** on the four key dependent variables used as criterion variables in the clustering regime described in Chapter 7 (data not shown here; see Table 29 for the relationship between these and the criterion clusters). On the basis of many other characteristics, however, the two categories of homeowners are apparently quite different, as indicated in Tables 36 through 39. In particular, Tables 36 through 38 contain the percentages of individuals in the ***HL Pacesetter*** and ***HL Steady Positive*** categories who responded most favorably to survey questions representing perceived benefits, perceived barriers, and product attributes of GPV systems. In all cases, the percentages of ***HL Pacesetters*** who responded very favorably to these questions are higher than the corresponding percentages of ***HL Steady Positives***. This finding suggests that, although homeowners in both these groups are expected to be near-term purchasers of GPV, the two groups of homeowners are indeed different in their overall approach to adoption of the technology. In general, ***HL Pacesetters*** express stronger feelings than the ***HL Steady Positives*** on all items of interest.

The information contained in Table 36 specifically pertains to perceived benefits of GPV technology. For example, high percentages of both ***HL Pacesetters*** and ***HL Steady Positives*** rate environmental benefits as very important (9-10 on a 10-point scale), while the percentages of the two groups giving high ratings to financial advantages of GPV purchase (such as reducing utility bills now, selling electricity to the utility, and long-term savings) are markedly different. ***HL Pacesetters*** emphasize financial advantages considerably more than do ***HL Steady Positives***.

Table 36. Comparative Responses of *HL Pacesetters* and *HL Steady Positives* Relative to Selected Perceived Benefits

Responses*	***HL Pacesetters***	***HL Steady Positives***
Protect the environment	80	74
Conserve natural resources	83	79
Reduce local air pollution and acid rain	83	74
Reduce global warming	74	65
Benefit future generations	83	76
Reduce utility bills now	81	42
Sell electricity to utility	78	31
Long-term savings	89	63
Pay for itself over 20 years	75	50
Increase resale value of home	79	39
First on block to have PV system	26	0
New technology to enjoy	54	13
Chance to make a difference in my community	62	26
Help create and expand the PV market	49	37

*Percentage of respondents answering 9-10 on a 10-point scale.

Source: Constructed by the authors.

Table 37 specifically pertains to perceived barriers to GPV technology. Both groups are apparently concerned about the operating reliability of GPV systems, and large percentages of the two groups rate the reputability of PV manufacturers and GPV system performance as very important. A much higher percentage of ***HL Pacesetters*** rate neighborhood concerns as very important than did ***HL Steady Positives***. A higher percentage of ***HL Pacesetters*** also rated possible cost barriers as very important.

Table 37. Comparative Responses of *HL Pacesetters* and *HL Steady Positives* to Selected Perceived Barriers

Responses*	***HL Pacesetters***	***HL Steady Positives***
Operating reliability of the PV system	94	89
Dependability and reputability of PV manufacturer	91	76
Amount of electricity produced	86	76
Dependability and reputability of PV vendor	88	68
Codes or covenants that might prohibit it	65	11
What friends and neighbors might say	10	0
Initial system cost	78	57
Maintenance costs	78	55
Effect on home resale costs	77	32

*Percentage of respondents answering 9-10 on a 10-point scale.

Source: Constructed by the authors.

Table 38 presents differences in percentages for selected variables pertaining to GPV product attributes. For example, a higher percentage of ***HL Pacesetters*** rated the availability of a system warranty as very important than did the ***HL Steady Positives***. Similar differences in percentages are reported for the availability of a maintenance agreement, availability of utility financing, and attractiveness of the system. Financial incentives, such as rebates or tax credits, and utility rates guaranteed to stay at the same level for 5 years are very important to a higher percentage of ***HL Pacesetters*** than ***HL Steady Positives***.

In addition to Tables 36 through 38, Table 39 reports differences in the two groups of individuals relative to lifestyle and values. Apparently, higher percentages of the ***HL Steady Positives*** than ***HL Pacesetters*** will accept lifestyle modifications to help the environment and to buy green, and a higher percentages of the ***HL Steady Positives*** are innovative. On the other hand, higher percentages of ***HL Pacesetters*** are self-reliant and opinion leaders than are ***HL Steady Positives***. It is these latter differences in characteristics that may really distinguish the two groups.

Although the ***HL Pacesetters*** and the ***HL Steady Positives*** responded differently on several key variables, marketing messages about GPV could address both of these groups without alienating either one. Both are interested in the environmental benefits that GPV can offer. Financial advantages are a plus to both groups, although a higher percentage of ***HL Pacesetters*** regards them as very important. Although they are somewhat indifferent to pacesetting, ***HL Steady Positives*** would probably not be turned away by messages appealing to the pacesetting aspects of a GPV purchase—one to which ***HL Pacesetters*** would definitely respond.

Table 38. Comparative Responses of *HL Pacesetters* and *HL Steady Positives* Relative to Selected Product Attributes

Responses*	***HL Pacesetters***	***HL Steady Positives***
Warranty on PV system	90	77
Maintenance agreement	77	52
Extended warranty on installation	83	44
Attractive-looking system	76	46
Rebates or tax credits	87	69
Owning the PV system	66	32
Finance the system through the utility	48	21
Guarantee same utility rates for 5 years	68	34
Option to do own installation	41	31

*Percentage of respondents answering 9-10 on a 10-point scale.

Source: Constructed by the authors.

Table 39. Comparative Responses of *HL Pacesetters* and *HL Steady Positives* Relative to Values and Lifestyles

Characteristics of Respondents*	***HL Pace-setters***	***HL Steady Positives***
Percentage who would accept lifestyle modifications to help the environment	68	71
Percentage who would buy green	59	71
Percentage who are self-reliant	86	79
Percentage who are innovative	80	90
Percentage who are opinion leaders	74	58

*Percentage of respondents answering 9 or 10 on a 10-point scale

Source: Constructed by the authors.

As noted earlier, Appendix F contains the complete details of this analysis. A careful perusal of all the findings appears to suggest that the ***HL Steady Positives*** may be more realistic in their GPV expectations than the ***HL Pacesetters***, and may thus represent a more realistic market for the technology.

Chapter 10
Validating Study Hypotheses

Dependent Variables

As noted in Chapter 2, the study has four dependent variables, summarized in Table 1. These are:

- *Favorability to GPV* (including favorability to making GPV available to Colorado residents and favorability to the idea of using GPV on one's own home)

- *System size/price trade-offs* (preferences for smaller, less expensive to larger, more expensive GPV systems)

- *Willingness to pay for GPV* (net electricity cost increases for small, medium, and large GPV systems, and likelihood of purchase of a no-added-cost GPV system)

- *Behavioral intention* (likelihood of looking for more information on GPV).

Chapter Highlights

- Hypotheses presented in Chapter 2 were tested.
- Hypotheses concerning the importance of perceived benefits, perceived feasibility, interest in information, and compatible lifestyle and values in a GPV purchase decision are supported.
- The hypothesis concerning the importance of perceived barriers as impeding GPV purchase is not supported.
- The hypothesized importance of knowledge to GPV system purchase is only partially supported.
- Hypotheses involving gender, age, and political orientation are supported.
- Null hypotheses involving area of residence, geographic locale in Colorado, and primary heating fuel are supported.
- Hypotheses involving marital status, household type, education, occupation, income, and likelihood of moving are not supported.
- The hypothesis that near-term purchasers would be more likely to support GPV subsidies is supported.

Independent Variables

The study's independent (predictor) variables include a number of factors that are hypothesized to affect homeowners' positions in the GPV adoption process. These variables are also described in Chapter 2, and are summarized there in Table 2. Tables 40 and 41 show these variables again along with their hypothesized relationship to likelihood of GPV purchase and the results of hypothesis testing.

Hypothesis Testing Approach

As discussed in Chapter 7, information provided by the dependent variables was reduced to a single index representing group membership using the multivariate statistical technique of cluster analysis. The derived groups, representing various degrees of likelihood of purchase, are referred to as the *criterion clusters*. Each survey respondent satisfying the criteria of the clustering regime was assigned to one of these groups. The cluster index provides an effective mechanism for testing the study's hypotheses about concepts such as perceived relative advantage, perceived feasibility, and perceived barriers in that conclusions about them can be drawn on the basis of statistical comparisons among the groups (principally using Chi-square analysis). Appendix I summarizes the results of statistical tests that compare various survey responses of individuals who are likely to purchase with those of individuals who are not.

A similar, and perhaps better, way to test the study's hypotheses is to use the market tiers; that is, the tiers represent another grouping of respondents among which statistical comparisons can be made. Recall that the market tiers are derived by crosstabulating two different sets of clusters—the *criterion clusters* and the *predictor clusters* (see Chapter 7). In fact, the principal use of the market tiers is to support hypothesis testing; and in the discussion that follows, comparisons among market tiers are shown to constitute some of the most important evidence for and against the various hypotheses. Appendix E provides more detailed results based on Chi-square analysis of responses to various survey questions by individuals encompassed by the four tiers.

The market tiers, however, cannot be used for testing some hypotheses because of the fact that they involve grouping on the basis of the predictor clusters. The problem arises because the predictor clusters, in and of themselves, were constructed in such a way as to incorporate information about some of the same ideas formulated in the hypotheses (e.g., perceived relative advantage, perceived feasibility, and perceived barriers of GPV). Therefore, to avoid any possibility of a circular argument, hypothesis tests about these concepts are restricted to comparisons among criterion clusters only, which are independent of such effects.

Results of Hypothesis Testing

The study's independent (predictor) variables include a number of factors that are hypothesized to affect homeowners' positions in the GPV adoption process. These variables are also described in Chapter 2 and summarized in Table 2. Table 40 shows these variables, the ways in which they were operationalized in the study, and their hypothesized relationship to likelihood of GPV purchase (again, see Appendix E for the details).

Table 40. The Study's Hypotheses and Results of Hypothesis Testing on Attitudes, Knowledge, and Preferences

Variables and Hypotheses	Measurements/Operationalization
Perceived relative advantage of GPV adoption *Hypothesis*: The higher the perceived relative advantage of GPV, the more likely is near-term GPV purchase. *Supported*	• Rated importance of 23 perceived benefits *Result:* A significantly higher percentage of individuals in the ***Highly Likely*** criterion cluster rate all 23 perceived benefits as very important than do individuals in the other criterion clusters. • Perceived source of electricity in Colorado *Result:* No significant difference by tier in identifying sources of electricity.
Perceived feasibility of GPV *Hypothesis*: The higher the perceived feasibility of GPV, the more likely is near-term purchase. *Largely supported*	• Perceived importance of 21 product attributes *Result*: A significantly higher percentage of individuals in the ***Highly Likely*** criterion cluster rate 18 of 21 product attributes as very important than do individuals in the other criterion clusters; among all the criterion clusters; there are no significant differences by criterion cluster in the percentages of individuals who rate the three remaining product attributes as very important. • Preferences for paying for system *Result*: No significant difference by tier. • Preferred supplier of GPV system *Result*: A significantly higher percentage of individuals in the ***Highly Likely*** criterion cluster rate their likelihood of considering a purchase from each of five potential system suppliers as very high than do individuals in the other criterion clusters.
Perceived barriers *Hypothesis*: The more important the perceived barriers to GPV adoption, the less likely is near-term purchase. *Not supported*	Rated importance of 18 potential problems or barriers *Result*: A significantly higher percentage of individuals in the ***Highly Likely*** criterion cluster rate 15 of 18 perceived barriers as very important than do individuals in the other criterion clusters; among all the criterion clusters; there are no significant differences by criterion cluster in the percentages of individuals who rate the three remaining perceived barriers as very important.

Table 40. The Study's Hypotheses and Results of Hypothesis Testing on Attitudes, Knowledge, and Preferences (cont'd.)

Variables and Hypotheses	Measurements/Operationalization
Knowledge *Hypothesis*: The more knowledge, the more likely is near-term purchase. Self-report on knowledge: *Not supported* Familiarity and experience with efficiency and renewables: *Supported*	• Initial familiarity with GPV *Result*: A significantly higher percentage of Tier 4 respondents is initially familiar with GPV than in other tiers, but Tier 4 members are the least likely purchasers. • Knowledge to make an informed decision *Result*: A significantly higher percentage of Tier 4 respondents claim to have enough information to make an informed purchase decision than in other tiers, but Tier 4 members are the least likely purchasers. • Familiarity and experience with efficiency and renewables technologies *Result:* Consistently, a significantly higher percentage of Tier 1 respondents report high familiarity with a collection of energy efficiency and renewable energy equipment than in other tiers.
Information *Hypothesis*: The more interest in information, the more likely is near-term purchase. *Support*ed	• Rated importance of 15 information needs *Result*: A significantly higher percentage of Tier 1 respondents rate each of 14 information needs as very important than do respondents in other tiers; among the tiers, there is no significant difference in the percentage of individuals who rate the one remaining information need as very important. • Preferences among 24 information sources *Result*: A significantly higher percentage of Tier 1 respondents rate each of 22 information sources as very important than do respondents in other tiers; among the tiers, there are no significant differences in the percentage of individuals who rate the two remaining information sources as very important.
Policy preferences *Hypothesis*: The more favorable to a GPV subsidy, the more likely is near-term purchase. *Supported*	Subsidy preference and how to pay for PV *Result*: A significantly higher percentage of Tier 4 respondents is opposed to all subsidies than in other tiers; significantly higher percentages of respondents in Tiers 1 and 2 choose some form of subsidy when given that option than in Tiers 3 and 4.

Table 40. The Study's Hypotheses and Results of Hypothesis Testing on Attitudes, Knowledge, and Preferences (cont'd.)

Variables and Hypotheses	Measurements/Operationalization
Compatible lifestyle and values *Hypothesis*: The more compatible GPV is perceived to be with personal values and lifestyles, the more likely is near-term purchase. *Supported*	• Environmental values *Result*: A significantly higher percentage of Tier 1 respondents agree with statements suggesting willingness to adopt lifestyle modifications and to purchase more costly products to help the environment than do respondents in other tiers. • Early adopter characteristics *Result*: A significantly higher percentage of Tier 1 respondents agree with statements that suggest self-sufficiency, innovativeness, and opinion leadership than do respondents in other tiers.

Source: Constructed by the authors.

The study collected data on the following demographic variables:

- Gender
- Age
- Marital status
- Household composition
- Rural, town, or city resident
- Geographic locale of Colorado
- Educational attainment
- Occupation
- Annual income
- Political orientation
- Primary heating fuel
- Likelihood of moving.

The hypothesized relationships of these demographic variables with likelihood of GPV purchase and the findings from the study's analysis are presented in Table 41.

Table 41. The Study's Hypotheses and Findings on Demographics

Hypotheses of the Study	Findings from the Study
Gender The ratio of male to female respondents who are heads of households is somewhat different among the tiers.	Men are more favorable* than women heads of household. *(Nearly significant, p=.054) (Supported)*
Age Younger homeowners are more favorable than older ones.	There is a significant difference among the tiers in the age distribution of respondents. Older homeowners are less favorable than younger ones. *(Supported)*
Marital status Married homeowners are more favorable than single ones.	There is no significant difference among the tiers in the percentages of respondents who are married. *(Not supported)*
Household composition Married homeowners with children are more favorable than other household types.	There is no difference among the tiers in the percentages of respondents who are married and have children. *(Not supported)*
Rural, town, or city resident There is no difference in favorability by area of residence.	There is no difference among the tiers in the percentages of respondents who live in urban, suburban, and rural areas. *(Supported)*
Geographic locale of Colorado There is no difference in favorability by geographic locale.	A significantly lower percentage of Tier 1 respondents lives in the Denver/Boulder area than in other tiers. *(Not supported)*
Educational attainment More highly educated homeowners are more favorable than others.	A significantly higher percentage of Tier 2 respondents is more highly educated than are respondents in other tiers. *(Not supported)*
Occupation Homeowners in professional and managerial occupations are more favorable than others.	A significantly higher percentage of Tier 2 respondents is employed in professional and managerial occupations than in other tiers, with the percentage in Tier 4 being the smallest. *(Not supported)*
Annual income Higher income homeowners are more favorable than others.	A significantly higher percentage of Tier 2 respondents has incomes exceeding $50K than in other tiers. *(Not supported)*
Political orientation Liberal homeowners are more favorable than conservative homeowners.	The highest percentage of politically conservative respondents are found in Tier 3, followed by the percentage in Tier 4. *(Supported)*
Primary heating fuel There is no difference in favorability by primary heating fuel used.	There is no difference among the tiers in the percentages of respondents who currently use various primary home heating fuels. *(Supported)*
Likelihood of moving Homeowners less likely to move in the near term are more favorable toward GPV.	The percentages of respondents likely to move in the near term are not different among the tiers. *(Not supported)*

*The terms "favorable" or "favorability" used in this table refer to likelihood of near-term GPV purchase.

Source: Constructed by the authors.

Discussion of Hypothesis Testing Results

The hypothesis testing results, which are summarized in Tables 40 and 41, are as follows.

Perceived Relative Advantage (Perceived Benefits)

The first hypothesis involves the perceived relative advantage of GPV. The perceived benefits of GPV purchase were measured by 23 separate variables (survey questions). Responses on these variables were individually crosstabulated with the cluster membership index (criterion clusters). All 23 of the perceived benefits are rated important by a higher percentage of the ***Highly Likely*** criterion cluster—that is, the respondents determined to be most likely to take action regarding GPV purchase—than by the other clusters. This finding supports the hypothesis that the higher the perceived relative advantage of GPV, the more likely is near-term GPV purchase.

In addition, respondents were asked to identify the primary source of electricity in Colorado, which is coal-burning. The rationale for this question as an indicator for relative advantage was that, if homeowners knew that coal-burning is used to produce most electricity in Colorado, and if they were concerned about negative impacts of coal-burning on air quality, they might be more favorable toward GPV. This aspect of the hypothesis concerning perceived relative advantage can be most directly tested by comparing differences among the market tiers. The results indicate that, in fact, there is no significant difference among the tiers as to respondents' ability to identify the primary source of electricity in Colorado. Hence, there is no support for the argument.

Perceived Feasibility

The second hypothesis involves perceived feasibility of GPV. The argument is made that respondents who view GPV to be more technologically and economically feasible are more likely to adopt it. The technological aspect of perceived feasibility was measured by responses to 21 survey questions pertaining to product attributes. The hypothesis was tested by crosstabulating responses to these questions with the cluster membership index (criterion clusters). Eighteen of the 21 product attributes are rated important by a higher percentage of the ***Highly Likely*** criterion cluster than by the other clusters, thereby supporting the hypothesis.

The economic aspect of perceived feasibility has to do with the way respondents would prefer to pay for a GPV system and the sources from which they would prefer to acquire such a system. Two separate survey questions addressed this concept. The most direct test of this aspect of the hypothesis can be made on the basis of comparing differences in responses among the market tiers. The results of the test indicate that there are no significant differences among tiers regarding paying preferences, but that a higher percentage of Tier 1 would embrace all potential sources (utility companies, PV manufacturers, etc.) than would the other tiers. Hence, the economic aspect of the hypothesis concerning perceived feasibility is only partly supported.

Perceived Barriers

A third hypothesis has to do with perceived barriers to the adoption of GPV technology. However, the idea that important concerns would constitute real barriers to GPV purchase is not borne out in the analysis.

Eighteen potential areas of concern were posed in the survey questionnaire. A significantly higher percentage of the ***Highly Likely*** criterion cluster rate 15 of them to be important than do the other clusters. These, however, are the respondents deemed to be most likely to take action. Hence, it can be concluded that even though such concerns about the technology are real and present a potential for risk, likelihood of purchase would not be diminished among such individuals, unless these concerns remain unaddressed by those marketing GPV systems.

Similarly, it appears that higher percentages of individuals who are less interested in GPV tend to rate potential areas of concern as unimportant, and that they do this because they have no intention of making a purchase anyway. In fact, a significantly higher percentage of the ***Highly Unlikely*** criterion cluster rate 15 of the potential concerns as very unimportant (1 or 2 on a 10-point scale) than do the other clusters. For example, as a general rule, respondents in the ***Highly Unlikely*** criterion cluster give more importance to what friends and neighbors would say (if they purchase a GPV system), whereas respondents in the ***Highly Likely*** criterion cluster regard this concern to be less important.

Of note, three of the original 18 concerns apparently have little importance among any of the criterion clusters. These three are potential weather damage to a GPV system, potential difficulty in obtaining insurance, and a concern that the utility might discontinue its GPV offering. In addition, concerns that neighborhood codes and covenants might impede GPV installation is apparently important to no more of the ***Highly Likely*** criterion cluster than the ***Highly Unlikely*** criterion cluster.

Knowledge

The hypothesis that near-term purchase of a GPV system is more likely among respondents (homeowners) having more knowledge about GPV systems and related technologies is only partly supported. The percentage of respondents who say they are familiar with GPV systems and have enough information to make an informed decision about a GPV purchase is significantly higher in Tier 4 (those who will absolutely not purchase) than in the other tiers. Thus, the hypothesis is *not* supported when measured by respondents' own assertions about knowledge and familiarity.

A somewhat contradictory result was obtained, however, when considering respondents' experience with home-related features and conveniences related to energy efficiency and renewable energy. As part of the survey, respondents were asked to rate their familiarity with nine such items:

- PV ***not tied*** to the utility grid
- Solar panels to heat water for homes
- Solar panels to heat homes
- Attached solar greenhouses to heat homes
- Wind machines (or windmills) to produce electricity or pump water
- Passive solar design (such as using south-facing windows to get heat from the sun; using water containers, walls, floors, or ceilings to collect and store the sun's heat; etc.)
- Energy-efficient retrofits (such as added insulation, double-pane or low-E glass, energy-efficient lighting, energy-efficient appliances, etc.)
- Solar panels to heat swimming pools, hot tubs, or spas
- Woodstoves to heat homes.

The results contained in Appendix H indicate that significantly higher percentages of Tier 1 respondents have high familiarity (and by extension, a high level of experience) with the nine items than respondents in the other tiers. In particular, a significantly lower percentage of Tier 4 respondents (particularly in comparison to Tier 1 respondents) have high familiarity with energy-efficiency retrofits, conventional PV systems, and wind technology. Even the percentage of Tier 4 respondents who have high familiarity with woodstoves was substantially lower. Hypothesis testing results contained in Appendix H also indicates that a significantly higher percentage of respondents in Tier 4 (24%) give an overall negative rating to their experience with energy efficiency and renewable energy features than do respondents in other tiers, and a significantly lower percentage give overall positive ratings (58%) than in other tiers (ranging from 84% to 97%).

These results suggest that Tier 4 respondents, in particular, may confuse conventional PV systems (solar electric systems) with the solar thermal water and space heating systems installed in homes in the 1970s and 1980s when federal and state solar tax credits were in existence. Negative experiences with solar thermal systems could negatively affect current attitudes toward GPV systems.

Information

The hypothesis that interest in obtaining more information about GPV is likely to affect near-term purchase is supported. Respondents were asked to rate the importance of 15 informational items concerning GPV (such as "description of system components" and "battery costs, maintenance, and disposal"). A significantly higher percentage of respondents in Tier 1 assign ratings of high importance to 14 of the 15 items on information needs than do respondents in other tiers. Respondents were also asked to rate the importance of 24 different sources of information about GPV (such as "utility companies" and "home builders"). A significantly higher percentage of respondents in Tier 1 assign ratings of high importance to 22 of these sources than do respondents in the other tiers.

Policy Preferences

The hypothesis that individuals who are more favorable toward a GPV subsidy are more likely to be GPV purchasers is supported. A significantly higher percentage of respondents in Tier 4 are opposed to all subsidies than are respondents in the other tiers. The percentages of respondents who prefer subsidies for on-site solar electric systems are significantly higher in Tiers 1 and 2 than in Tiers 3 and 4.

Lifestyle and Values

The hypothesis that compatibility of GPV systems with personal values and lifestyles positively impacts near-term purchase is supported. A higher percentage of respondents in Tier 1 is environmentally concerned and willing to live a more environmentally conscious lifestyle than are respondents in other tiers. A higher percentage of respondents in Tier 1 is also concerned about self reliance and self sufficiency than in the other tiers. Supporting the diffusion of innovation theory about early adopters, Tier 1 respondents appear to be more innovative and inclined toward opinion leadership than are respondents in other tiers.

Demographics

The results of hypothesis tests pertaining to respondent demographics are somewhat more surprising than the other hypothesis testing results. Several of the expected relationships are not borne out. Gender appears to be a nearly significant factor in GPV adoption, with a significantly higher percentage of male heads of households being favorable toward GPV than female heads of households ($p = .054$).

It was hypothesized that younger homeowners would be more favorable to GPV than older ones; however, the analysis shows that older homeowners are less favorable than younger ones (a result similar in meaning to the hypothesis, but with a difference in emphasis). This is particularly true when considering respondents 65 years of age or older.

The preliminary qualitative work for this study suggested that greater interest in GPV would be found among married homeowners than unmarried ones, but this relationship is not borne out by the survey results. Nor is it found that married homeowners with children are significantly more likely to purchase GPV than other household types.

As hypothesized, the type of residence locale (urban, suburban, or rural) has no relationship to the percentage of respondents likely to purchase a GPV system. The actual area of Colorado in which respondents live, however, is an important factor (as hypothesized). In fact, the percentage of respondents who live in the Denver/Boulder area is significantly lower for Tier 1 (the ***Early Adopters***) than for the other tiers.

Some demographic variables, such as education, occupation, and income, are known to be inter-correlated in the general population. It was hypothesized that more highly educated homeowners with higher incomes working in professional and managerial occupations would be more likely GPV purchasers. In fact, the analysis indicates that Tier 1 respondents (***Early Adopters***) do not necessarily have the highest income levels. A higher percentage of Tier 2 respondents (***Mid-term Adopters***) have annual incomes of at least $50,000. Similarly, the highest percentage of respondents having the most education is found among Tier 2 respondents; and Tier 2 also contains the highest percentage of respondents working as professionals and managers. Tier 4 (***Non-Adopters***) has the smallest percentage of individuals working as professionals and managers.

Only partial support was found for the hypothesis that liberal homeowners are more favorable toward GPV than conservative ones. The highest percentage of politically conservative respondents is found in Tier 3, with the second-highest percentage found in Tier 4.

It was hypothesized that the less likelihood that a respondent would move during the next five years, the greater the likelihood of a GPV system purchase. However, no such relationship was found.

No relationship was hypothesized—and none was found—between the primary heating fuel used in respondents' homes and the likelihood of GPV purchase.

In general, then, the GPV adoption model presented in Chapter 2 is supported by the overall analysis, with a few exceptions. A particularly informative exception is that individuals who are most likely to purchase GPV systems are also those who are most concerned about possible problems. In retrospect, this finding is entirely understandable. In addition, some of the unexpected demographic results are particularly intriguing. Many conservative homeowners, for example, also appear to be likely GPV purchasers, and homeowners with the highest incomes are not necessarily the largest part of the near-term market. Finally, GPV systems appear to have a certain appeal to men—more so than to women—perhaps because they are technologically interesting.

Chapter 11
Findings, Conclusions, and Discussion

This study comprises the most extensive research available on the potential market penetration of GPV technology. The extensive nature of the questionnaire, the large number of homeowners questioned, the strong response rate, and the thorough and detailed analysis of the resulting data provide a convincing account of consumer attitudes and preferences about this important energy technology.

The prevailing conclusion that can be drawn from this work is that ***a market for residential grid-tied PV systems exists in Colorado today,*** and that the market is substantial enough for companies to successfully promote GPV systems to Colorado homeowners. Depending on size and price trade-offs, the extent of this market conservatively ranges upward to as many as 31,000 households. Whether or not such a market exists in other areas of the country or world is debatable, depending largely on comparability of a number of factors; but the evidence suggests that, at least in Colorado, enough consumers will participate in this technology at some level to make it an economically viable venture.

Chapter Highlights

- A substantial residential market for GPV system exists.
- Near-term purchasers need considerably more information before they will buy systems.
- Financial advantages of GPV system purchase, both near and long term, are important to potential customers.
- Environmental values will also play a role in near-term GPV system purchases.
- Two distinct types of near-term purchasers have been identified: Pacesetters and Steady Positives. However, these two types are likely to respond positively to similar marketing messages.
- The size of the near-term market for a system providing 100% of a household's electricity at a cost of $100 a month for up to seven years is estimated at 5,000 households.
- Higher prices than those used in the survey and lack of net metering will impede market development.

Some Specific Findings of the Study

The research encompassed by this study has produced extensive findings about consumers and their inclinations to become involved with GPV technology, along with projections about the potential market size. The most important of these findings are summarized here.

Foremost among the study's findings is the confirmation that it will take time for this market to mature, because most homeowners do not yet know enough about GPV to make truly informed decisions. Prospective near-term purchasers need more information, and some product features about which they require information will have to be newly designed or redesigned in such as way as to satisfy consumer needs and expectations. For example, the results of the study suggest that many homeowners believe financial advantages are important, even though they still say they would be willing to incur incremental amounts in monthly utility costs to obtain GPV systems. Availability of net metering will be an important factor in their purchase decisions. Rebates and other ways to reduce costs are desirable to offset the cost and lower the risk to homeowners. Environmental considerations will also play an important role.

The methodological approach used in the study identified two types of early GPV adopters whose attitudes are strongly predisposed toward GPV purchase and use.

The largest of the two groups, identified as ***Early Adopters,*** will move toward GPV purchase because of their *pacesetting* attitudes. They have more experience with residential energy efficiency and renewable energy features than do other groups. Consequently, they like the technology, they want to be the first to use it, and they want to be an example to others. Fifty percent of the ***Pacesetters*** fall in a category of homeowners that is highly likely to pursue GPV purchase, with an additional 32% falling in homeowner categories that have somewhat lower, but still positive, likelihood of purchase. Obviously, the ***Pacesetters*** market type requires a promotional approach that appeals to the importance of trendsetting.

A smaller group—the ***Steady Positives*** market type—distinguishable from the ***Pacesetters***—should be more attracted to GPV by a straightforward promotion of environmental and financial advantages. Like the ***Pacesetters,*** 50% of the ***Steady Positives*** fall in a category of homeowners highly likely to pursue GPV purchase, with an additional 35% falling in homeowner categories that have somewhat lower, but still positive, likelihood of purchase. Although they may not be as aggressively motivated to purchase as the ***Pacesetters, Steady Positives*** also do not have some of the concerns about risk that ***Pacesetters*** do, and therefore the purchase decision may be easier for them. An effective marketing campaign could communicate benefits of GPV purchase to both key market types without disaffecting either one.

A "next-tier" organization of the study's respondent base was used to assess willingness to pay on the part of homeowners.[1] Not surprisingly, it was found that, as net system cost increased, willingness to pay declined, with the threshold being about $50 in incremental monthly utility costs for either a 50% or 100% GPV system. The size of the immediate market under the 100% system scenario at $100 per month in incremental utility cost is projected to be a minimum of about 4,500 Colorado homeowners. Similarly, the size of the market at incremental monthly utility costs up to $125 for a system providing 100% of a home's electricity is estimated to be a minimum of about 1,300 homeowners. In addition, there is more homeowner interest in GPV systems that provide all of a home's electricity than in systems that provide half of a home's electricity. If, because of policy actions, no-added-cost GPV systems were made available in Colorado, a minimum of approximately 18,000 homeowners would comprise the near-term market for them. Because of the methodology employed to derive them, these estimates are considered to be conservative.

Caveats to Market Size Estimates

Clearly, even in such an extensive study as this one, it is not possible to encompass all of the potential factors affecting the size of the GPV market. Some of these factors pertain to the structural and physical nature of residences, such as roof size, roof orientation, extent of landscaping and vegetation, and proximity to other buildings. Some factors also have to do with the political entities in which residences are located, such as neighborhood codes and covenants, which might impede GPV installation. While these kinds of issues and situations will undoubtedly diminish the size of the GPV market, their exact importance is unknown and the extent of any associated market size attrition remains undetermined.

[1]As noted previously, willingness to pay was a hypothetical concept at the time of the survey since GPV systems were not yet available to Colorado consumers.

Developing a Successful GPV Product

Despite these caveats, the results of this study point to a viable market for GPV technology in Colorado and suggest clear-cut strategies for maximizing the marketing opportunity. The most important ingredients of a GPV product are (1) the source from which the GPV system is obtained, (2) the repayment mechanism, and (3) the overall cost, in terms of incremental household energy dollars. For example, the results of this study suggest that homeowners willing to purchase GPV systems would prefer to do so from their utility providers, and to pay for those systems as part of their regular monthly utility bills. GPV manufacturers are also preferred sources. Other components of a successful GPV product will include the physical appearance and placement of the system, the availability of certain system amenities (such as the ability to withstand power outages), the potential for energy self-sufficiency, operating reliability, and the availability of warranties.

Developing a Successful Marketing Strategy

The evidence from this study suggests that, although a few Colorado homeowners will purchase GPV systems on their own initiative, most will have to be actively courted. The most effective marketing strategy will integrate information from this study about homeowner characteristics, preferences, and demographics. In addition to marketing a product that adds value for customers, successful marketing will emphasize three key benefits of GPV purchase: (1) environmental advantages (such as conserving natural resources, reducing air pollution, benefitting future generations, and increasing energy diversity), (2) financial advantages (such as reducing electricity bills right away and achieving long-term savings), and (3) pacesetting advantages (such as personal satisfaction in being first, enjoying a new technology, and helping to create the market for PV). To be most effective, other messages should amplify these key benefits of GPV purchase.

In addition, because potential purchasers have important concerns, marketing should emphasize such aspects as system performance and operating reliability and the reputability of the firms manufacturing and selling the system. Such concerns—if they remain unaddressed—could be an impediment to purchase.

With respect to demographics, marketing efforts should focus on men's interests in energy, technology, and gadgets, as well as women's interests in the environment. Because of the price of PV technology, homeowners with discretionary income should be targeted. Homeowners in their thirties through late fifties comprise the best market opportunity. PV systems can be marketed to urban, suburban, exurban, and rural homeowners around the state.

The Market Impacts of Institutional Intervention and Advocacy

The most serious threat to market development—in Colorado or elsewhere—stems from the current and future practices of utility companies, as well as the actions and policies of government entities. During 1999, the State of Colorado offered a consumer rebate on GPV system cost which, if history repeats itself, was an effective tool for promoting adoption of PV technology around the state.[2] If the State of Colorado or the federal government were to implement additional financial incentives for homeowners, the size of the market and the speed of uptake would increase. For example, this study suggests that even politically conservative homeowners (those usually opposed to any kind of government subsidies) would be inclined to purchase a highly subsidized system. As an illustration, such an arrangement might be effectively promoted through system benefit charges associated with utility restructuring. The financing of GPV systems by rolling their

[2] The rebate applied to both standalone PV and GPV systems.

cost into home mortgages is another means to amortize up-front costs. This incentive would be particularly helpful to purchasers of new homes with a GPV system.

The potential for the success of financial incentives for GPV must be evaluated in light of the experience with similar financial incentives implemented for solar domestic water-heating systems in the late 1970s and early 1980s. When the tax credits for these systems were repealed, the solar industry largely died away because its existence was predicated on the federal subsidy. Consequently, establishment of a sustainable GPV industry would represent a more sound economic approach.

Like government entities, utility companies themselves—the very organizations that many consumers respect—have the capacity to adversely impact the size of the GPV market. Unfavorable pricing scenarios are often the culprits. As an example, consider that, in September 1999, Public Service Company of Colorado offered its customers a net-metered GPV system advertised to have a lifetime of 20 to 30 years. This promotional offer was included as part of the utility bill stuffer entitled *Energy Update* provided in customers' regular monthly bills. Part of the language contained in the flyer is repeated below:

> The price of an installed system can range from about $8,000 for a small supplementary system to $45,000 or more for a system that supplies a building's entire electricity needs and includes an emergency back-up system. PV systems connected to the utility grid installed before December 31, 1999, are eligible for a rebate of up to $2,500 from the Colorado Office of Energy Conservation.

Unfortunately, these costs appear to be markedly higher than those used in this study to estimate the size of the residential GPV market in Colorado. It is anticipated that such high prices would do little to support market development.

Clearly, if the GPV industry wants the market to grow, it must work to reduce the costs of systems as much as possible. As noted above, the results of this study suggest that an incremental $50 per month is a threshold cost which most consumers will not exceed. Hence, this would appear to be an important pricing goal. Such a goal could be achieved in the near-term by effective partnering between industry and government. Industry could potentially meet the goal alone once the market is better developed.

The evidence suggests that, lacking substantial legislative intervention, utilities have the greatest potential to make or break the GPV demand. They (and by extension, their contractors) are not only a highly authoritative source of information about GPV, they also can affect pricing, marketing, service delivery, and maintenance. They also control net metering policies (unless the state Public Utility Commission assumes favorable and binding positions on net metering). Based on the results of this study, net metering appears to be one of the most crucial factors in providing financial advantages to homeowners who will consider purchasing a GPV system. Many potential customers need to feel that they will break even financially at some point in the future—even if it is in the distant future. On the other hand, utilities also have the power to forcefully stimulate the GPV market by offering their customers attractive financing options (as opposed to other repayment alternatives). This conclusion is based on the results of this study that indicate utility company financing would be preferred by more prospective GPV purchasers than other financing options presented.

An Overall Conclusion

The results of this study suggest that Colorado homeowners are ready to move forward with GPV—they are ready to learn more about the technology and they are ready to initiate the purchase process. The number of homeowners included in this group is undoubtedly a function of the technology's economic feasibility. In Colorado, that economic environment is controlled by state institutions, the state government, utility companies, and, to a lesser extent, the state's home builders. The evidence suggests that if these institutions, too, are ready to move forward, a market will develop in sufficient size to support a viable long-term PV industry.

Chapter 12
Recommendations and Summary Remarks

This study has produced an extensive and invaluable body of information that should serve to guide utility companies, government entities, equipment manufacturers, homebuilders, mortgage lenders, and, collectively, the entire GPV industry for years to come. Continued analysis and re-analysis of the data will lead to even greater knowledge about the relationship between consumers and this important technology. The study itself will serve as a model for obtaining similar information concerning consumer acceptance of other energy efficiency and renewable energy technologies.

Although any number of recommendations could be formulated, in the authors' best judgment the ones presented below represent the best approach for stimulating the GPV market in Colorado given the overall results of the study, and the findings and conclusions summarized in Chapter 11. These recommendations are organized according to several different categories to underscore the need for collaborative work and contributions from many different parties. Each recommendation is presented as a specific action to be taken, along with some associated discussion. Some final summary remarks about the study are also provided at the end of this chapter.

PV System Marketers (Utility Companies, PV Manufacturers, and Home Builders)

Market GPV—Using the approach of "suggestive selling," marketers should actively inform customers about the availability of the technology and about its benefits. The market base exists, but sufficient consumer knowledge is lacking.

Develop opportunistic business strategies designed to capture the market—At the present time, the demand for GPV systems—and certainly information about GPV systems—appears to be outstripping the supply. As more information becomes available, and as the technology matures even further, the market is expected to grow. Companies need to effectively expand their thinking and enlarge their activities to take full advantage of the opportunity that exists. Ease of financing and strong warranties are keys to PV market development. Companies need to address potential customer concerns about operating reliability. Business strategies should be well founded in the current research on Colorado residential markets.

Develop marketing strategies around important themes—To be effective, marketing strategies— particularly those employed by utility companies—should focus on the major benefits of GPV purchase that will appeal to the most likely customers. In particular, environmental benefits, financial advantages, and trendsetting should be initially stressed to attract the early adopters.

Actively market to more affluent homeowners—Homeowners with discretionary income are the most likely purchasers, especially households in the upper-middle-income category. Individuals identified in Chapter 7 as ***Pacesetters*** and ***Steady Positives*** should be targeted, with special emphasis given to male heads of households.

Be straight with customers—Information about potential problems, questions, and concerns should be included in marketing presentations and materials, in addition to a fair assessment of the benefits and advantages of the technology. Accurate customer expectations will help ensure overall customer satisfaction with GPV purchases and enhance the PV industry's reputation.

Educate and inform—Not surprisingly, Colorado homeowners are uncertain about GPV technology, even though they are favorable to the overall concept. Much more information is needed, especially through opportunities to see the technology firsthand, and to talk with those who have already experienced its use. Demonstrations, model GPV homes, and home show events are key needs, along with attractive and informative printed materials.

Make GPV available through green-pricing options—An approach that appeals to a substantial number of homeowners is the availability of a voluntary, optional choice to acquire systems by paying a slightly-to-somewhat higher cost for electricity than the cost paid by conventional utility customers. Colorado utilities already offer voluntary green-pricing programs to customers who wish to promote the environmental benefits of renewable energy, and such programs could be adapted to advance the market for GPV. Because of their environmental activism, some customers may even participate in a green-pricing GPV without actually acquiring an on-site system. Financing options, including green-pricing, provided by the utilities themselves are favored mechanisms among Colorado homeowners for repayment of GPV purchases.

Roll GPV purchase options into home mortgages—GPV option packages can be a market differentiating tool for builders. Through energy-efficiency financing, builders can offer purchasers of energy-efficient new homes the option of a GPV system that can be financed through a loan having potentially more advantageous terms. To offer such option packages, builders and their sales staffs need to be fully informed about GPV technology in order to provide customers with realistic expectations about their performance, costs, and benefits. Such offers would help distinguish GPV option packages from other amenities offered without advantageous mortgage terms.

Lenders

Because a market for GPV technology currently exists in Colorado, the state's lenders have the opportunity to differentiate themselves by developing expertise in innovative on-site electricity generation technologies such as GPV. Current policies of the Federal Housing Administration (FHA), the Federal National Mortgage Association (Fannie Mae), and the Federal Housing Loan Corporation (Freddie Mac) promote energy-efficient mortgages, and these can be adapted to include the financing of GPV systems. Loan officers and underwriters need to be fully informed about the costs and benefits of both standalone and grid-tied PV systems.

State Policy Makers

Involve utility companies—Colorado homeowners perceive their utility companies—and not state agencies—to be the experts on GPV technology and systems. To stimulate the marketplace, government policies concerning GPV and other renewable energy technologies need to be formulated with this reality in mind.

Implement a net-metering policy—The Public Utilities Commission has the authority to mandate a net-metering policy for the investor-owned utilities it regulates. A net-metering policy would hasten the overall development of the GPV market and considerably increase the near-term potential. A net-metering policy requiring retail buyback rates beyond zero would facilitate market development even further.

Develop industry support mechanisms—Tax considerations, business incubators, and similar mechanisms will underscore for Colorado homeowners the state's support for the technology and for the industry as a whole. GPV represents a relatively new industry that can contribute jobs to the local economy, and homeowners would be more apt to participate knowing the technology enjoys widespread support.

Implement rate-basing of GPV cost—In regulated utility markets, rate-basing would make GPV systems even more affordable to homeowners. All conventional fuel sources for electricity production have been rate-based, and residential customers tend to favor rate-basing of PV as well. Protection for lower-income customers against price increases should be weighed in this decision.

Implement PV-friendly legislation—Because the results of the present study suggest considerable support for GPV in Colorado, the state's governing bodies should consider implementing PV-friendly legislation. Such legislation should encompass not only net metering, but consideration of other factors such as a systems benefit charge for subsidization of GPV systems, portfolio standards, and utility restructuring.

Promote GPV profitability for utility companies and PV manufacturers—To become a sustainable enterprise, GPV technology must ultimately become profitable to the companies involved—principally the utilities and PV manufacturers. Profitability-ensuring policies should be devised and implemented at the state level in order to sustain and enhance the economic viability of the technology, and by extension, the overall market.

State and Local Energy Offices

Implement educational and informational programs for consumers—Many utility customers do not realize they can purchase GPV systems. To stimulate the market for GPV, more needs to be done to increase the knowledge base. Also, to make informed energy decisions, citizens need information about energy in general and about the fuels used to produce the state's electricity. In addition to written materials, audio-visual programs, and other conventional consumer outreach materials, providing a web-based network of GPV users and interested parties would prove particularly effective in informing and educating consumers. Use of conventional forms of advertising should also be investigated.

Reinstate the rebate for GPV systems—The results of the present study suggest that a rebate—such as the rebate of up to $2,500 available to Colorado homeowners during 1999—will help to increase the size of the PV market and to stimulate overall development of the industry.[1] Absence of knowledge on the part of consumers, absence of aggressive marketing, and the requirement for custom evaluations of each home prior to GPV installation appear to slow market uptake. A well-marketed rebate program could help overcome these obstacles. In addition, the network capable of providing customized services associated with GPV installation is still modest in Colorado. Consequently, reinstatement of the rebate program would permit experience with the technology to increase and lead to further development of the overall market and the local PV industry.

Provide technical assistance to policy makers—Decision makers, such as those within the Colorado Public Utilities Commission and the state legislature, need a source of reliable information about GPV, as well as thorough economic, technological, and policy analysis, on which to base decisions that are sound and

---

[1]Rebates for PV system purchase were made available by the State of Colorado through the Colorado Solar Energy Industries Association. The $220,000 rebate program was fully expended during 1999, leaving a waiting list of applicants without funds. However, the Colorado Office of Energy Conservation and Management had no plans to continue the rebate program after January 1, 2000. Karen Renshaw of the Colorado Solar Energy Industries Association has prepared a report on the rebate program.

beneficial from a statewide perspective. State and local energy offices should provide ongoing support from technical staff so that knowledge about the GPV market can be effectively transmitted to state officials and incorporated into the legislative agenda.

Interested Parties and Consumers

Take advantage of rebates for GPV systems—Certain PV companies in Colorado have federally funded rebates available for customers. Participating in rebate programs is highly advantageous to consumers interested in acquiring GPV systems for home use.

Communicate and network—GPV purchasers relish the opportunity to talk among themselves and share their experiences. Prospective buyers desire input from homeowners who have already purchased systems. This is a good match of interests, because many GPV purchasers want to make others aware of the opportunity to own a system. A formal means of linking these homeowners would be welcome and useful. Consumers are encouraged to voice their interest and to seek assistance from organizations such as the Colorado Solar Energy Industries Association, Public Service Company of Colorado, the Western Area Power Administration, the National Renewable Energy Laboratory, the Colorado Office of Energy Conservation, and various municipal energy offices.

Engage in activism—Colorado homeowners who feel strongly about acquiring GPV systems must continue to press their utilities and the state agencies for access to the technology. For the overall market to grow, and for the industry to become a sustainable one, more consumers need to make their interests known. Otherwise, policy makers and corporate strategists may assume a viable market does not exist, and further progress will be impeded.

Final Summary Remarks

The creativity of organizations marketing GPV systems and devising policies to encourage the use of green power can and will result in many other actions to encourage the use of on-site electricity generation using PV systems tied to the utility grid. GPV systems and standalone PV systems have the potential to become an important energy market in Colorado. The degree to which that market develops, however, depends on the collective and sustained response of all concerned parties.

This study provides extensive information for those seeking to develop their own individual and organizational responses to the favorable GPV market climate that presently exists. Effectively employed, this information can serve as the basis for solidifying an industry that can have a substantial impact on the Colorado economy for many years to come.

Bibliography

Albrecht, Don, Gordon Bultena, Eric Hoiberg, and Peter Nowak. 1982. "The New Environmental Paradigm Scale." *Journal of Environmental Education, 13:* 39–43.

Buhrmann, Jan and Barbara C. Farhar. 1998. *Willingness to Pay for Renewable Energy: A Follow-up Study of Colorado Homeowners Interested in Residential Grid-Tied PV Systems.* Boulder: University of Colorado, Bureau of Sociological Research, December, 60 pp.

Cohen, Jacob and Patricia Cohen. 1983. *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences.* 2nd Ed. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Dillman, Don. A. 1978. *Mail and Telephone Surveys: The Total Design Method.* New York: Wiley, 325 pp.

Dillon, William R. and Matthew Goldstein. 1984. *Multivariate Analysis: Methods and Applications.* New York: John Wiley & Sons, 587 pp.

Dunlap, Riley E. and Kent D. Van Liere. 1978. "The 'New Environmental Paradigm': A Proposed Measuring Instrument and Preliminary Results." *Journal of Environmental Education, 9:* 10–19.

Farhar, Barbara C. 1999. *Willingness to Pay for Electricity from Renewable Resources: A Review of Utility Market Research.* NREL/TP-550-26148. Golden, CO: National Renewable Energy Laboratory, July, 20 pp.

Farhar, Barbara C. 1996. "Energy and the Environment: The Public View." *Renewable Energy Policy Project (REPP) Issue Brief,* No. 3. College Park: University of Maryland, October, 20 pp.

Farhar, Barbara C. 1994a. "Trends: Public Opinion about Energy." *Public Opinion Quarterly, 58:* 603–632.

Farhar, Barbara C. 1994b. "Trends in U.S. Public Perceptions and Preferences on Energy and Environmental Policy." *Annual Review of Energy and the Environment, 19:* 211–239.

Farhar, Barbara C. 1993. *Trends in Public Perceptions and Preferences on Energy and Environmental Policy.* NREL/TP-461-4857. Golden, CO: National Renewable Energy Laboratory, 376 pp.

Farhar, Barbara C. and Timothy C. Coburn. 1999. *Colorado Homeowner Preferences on Energy and Environmental Policy.* NREL/TP-550-25285. Golden, CO: National Renewable Energy Laboratory, June, 39 pp.

Farhar, Barbara C. and Ashley Houston. 1996. *Willingness to Pay for Electricity from Renewable Energy,* NREL/TP-460-21216, Golden, CO: National Renewable Energy Laboratory, September, 26 pp.

Farhar-Pilgrim, Barbara C. and Charles T. Unseld. 1982. *America's Solar Potential: A National Consumer Study.* New York: The Free Press.

Glaser, Barney and Anselm Strauss. 1967. *The Discovery of Grounded Theory: Strategies for Qualitative Research.* Chicago: Aldine Publishing Company.

Kinnear, Paul R. and Colin D. Gray. 1997. *SPSS for Windows Made Simple,* 2nd Ed., East Sussex, UK: Psychology Press, 386 pp.

Kleinbaum, David G. and Lawrence L. Kupper. 1978. *Applied Regression Analysis and Other Multivariable Methods.* North Scituate, MA: Duxbury Press.

Leonard-Barton, Dorothy. 1978. *The Diffusion and Adoption of Solar Equipment Among California Homeowners: Report on a Pretest Study.* Stanford, CA: Institute for Communications Research, Stanford University.

Leonard-Barton, Dorothy and E.M. Rogers. 1979. "Adoption of Energy Conservation Among California Homeowners." White paper, Department of Communications. Stanford: Stanford University.

Merton, Robert. 1990. *The Focused Interview: A Manual of Problems and Procedures.* 2nd Ed. New York: The Free Press.

Morrison, Donald F. 1976. *Multivariate Statistical Methods.* 2nd Ed. New York: McGraw-Hill Book Company.

Rogers, Everett M. 1995. *Diffusion of Innovations.* 4th Ed. New York: The Free Press, 519 pp.

Rogers, Everett M. and F. Floyd Shoemaker. 1971. *Communication of Innovations.* 2nd Ed. New York: The Free Press.

Starrs, Thomas J. 1996. "Net Metering: New Opportunities for Home Power." *Renewable Energy Policy Project (REPP) Issue Brief,* No. 2, College Park: University of Maryland, September, 11 pp.

Appendix A. Respondent Characteristics (Demographics, Values and Lifestyles, and Other Variables)

Appendix A
Respondent Characteristics
(Demographics, Values and Lifestyles, and Other Variables)

A number of items pertaining to respondent characteristics were included in the questionnaire. These included gender, age, marital status, income, household structure, rural or urban location, occupation, educational attainment, geographic locale within the state, prior experience with efficiency and renewables, lifestyle and values. Appendix A discusses the findings and presents the data tables on these respondent characteristics.

Gender

At the beginning of the questionnaire's section on demographics, the instructions said: "*If two people have completed the questionnaire together, please select one head of household for answering the questions [about yourself and your household]*." In response to this instruction, more households selected "male" than "female" to characterize the head of household, even though both partners may have been involved in completing the questionnaire. Sixty-six percent indicate male and 34% female heads of household (Table A-1).[1]

Age

Home ownership is an adult characteristic. A majority of the sample are 25 to 49 years of age (53%); 31% are 50 to 64 years of age. Fifteen percent are 65 years of age or older, and only 1% are 24 years old or younger (Table A-2).

Marital Status

Most (79%) of the respondents are married; 21% of the respondents are unmarried (Table A-3).

Annual Household Income before Taxes

Nearly one-third of respondents (31%) have annual incomes between $50,000 and $75,000—the modal response. Twenty-eight percent have incomes ranging from $25,000 to $50,000 per year. Sixteen percent have incomes from $75,000 to $100,000 per year, and the incomes of another 16% exceed $100,000 per year. Nine percent of homeowners have annual incomes below $25,000 (Table A-4).[2]

---

[1]Telephone conversations with respondents showed that, in at least some cases, both husbands and wives completed the questionnaire together.

[2]Various occupations are linked with the highest income level ($150,000 annual income), including farm owners/managers, housewives, managers and executives, professional workers, self-employed, and unemployed (probably those with independent means).

Household Composition

Forty-one percent of households comprise two adults. Thirty-nine percent of households have two adults with children. Thirteen percent are single-adult households and 3% are single-parent families. Five percent of households comprise three or more adults or three or more adults with children (Table A-5).

Rural or Urban Location

Forty-six percent live in cities or suburbs with more than 100,000 in population. Approximately one-third (32%) live in towns, cities, or suburbs with populations of 10,000 to 100,000 people. Eleven percent live in rural areas, but not on farms, while only 2% live on farms (Table A-6).

Occupation

Professional workers comprise 27% of the respondents. Almost one-fifth of the respondents (18%) are retired. Fifteen percent are managers, executives, or officials, and 11% are skilled trade or craft workers. Nine percent own their own businesses and 5% are employed in retail or wholesale sales or real estate. Four percent are local government employees (such as police officers and firefighters) and 4% are clerical or office workers. Service workers, laborers, farmers, and farm workers comprise the balance of the respondents (Table A-7).

Educational Attainment

One-fifth of the respondents' households have completed a master's degree or further graduate work, while 5% have completed their doctorates. Half have completed at least a bachelor's degree. At least 73% have completed some college education, even if they have not graduated. Seven percent have a trade or technical school certificate, and 6% have an associate's degree (Table A-8). These results may be a function of the questionnaire itself. Because it was long and dealt with a somewhat unfamiliar and fairly technical topic, respondents had to be literate enough to be able to complete it. Therefore, the findings may slightly overrepresent the views of the somewhat more educated households in the state.

Geographic Locale

As would be expected, 62% live in the greater Denver/Boulder area, and 13% live in the greater Colorado Springs area. Another 10% live in the Fort Collins, Loveland, or Greeley areas. Four percent live in the greater Pueblo area, 4% on the Eastern plains, and 4% on the Western slope other than in Grand Junction. Three percent live in the Grand Junction area (Table A-9.)

Political Orientation

Respondents were asked, *"Regardless of your party identification, how would you rate yourself politically on a 1-to-10 scale, from very conservative to very liberal?"* The mean score is 4.78, indicating an overall conservative orientation. The plurality (45%) rates itself as very conservative or conservative (1–4 on a 10-point scale); 33% rate themselves as "middle-of-the-road" politically (5 or 6 on a 10-point scale); and 22% indicate that they are liberal or very liberal (7–10 on a 10-point scale) (Table A-10).

Primary Heating Fuel

Most (81%) use natural gas as their primary heating fuel. Another one in eight use electricity for heating. Fifteen respondents say that solar is their primary heating fuel (Table A-11).

Likelihood of Moving

A majority (59%) say they are unlikely or very unlikely (1–4 on a 10-point scale) to move in the next few years. The mean score is 4.18. Thirty-one percent indicate that they are likely or very likely to move (7–10 on a 10-point scale) (Table A-12).

Utility Company

The respondents were asked to identify their utility company, and the range of responses given is comparable to the population distribution of the utility service territories across the state. Sixty-five percent identify Public Service Company/New Century Energy as their utility company (Table A-13).

Lifestyle and Values

Based on prior research on the diffusion of innovations and on opinions about renewable energy, data were collected on several variables hypothesized to be related to favorability toward GPV. These included lifestyle and values (such as environmentalism and self-sufficiency) (Leonard-Barton 1978; Leonard-Barton and Rogers 1979) and innovativeness and opinion leadership (Rogers 1995).[3] Table A-14 shows data on these variables.

Forty-six percent indicate that they are willing to accept modifications to their lifestyle if it helps the environment (6, 7, or 8 on an 8-point scale); 34% indicate that they are in the middle-of-the-road (4 or 5 on an 8-point scale); and 20% indicate they would not accept such modifications (1, 2, or 3 on the scale). The mean score on being likely to modify lifestyle to protect the environment is 5.22 (Table A-14).

Forty-one percent indicate that they buy environmentally friendly products even if they cost somewhat more; 37% are in the middle, and 22% indicate that they do not. The mean score of 4.9 on a 1-to-8 scale is in the favorable range (Table A-14).

A majority (70%) indicate that they like to be as independent as possible so as not to rely upon others to meet their needs (Table A-14). The mean score on an 8-point scale is 6.3. A majority (56%) also say they like to experiment with new ways of doing things (the measure of innovativeness used in this study) (Table A-14). The mean score on innovativeness is 5.6. A majority of 54% also indicate that they are seen as leaders in work life, social life, or volunteer activities (the measure of opinion leadership used in the study) (Table A-14). The mean score on opinion leadership is 5.5.

[3] Although there were plans to do so, there was insufficient space in the questionnaire to measure respondent values using the scale for the New Environmental Paradigm (Dunlap and Van Liere 1978; Albrecht, et al. 1982). The items included defined factors resulting from the Leonard-Barton and Leonard-Barton and Rogers studies on voluntary simplicity cited above.

Experience with Efficiency and Renewables

Although familiarity with at least some efficiency and renewables technologies is fairly extensive among respondents, actual experience with these technologies is quite limited.[4] Majorities are familiar with wood stoves to heat homes (66%) and energy-efficiency retrofits (such as added insulation and double-pane or low-e windows) (59%). Forty-one percent are familiar with passive solar design, 38% with active solar thermal systems to heat water, and 35% with solar thermal systems to heat homes. More than one in four indicate familiarity with wind machines to produce electricity; 27% indicate familiarity with solar swimming pool, hot tub, or spa heating; 24% are familiar with solar greenhouses; and 23% indicate familiarity with solar cells (PV) to produce electricity *not tied* to the utility grid. More than half (54%) say they are not familiar with standalone PV systems and approximately half are unfamiliar with solar greenhouses and solar panels to heat swimming pools, hot tubs, or spas (Table A-15).

Few respondents report current or previous ownership of any of the nine listed renewables and efficiency technologies. Seventeen percent say they own or have owned wood stoves to heat their homes; 11% claim current or prior ownership of energy-efficiency retrofits. Seven percent indicate they currently own or have previously owned active solar hot water systems, 6% homes with passive solar design, and 4% active solar heating systems. One percent claim current ownership and one percent claim previous ownership of PV systems (Table A-15).

[4] The questionnaire asked about experiences with a list of nine technologies, including standalone PV systems to produce electricity; solar panels to heat water for homes; solar panels to heat homes; wind machines to produce electricity or pump water; passive solar design; solar panels to heat swimming pools, hot tubs, or spas; energy-efficiency retrofits; and wood stoves to heat homes.

Table A-1. Gender

Response categories	%
Male	66
Female	34
Totals	100
Base n*	2706

*"Base n" is used to refer to the total number of respondents answering a question; it is therefore the denominator used in calculating the percentages of responses in each category.

Table A-2. Age

Response categories	%
24 years or under	1
25 to 49 years	53
50 to 64 years	31
65 years or over	15
Totals	100
Base n	2764

Table A-3. Marital Status

Response categories	%
Married	79
Never married or no longer married	21
Totals	100
Base n	2746

Table A-4. Annual Household Income before Taxes

Response categories	%
Under $15,000	2
$15,000 to $24,999	7
$25,000 to $49,999	28
$50,000 to $74,999	31
$75,000 to $99,999	16
$100,000 to $150,000	11
Over $150,000	5
Totals	100
Base n	2596

Table A-5. Household Composition

Response categories	%
One adult	13
Two adults	41
Two adults and children	39
One adult and children	3
Three or more adults	3
Three or more adults and children	2
Totals	101*
Base n	2490
*Percentages do not add to 100 because of rounding.	

Table A-6. Rural or Urban Location

Response categories	%
City or suburb with more than 100,000 people	46
Small town, city, or suburb with 10,000 to 100,000 people	32
Small town, city, or suburb with less than 10,000 people	9
Rural area, but not a farm	11
Farm	2
Totals	101*
Base n	2766
*Percentages do not add to 100 because of rounding.	

Table A-7. Occupation

Response categories	%
Professional worker (lawyer, doctor, scientist, teacher, systems analyst, musician, etc.)	27
Retired	18
Manager, executive, or official (in business, government agency, or other organization)	15
Skilled trade or craft worker (machine operator, technician, printer, baker, plumber, mechanic, carpenter, hairdresser, etc.)	11
Self-owned business	9
Sales professional or retail sales (real estate, manufacturer's representative, other retail or wholesale business)	5
Local government employee who provides services for the community (police officer, firefighter, city or county official)	4
Clerical or office worker	4
Service worker (assembly line worker, truck driver, taxi driver, waitperson, etc.)	2
Laborer other than farm (construction worker, plumber assistant, other physical work)	2
Farmer (farm owner, farm manager)	1
Farm foreman, laborer, or helper, homemaker, student, unemployed, and other (combined)*	2
Totals	100
Base n	2747

*Other includes federal/state employee and military.

Table A-8. Educational Attainment

Response categories	%
Doctoral degree	5
Work beyond the master’s, but no degree	4
Master’s degree	11
Some graduate work, but no degree	9
Bachelor’s degree	21
Trade or technical school certificate	7
Associates degree	6
Some college, but no degree	22
High school graduate or equivalent	13
Elementary school through some high school	2
Totals	100
Base n	2755

Table A-9. Geographic Locale

Response categories	%
Greater Denver/Boulder area	62
Greater Colorado Springs area	13
Ft. Collins/Loveland/Greeley area	10
Greater Pueblo area	4
Eastern Plains	4
Other Western Slope	4
Grand Junction area	3
Total	100
Base n	2745

Table A-10. Political Orientation

Response categories (1-10 scale)	%
Very conservative (1-2)	15
Conservative (3-4)	30
Middle-of-the-road (5-6)	33
Liberal (7-8)	18
Very liberal (9-10)	4
Totals	100
Base n	2701

Table A-11. Primary Heating Fuel

Response categories	%
Natural gas	81
Electricity	12
Propane	5
Wood	2
Solar*	1
Fuel oil, other	–**
Totals	101***
Base n	2769

*Fifteen respondents in the primary sample say solar is their primary heating fuel.
** < 0.5%.
***Percentages do not add to 100 because of rounding.

Table A-12. Likelihood of Moving

Response categories (1-10 scale)	%
Very unlikely (1-2)	46
Unlikely (3-4)	13
In between (5-6)	10
Likely (7-8)	14
Very likely (9-10)	17
Totals	100
Base n	2608

Table A-13. Utility Company

Response categories	%
Public Service Company/New Century Energies	65
Colorado Springs Utilities/El Paso Electric	9
REA/IREA	9
West Plains	3
Mountain View Electric	2
Fort Collins Municipal Utility	2
United Power	1
Delta Municipal Light and Power	1
Longmont Electric	1
Loveland Department of Water and Power	1
Other*	7
Totals	101**
Base n	2423

*Mentioned by fewer than 1% are Center Municipal Light and Power, Empire Electric, Estes Park Light and Power, Fort Morgan Electric, Fountain Municipal Light, Glenwood Springs Electric, Grand Valley Power, Greeley Gas, Gunnison Municipal Light and Power, Holyoke Municipal Light and Power, La Junta Municipal Utilities, Lamar Utilities Board, La Plata Electric, Las Animas Municipal Light and Power, Lyons Municipal Light and Power, People's Natural Gas, Trinidad Municipal Light and Power, City of Ouray, Yuma Municipal Light, and other utilities. One respondent says he/she has no utility company.
**Percentages do not add to 100 because of rounding.

Table A-14. Lifestyle and Values

Willing to accept modifications to lifestyle if it helps environment	
Response categories (1–8 scale)	**%**
Agree (6, 7, 8)	46
Middle-of-the-road (4 - 5)	34
Disagree (1, 2, 3)	20
Totals	100
Base n	2636

Buys environmentally friendly products even if they cost somewhat more	
Response categories (1–8 scale)	**%**
Agree (6, 7, 8)	41
Middle-of-the-road (4 - 5)	37
Disagree (1, 2, 3)	22
Totals	100
Base n	2678
Likes to be as independent as possible so as not to rely upon others to meet needs	
Response categories (1–8 scale)	**%**
Agree (6, 7, 8)	70
Middle-of-the-road (4, 5)	21
Disagree (1, 2, 3)	9
Totals	100
Base n	2706
Likes to experiment with new ways of doing things	
Response categories (1–8 scale)	**%**
Agree (6, 7, 8)	56
Middle-of-the-road (4, 5)	30
Disagree (1, 2, 3)	14
Totals	100
Base n	2681

Table A-14. Lifestyle and Values, cont'd.

Seen as leader in work life, social life, or volunteer activities	
Response categories (1-8 scale)	**%**
Agree (6, 7, 8)	54
Middle-of-the-road (4, 5)	30
Disagree (1, 2, 3)	16
Totals	100
Base n	2587

Table A-15. Experience with Renewables and Efficiency

Type of equipment	Tends *not* to be familiar (1-3) %	Mixed/ unsure (4-5) %	Tends to be familiar (6-8) %	Owned previously (9) %	Own now (10) %	Totals	Base n
Wood stoves to heat homes	18	17	49	10	7	101*	2632
Energy-efficiency retrofits (such as added insulation, double-pane or low-E glass, energy-efficient lighting, energy-efficient appliances)	22	20	48	2	9	101*	2627
Passive solar design	35	24	35	2	4	100	2607
Solar panels to heat water for homes	39	26	31	4	3	100	2626
Solar panels to heat homes	39	27	31	2	2	101*	2625
Wind machines (or windmills) to produce electricity or pump water	44	28	27	1	--**	100	2603
Solar panels to heat swimming pools, hot tubs, or spas	49	23	26	1	--**	99*	2579
Attached solar greenhouses to heat homes	52	24	23	1	–	100	2575
Solar cells (PV) to produce electricity ***not tied*** to the utility grid	54	24	21	1	1	101*	2583

*Percentages do not add to 100 because of rounding.
**Less than 0.5%.

Appendix B. Research Approach

Appendix B
Research Approach

The quantitative survey was the final step in the market assessment. Its intent was to develop survey findings on opinion toward GPV among Colorado homeowners that could be generalized to the entire state. The purpose was to estimate the size of the residential market for GPV and to describe the potential market's characteristics, its reasons for adoption, its concerns, and its preferred policies and marketing approaches.

The research plan and data collection instruments were approved by the University of Colorado Human Research Committee.

As indicated below, the study involved the development and administration of two parallel survey efforts. Results of the principal survey are described in the main body of this report. Results of the secondary survey are reported in Farhar and Coburn (1999). From a research standpoint, however, the two efforts were highly interrelated; consequently, details of the research methodology established for the two parallel efforts are presented in this appendix.

Appendix Highlights

- Probability sample of Colorado homeowners on GPV
- Data collected by mail questionnaire
- 3,001 respondents
- 60% response rate
- $\pm$ 1.65% margin of error
- Representative sample
- Data collected summer 1998
- Approach to the study's statistical analysis

Questionnaire Construction

The study's hypotheses, along with results from the Phase One qualitative interviews, guided construction of the survey questionnaires. The study's data collection instruments were written "from scratch." To help guide the team, a set of 3-ring notebooks was organized containing items from earlier public opinion polls and studies of national and local area samples (such as Farhar-Pilgrim and Unseld 1982), as well as tables containing the findings from the qualitative interviews and other ideas for questions, one to a page. The items were grouped by the study's major dependent and independent variables, as well as by demographic, lifestyle, and values measures. The research team and consultants reviewed these collections of items, data, and ideas, and narrowed the selection for the first draft of the data collection instrument.

The number of items in the early drafts of the questionnaire far exceeded the number that could reasonably be included. The questionnaire was reviewed and revised sequentially by the team, and items were prioritized; many were removed. However, no data existed on which of the many perceived benefits and barriers items could be omitted without weakening explanatory power. Therefore, a complete set of each of these variables was retained. After numerous drafts had been produced, the decision was made to develop two separate questionnaires. The main one focused on GPV and the secondary one (termed the "optional" questionnaire[1]) addressed broader but related issues on energy, the environment, utility restructuring, and attitudes toward utility companies. This occurred because the broader issues were considered important and theoretically relevant, but the main questionnaire was already too long to include them. It was decided that a small probability sample of selected homeowners (married couples with annual incomes of at least $50,000) would perhaps be willing to complete these extra questions.

The two instruments were further developed, reviewed, revised, and pretested by approximately 20 homeowners who were unaffiliated with the project. The main questionnaire took a minimum of 35 to 45 minutes to complete and the optional questionnaire took approximately 10 minutes. Questions were revised on the basis of the pretests, and the instruments were finalized. The entire process took approximately 11 months. Appendix J contains the main questionnaire, and the optional questionnaire is contained in Farhar and Coburn (1999).

Sampling

The study was designed to gather data from a probability sample of Colorado homeowners permitting generalization of findings to the universe of homeowners in the state. Because homeowners were expected to know little about GPV, and because estimates of GPV system cost presented in the data collection instrument were much higher than conventional electricity costs, a very small "participation rate" was expected; that is, the expected rate of respondents interested in purchasing GPV at market value was expected to be less than ½ of 1%. In addition, because a realistic estimate of the size of the GPV market was a study goal, a very low margin of error was required. Therefore, the sample size thought to be needed was quite large—larger than for most national probability samples.

Sample Sizes

The study design required two different samples to be selected—a primary sample of single-family households for purposes of receiving a mail survey about GPV, and a separate oversample of single-family households, the owner-occupants of which were mailed the same GPV survey along with additional general questions pertaining to utility restructuring, comparative energy preferences, and environmental concerns. The sample sizes were dictated by analytic needs for subgroups of sufficient size and by the overall level of precision required. A primary sample size of 3,041 was determined using a participation rate of ½ of 1%, or .005, for an estimated margin of error of 0.0025, with a projected 35% nonresponse.[2] Other assumptions used in calculating the sample size were a 90% postal deliverability rate (defined by the R.L. Polk Company), and an estimated contamination rate of 2% townhomes and condominiums on the sample list which would disqualify them (because they could not be completely removed from the sampling frame prior to sampling). These factors increased the necessary sample size to 5,532. The same approach was used to estimate the sample size for the oversample, resulting in an oversample size of 555.

---

[1]Actually, all questionnaires are optional in that potential respondents always have the option to complete or refuse to complete any questionnaire or interview.

[2]Researchers anticipated that very few respondents would respond favorably to the idea of purchasing GPV systems at realistic market prices; therefore, the sample was designed to have a very small margin of error to "pick up the signal from the noise."

Drawing the Sample

The target population consisted of owner-occupied single-family dwelling units in the State of Colorado. A sampling frame was constructed from the *Totalist Flat File* maintained by the Polk Company. The multiple sources of this file include, for example, county assessor records and warranty cards on products returned by consumers to manufacturers. Omitted from the frame were individuals known to reside in condominiums, town homes, apartments, trailers, and mobile homes. Military housing and Native American reservation general delivery addresses were also excluded. The resulting sampling frame consisted of 624,321 households. Each entry was assigned a sequence number from 1 to 624,321. To draw the primary sample, a table of random numbers was prepared by sampling 5,532 numbers without replacement from a uniform distribution from 1 to 624,321. The random numbers were then applied to the sampling frame, and the 5,532 households whose sequence numbers were found in the table of random numbers were drawn for the primary sample.

For purposes of selecting the oversample, a new sampling frame was created from the households not chosen for the primary sample, with the additional requirement that the records would represent married couple households with annual incomes of $50,000 or greater. This sampling frame contained 178,381 records, to which a new sequence number ranging from 1 to 178,381 was applied. An interval selection method was used to draw the sample from this revised frame.

The sampling interval was calculated by dividing the total size of the sampling frame (178,381) by the required size of the sample (555). This yielded a sampling interval of 321 (rounded down from 321.41). The starting point for sampling was determined by dividing the sampling interval by four and rounding up to the next whole number. By this calculation, the starting point was found to be 81. Thus, the household with sequence number 81 was the first household selected for the oversample, and then every 321st numbered household thereafter was selected (402, 723, 1044, etc.). This sampling method actually yielded 556 records, the result of rounding down the calculated sampling interval.

A listing of the sampled households (name and address) was provided in ASCII format to Direct Marketing Designs, Inc., the list broker firm responsible for data processing of the list and mail handling. The final sample sizes were 5,532 for the primary sample and 556 for the oversample, totaling 6,088. The principal questionnaire was mailed to all 6,088 of these households. The 556 households in the oversample also received the additional questions.

As previously noted, responses were obtained from 2,709 in the primary sample and 292 in the oversample. (Ten of these 3,001 were ultimately eliminated from consideration.)

Response Rate and Margins of Error

To one degree or another, the response rate of a survey affects the respresentativeness of responses obtained from the sample. Sample sizes are determined in such a way as to guarantee a certain level of statistical precision, and when elements of the sample fail to respond, additional, unplanned uncertainty is introduced. Response rates can be legitimately computed in a number of ways, depending on the survey objective. For the present study, the response rate represents the ratio of the total number of responses received (whether completed or not) to the total number of deliverable questionnaires.

Margin of error, or maximum error of estimation, is an indicator of the overall precision of a statistical estimator obtained from a sample. Margin of error depends on the effective sample size, the presumed variance of the estimator, and the confidence level desired. In the present study, margin of error applies to the percentage of individuals indicating a favorable response on any given survey question.

For the primary sample, the response rate is approximately 60% and the margin of error for the response on any individual question is approximately ±1.65% (with 95% confidence). For the oversample, the response rate is approximately 60% and the margin of error for the response on any individual question is approximately ±5.16% (with 95% confidence).

The original assumption that the sample list included only 2% of ineligible entries—for example, townhomes, rented homes, and military housing—proved to be optimistic. In fact, 5.19% of the returned questionnaires were marked as ineligible by the potential respondents themselves. As a result, at least 925 of the original size is presumed to have been ineligible, making the actual number of potential respondents in the primary sample closer to 4,600.

The margin of error for the primary sample is excellent for the purpose of estimating the size of the GPV market among Colorado homeowners—well below the margins of error for most national probability samples. Actual margins of error for some representative questions are shown in Table B-1.

Table B-1. Margins of Error for Selected Dependent Variables

Variable	Quantified Response	Value (%)	Margin of Error (%)	Responses (n)
System size/price tradeoffs	Percent who would purchase some kind of system	44	1.85	2784
Willingness to pay, Scenario A	Percent who would pay something more per month, 15% system	74.1	1.64	2722
Willingness to pay, Scenario B	Percent who would pay something more per month, 50% system	77.7	1.56	2714
Willingness to pay, Scenario C	Percent who would pay something more per month, 100% system	77	1.58	2722
Likelihood of purchase, Scenario D	Percent who responded positively to no-added-cost system	74.2	1.63	2745
Average			1.65	

The response rates are also quite good, relative to similar kinds of large-scale surveys. The relatively high response rate may have resulted, in part, from the fact that respondents received their questionnaires and mailings from the University of Colorado, Boulder, and mailed their responses to the university, which added scientific credibility to the project.

Data Collection

Data were collected over a span of six weeks. Upon receiving the list of sampled households, Direct Marketing Designs, Inc., processed the mailing list data and subcontracted the mailings to a mail handling firm, The Address Pro, Inc. Five different mailings were sent to households on the lists of sampled addresses between May 15 and July 10, 1998, and responses were recorded on questionnaires received between May 28, and July 31, 1998. The five mailings, sent from the University of Colorado in Boulder, consisted of the following:

5/15/98 — A postcard alert. The postcard addressed households in the study and informed them that they were part of the scientific sample (n = 6088)

5/27-28/98 — The main questionnaire package. This package included:

- A cover letter
- A sheet with four pictures of PV systems printed front and back (included in this report)
- Two crisp one-dollar bills paper-clipped to the front of the package
- The main questionnaire of nine pages (a copy printed on white paper was sent to the primary sample and on yellow paper to the oversample)
- A blank 4" x 6" white envelope within which respondents could seal their completed questionnaires before mailing
- A postage paid 5" x 7" business reply envelope with the respondent's return address in the upper right-hand corner, permitting nonrespondents to be removed from the list
- *(For the oversample only)* An "optional" questionnaire of four pages offering an entry in a $100 lottery if respondents opted to complete this additional questionnaire (printed on yellow paper).

6/10/98 — Reminder follow-up postcard sent to nonrespondents (n = 5,119)

6/23/98 — First-class reminder follow-up letter sent to nonrespondents (n = 3,758)

7/10/98 — Final questionnaire packet sent to nonrespondents (n = 3,128). This mailing included a cover letter offering nonrespondents completing their questionnaires by July 31, 1998, a chance at a $100 lottery, the main questionnaires, the optional questionnaire (non-respondents from the oversample only), and the return envelopes.

The cut-off for accepting completed questionnaires was July 31, 1998.

Six hundred and two dollars of the financial incentive money was returned to the project by both respondents and nonrespondents.

Reasons for Nonresponse

As part of the information provided in the survey mailings, all prospective respondents were supplied with a study contact name, telephone number, and mailing address. As a result, numerous calls were received from recipients. Various reasons were given for calling; for example, the addressee was deceased or had moved. Where appropriate, callers were referred to The Polk Company for correction or deletion of list entries. Because of mail delays or errors, many callers had received a follow-up mailing asking them to return the questionnaire even though they had already responded. These callers said that they had already returned their questionnaire and would like to be removed from the mailing list. Some callers explained that they would not be responding for various reasons which paralleled those provided by respondents in writing.[3]

Records were kept on reasons given for nonresponse written on questionnaires or in letters received separately (Table B-2). In general, most of the reasons given would not be expected to bias results in a favorable or unfavorable direction toward GPV, with the exception of those not interested in the subject matter (n = 44) and those older respondents who did not wish to complete the questionnaire (n = 25). If these respondents had completed the questionnaire, responses may have been slightly less favorable toward GPV than the findings reported.

Table B-2. Reasons for Nonresponse

Reasons given	**%**
Not interested	33
Too old, ill, or disabled to respond	19
Too busy; not enough time to respond	14
Deceased	13
Did not like questionnaire	8
Never respond to surveys	4
Caregiver for ill family member	3
Does not want to be on mailing lists	3
Is planning to sell home soon	2
Total	99*
Base n	133

*Percentages do not add to 100 because of rounding.

Source: Constructed by the authors.

Data Coding and Reconciliation

All returned questionnaires were received at the University of Colorado in the sealed return envelopes provided to the prospective respondents. Outer envelopes were opened and separated from the sealed white inner envelopes. The outer envelopes were delivered to Direct Marketing Designs, Inc., permitting removal of respondent addresses from the mailing list prior to the next mailing. The sealed inner envelopes were delivered to Alexander's Data Services, Inc., the firm responsible for data entry.

[3] These are impressions; records were not tallied for the approximately 200 telephone calls received about the survey.

Alexander's Data Services, Inc., developed the codebook, which was reviewed, revised, and approved by the principal investigator. Each questionnaire was assigned a unique respondent identification number. Questionnaires were checked and data were entered by two independent coders and checked by computer for consistency. All anomalies and inconsistencies were resolved. Data were stored in an ASCII file and delivered to the National Renewable Energy Laboratory (NREL) for analysis.

At NREL, staff imported the data into a Microsoft Excel spreadsheet file and then into an SPSS-8 (Statistical Package for the Social Sciences) file. The data were carefully checked and corrections made, and a new master data base file was prepared at each step. Electronic records were spot-checked against original data files and paper questionnaires to ensure accuracy and consistency.

At this point, all responses to the principal questionnaire, from both the primary sample and the oversample, were combined. Responses to the secondary questionnaire obtained from the oversample were separated out for analysis elsewhere (see Farhar and Coburn 1999).

Representativeness of the Study's Respondents

Whenever probability samples are selected at random, the question arises as to whether those samples are also representative of the population they are intended to reflect. The question is posed because, by the very nature of random selection, there is the *potential* to obtain samples that appear to be somewhat skewed in their composition, even when the likelihood of sampling error is low. Such situations don't arise very often, owing to the care that is taken to operationalize the sampling plan, but they *can* occur. Consequently, it is reasonable to ask whether the sample selected for the quantitative phase of this study (relative to the principal questionnaire) is, indeed, representative of Colorado residents.

The answer to the question in the particular context of this study has to do with the definition of the target population. Indeed, that definition encompasses all owner-occupants of single-dwelling structures in Colorado. No detailed, affordable source of information about this population is available; and so, about the best that can be done is to use a proxy population for comparison purposes.

The question about representativeness also has to do with nonresponse, because high rates of nonresponse adversely affect the final composition of the subset of the population used to estimate its characteristics, opinions, and attitudes (see the prior discussion of response rates). In every situation such as this, the most practical alternative is to regard the actual survey respondents as "the sample" for purposes of estimating population characteristics. Hence, the survey respondents, rather than the original random sample, become the subset to which questions about representativeness must be addressed.

This is the approach taken in this study to address the question of sample representativeness. The collection of sample respondents is taken to be "the sample," and a proxy for the target population is used for comparison purposes. The most readily available proxy consists of Colorado's 1990 census data.

The use of census data presents a particularly difficult challenge in comparison with the sample data because it is not possible to enforce, or screen on, this study's more restrictive household definition. In some cases, it is simply not possible to make direct comparisons on the basis of certain demographic characteristics—any results and conclusions made on the basis of such comparisons can only be approximate. In fact, because the target population was restricted to owner-occupants of single-dwelling structures, "the sample" was expected—and desired—to be differently composed than the broader Colorado population reflected by census data.

Because the sample is restricted to homeowners and no census data exist that are limited just to homeowners, meaningful comparisons could not be drawn between the sample results and census data on such individualistic demographic characteristics as gender, age, and income. For example, homeowners would be expected to be older than the total population of Colorado residents, have higher incomes, and have families with children or grown children. They would also be expected to have better-paying occupations than the population as a whole. These differences are borne out by this sample when compared with census data for the total Colorado population. However, it was reasonable to make comparisons between the sample and census data on the basis of geographic locale of residence, present type of home heating fuel, and utility service provider. These comparisons are presented below.

Geographic Location

Geographic locale, or area of residence, across the state is a characteristic for which a reasonably direct and reliable comparison can be made between the survey respondents and the general Colorado population. Table B-3 shows the comparative percentage distributions among seven areas of the state. Note the high degree of similarity between these distributions, indicating the survey respondents ("the sample") closely resemble the statewide geographic population pattern. The only discrepancies, if they can be called such, are that a somewhat higher percentage of survey respondents reside in the Denver/Boulder metropolitan area than does the general population (61.9% versus 56.2%, respectively), and a somewhat smaller percentage of the survey respondents reside on the Western Slope (other than in the Grand Junction area) than does the general population (3.5% versus 9.4%, respectively).

Table B-3. Comparison of Distributions of Percentages of Households Living in Various Geographic Areas of Colorado

Geographic location	Colorado population (%)	Survey respondents (%)
Denver/Boulder	56.20	61.90
Colorado Springs	12.40	13.40
Fort Collins	9.60	10.00
Grand Junction	2.80	3.10
Other Western Slope	9.40	3.50
Pueblo	3.70	4.30
Eastern Plains	5.60	3.90

Source: Constructed by the authors.

Primary Heating Fuel

The principal type of heating fuel used in homes is another characteristic for which a more direct and reliable comparison can be made between the survey respondents and the general Colorado population. Table B-4 shows the percentage distribution of use among seven different fuels. Again, there is a high degree of similarity between the survey respondents and the general Colorado population in 1990 regarding fuel use—a slightly higher percentage of survey respondents use natural gas as their primary heating fuel than does the population in general (81% versus 77%, respectively), but the percentages of survey respondents and the general population using electricity and propane are essentially equivalent (for electricity, 11.5% versus 12.9%; for propane, 4.7% versus 4.8%). This finding would indicate the survey respondents ("the sample") adequately reflect heating fuel use among the Colorado population in general.

Table B-4. Comparison of Distributions of Percentages of Households Using Various Fuels as Their Primary Heating Sources

Primary Heating Fuel	Colorado population (%)	Survey respondents (%)
Natural gas	77.01	81.00
Electricity	12.87	11.50
Propane	4.77	4.70
Wood	3.30	2.00
Fuel oil	0.26	0.10
Solar	0.30	0.50
All other	1.46	0.30

Source: Constructed by the authors.

Utility Company

Finally, the nature of the surveys involved in this study makes it interesting to compare which utilities around the state are providing most of the power. There are many service providers to consider, and the list has been restricted to the six "major players" and an "all other" category. Among the six "major players," Public Service Company of Colorado provides service to a large majority of Colorado residents (roughly 70%). Table B-5 lists the percentages of the survey respondents served by each of the six entities and the "all other" category, and the corresponding percentages for the general population. The two distributions of percentages follow the same general pattern. However, the percentages of survey respondents who identified the six "major players" as their service providers are all slightly lower than the corresponding percentages for the general population; and a higher percentage of the survey respondents identified "other" service providers than the corresponding percentage for the general population. This is perhaps a reflection on the way in which service providers are defined, named, identified, or marketed to the customer.

Is the Sample Representative?

On the basis of characteristics that have to do more with the marketplace and industry structure than with individuals, the answer appears to be "yes." The survey respondents reflect geographic placement and economic attachment in the energy arena that are vital to the success of this study. For these reasons, and because of the way the sample was drawn, it is reasonable to conclude that the sample closely represents Colorado homeowners.

Table B-5. Comparison of Distributions of Percentages of Households Served by Various Utilities/Energy Providers

Service provider	Colorado population(%)	Survey respondents (%)
Public Service of Colorado	71.96	64.7
Colorado Springs Utilities	11.93	9.40
West Plains	5.37	2.80
Fort Collins	2.65	1.60
Longmont	1.92	0.90
Loveland	1.54	0.80
All other	4.67	19.8

Source: Constructed by the authors.

Statistical Analysis

A broad-based approach to statistical analysis of the data was taken. Considering each individual question as a stand-alone response item, descriptive statistics were prepared, including percentages, means, standard deviations, and coefficients of variation. Appendix C contains some of these statistical measures for all the survey questions as well as a description of some of the inferences that can be drawn from them. Such statistics were further computed for various demographic subsets of the respondents. In addition to the computation of descriptive statistics, a number of standard cross-tabulations were performed, comparing respondent demographic characteristics to responses on various questions. Use of Chi-square statistical significance tests helped guide the interpretation of these analyses. The results of this work are detailed throughout the main body of the report.

After concluding the descriptive assessment of the data, a number of multivariate statistical analyses were performed. To support the multivariate methods, a complete matrix of pairwise Pearson product-moment correlation coefficients between the survey questions was prepared, and pairs of questions (variables) having high correlations were examined for potential use in constructing and interpreting the multivariate analyses. Because of the size of the correlation matrix, it is not reproduced in this report. Care was taken to avoid multicollinearity among variables to the degree possible.

The first step in the multivariate analysis involved the use of factor analysis in an attempt to affect data reduction (the objective was to reduce the large number of survey questions down to a smaller collection of "factors" that could be used to more succinctly characterize responses to the survey). A conventional varimax factor rotation procedure available in SPSS-8 was used (see Kinnear and Gray 1997; Dillon and Goldstein 1984). The results of the factor analysis approach are described in Chapter 6.

Following determination of the most important factors, stepwise multiple regression was used to assess the predictive power of all independent variables (including the newly determined "factor" variables). The results of the regression analysis were also used to select variables for subsequent use in cluster analysis. All independent variables were standardized in advance. In most cases, the predictive power of various groups of independent variables was good or moderately good (R^2 values were at or below .65). It was possible to identify two or three subsets of variables that could reasonably be expected to explain a majority of the variability among all the responses on one or more of the dependent variables.

Finally, cluster analysis was used to categorize respondents into prospective market-based segments. Cluster analysis is the most important part of the data analysis because it helps establish the potential size of the market and it determines where GPV marketing strategies should likely be focused. Because of the large size of the data set, a k-means clustering algorithm available in SPSS-8 was used to perform the cluster analysis. Various combinations of variables were tested in the cluster analysis phase in order to arrive at the best possible segmentation results, with emphasis initially placed on variables identified in the regression analysis as "good" predictors. All variables evaluated in the cluster analysis phase, including "factor" variables, were standardized in advance. Numerous sensitivity runs were performed, contrasting the effects of changing one of two variables and of changing the number of clusters, until a single "best" set of clusters was determined. Various strategies (see Dillon and Goldstein 1984) were pursued for purposes of comparing cluster regimes and selecting the final "best" set, including cross-tabulation and Chi-square tests of significance, as well as conventional analysis of variance (ANOVA). The results of the cluster analysis work are described in Chapters 7 and 8.

Appendix C. Base n's, Means, Standard Deviations, and Coefficients of Variation for Scaled Responses

Appendix C. Base n's, Means, Standard Deviations, and Coefficients of Variation for Scaled Responses

Descriptive Statistics

This appendix presents descriptive statistics on the responses to all questions contained in the survey. For each question (or variable) contained in the survey, Appendix C presents the number of respondents, an average rating (average score assigned by all respondents), the standard deviation of all responses, and the coefficient of variation (CV) relating the standard deviation (variation in ratings or scores) to the corresponding average value.

The CV, stated in percent, is an index ranging in size from 0 to 100 that indicates the variability in a specific set of responses above and beyond the average response value. High CV values indicate excessive variation. Note, however, that because the survey responses constitute ordinal measurements (where a high average value is considered "good" and a low average value is considered "bad"), the CV can only be regarded as a relative measure, and care must be exercised when comparing different CV values.

For the most part, variation in responses is fairly stable across all questions (variables), with standard deviations ranging from a low of about 1.3 to a high of about 3.3, with a majority ranging from about 2.2 to 2.8. Though the standard deviations are stable, the average ratings fluctuate widely, depending on the degree of agreement or concurrence among the respondents. These results suggest that, for the most part, there is a fairly homogenous pattern to the way respondents answered the survey questions—that is, when they responded positively (or negatively) to a question, they all did so about the same way, with relatively little fluctuation. (Certainly there is no evidence of wide fluctuations in the way the respondents, as a group, answered the questions.) Relative to the representativeness of the sample, and to future marketing potential, this is a very supportive finding, because it indicates that conclusions and future actions based on the survey results are not likely to be off target in terms of the overall Colorado population of single-family households.

It is interesting to note response patterns among individual questions and groups of questions. For example, many of the questions for which the standard deviations of the responses are lowest are those having to do with information needs. The corresponding averages of the ratings assigned by the respondents are in the 8 to 9 range. The combination of these values would indicate that the respondents are strongly in need of additional information about GPV of various types and that most respondents feel about the same way. Similarly, there is a group of questions pertaining to perceived barriers for which the average respondent ratings are quite high, and the corresponding standard deviations are low—an indication that the respondents, as a group, see these barriers as important ones, and that there is very little deviation among the respondents relative to those perceptions.

Variables having average ratings under 4 on a 1-8 or 1-10 scale (indicating relatively small degrees of agreement or concurrence) are:

- Initial familiarity (with GPV)
- Perceived advantages—profitable for utilities
- Perceived barriers—friends and neighbors
- Excess electricity—donate to low-income customers

- Knowledge levels
- Information sources—lobbying organizations
- Information sources—green power marketing companies
- Prior experience—PV
- Prior experience—solar greenhouse
- Prior experience—solar panels for swimming pools, etc.

Summarizing this information, survey respondents on the whole had little initial familiarity with GPV (as expected); they did not see as advantages the fact of being the first on the block to have a GPV system or potential profitability for the public utilities; they do not consider what friends and neighbors will think as a barrier; they are not willing to donate excess electricity to needy customers; they have generally low knowledge levels; they do not see lobbying organizations or green power marketing companies as viable sources of information about GPV; and they have little prior experience with conventional PV systems, solar greenhouses, or solar panels for swimming pools and other recreational facilities.

Variables having average ratings of 9 or above on a 1-10 scale (indicating relatively high degrees of perceived importance) are:

- Product attributes—warranty on PV system
- Perceived barriers—initial system cost
- Perceived barriers—maintenance costs
- Perceived barriers—amount of electricity produced
- Perceived barriers—operating reliability
- Perceived barriers—reputability of PV manufacturer
- Perceived barriers—reputability of PV vendor
- Information needs—savings on utility bills
- Information needs—amount of electricity produced

The standard deviation for each of these nine variables is under 2, indicating relatively little fluctuation in response. Coupled with the high average ratings, it can be concluded that the respondents seem very clear about these nine items relative to the efficacy of GPV—a warranty on the system is essential, there are six real barriers to overcome, and there are two kinds of information that must be provided and corroborated.

Table C-1 lists six variables for which the standard deviations are 3 or more (the highest level of fluctuation, or uncertainty, in responses). The corresponding average ratings are also shown. Note that most of the average ratings would be classified in the "neutral" category. Clearly, the respondents were highly undecided about the usefulness of these items relative to the efficacy of GPV.

Table C-1. Variables with High Standard Deviations

Variables	Mean*	Std. dev.
Product attributes - options to do own installation	5.78	3.30
Product attributes - easily moved to next home	6.51	3.20
Information sources - friends	5.28	3.03
Information sources - libraries	5.51	3.01
Information sources - the Internet	5.32	3.29
Information sources - classes and workshops	5.36	3.04

*1-10 scale.

Source: Constructed by the authors.

The average responses and standard deviations associated with the remaining variables contained in Appendix C fall between these endpoints of consideration. Many individual questions/variables are insightful in and of themselves, but space considerations prevent a full accounting of their importance and contribution to the respondents' overall assessment of GPV.

The findings mentioned here are discussed in more detail in the main body of the report.

Table C-2 presents the statistics (valid n, mean, standard deviation, and coefficient of variation) for each of the study's variables.

Table C-2. Statistics*

Variable	Valid n	Mean	Std. dev.	Coeff. of variation
Initial Familiarity	2392	3.20	2.55	9.69
Initial Favorability	2353	7.51	2.58	34.35
Perceived Advantages - Reduce Electricity Bills	2443	8.34	2.19	26.26
Perceived Advantages - Sell Electricity to Utility	2371	7.66	2.59	33.81
Perceived Advantages - Long-Term Savings	2420	8.52	2.03	23.83
Perceived Advantages - Pay for Itself over 20 Years	2334	7.68	2.49	32.42
Perceived Advantages - Increase Resale Value of Home	2402	8.05	2.30	28.57
Perceived Advantages - Increase Self-Sufficiency	2403	7.52	2.56	34.04
Perceived Advantages - Makes Me Feel Good	2391	6.27	2.94	46.89
Perceived Advantages - Increase Awareness of Energy Use	2420	6.08	2.74	45.07
Perceived Advantages - Could Be First on Block	2403	2.75	2.59	94.18
Perceived Advantages - Chance to Make Difference in Community	2412	5.86	2.77	47.27
Perceived Advantages - New Technology to Enjoy	2410	5.02	2.94	58.57
Perceived Advantages - Electricity During Outage	2438	7.84	2.44	31.12
Perceived Advantages - Create and Expand PV Market	2374	5.32	2.94	55.26
Perceived Advantages - Profitable for Utilities	2331	3.86	2.86	74.09
Perceived Advantages - Encourage Others to Use Renewables	2419	6.84	2.72	39.77
Perceived Advantages - Increase Diversity of Energy Mix	2417	7.39	2.42	32.75
Perceived Advantages - Good for Colorado's Economy	2368	7.24	2.48	34.25
Perceived Advantages - Create Jobs	2356	7.27	2.54	34.94
Perceived Advantages - Protect the Environment	2455	8.26	2.28	27.60
Perceived Advantages - Conserve Natural Resources	2461	8.41	2.15	25.56
Perceived Advantages - Reduce Local Air Pollution/Acid Rain	2426	8.45	2.23	26.39
Perceived Advantages - Reduce Global Warming	2341	7.77	2.87	36.94
Perceived Advantages - Benefit Future Generations	2404	8.36	2.26	27.03

Variable	Valid n	Mean	Std. dev.	Coeff. of variation
Product Attributes - System Last 20 Years	2406	8.92	2.04	22.87
Product Attributes - Measure System Performance	2407	8.29	2.32	27.99
Product Attributes - Produce Excess Electricity	2402	7.46	2.59	34.72
Product Attributes - Own PV System	2264	6.57	2.89	43.99
Product Attributes - Lease PV System	2245	5.34	2.84	53.18
Product Attributes - Finance through Utility	2216	6.19	2.93	47.33
Product Attributes - Pay for System Up Front	2173	5.45	2.85	52.29
Product Attributes - Guarantee Rates Same for 5 Years	2305	7.63	2.51	32.90
Product Attributes - Rebates or Tax Credits	2422	8.60	2.17	25.23
Product Attributes - Maintenance Agreement	2400	8.27	2.38	28.78
Product Attributes - Warranty on PV System	2444	9.13	1.90	20.81
Product Attributes - Extended Warranty on Installation	2381	8.00	2.61	32.63
Product Attributes - Option to Do Own Installation	2355	5.78	3.30	57.09
Product Attributes - Attractive-Looking System	2440	8.26	2.37	28.69
Product Attributes - Mounted Flush with Roof	2330	8.04	2.37	29.48
Product Attributes - Mounted on Ground	2197	4.79	2.98	62.21
Product Attributes - Integrated into Home	2312	7.69	2.51	32.64
Product Attributes - Easily Moved to Next Home	2302	6.51	3.20	49.16
Product Attributes - Able to Add on or Upgrade	2376	8.00	2.27	28.38
Product Attributes - Battery for Excess Power	2373	8.29	2.33	28.11
Product Attributes - Battery for Emergency Power	2407	8.46	2.30	27.19
Perceived Barriers - Initial System Cost	2430	9.14	1.50	16.41
Perceived Barriers - Maintenance Costs	2403	9.02	1.52	16.85
Perceived Barriers - Effect on Home Resale Value	2408	8.29	2.14	25.81
Perceived Barriers - Getting Insurance Coverage	2385	8.64	1.86	21.53
Perceived Barriers - Property Taxes	2378	8.45	2.01	23.79
Perceived Barriers - Amount of Electricity Produced	2424	9.15	1.40	15.30

Variable	Valid n	Mean	Std. dev.	Coeff. of variation
Perceived Barriers - Operating Reliability	2420	9.32	1.26	13.52
Perceived Barriers - Reputability of PV Manufacturer	2414	9.12	1.45	15.90
Perceived Barriers - Reputability of PV Vendor	2411	9.00	1.56	17.33
Perceived Barriers - Maintenance Time	2393	8.81	1.65	18.73
Perceived Barriers - Suitability of Site	2385	8.45	2.00	23.67
Perceived Barriers - Amount of Space Needed	2402	8.26	2.10	25.42
Perceived Barriers - Codes and Covenants	2357	7.71	2.77	35.93
Perceived Barriers - Friends and Neighbors	2394	3.66	2.90	79.23
Perceived Barriers - System Could Become Outdated	2406	8.25	2.23	27.03
Perceived Barriers - Weather Damage to System	2424	8.78	1.79	20.39
Perceived Barriers - System Safety	2406	8.49	2.27	26.74
Perceived Barriers - Concern Utility Might Pull Out	2404	8.79	1.97	22.41
Excess Electricity - Wants Retail Cost	2277	7.30	1.37	18.77
Excess Electricity - Would Accept Avoided Costs	2130	5.25	2.31	44.00
Excess Electricity - Donate to Low-Income Customers	2154	3.72	2.40	64.52
Information Needs - General Basic Information	2335	8.66	2.03	23.44
Information Needs - Utility Financing	2316	7.72	2.58	33.42
Information Needs - Financial Incentives	2341	8.55	2.03	23.74
Information Needs - Savings on Utility Bills	2381	9.05	1.55	17.13
Information Needs - Electricity Buyback Rates	2332	8.50	1.91	22.47
Information Needs - Payback Period	2296	8.63	1.89	21.90
Information Needs - Sizes and Brands of PV Systems Available	2329	8.30	1.96	23.61
Information Needs - System Components	2302	7.84	2.25	28.70
Information Needs - Technical Information - How System Works	2346	7.90	2.31	29.24
Information Needs - Options Available (e.g., Maintenance, Warranties)	2361	8.48	1.91	22.52
Information Needs - Amount of Electricity Produced	2374	9.09	1.48	16.28

Variable	Valid n	Mean	Std. dev.	Coeff. of variation
Information Needs - Battery Costs, Maintenance, and Disposal	2375	8.99	1.61	17.91
Information Needs - Government Policies	2338	8.25	2.14	25.94
Information Needs - Benefits to Community and State	2334	7.29	2.51	34.43
Information Needs - Benefits Globally	2330	7.04	2.72	38.64
Overall Favorability	2316	6.95	2.41	34.68
Knowledge Levels	2361	3.31	2.61	78.85
Will Look for More Information	2383	5.38	2.86	53.16
Information Sources - Friends	2363	5.28	3.03	57.39
Information Sources - PV System Owners	2368	6.92	2.80	40.46
Information Sources - Environmental Organizations	2348	5.11	2.87	56.16
Information Sources - Consumer Protection Organizations	2360	5.91	2.95	49.92
Information Sources - Lobbying Organizations	2321	3.09	2.29	74.11
Information Sources - PV Manufacturers	2368	6.26	2.84	45.37
Information Sources - Utility Companies	2376	6.75	2.72	40.30
Information Sources - Banks, Lending Organizations	2332	4.60	2.86	62.17
Information Sources - Builders	2337	5.28	2.91	55.11
Information Sources - Contractors	2335	5.31	2.89	54.43
Information Sources - Home Supply Stores	2353	5.20	2.77	53.27
Information Sources - Libraries	2363	5.51	3.01	54.63
Information Sources - Colleges and Universities	2337	4.96	2.99	60.28
Information Sources - State and Local Governments	2340	4.84	2.88	59.50
Information Sources - Federal Government	2341	4.82	2.96	61.41
Information Sources - Green Power Marketing Companies	2220	3.94	2.71	68.78
Information Sources - The Internet	2331	5.32	3.29	61.84
Information Sources - Television and Radio	2351	4.91	2.81	57.23
Information Sources - Books, Journals, Reports	2374	6.54	2.82	43.12
Information Sources - Magazines and Newspapers	2372	6.19	2.78	44.91

Variable	Valid n	Mean	Std. dev.	Coeff. of variation
Information Sources - Brochures	2376	6.37	2.73	42.86
Information Sources - Demonstrations	2369	6.88	2.81	40.84
Information Sources - Events and Tours	2374	6.32	2.90	45.89
Information Sources - Classes and Workshops	2350	5.36	3.04	56.72
Preferred Source - Utility Company	2263	7.45	2.50	33.56
Preferred Source - Local Contractors/Businesses	2214	6.42	2.47	38.47
Preferred Source - Retail Home Improvement Center	2222	5.53	2.78	50.27
Preferred Source - PV Manufacturer	2212	6.45	2.61	40.47
Preferred Source - Renewable Energy Supplier	2175	6.06	2.69	44.39
Prior Experience - PV	2322	3.53	2.31	65.44
Prior Experience - Solar Domestic Hot Water	2361	4.61	2.53	54.88
Prior Experience - Solar Thermal for Heating	2361	4.38	2.37	54.11
Prior Experience - Solar Greenhouse	2312	3.64	2.29	62.91
Prior Experience - Wind Turbines	2340	4.00	2.26	56.50
Prior Experience - Passive Solar Design	2342	4.70	2.61	55.53
Prior Experience - Energy-Efficiency Retrofits	2362	5.62	2.60	46.26
Prior Experience - Solar Panels for Swimming Pools, etc.	2319	3.80	2.42	63.68
Prior Experience - Woodstoves	2365	6.19	2.59	41.84

*Statistics provided on variables with response scales of 1-8, 1-10, and 1-11 using data from the primary sample, excluding the “Don’t know” responses.

Appendix D. Detailed Factor Analysis Results

Appendix D. Detailed Factor Analysis Results

Table D-1. Perceived Relative Advantages

Rotated Component Matrix

	Component		
	1	2	3
Perceived Advantages - Reduce Electricity Bills	.114	.821	.029
Perceived Advantages - Sell Electricity to Utility	.118	.750	.146
Perceived Advantages - Long-Term Savings	.228	.843	.083
Perceived Advantages - Pay for Itself over 20 Years	.234	.698	.176
Perceived Advantages - Increase Resale Value of Home	.297	.723	.191
Perceived Advantages - Increase Self-Sufficiency	.255	.611	.356
Perceived Advantages - Makes Me Feel Good	.456	.271	.551
Perceived Advantages - Increase Awareness of Energy Use	.377	.348	.578
Perceived Advantages - Could Be First on Block	-.004	.126	.767
Perceived Advantages - Chance to Make Difference in Community	.508	.195	.575
Perceived Advantages - New Technology to Enjoy	.197	.177	.754
Perceived Advantages - Electricity During Outage	.239	.492	.352
Perceived Advantages - Create and Expand PV Market	.358	.138	.699
Perceived Advantages - Profitable for Utilities	.114	.066	.721
Perceived Advantages - Encourage Others to Use Renewables	.641	.174	.461
Perceived Advantages - Increase Diversity of Energy Mix	.669	.229	.420
Perceived Advantages - Good for Colorado's Economy	.609	.314	.424
Perceived Advantages - Create Jobs	.555	.343	.372
Perceived Advantages - Protect the Environment	.893	.206	.164
Perceived Advantages - Conserve Natural Resources	.895	.229	.153
Perceived Advantages - Reduce Local Air Pollution/Acid Rain	.889	.227	.106
Perceived Advantages - Reduce Global Warming	.828	.163	.147
Perceived Advantages - Benefit Future Generations	.845	.251	.163

Table D-2. Product Attributes

Rotated Component Matrix

	Component				
	1	2	3	4	5
Product Attributes - System Last 20 Years	.703	.149	.170	.069	.232
Product Attributes - Measure System Performance	.678	.095	.088	.127	.288
Product Attributes - Produce Excess Electricity	.452	.217	.0059	.369	.333
Product Attributes - Own PV System	.449	.099	.0036	.283	.531
Product Attributes - Lease PV System	.213	.094	.106	.789	.111
Product Attributes - Finance through Utility	.305	.111	.133	.796	.008
Product Attributes - Pay for System Up Front	.187	-.011	.196	-.138	.697
Product Attributes - Guarantee Rates Same for 5 Years	.449	.301	.198	.236	.176
Product Attributes - Rebates or Tax Credits	.623	.284	.277	.177	.073
Product Attributes - Maintenance Agreement	.729	.156	.248	.207	-.034
Product Attributes - Warranty on PV System	.780	.201	.287	.068	.089
Product Attributes - Extended Warranty on Installation	.672	.141	.243	.206	-.012
Product Attributes - Option to Do Own Installation	.084	.224	.075	.141	.655
Product Attributes - Attractive-Looking System	.423	.080	.643	.051	.201
Product Attributes - Mounted on Ground	-.151	.298	.215	.337	.416

Table D-2. Product Attributes (Cont'd.)

	Component				
	1	**2**	**3**	**4**	**5**
Product Attributes - Mounted Flush with Roof	.302	.152	.781	.130	.122
Product Attributes - Integrated into Home	.211	.195	.792	.130	.118
Product Attributes - Easily Moved to Next Home	-.008	.658	.161	.240	.298
Product Attributes - Able to Add on or Upgrade	.422	.516	.249	.149	.313
Product Attributes - Battery for Excess Power	.445	.762	.119	.038	.066
Product Attributes - Battery for Emergency Power	.444	.743	.120	.037	.019

Table D-3. Perceived Barriers

Rotated Component Matrix

	Component	
	1	**2**
Perceived Barriers - Initial System Cost	.681	.110
Perceived Barriers - Maintenance Costs	.751	.182
Perceived Barriers - Effect on Home Resale Value	.445	.425
Perceived Barriers - Getting Insurance Coverage	.655	.384
Perceived Barriers - Property Taxes	.613	.393
Perceived Barriers - Amount of Electricity Produced	.807	.134
Perceived Barriers - Operating Reliability	.862	.157
Perceived Barriers - Reputability of PV Manufacturer	.839	.174
Perceived Barriers - Reputability of PV Vendor	.806	.184
Perceived Barriers - Maintenance Time	.696	.300
Perceived Barriers - Suitability of Site	.418	.598
Perceived Barriers - Amount of Space Needed	.378	.673
Perceived Barriers - Codes and Covenants	.173	.718
Perceived Barriers - Friends and Neighbors	-.185	.682
Perceived Barriers - System Could Become Outdated	.386	.533
Perceived Barriers - Weather Damage to System	.596	.447
Perceived Barriers - System Safety	.522	.428
Perceived Barriers - Concern Utility Might Pull Out	.557	.393

Table D-4. Information Needs

Rotated Component Matrix

	Component		
	1	2	3
Information Needs - General Basic Information	.409	.457	.145
Information Needs - Utility Financing	.048	.761	.250
Information Needs - Financial Incentives	.175	.822	.155
Information Needs - Savings on Utility Bills	.402	.699	.029
Information Needs - Electricity Buyback Rates	.421	.599	.090
Information Needs - Payback Period	.393	.690	.075
Information Needs - Sizes and Brands of PV Systems Available	.684	.419	.173
Information Needs - System Components	.793	.183	.235
Information Needs - Technical Information - How System Works	.816	.084	.181
Information Needs - Options Available (e.g., Maintenance, Warranties)	.719	.344	.148
Information Needs - Amount of Electricity Produced	.654	.511	.084
Information Needs - Battery Costs, Maintenance, and Disposal	.639	.475	.119
Information Needs - Government Policies	.584	.260	.386
Information Needs - Benefits to Community and State	.252	.163	.920
Information Needs - Benefits Globally	.206	.148	.930

Table D-5. Information Sources
(Individuals, Groups, and Organizations)

Rotated Component Matrix

	Component		
	1	**2**	**3**
Information Sources - Friends and Neighbors	.017	.232	.741
Information Sources - PV System Owners	.175	.375	.727
Information Sources - Environmental Organizations	.479	.172	.681
Information Sources - Consumer Protection Organizations	.470	.206	.637
Information Sources - Lobbying Organizations	.402	.257	.458
Information Sources - PV Manufacturers	.270	.596	.362
Information Sources - Utility Companies	.275	.572	.378
Information Sources - Banks, Lending Organizations	.286	.656	.265
Information Sources - Builders	.208	.849	.173
Information Sources - Contractors	.192	.860	.163
Information Sources - Home Supply Stores	.268	.661	.220
Information Sources - Libraries	.701	.318	.146
Information Sources - Colleges and Universities	.796	.269	.133
Information Sources - State and Local Governments	.861	.242	.190
Information Sources - Federal Government	.860	.202	.184
Information Sources - Green Power Marketing Companies	.669	.235	.337

Table D-6. Information Channels

Rotated Component Matrix

	Component	
	1	**2**
Information Sources - The Internet	.142	.776
Information Sources - Television and Radio	.182	.816
Information Sources - Books, Journals, Reports	.540	.650
Information Sources - Magazines and Newspapers	.426	.763
Information Sources - Brochures	.620	.577
Information Sources - Demonstrations	.850	.292
Information Sources - Events and Tours	.855	.225
Information Sources - Classes and Workshops	.808	.195

Table D-7. Values and Lifestyles

Rotated Component Matrix

	Component	
	1	**2**
Voluntary Simplicity - Modify Lifestyle	.160	.894
Voluntary Simplicity - Buy Green	.173	.890
Voluntary Simplicity - Independence	.706	.151
Innovativeness	.767	.306
Opinion Leadership	.758	.030

Appendix E. "Positive" Response Patterns on All Study Variables (Including Demographics) Relative to Tier Membership

Table E-1. "Positive" Response Patterns on All Study Variables Relative to Tier Membership

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Initial Familiarity and Favorability							
Initial Familiarity	% Very familiar (9-10)	7	4	2	12	6	.005
Initial Favorability	% Very favorable (9-10)	65	59	42	2	56	.0001
Perceived Advantages							
Reduce Electricity Bills	% Very Important (9-10)	65	61	76	22	61	.0001
Sell Electricity to Utility	% Very Important (9-10)	57	48	53	10	49	.0001
Long-Term Savings	% Very Important (9-10)	73	63	71	3	63	.0001
Pay for Itself over Years	% Very Important (9-10)	60	48	50	3	49	.0001
Increase Resale Value of Home	% Very Important (9-10)	63	53	44	7	53	.0001
Increase Self-Sufficiency	% Very Important (9-10)	61	43	47	2	47	.0001
Makes Me Feel Good	% Very Important (9-10)	53	24	5	0	32	.0001
Increase Awareness of Energy Use	% Very Important (9-10)	39	15	2	0	22	.0001
Could Be First on Block	% Very Important (9-10)	14	1	0	0	6	.0001
Chance to Make Difference in Community	% Very Important (9-10)	39	14	0	0	21	.0001
New Technology to Enjoy	% Very Important (9-10)	32	6	2	0	15	.0001
Electricity during Outage	% Very Important (9-10)	63	42	42	5	47	.0001
Create and Expand PV Market	% Very Important (9-10)	38	11	5	0	19	.0001
Profitable for Utilities	% Very Important (9-10)	18	2	2	2	8	.0001
Encourage Others to Use Renewables	% Very Important (9-10)	56	32	2	0	36	.0001
Increase Diversity of Energy Mix	% Very Important (9-10)	63	37	2	0	41	.0001

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Good for Colorado's Economy	% Very Important (9-10)	58	33	5	0	37	.0001
Create Jobs	% Very Important (9-10)	55	35	9	3	38	.0001
Protect the Environment	% Very Important (9-10)	75	68	2	7	61	.0001
Conserve Natural Resources	% Very Important (9-10)	78	70	5	3	62	.0001
Reduce Local Air Pollution/Acid Rain	% Very Important (9-10)	79	75	2	7	65	.0001
Reduce Global Warming	% Very Important (9-10)	67	62	2	5	54	.0001
Benefit Future Generations	% Very Important (9-10)	78	69	6	12	63	.0001
Product Attributes							
System Last Years	% Very important (9-10)	77	63	71	17	65	.0001
System Last Years	% Must have	11	5	11	2	7	
Measure System Performance	% Very important (9-10)	62	43	56	16	49	.0001
Measure System Performance	% Must have	8	7	9	2	7	
Produce Excess Electricity	% Very important (9-10)	50	30	44	10	37	.0001
Produce Excess Electricity	% Must have	4	2	5	0	3	
Own PV System	% Very important (9-10)	42	20	29	2	28	.0001
Own PV System	% Must have	4	2	8	0	3	
Lease PV System	% Very important (9-10)	22	10	17	0	14	.0001
Lease PV System	% Must have	1	*	0	0	1	
Finance through Utility	% Very important (9-10)	31	20	23	2	23	.0001
Finance through Utility	% Must have	2	1	2	0	1	

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Pay for System Up Front	% Very important (9-10)	21	11	18	2	14	.0001
Pay for System Up Front	% Must have	1	*	0	0	1	
Guarantee Rates Same for 5 Years	% Very important (9-10)	49	30	38	10	36	.0001
Guarantee Rates Same for 5 Years	% Must have	2	1	3	0	2	
Rebates or Tax Credits	% Very important (9-10)	71	58	58	12	60	.0001
Rebates or Tax Credits	% Must have	8	5	8	2	6	
Maintenance Agreement	% Very important (9-10)	64	50	53	7	52	.0001
Maintenance Agreement	% Must have	5	4	6	2	4	
Warranty on PV System	% Very important (9-10)	76	67	77	24	67	.0001
Warranty on PV System	% Must have	10	8	12	2	9	
Extended Warranty on Installation	% Very important (9-10)	62	45	52	10	49	.0001
Extended Warranty on Installation	% Must have	5	4	5	2	4	
Option to Do Own Installation	% Very important (9-10)	33	19	24	12	24	.0001
Option to Do Own Installation	% Must have	3	2	3	0	2	
Attractive-Looking System	% Very important (9-10)	62	52	55	26	54	.0001
Attractive-Looking System	% Must have	5	3	6	0	4	
Mounted Flush with Roof	% Very important (9-10)	60	51	46	17	51	.0001
Mounted Flush with Roof	% Must have	3	1	3	0	2	
Mounted on Ground	% Very important (9-10)	13	11	18	12	12	.118
Mounted on Ground	% Must have	*	*	0	0	*	
Integrated into Home	% Very important (9-10)	52	46	50	17	46	.0001

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Integrated into Home	% Must have	2	2	2	0	2	
Easily Moved to Next Home	% Very important (9-10)	35	25	30	28	29	.002
Easily Moved to Next Home	% Must have	3	1	2	0	2	
Able to Add on or Upgrade	% Very important (9-10)	57	38	39	21	44	.0001
Able to Add on or Upgrade	% Must have	7	3	3	2	4	
Battery for Excess Power	% Very important (9-10)	59	51	50	21	52	.0001
Battery for Excess Power	% Must have	7	6	3	3	6	
Battery for Emergency Power	% Very important (9-10)	64	54	64	22	56	.0001
Battery for Emergency Power	% Must have	7	5	3	3	5	
Willingness to Pay							
System Size/Price Tradeoffs	% Medium-sized system	36	36	30	2	33	.0001
	% Very large system	25	22	23	0	22	
Willingness to Pay - Scenario A	% $3 more	7	9	8	10	8	.0001
	% $5 more	12	13	14	3	12	
	% $15 more	11	10	8	2	9	
Willingness to Pay - Scenario B	% $25 more	30	35	32	14	32	.0001
	% $50 more	24	26	20	0	23	
	% $70 more	3	2	6	0	2	
Willingness to Pay - Scenario C	% $25 more	18	12	14	16	15	.0001

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
	% $50 more	24	25	30	19	25	
	% $125 more	2	4	12	0	4	
Willingness to Pay - Scenario D	% Very likely (9-10)	74	69	68	5	66	.0001
Prefer to Pay							
As Part of Utility Bill	% Ranking first	69	74	67	58	70	.395
As Part of Mortgage	% Ranking first	43	38	37	53	40	.937
PV Manufacturer	% Ranking first	26	17	14	35	21	.253
As Part of Home Equity Loan	% Ranking first	26	12	19	17	18	.183
Perceived Barriers							
Initial System Cost	% Very important (9-10)	74	62	65	79	68	.001
Maintenance Costs	% Very important (9-10)	71	59	62	76	65	.068
Effect on Home Resale Value	% Very important (9-10)	59	48	50	45	52	.0001
Getting Insurance Coverage	% Very important (9-10)	60	50	61	55	55	.365
Property Taxes	% Very important (9-10)	55	42	42	60	48	.004
Amount of Electricity Produced	% Very important (9-10)	81	67	77	66	73	.0001
Operating Reliability	% Very important (9-10)	90	77	82	69	82	.0001
Reputability of PV Manufacturer	% Very important (9-10)	84	69	58	60	73	.0001
Reputability of PV Vendor	% Very important (9-10)	79	63	59	57	68	.0001
Maintenance Time	% Very important (9-10)	68	56	62	66	62	.237
Suitability of Site	% Very important (9-10)	60	55	53	57	57	.003
Amount of Space Needed	% Very important (9-10)	49	50	47	55	50	.0001

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Codes and Covenants	% Very important (9-10)	45	49	38	53	47	.0001
Friends and Neighbors	% Very important (9-10)	7	5	5	17	6	.002
System Could Become Outdated	% Very important (9-10)	51	50	33	66	50	.001
Weather Damage to System	% Very important (9-10)	64	60	58	60	61	.059
System Safety	% Very important (9-10)	64	58	42	55	59	.157
Concern Utility Might Pull Out	% Very important (9-10)	69	61	61	67	64	.032
Aesthetics/Performance Trade-offs							
Aesthetics/Performance	% Maximize electricity produced	33	27	29	10	28	.0001
	% Mount flush with roof	25	26	15	14	24	
	% Maximize aesthetics	31	39	42	33	36	
Excess Electricity							
Net Metering (#1)	% Very positive (8)	73	73	77	43	71	.0001
Avoidable Costs (#2)	% Very positive (8)	30	16	20	8	21	.003
Donate Excess (#3)	% Very positive (8)	13	8	3	4	9	.0001
Information Needs							
General Basic Information	% Very important (9-10)	69	63	58	61	65	.002
Utility Financing	% Very important (9-10)	57	47	43	29	49	.0001
Financial Incentives	% Very important (9-10)	70	62	60	29	62	.0001
Savings on Utility	% Very important (9-10)	77	69	82	46	72	.0001
Electricity Buyback Rates	% Very important (9-10)	60	51	66	34	54	.0001

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Payback Period	% Very important (9-10)	68	58	66	45	61	.0001
Sizes and Brands of PV Systems Available	% Very important (9-10)	59	40	52	31	48	.0001
System Components	% Very important (9-10)	54	34	35	36	42	.0001
Technical Information - How System Works	% Very important (9-10)	59	36	39	33	44	.0001
Options Available (e.g., Maintenance, Warranty	% Very important (9-10)	66	51	49	36	55	.0001
Amount of Electricity Produced	% Very important (9-10)	81	67	76	60	73	.0001
Battery Costs, Maintenance, and Disposal	% Very important (9-10)	79	67	70	59	71	.0001
Government Policies	% Very important (9-10)	63	45	40	45	51	.0001
Benefits to Community and State	% Very important (9-10)	46	30	3	16	33	.0001
Benefits Globally	% Very important (9-10)	45	28	3	15	31	.0001
Overall Favorability							
Overall Favorability	% Very favorable (9-10)	54	39	26	0	40	.0001
Knowledge Levels							
Knowledge Levels	% Know enough (9-10)	11	3	6	24	8	.0001
Will Look for More Information							
Will Look for More Information	% Very likely (9-10)	32	17	11	2	21	.0001
Information Sources							
Friends	% Very likely (9-10)	22	13	12	7	16	.0001
PV System Owners	% Very likely (9-10)	47	28	23	20	34	.0001

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Environmental Organizations	% Very likely (9-10)	19	14	3	2	14	.0001
Consumer Protection Organizations	% Very likely (9-10)	34	19	8	11	23	.0001
Lobbying Organizations	% Very likely (9-10)	5	1	0	2	3	.0001
PV Manufacturers	% Very likely (9-10)	38	20	26	7	26	.0001
Utility Companies	% Very likely (9-10)	42	29	26	9	32	.0001
Banks, Lending Organizations	% Very likely (9-10)	20	8	2	2	11	.0001
Builders	% Very likely (9-10)	21	12	14	4	15	.0001
Contractors	% Very likely (9-10)	23	12	17	4	16	.0001
Home Supply Stores	% Very likely (9-10)	21	10	9	4	13	.0001
Libraries	% Very likely (9-10)	29	19	17	7	21	.0001
Colleges and Universities	% Very likely (9-10)	21	13	17	2	16	.0001
State and Local Governments	% Very likely (9-10)	17	11	5	0	12	.0001
Federal Government	% Very likely (9-10)	21	12	5	0	14	.0001
Green Power Marketing Companies	% Very likely (9-10)	12	6	0	0	8	.0001
The Internet	% Very likely (9-10)	37	31	26	4	31	.0001
Television and Radio	% Very likely (9-10)	15	12	5	2	12	.0001
Books, Journals, Reports	% Very likely (9-10)	41	34	24	12	34	.0001
Magazines and Newspapers	% Very likely (9-10)	30	25	20	9	25	.0001
Brochures	% Very likely (9-10)	38	23	24	2	27	.0001
Demonstrations	% Very likely (9-10)	49	36	30	7	38	.0001
Events and Tours	% Very likely (9-10)	41	24	24	7	29	.0001

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Classes and Workshops	% Very likely (9-10)	35	16	19	5	22	.0001
Preferred Source of PV							
Utility Company	% Very Likely (9-10)	48	45	35	22	44	.0001
Local Contractors/Businesses	% Very likely (9-10)	26	17	20	2	20	.0001
Retail Home Improvement Center	% Very likely (9-10)	18	13	17	4	14	.0001
PV Manufacturer	% Very likely (9-10)	34	22	20	11	26	.0001
Renewable Energy Supplier	% Very likely (9-10)	27	20	11	4	21	.0001
Policy Preferences							
Policy Preferences	% Electricity rate increase (#1)	11	9	3	7	9	.0001
	% Federal income tax credit (#2)	44	47	53	16	44	
	% Low interest finance through utility (#4)	21	19	12	3	18	
	% Opposed to all subsidies	5	5	20	49	9	
Prior Experience							
PV	% Familiar (6-8)	39	25	29	26	31	.004
Solar Domestic Hot Water	% Familiar (6-8)	47	38	42	23	41	.160
Solar Thermal for Heating	% Familiar (6-8)	44	39	42	29	40	.197
Solar Greenhouse	% Familiar (6-8)	36	28	31	32	31	.175
Wind Turbines	% Familiar (6-8)	38	29	36	35	33	.031

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Passive Solar Design	% Familiar (6-8)	48	41	46	39	44	.198
Energy-Efficiency Retrofits	% Familiar (6-8)	64	49	61	48	55	.0001
Solar Panels for Swimming Pools, etc.	% Familiar (6-8)	37	38	32	30	36	.374
Woodstoves	% Familiar (6-8)	54	55	64	42	54	.089
Ownership							
PV	% Own technology	2	3	2	4	2	.004
Solar Domestic Hot Water	% Own technology	9	8	9	9	9	.160
Solar Thermal for Heating	% Own technology	5	4	6	5	5	.197
Solar Greenhouse	% Own technology	2	1	0	0	1	.175
Wind Turbines	% Own technology	3	1	0	0	1	.031
Passive Solar Design	% Own technology	8	9	5	2	8	.198
Energy-Efficiency Retrofits	% Own technology	11	15	15	0	12	.0001
Solar Panels for Swimming Pools, etc.	% Own technology	2	2	2	2	2	.374
Ownership - Woodstoves	% Own technology	19	19	15	13	18	.089
Ownership Experience							
Ownership Experience	% Very positive	16	14	3	2	13	.001
Demographics							
Gender	% Male	77	73	82	62	74	.054
Gender	% Female	24	27	18	38	26	
Age	% < 50 years	62	66	70	48	63	.0001
	% ≥ 50 years	38	34	30	63	37	

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Marital Status	% Married	80	82	92	84	83	.117
Household Composition	% Two adults (no children)	37	36	33	45	37	.668
	% Two adults with children	42	46	55	38	45	
Rural vs Urban Area	% Big City > 100,000	44	49	38	45	46	.273
	% Farm	3	1	2	2	2	
Area of Colorado	% Denver/Boulder	58	71	47	70	64	.001
	% Grand Junction/Western Slope	11	4	11	4	7	
Educational Attainment	% College degree or above	47	69	58	55	59	.0001
Income	% ≥ $50K annual income	63	80	64	67	71	.002
Political Orientation	% Very conservative (1-2)	13	10	33	26	14	.0001
	% Very liberal (9-10)	5	6	2	6	5	
Occupation	% Professional/Managerial	45	61	48	38	52	.0001
	% Retired	14	5	5	28	10	
	% Skilled Worker	14	8	17	4	11	
Likelihood of Moving	% Very unlikely (1-2)	40	40	40	61	41	.330

Variable Description	Meaning	Early Adopters (Tier 1)	Mid-term Adopters (Tier 2)	Later Adopters (Tier 3)	Non-adop-ters (Tier 4)	All Tiers	p ≤
Environmental Values and Lifestyle							
Modify Lifestyle	% Would accept lifestyle modifications to help environment (7-8)	62	57	11	9	52	.0001
Buy Green	% Would buy green (7-8)	58	52	17	13	48	.0001
Other Characteristics							
Independence	% Self-reliant (7-8)	80	68	74	50	72	.0001
Innovativeness	% Innovative (7-8)	78	65	44	29	65	.0001
Opinion Leadership	% Opinion leader (7-8)	63	62	55	39	60	.002
Perceived Primary Source of Electricity							
Perceived Primary Source of Electricity	% Coal	60	62	66	56	61	.785

* Less than 0.5%

Appendix F. "Positive" Response Patterns on All Study Variables (Including Demographics) Relative to Highly Likely Predictor Clusters

Table F-1. "Positive" Response Patterns on All Study Variables Relative to Highly Likely Predictor Clusters

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Intial Familiary and Favorabiliy									
Initial Familiarity	% Very familiar (9-10)	6	11	2	2	0	18	7	.056
Initial Favorability	% Very favorable (9-10)	70	81	70	73	67	69	72	.961
Perceived Advantages									
Reduce Electricity Bills	% Very important (9-10)	81	42	84	61	69	31	65	.0001
Sell Electricity to Utility	% Very important (9-10)	78	31	69	53	56	19	56	.0001
Long-Term Savings	% Very important (9-10)	89	63	86	82	81	29	75	.0001
Pay for Itself over Years	% Very important (9-10)	75	50	75	80	50	21	64	.0001
Increase Resale Value of Home	% Very important (9-10)	79	39	75	76	56	12	61	.0001
Increase Self-Sufficiency	% Very important (9-10)	72	50	69	59	50	29	59	.0001
Makes Me Feel Good	% Very important (9-10)	68	40	33	41	6	21	44	.0001
Increase Awareness of Energy Use	% Very important (9-10)	58	13	20	33	0	5	30	.0001
Could Be First on Block	% Very important (9-10)	27	0	0	0	0	5	9	.0001
Chance to Make Difference in Community	% Very important (9-10)	62	26	14	35	0	12	34	.0001
New Technology to Enjoy	% Very important (9-10)	54	13	9	12	0	5	24	.0001
Electricity during Outage	% Very important (9-10)	83	39	59	61	56	17	58	.0001
Create and Expand PV Market	% Very important (9-10)	49	37	13	25	0	14	30	.0001
Profitable for Utilities	% Very important (9-10)	29	5	6	6	0	0	12	.0001
Encourage Others to Use Renewables	% Very important (9-10)	69	52	42	51	0	29	50	.0001

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Increase Diversity of Energy Mix	% Very important (9-10)	77	57	50	59	0	29	56	.0001
Good for Colorado's Economy	% Very important (9-10)	74	44	50	47	0	24	51	.0001
Create Jobs	% Very important (9-10)	70	42	48	51	13	26	50	.0001
Protect the Environment	% Very important (9-10)	80	74	78	80	6	60	73	.0001
Conserve Natural Resources	% Very important (9-10)	83	79	81	82	0	64	76	.0001
Reduce Local Air Pollution/Acid Rain	% Very important (9-10)	83	74	86	90	0	76	78	.0001
Reduce Global Warming	% Very important (9-10)	74	65	78	78	6	60	69	.0001
Benefit Future Generations	% Very important (9-10)	83	76	86	90	6	55	76	.0001
Product Attributes									
System Last Years	% Very important (9-10)	82	69	83	71	56	45	73	.0001
	% Must have	12	10	8	12	19	2	10	
Measure System Performance	% Very important (9-10)	68	60	58	49	63	29	57	.0001
	% Must have	9	5	11	22	13	0	10	
Produce Excess Electricity	% Very important (9-10)	65	27	45	25	44	21	43	.0001
	% Must have	5	2	3	4	6	0	4	
Own PV System	% Very important (9-10)	58	29	39	16	25	17	37	.0001
	% Must have	7	3	6	2	13	0	5	
Lease PV System	% Very important (9-10)	36	5	13	8	19	7	18	.0001
	% Must have	2	2	2	0	0	0	1	

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Finance through Utility	% Very important (9-10)	45	21	23	31	31	24	32	.005
	% Must have	3	0	2	2	6	0	2	
Pay for System Up Front	% Very important (9-10)	27	11	34	0	13	5	19	.0001
	% Must have	2	0	2	0	0	0	1	
Guarantee Rates Same for 5 Years	% Very important (9-10)	65	32	52	37	44	7	45	.0001
	% Must have	4	2	2	2	6	0	2	
Rebates or Tax Credits	% Very important (9-10)	79	61	72	67	63	45	68	.014
	% Must have	9	8	6	14	13	2	8	
Maintenance Agreement	% Very important (9-10)	70	50	63	78	56	17	59	.0001
	% Must have	7	2	6	14	13	0	6	
Warranty on PV System	% Very important (9-10)	79	66	77	69	69	48	71	.0001
	% Must have	12	11	11	25	13	2	12	
Extended Warranty on Installation	% Very important (9-10)	78	37	56	57	44	29	56	.0001
	% Must have	5	7	5	12	13	0	6	
Option to Do Own Installation	% Very important (9-10)	39	27	42	0	31	19	29	.0001
	% Must have	3	3	5	0	6	2	3	
Attractive-Looking System	% Very important (9-10)	69	45	70	45	44	36	56	.0001
	% Must have	7	2	6	8	13	0	6	
Mounted Flush with Roof	% Very important (9-10)	74	42	66	63	50	38	60	.001
	% Must have	6	2	3	2	6	0	4	

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Mounted on Ground	% Very important (9-10)	18	0	25	8	31	5	14	.0001
	% Must have	1	0	2	0	0	0	1	
Integrated into Home	% Very important (9-10)	69	36	55	55	31	41	53	.001
	% Must have	4	0	3	2	6	2	3	
Easily Moved to Next Home	% Very important (9-10)	45	19	42	20	25	10	31	.0001
	% Must have	4	2	2	2	0	0	2	
Able to Add-On or Upgrade	% Very important (9-10)	68	48	58	39	31	14	50	.0001
	% Must have	9	7	6	6	6	0	6	
Battery for Excess Power	% Very important (9-10)	72	47	66	59	69	43	61	.020
	% Must have	7	10	8	12	6	5	8	
Battery for Emergency Power	% Very important (9-10)	74	55	69	63	75	31	63	.001
	% Must have	9	7	8	12	6	5	8	

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Positives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clusters	p ≤
Willingness to Pay									
System Size/Price Trade-offs	% Medium-sized system	37	52	34	51	31	52	43	.228
	% Very large system	35	27	39	27	44	14	31	
Willingness to Pay - Scenario A	% $3 more	4	7	14	10	19	7	8	.088
	% $5 more	11	11	14	12	0	7	11	
	% $15 more	12	18	5	14	19	7	12	
Willingness to Pay - Scenario B	% $25 more	34	19	38	25	25	41	31	.246
	% $50 more	32	31	23	37	19	29	30	
	% $70 more	3	5	0	4	13	2	3	
Willingness to Pay - Scenario C	% $25 more	12	15	14	2	19	7	11	.077
	% $50 more	23	18	9	22	19	26	20	
	% $125 more	2	8	8	8	13	0	5	
Willingness to Pay - Scenario D	% Very likely (9-10)	82	79	83	84	94	76	82	.867
Prefer to Pay									
As Part of Utility Bill	% Ranking first	71	63	82	69	77	60	71	.193
As Part of Mortgage	% Ranking first	42	31	37	58	44	42	42	.507
PV Manufacturer	% Ranking first	21	26	12	11	0	20	17	.510
As Part of Home Equity Loan	% Ranking first	26	31	6	12	9	18	19	.390

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Perceived Barriers									
Initial System Cost	% Very important (9-10)	78	57	66	71	44	29	63	.0001
Maintenance Costs	% Very important (9-10)	78	55	63	74	44	21	62	.0001
Effect on Home Resale Value	% Very important (9-10)	77	32	56	59	50	12	54	.0001
Getting Insurance Coverage	% Very important (9-10)	77	29	61	63	50	10	54	.0001
Property Taxes	% Very important (9-10)	70	26	56	55	31	2	47	.0001
Amount of Electricity Produced	% Very important (9-10)	86	76	83	86	81	31	77	.0001
Operating Reliability	% Very important (9-10)	94	89	89	96	94	38	86	.0001
Reputability of PV Manufacturer	% Very important (9-10)	91	76	84	84	69	38	79	.0001
Reputability of PV Vendor	% Very important (9-10)	88	68	77	78	69	31	73	.0001
Maintenance Time	% Very important (9-10)	81	42	61	67	69	26	61	.0001
Suitability of Site	% Very important (9-10)	80	26	66	63	44	31	58	.0001
Amount of Space Needed	% Very important (9-10)	71	11	55	51	38	29	48	.0001
Codes and Covenants	% Very important (9-10)	65	11	59	61	25	33	48	.0001
Friends and Neighbors	% Very important (9-10)	10	0	5	2	0	2	5	.0001
System Could Become Outdated	% Very important (9-10)	68	26	59	59	25	24	50	.0001
Weather Damage to System	% Very important (9-10)	80	34	69	67	56	31	61	.0001
System Safety	% Very important (9-10)	81	42	72	69	19	26	61	.0001
Concern Utility Might Pull Out	% Very important (9-10)	81	48	72	67	44	36	65	.0001

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Aesthetics/Perfomance Trade-offs									
Aesthetics/Performance	% Maximize electricity produced	27	47	37	35	31	22	33	.004
	% Mount flush with roof	29	24	22	18	13	44	27	
	% Maximize aesthetics	38	23	29	43	38	27	33	
Excess Electricity									
Net Metering (#1)	% Very positive (8)	84	71	86	80	94	52	78	.004
Avoided Costs (#2)	% Very positive (8)	33	23	19	21	13	2	22	.067
Donate Excess (#3)	% Very positive (8)	11	13	11	14	0	5	10	.0001
Information Needs									
General Basic Information	% Very important (9-10)	83	48	72	82	63	36	68	.0001
Utility Financing	% Very important (9-10)	74	37	64	67	56	29	58	.0001
Financial Incentives	% Very important (9-10)	84	58	78	80	69	44	72	.0001
Savings on Utility	% Very important (9-10)	91	61	80	82	81	45	76	.0001
Electricity Buyback Rates	% Very important (9-10)	77	40	66	65	69	22	60	.0001
Payback Period	% Very important (9-10)	83	44	75	76	63	34	67	.0001
Sizes and Brands of PV Systems Available	% Very important (9-10)	76	42	59	59	44	14	56	.0001
System Components	% Very important (9-10)	72	37	50	44	27	22	50	.0001
Technical Information - How System Works	% Very important (9-10)	70	49	55	45	44	33	54	.066

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Options Available (e.g., Maintenance, warranty)	% Very important (9-10)	84	47	56	76	56	26	63	.0001
Amount of Electricity Produced	% Very important (9-10)	88	76	86	90	88	43	80	.0001
Battery Costs, Maintenance, and Disposal	% Very important (9-10)	87	69	81	86	88	50	78	.0001
Government Policies	% Very important (9-10)	81	39	66	55	38	29	59	.0001
Benefits to Community and State	% Very important (9-10)	60	34	44	49	6	29	45	.0001
Benefits Globally	% Very important (9-10)	59	39	42	47	6	26	44	.0001
Overall Favorability									
Overall Favorability	% Very favorable (9-10)	77	74	77	74	56	62	73	.253
Knowledge Levels									
Knowledge Levels	% Know enough (9-10)	12	16	5	0	6	15	10	.094
Will Look for More Information									
Will Look for More Information	% Very likely (9-10)	54	40	38	35	25	33	42	.054

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi- tives	Highly Likely Self- reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus- ters	p ≤
Information Sources									
Friends	% Very likely (9-10)	27	13	20	15	13	10	19	.052
PV System Owners	% Very likely (9-10)	64	42	49	39	19	31	48	.003
Environmental Organizations	% Very likely (9-10)	27	15	25	23	0	17	21	.002
Consumer Protection Organizations	% Very likely (9-10)	45	21	32	35	6	14	31	.0001
Lobbying Organizations	% Very likely (9-10)	9	0	5	2	0	0	4	.0001
PV Manufacturers	% Very likely (9-10)	50	39	41	27	25	17	38	.106
Utility Companies	% Very likely (9-10)	54	39	41	43	38	26	43	.039
Banks, Lending Organizations	% Very likely (9-10)	36	5	19	10	6	2	18	.0001
Builders	% Very likely (9-10)	33	15	24	21	13	7	22	.001
Contractors	% Very likely (9-10)	31	19	21	19	19	7	22	.008
Home Supply Stores	% Very likely (9-10)	34	10	18	10	6	5	18	.0001
Libraries	% Very likely (9-10)	34	32	36	31	19	12	30	.058
Colleges and Universities	% Very likely (9-10)	26	26	22	20	13	17	23	.0001
State and Local Governments	% Very likely (9-10)	27	11	21	17	0	12	19	.016
Federal Government	% Very likely (9-10)	28	16	22	21	0	12	21	.002
Green Power Marketing Companies	% Very likely (9-10)	19	10	16	2	0	12	13	.020
The Internet	% Very likely (9-10)	42	48	30	40	25	26	38	.037
Television and Radio	% Very likely (9-10)	21	5	19	10	0	5	13	.0001
Books, Journals, Reports	% Very likely (9-10)	50	50	53	47	19	29	46	.013

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Magazines and Newspapers	% Very likely (9-10)	41	28	39	31	25	21	34	.034
Brochures	% Very likely (9-10)	49	36	41	31	19	12	36	.003
Demonstrations	% Very likely (9-10)	63	48	55	48	44	24	51	.020
Events and Tours	% Very likely (9-10)	51	40	38	29	44	21	39	.011
Classes and Workshops	% Very likely (9-10)	49	34	20	31	53	24	36	.001
Preferred Source of PV									
Utility Company	% Very likely (9-10)	55	44	48	61	50	37	50	.019
Local Contractors/Businesses	% Very likely (9-10)	28	25	30	18	19	7	24	.043
Retail Home Improvement Center	% Very likely (9-10)	27	10	21	14	13	2	17	.017
PV Manufacturer	% Very likely (9-10)	42	32	30	29	13	12	31	.024
Renewable Energy Supplier	% Very likely (9-10)	33	27	29	37	13	12	28	.327
Policy Preferences									
Policy Preferences	% Electricity rate increase (#1)	13	11	11	12	6	7	11	.509
	% Federal income tax credit (#2)	42	48	46	39	56	50	45	
	% Low interest finance through utility (#4)	24	18	22	27	13	19	22	
	% Opposed to all subsidies (#6)	3	5	2	6	13	5	4	

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Prior Experience									
PV	% Familar (6-8)	43	42	32	33	31	40	38	.283
Solar Domestic Hot Water	% Familar (6-8)	49	52	32	49	63	55	48	.484
Solar Thermal for Heating	% Familar (6-8)	49	47	32	52	56	56	47	.025
Solar Greenhouse	% Familar (6-8)	36	36	30	34	44	42	35	.406
Wind Turbines	% Familar (6-8)	39	48	29	35	50	44	39	.784
Passive Solar Design	% Familar (6-8)	49	57	46	39	50	54	49	.035
Energy-Efficiency Retrofits	% Familar (6-8)	64	66	52	63	63	51	61	.017
Solar Panels for Swimming Pools, etc.	% Familar (6-8)	45	34	40	46	50	51	43	.239
Woodstoves	% Familar (6-8)	55	49	56	55	63	56	55	.397
Ownership									
PV	% Own technology	1	2	3	6	0	3	2	.283
Solar Domestic Hot Water	% Own technology	10	13	10	10	6	14	11	.484
Solar Thermal for Heating	% Own technology	4	10	8	0	0	7	5	.025
Solar Greenhouse	% Own technology	2	5	2	0	0	7	3	.406
Wind Turbines	% Own technology	2	3	2	0	0	0	2	.784
Passive Solar Design	% Own technology	5	15	6	6	13	17	9	.035
Energy-Efficiency Retrofits	% Own technology	6	23	16	6	19	27	14	.017
Solar Panels for Swimming Pools, etc.	% Own technology	0	5	0	2	0	7	2	.239
Woodstoves	% Own technology	14	30	24	18	19	24	21	.397

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Ownership Experience									
Ownership Experience	% Very positive	12	27	21	14	0	5	15	.474
Demographics									
Gender	% Male	79	76	71	72	88	83	77	.531
	% Female	21	24	29	28	13	17	23	
Age	% < 50 Years	58	73	64	63	63	74	65	.386
	% ≥ 50 Years	42	28	37	37	38	26	36	
Marital Status	% Married	79	81	76	88	94	86	81	.394
Household Composition	% Two adults (no children)	37	42	38	27	50	41	38	.658
	% Two adults with children	44	37	41	55	38	48	44	
Rural vs Urban Area	% Big City > 100,000	51	37	46	45	25	52	46	.171
	% Farm	1	10	2	0	6	2	3	
Area of Colorado	% Denver/Boulder	54	58	67	71	56	66	61	.080
	% Grand Junction/ Western Slope	8	11	3	6	13	0	7	
Educational Attainment	% College degree or above	44	53	59	71	63	76	57	.067
Income	% ≥ $50K annual income	67	57	76	88	60	90	72	.002

Variable Description	Meaning	Highly Likely Pacesetters	Highly Likely Steady Posi-tives	Highly Likely Self-reliant Savers	Highly Likely Need Reassurance	Highly Likely Green No, $ Yes	Highly Likely No Worry, Minimum Interest	All Highly Likely Clus-ters	p ≤
Political Orientation	% Very conservative (1-2)	15	8	8	12	38	7	12	.115
	% Very liberal (9-10)	4	3	8	2	6	7	5	
Occupation	% Professional/ Managerial	48	50	59	63	44	67	55	.014
	% Retired	12	11	5	4	6	5	8	
	% Skilled Worker	11	21	5	8	31	7	12	
Likelihood of Moving	% Very unlikely (1-2)	33	43	42	36	63	42	40	.873
Environmental Values and Lifestyle									
Modify Lifestyle	% would accept lifestyle modifications to help environment. (7-8)	68	71	69	67	13	64	65	.0001
Buy Green	% Who would buy green (7-8)	59	71	56	55	0	62	58	.0001
Other Characteristics									
Independence/Self-sufficiency	% Self-reliant (7-8)	86	79	89	61	75	76	80	.015
Innovativeness	% Innovative (7-8)	80	90	83	67	81	76	80	.059
Opinion Leadership	% Opinion leader (7-8)	74	58	63	69	63	61	66	.452
Perceived Primary Source of Electricity									
Perceived Primary Source of Electricity	% Coal	59	73	60	60	75	86	66	.112

Appendix G. Relationship of Cluster Matrix Membership and Membership in the Tiers to the Sample as a Whole

Appendix G.
Relationship of Cluster Matrix Membership and Membership in the Tiers to the Sample as a Whole

As discussed in Chapter 7, the statistical technique of cluster analysis was used to establish market segments by categorizing survey respondents from two different perspectives—one reflecting attitudinal predisposition and the other behavioral intention. The two sets of categories, or clusters, were then crosstabulated to identify those survey respondents who simultaneously possess both characteristics. The resulting cluster matrix contained substantially fewer respondents than the overall sample for the following reasons: (1) the two cluster regimes ultimately involved different batteries of survey questions; (2) the computational aspects of cluster analysis require all respondents included to have answered every question included in a battery, and not all respondents answered every survey question; and (3) the pattern of item nonresponse was inconsistent. Consequently, it is important to address whether members of the cluster matrix (see Table 29) are representative of the sample as a whole, since prospective market segments are identified in terms of this matrix.

Similarly, Chapter 9 discusses the mechanism used to establish the next tiers of market development, those tiers representing distinct subsets of respondents encompassed by the cluster matrix (Table 30). The principal purpose of these tiers is to facilitate testing of the hypotheses on which the study is founded, and so respondents encompassed by the tier structure are expected to be somewhat unrepresentative of the sample as a whole. A secondary purpose is to use the tier structure, in part, in the calculation of GPV market size estimates. Therefore, it is also important to address how representative the tiers are of the sample as a whole.

A formal statistical analysis was conducted to assess the representativeness of respondents included in the cluster matrix and in the tiers. Tables G-1 through G-8 contain the results of this analysis. Specifically, these tables compare the distributions of responses of these two important subgroups of individuals to those of the overall sample on survey questions representing the study's key dependent variables. In order of presentation, the four variables of interest are: (1) likelihood of purchasing a fully subsidized GPV system, (2) willingness to look for more information about GPV, (3) preferred trade-off between GPV system size and price in a hypothetical purchase, and (4) overall favorability toward the idea of using GPV on one's own home. Comparisons between each subgroup's responses and those of the overall sample could also be made on the basis of other study variables, but these four are very important to the study and are thought to be characteristic.

The first set of tables, Tables G-1 through G-4, compare the distributions of responses of all individuals in the entire sample to those of individuals included only in the cluster matrix. The second set of tables, Tables G-5 through G-8, compares the distributions of responses of all individuals in the entire sample to those of individuals included only in the tiers. In all cases, the comparisons are formalized through the performance of Chi-square tests on the tabulated counts.

The results shown in Tables G-1 through G-4 indicate that the distribution of responses of individuals contained in the cluster matrix is not significantly different from the distribution of responses of the sample as a whole for three of the four variables. The responses of the subgroup of individuals contained in the cluster matrix appear to be different from those of the sample as a whole only on the basis of overall favorability, with those in the cluster matrix tending to be somewhat more favorable. (This may simply reflect that respondents favorable toward GPV were more careful to answer every question in the questionnaire, guaranteeing their inclusion in the cluster matrix.) For all intents and purposes, then, the respondents encompassed by the cluster matrix are assumed to be representative of the entire sample.

On the other hand, the results shown in Tables G-5 through G-8 indicate that the distribution of responses of individuals contained in the tiers is significantly different from the distribution of responses of the sample as a whole for all four variables. This suggests that respondents encompassed by the tiers are not representative of the entire sample, a result that is not unexpected because of the mechanism used to form the tiers. Inspection of Tables G-5 through G-8 verifies that respondents included in the tiers tend to be more positive in their responses than the sample as a whole.

Table G-1. Likelihood to Purchase a No-Added-Cost GPV System (Scenario D), Cluster Matrix Members versus Entire Sample*

Response (1-10 scale)	Percentage in Matrix	Percentage in Entire Sample
Very likely (9-10)	54	51
Likely (7-8)	24	24
Mixed/neutral (5-6)	12	12
Unlikely (3-4)	4	4
Very unlikely (1-2)	7	9
Totals	101**	100

*Chi-square = 8.213, d.f. = 4, $.10 < p < .05$.
**Percentages do not add to 100 because of rounding.

Table G-2. Likelihood of Looking for More Information on GPV, Cluster Matrix Members versus Entire Sample*

Response (1-10 scale)	Percentage in Matrix	Percentage in Entire Sample
Very likely (9-10)	16	15
Likely (7-8)	25	24
Mixed/neutral (5-6)	26	25
Unlikely (3-4)	16	16
Very unlikely (1-2)	17	21
Totals	100	101**

*Chi-square = 7.53, d.f. = 4, $p < .10$.
**Percentages do not add to 100 because of rounding.

Table G-3. System Size/Price Trade-offs, Cluster Matrix Members versus Entire Sample*

Response	Percentage in Matrix	Percentage in Entire Sample
Would not purchase	30	35
Very small	2	1
Small	12	11
Medium-sized	29	27
Large	11	10
Very large	17	16
Totals	101**	100

*Chi-square = 6.86, d.f. = 5, p < .10.
**Percentages do not add to 100 because of rounding.

Table G-4. Favorability toward Using GPV on One's Own Home, Cluster Matrix Members versus Entire Sample*

Response (1-10 scale)	Percentage in Matrix	Percentage in Entire Sample
Very favorable (9-10)	32	27
Favorable (7-8)	37	34
Mixed/neutral (5-6)	22	27
Unfavorable (3-4)	4	5
Very unfavorable (1-2)	5	7
Totals	100	100

*Chi-square =20.49, d.f. = 4, p ≤ .001.

Table G-5. Likelihood to Purchase A No-Added-Cost GPV System (Scenario D), Members of Tiers versus Entire Sample*

Response (1-10 scale)	Percentage in Tiers	Percentage in Entire Sample
Very likely (9-10)	66	51
Likely (7-8)	26	24
Mixed/neutral (5-6)	4	12
Unlikely (3-4)	1	4
Very unlikely (1-2)	4	9
Totals	101**	100

*Chi-square = 105.18, d.f. = 4, $.10 < p < .001$.
**Percentages do not add to 100 because of rounding.

Table G-6. Likelihood of Looking for More Information on GPV, Members of Tiers versus Entire Sample*

Response (1-10 scale)	Percentage in Tiers	Percentage in Entire Sample
Very likely	21	15
Likely	32	24
Mixed/neutral	26	25
Unlikely	13	16
Very unlikely	9	21
Totals	101**	101**

*Chi-square = 79.03, d.f. = 4, $p \leq .001$.
**Percentages do not add to 100 because of rounding.

Table G-7. System Size/Price Trade-offs, Members of Tiers versus Entire Sample*

Response	Percentage in Matrix	Percentage in Entire Sample
Would not purchase	19	35
Very small	1	1
Small	12	11
Medium-sized	33	27
Large	13	10
Very large	22	16
Totals	100	100

*Chi-square = 71.18, d.f. = 5, $p \leq .001$.

Table G-8. Favorability toward Using GPV on One's Own Home, Members of Tiers versus Entire Sample*

Response (1-10 scale)	Percentage in Matrix	Percentage in Entire Sample
Very favorable (9-10)	40	27
Favorable (7-8)	42	34
Mixed/neutral (5-6)	13	27
Unfavorable (3-4)	2	5
Very unfavorable (1-2)	3	7
Totals	100	100

*Chi-square =120.31, d.f. = 4, $p \leq .001$.

Appendix H. Familiarity and Experience with Efficiency and Renewables of Respondents Assigned to the Different Market Tiers

Appendix H. Familiarity and Experience with Efficiency and Renewables of Respondents Assigned to the Different Market Tiers

It appears that negative prior experiences with efficiency and renewables affect current positions and interest toward GPV. A higher percentage of Tier 4 respondents—those unlikely ever to purchase GPV systems—rate their direct experience with efficiency and renewables as negative (24%) than do respondents in the other tiers, and a significantly lower percentage of Tier 4 respondents (58%) rate their experience as positive than do respondents in the other tiers (87%–97% of whom rate their experiences positively) (Table H-1).

Table H-1. Nature of Experience with Energy Efficiency and Renewable Energy Equipment by Tier

Response*	Percent			
	Tier 1	Tier 2	Tier 3	Tier 4
Positive	87	84	97	58
Mixed	6	9	3	18
Negative	7	7	0	24
Totals	100	100	100	100

*$p \leq .0001$

Table H-2, concerning overall familiarity with energy efficiency and renewable energy equipment, shows a similar overall pattern of differences by tier, as well. Consistently, a higher percentage of Tier 1 respondents report greater familiarity with energy efficiency and renewable energy equipment than do Tier 4 respondents. A significantly lower percentage of Tier 4 respondents report high familiarity with energy-efficiency retrofits, PV, and wind than in the other tiers (particularly Tier 1).

Fifty-six percent of Tier 1 respondents have high familiarity with solar water heating compared with 49% of Tier 4, although this difference is not statistically significant. Similarly, 50% of Tier 1 respondents report high familiarity with solar thermal heating compared with 34% of Tier 4 respondents; 39% of Tier 1 respondents report high familiarity with solar greenhouses compared with 32% of Tier 4 respondents; 57% of Tier 1 respondents report high familiarity with passive design compared with 41% of Tier 4 respondents; and 39% of Tier 1 respondents report high familiarity with solar swimming pools, hot tubs, and spa heaters compared with 32% of Tier 4 respondents.

These results support the hypothesis that higher knowledge levels about efficiency and renewables are associated with greater likelihood of GPV purchase.

Table H-2. Familiarity with Energy Efficiency and Renewable Energy Equipment, by Tier

Equipment Type	Percent*				
	Tier 1	Tier 2	Tier 3	Tier 4	Statistical Significance***
Energy-efficiency retrofits**	75	64	76	48	p ≤ .000
Photovoltaics	40	28	31	30	p ≤ .004
Wind turbines	40	29	36	35	p ≤ .035
Woodstoves	73	73	79	55	p ≤ .089
Passive design	57	50	50	41	p ≤ .198
Solar greenhouses	39	29	31	32	p ≤ .175
Solar thermal water heating	56	46	52	49	p ≤ .16
Solar thermal space heating	50	42	48	34	p ≤ .197
Solar panels to heat hot tubs, swimming pools, or spas	39	39	33	32	p ≤ .374

*Percentages responding that they are highly familiar with equipment (6-8 on a 1-8 scale, where 1 = Not at all familiar and 8 = Very familiar [code 8 was recoded to include responses indicating that respondents had owned the equipment previously or own it now]). Appendix E summarizes a Chi-square analysis on the relevant variables by tier membership.
**Twenty-five percent of Tier 4 are unfamiliar with energy-efficiency retrofits, as compared with 11%–14% of the other tiers.
***In all cases, the size of the p-value indicates that there is at least one significant difference among the tiers.

Appendix I. Differences between *Highly Likely* and *Highly Unlikely* Criterion Clusters on the Basis of Percentages of Highly Important Ratings Assigned to Relative Advantages, Product Attributes, and Barriers

Appendix I. Differences between *Highly Likely* and *Highly Unlikely* Criterion Clusters on the Basis of Percentages of Highly Important Ratings Assigned to Relative Advantages, Product Attributes, and Barriers

As noted in Chapter 9, the study's hypotheses concerning perceived relative advantage, perceived feasibility (measured by responses to questions on product attributes), and perceived barriers could not be tested using the grouping of respondents into market tiers. This is because the tiers, themselves, are derived in part from these same variables. Therefore it was determined to test hypotheses about these items on the basis of respondent membership in the criterion clusters.

The criterion clusters, described in Chapter 7, resulted from a statistical cluster analysis using four key dependent variables: (1) likelihood of looking for more GPV information, (2) favorability of using GPV on one's own home, (3) willingness to buy a no-added-cost GPV system, and (4) system size/price trade-offs. The six resulting criterion clusters, labeled as ***Highly Likely, Somewhat Likely, Slightly Likely, Slightly Unlikely, Somewhat Unlikely,*** and ***Highly Unlikely,*** segregate the survey respondents into different groups according to their suggested behavioral intention regarding GPV purchase.

As evidence that certain factors affect the position of homeowners in the GPV adoption process, Tables I-1 through I-3 compare the percentages of respondents in the ***Highly Likely*** and ***Highly Unlikely*** clusters who assigned ratings of high importance (9 or 10 on a 10-point scale) to each of the several relative advantages, product attributes, and barriers of GPV. Table I-1 pertains to relative advantage, Table I-2 pertains to product attributes, and Table I-3 pertains to barriers.

The comparative percentages shown in Tables I-1 through I-3 are extracted from more complete analyses of each variable (relative advantages, product attributes, barriers) in question. While comparisons other than those shown in Tables I-1 through I-3 could be shown, these results are sufficient to suggest that the hypothesized relationships are supported.

The more complete analyses (not shown here) consist of full crosstabulations of cluster membership against a range of importance ratings, along with associated Chi-square tests. For every variable identified in Tables I-1 through I-3, the Chi-square test is significant at the 95% confidence level, indicating consistent strength of association between the two notions of cluster membership and importance rating. Consequently, the statistical evidence indicates that homeowners who are highly likely to purchase GPV systems (on the basis of categorization according to the criterion clustering regime) tend to rate this group of relative advantages, product attributes, and barriers as very important. Similarly, the evidence indicates homeowners highly unlikely to purchase GPV systems rate them as very unimportant.

Table I-1. Comparisons of *Highly Likely* and *Highly Unlikely* Criterion Clusters on the Basis of the Percentages of Respondents Rating Selected Relative Advantages as Highly Important

Selected Variables	*Highly Likely* Criterion Cluster	*Highly Unlikely* Criterion Cluster
Reduce electric bills now	36	5
Long-term savings	40	4
Protect the environment	41	4
Conserve natural resources	41	4
Reduce local air pollution	40	4
Benefit future generations	41	4
Reduce global warming	42	4
Sell electricity	38	4
Increase resale value	39	4
Pay for itself over 20 years	44	4
Could be first on block	61	3
New technology to enjoy	57	1
Create and expand PV market	57	1
Increase self-sufficiency	45	3

*Percentages responding 9-10 on a 1-10 scale where 1 = not important and 10 = very important.

Table I-2. Comparisons of *Highly Likely* and *Highly Unlikely* Criterion Clusters on the Basis of the Percentages of Respondents Rating Selected Product Attributes as Highly Important

Selected Variables	*Highly Likely* Criterion Cluster	*Highly Unlikely* Criterion Cluster
System lasts 20 years	48	1
Rebates or tax credits	53	4
Warranty on PV system	44	5
Battery of excess power	51	4
Produce excess electricity	49	4
Own PV system	60	2
Maintenance agreement	47	6
Extended warranty	46	3
Option to do own installation	49	3
Attractive-looking system	39	6
Easily moved	49	6
Able to add on or upgrade	51	7
Battery for emergency back-up	48	6

*Percentages responding 9-10 on a 1-10 scale where 1 = not important and 10 = very important.

Table I-3. Comparisons of *Highly Likely* and *Highly Unlikely* Criterion Clusters on the Basis of the Percentages of Respondents Rating Selected Barriers as Highly Important

Selected Variables	*Highly Likely* Criterion Cluster	*Highly Unlikely* Criterion Cluster
Initial system cost	29	10
Maintenance costs	30	10
Amount of electricity produced	33	8
Operating reliability	33	9
Reputability of PV manufacturer	34	9
Reputability of PV vendor	34	10
Effect on home resale	32	10
Property taxes	30	12
Codes and covenants	31	10
System could become outdated	30	11

*Percentages responding 9-10 on a 1-10 scale where 1 = not important and 10 = very important.

Appendix J. Colorado Homeowner Questionnaire on Home-Based PV Systems Tied to the Utility Grid

PLEASE COMPLETE AND RETURN THIS QUESTIONNAIRE WITHIN 10 DAYS

PLEASE DO NOT WRITE YOUR NAME ON THIS QUESTIONNAIRE

Colorado Homeowner Questionnaire on Home-Based PV Systems Tied to the Utility Grid

1. Do you own or rent your home? ***[Please circle one.]***

   1 Own

   2 Rent, lease, or other arrangement*

***** *If you chose this option, please stop here and return your questionnaire in the business reply envelope without completing any of the other questions. Thank you for your participation.***

2. What kind of home do you live in? ***[Please circle one.]***

   1 Single-family dwelling

   2 Multi-family dwelling (apartment, townhome, condominium, duplex, etc.)*
   3 Mobile home*
   4 Military housing*
   5 Other* ***[Please specify]*** ____________________

***** *If you chose any of these options, please stop here and return your questionnaire in the business reply envelope without completing any of the other questions. Thank you for your participation.***

Electric utilities in Colorado are considering the addition of renewable resources as one of the sources from which your electricity is generated. One way to get electricity from renewable resources is from individually owned solar systems called photovoltaic or PV systems that are tied to the utility grid.

These **grid-tied PV systems,** as they are called, consist of solar panels that can be placed on or near your home, or they can be integrated into the structure of your home, such as PV shingles on the roof. *(See the enclosed pictures.)* The PV system converts sunlight directly into electricity. Your home will still be connected to the electric utility grid, enabling you to send the excess electricity your grid-tied PV system can generate during the day to the utility, and to receive electricity from the utility when your PV panels are not generating all the electricity you require. On a scale of 1 to 10, how familiar are you with these grid-tied PV systems? ***[Please circle one response.]***

Not at all familiar	1	2	3	4	5	6	7	8	9	10	Very familiar

Without knowing any more than you do right now about grid-tied PV systems, on a scale of 1 to 10, how favorable are you to these systems being available to Colorado residents? ***[Please circle one response.]***

Very unfavorable	1	2	3	4	5	6	7	8	9	10	Very favorable

Listed below are some possible benefits of using a grid-tied PV system. On a scale from 1 to 10, please indicate how important each benefit would be to you, if you were considering purchasing this kind of system for your home. ***[For each benefit, please circle one response.]***

	Not at all important									Very important	Don't know
1. It could reduce my electricity bills right away	1	2	3	4	5	6	7	8	9	10	☐
2. I could sell excess electricity back to the utility company	1	2	3	4	5	6	7	8	9	10	☐
3. It could result in long-term savings since electricity could be free once the system is paid for	1	2	3	4	5	6	7	8	9	10	☐
4. It could pay for itself over its expected lifetime of 20 years or more	1	2	3	4	5	6	7	8	9	10	☐
5. It could increase the resale value of my home	1	2	3	4	5	6	7	8	9	10	☐
6. It could increase my self-sufficiency	1	2	3	4	5	6	7	8	9	10	☐
7. It could make me feel good to do this	1	2	3	4	5	6	7	8	9	10	☐
8. It could increase my awareness about my household energy use	1	2	3	4	5	6	7	8	9	10	☐
9. I could be first on my block to have a PV system	1	2	3	4	5	6	7	8	9	10	☐
10. It could provide an opportunity to make a difference in my community	1	2	3	4	5	6	7	8	9	10	☐
11. It could be a new technology to enjoy	1	2	3	4	5	6	7	8	9	10	☐
12. I could have electricity during a power outage	1	2	3	4	5	6	7	8	9	10	☐
13. It could help to create and expand the PV market	1	2	3	4	5	6	7	8	9	10	☐
14. It could be profitable for utility companies	1	2	3	4	5	6	7	8	9	10	☐
15. It could encourage others to replace some of their gas and coal use with renewable energy	1	2	3	4	5	6	7	8	9	10	☐
16. It could increase the diversity of energy sources	1	2	3	4	5	6	7	8	9	10	☐
17. It could be good for Colorado's economy	1	2	3	4	5	6	7	8	9	10	☐
18. It could help create jobs in Colorado	1	2	3	4	5	6	7	8	9	10	☐
19. It could help protect the environment	1	2	3	4	5	6	7	8	9	10	☐
20. It could conserve natural resources	1	2	3	4	5	6	7	8	9	10	☐
21. It could help reduce air pollution and acid rain in our area	1	2	3	4	5	6	7	8	9	10	☐
22. It could help reduce global warming	1	2	3	4	5	6	7	8	9	10	☐
23. It could benefit future generations	1	2	3	4	5	6	7	8	9	10	☐
24. Other ***[Please specify]*** ________________	1	2	3	4	5	6	7	8	9	10	☐

If you were considering obtaining a grid-tied PV system, on a 1 to 10 scale, how important would each of the following features be to you? ***[For each feature, please circle or check one response.]***

		Not at all important									Very important	Must have	Don't know
1.	A system that lasts for at least 20 years	1	2	3	4	5	6	7	8	9	10	☐	☐
2.	A way to measure how much electricity the PV system produces	1	2	3	4	5	6	7	8	9	10	☐	☐
3.	Ability to produce more electricity than my household uses	1	2	3	4	5	6	7	8	9	10	☐	☐
4.	Owning the PV system	1	2	3	4	5	6	7	8	9	10	☐	☐
5.	Leasing the PV system, or leasing with an option to buy	1	2	3	4	5	6	7	8	9	10	☐	☐
6.	Financing the system through the utility	1	2	3	4	5	6	7	8	9	10	☐	☐
7.	Paying for the system up front rather than financing it	1	2	3	4	5	6	7	8	9	10	☐	☐
8.	A guarantee that electricity rates would stay the same for 5 years	1	2	3	4	5	6	7	8	9	10	☐	☐
9.	Rebates or tax credits for purchasing the system	1	2	3	4	5	6	7	8	9	10	☐	☐
10.	A maintenance agreement at reasonable cost	1	2	3	4	5	6	7	8	9	10	☐	☐
11.	A manufacturer-provided warranty on the system	1	2	3	4	5	6	7	8	9	10	☐	☐
12.	An extended warranty on the installation at reasonable cost	1	2	3	4	5	6	7	8	9	10	☐	☐
13.	An option to do my own installation	1	2	3	4	5	6	7	8	9	10	☐	☐
14.	An attractive-looking system	1	2	3	4	5	6	7	8	9	10	☐	☐
15.	PV panels that can be mounted flush with my roof	1	2	3	4	5	6	7	8	9	10	☐	☐
16.	PV panels that can be mounted on the ground	1	2	3	4	5	6	7	8	9	10	☐	☐
17.	A system that is integrated into my home, such as PV shingles or PV skylights	1	2	3	4	5	6	7	8	9	10	☐	☐
18.	A PV system that can easily be moved to my next home	1	2	3	4	5	6	7	8	9	10	☐	☐
19.	Add-on or upgrade capability	1	2	3	4	5	6	7	8	9	10	☐	☐
20.	A battery with which to store excess power for use at night	1	2	3	4	5	6	7	8	9	10	☐	☐
21.	A battery to provide emergency power during power outages	1	2	3	4	5	6	7	8	9	10	☐	☐
22.	Other ***[Please specify]*** ______________	1	2	3	4	5	6	7	8	9	10	☐	☐

NEXT IS A QUESTION ON PV SYSTEM SIZE AND PRICE TRADEOFFS...

PV systems can be sized to meet a variety of needs. Larger ones produce more electricity and are more expensive than the smaller ones. If you were to purchase a PV system outright for your home, which of the following sizes and price ranges would you prefer? ***[Please check one response.]***

Note: *The following cost ranges are based on the installed cost of a PV system. They are centered around an average home electricity consumption of 600 kWh a month at a cost of $45 a month. Remember that these costs are hypothetical. Electricity use varies considerably by household.*

☐ 1. A very small system that powers one large appliance (such as a refrigerator) at a one-time cost of $2,500

☐ 2. A small system that provides 25% of your household electricity at a one-time cost of between $4,500 and $9,500, depending on your electricity usage.

☐ 3. A medium-sized system that provides 50% of your household electricity at a one-time cost of between $8,500 and $16,500, depending on your electricity usage.

☐ 4. A large system that provides 75% of your household electricity at a one-time cost of between $11,500 and $23,000, depending on your electricity usage.

☐ 5. A very large system that provides 100% of your household electricity at a one-time cost of between $14,000 and $28,000, depending on your electricity usage.

☐ 6. I would not purchase any of these systems

☐ 7. Other ***[Please specify]*** ______________________________

☐ 8. Don't know

NOW PLEASE CONSIDER SOME SCENARIOS FOR PURCHASING A PV SYSTEM.

Scenario A: Suppose you would purchase a PV system that produces **enough electricity to power one or two large appliances**, like a refrigerator and a dishwasher. The system reduces the amount of conventional electricity you buy from your utility by **a small amount (say, 7% to 15%)**. Your utility provides financing for 20 years at a competitive interest rate of 7%, and your payment for the PV system would be listed separately as part of your utility bill. What is the most you would be willing to add to your current electricity bill to purchase this PV system? ***[Please check one response.]***

- ☐ 1. $3 more per month
- ☐ 2. $5 more
- ☐ 3. $8 more
- ☐ 4. $10 more
- ☐ 5. $15 more
- ☐ 6. $20 more
- ☐ 7. $25 more
- ☐ 8. Nothing more

Scenario B: Suppose you would purchase a PV system with the same arrangement as in Scenario A, except that the PV system produces **half of the electricity used in your household**. That is, the amount of electricity you buy from your utility is reduced by half. What is the most you would be willing to add to your current electricity bill to purchase this PV system? ***[Please check one response.]***

- ☐ 1. $15 more per month
- ☐ 2. $20 more
- ☐ 3. $25 more
- ☐ 4. $50 more
- ☐ 5. $60 more
- ☐ 6. $70 more
- ☐ 7. $80 more
- ☐ 8. Nothing more

Scenario C: Suppose you would purchase a PV system with the same arrangement as in Scenario A, except that the PV system produces **100% of the electricity used in your household**. That is, on average you purchase no electricity from your utility because the PV system produces as much electricity as you use. The utility grid is your storage and backup. What is the most you would be willing to add to your current electricity bill to purchase this PV system? ***[Please check one response.]***

- ☐ 1. $25 more per month
- ☐ 2. $50 more
- ☐ 3. $60 more
- ☐ 4. $75 more
- ☐ 5. $100 more
- ☐ 6. $125 more
- ☐ 7. $150 more
- ☐ 8. Nothing more

Scenario D: Assume subsidies became available or the price of PV dropped, and you could purchase a grid-tied PV system for your home from your utility company. The PV system portion of your bill and the electricity portion combined **would equal your current electricity bill.** On a 1 to 10 scale, how likely would you be to purchase the grid-tied PV system? ***[Please circle one response.]***

Very unlikely	1	2	3	4	5	6	7	8	9	10	Very likely	Don't know ☐

If you were thinking of buying a PV system, regardless of its cost, which way would you prefer to make the payment for the system? ***[Please rank the following choices, with 1 for your first choice, 2 for your second choice, and so on.]***

___ 1. As part of your utility bill
___ 2. As part of your home mortgage
___ 3. A separate payment to a PV manufacturer or supplier
___ 4. A payment against a home equity loan or other personal financing
___ 5. Other ***[Please specify]*** ______________________
___ 6. Don't know

Here is a list of conditions you might see as problems with grid-tied PV. For each condition on the list, please indicate on a 1 to 10 scale, how important a concern it would be for you, if you were thinking about adding PV to your home. ***[For each condition, please circle one response.]***

	Not at all important								Very important	Don't know
1. Initial cost of PV system	1	2	3	4	5	6	7	8	9	10	☐
2. Expense of maintaining the PV system	1	2	3	4	5	6	7	8	9	10	☐
3. Effect on resale value of my house	1	2	3	4	5	6	7	8	9	10	☐
4. Cost or difficulty of getting PV system covered by homeowners insurance	1	2	3	4	5	6	7	8	9	10	☐
5. Effect on property taxes	1	2	3	4	5	6	7	8	9	10	☐
6. Performance of PV system (amount of electricity produced)	1	2	3	4	5	6	7	8	9	10	☐
7. Operating reliability of PV system (need for repairs, maintenance)	1	2	3	4	5	6	7	8	9	10	☐
8. Dependability and reputability of PV manufacturer	1	2	3	4	5	6	7	8	9	10	☐
9. Dependability and reputability of PV vendor	1	2	3	4	5	6	7	8	9	10	☐
10. Amount of time needed to maintain a PV system	1	2	3	4	5	6	7	8	9	10	☐
11. Suitability of my site for a PV system	1	2	3	4	5	6	7	8	9	10	☐
12. Amount of space needed at my home for a PV system	1	2	3	4	5	6	7	8	9	10	☐
13. Codes or covenant that might prohibit it	1	2	3	4	5	6	7	8	9	10	☐
14. What friends and neighbors might say	1	2	3	4	5	6	7	8	9	10	☐
15. System could become outdated technologically	1	2	3	4	5	6	7	8	9	10	☐
16. Possible damage to PV system by storms, vandalism, etc.	1	2	3	4	5	6	7	8	9	10	☐
17. Safety of PV system power	1	2	3	4	5	6	7	8	9	10	☐
18. Concern that the utility company might stop servicing and standing behind the PV systems	1	2	3	4	5	6	7	8	9	10	☐
19. Other ***[Please specify]*** ______	1	2	3	4	5	6	7	8	9	10	☐

There may be trade-offs between how much electricity a PV system will produce and its appearance when it is installed on a house. Of the following options, please select the one that would appeal most to you, assuming you were thinking of purchasing a PV system. ***[Please check only one response.]***

☐ 1. I'd want the PV system to maximize the electricity produced, even if it means that the panels stick up from my roof at an odd angle
☐ 2. I'd want the PV panels mounted flat on my roof, even if this would slightly reduce the amount of electricity they produced
☐ 3. I'd want the PV system to blend into my home as much as possible (such as PV shingles), even if this would somewhat reduce the amount of electricity produced
☐ 4. I'd prefer a ground-mounted system not on my home
☐ 5. Don't know

Because roof space on homes is limited, a grid-tied PV system would probably not produce more electricity than is consumed in your home. However, at certain times (such as in the middle of the day in the summer), the PV system could produce more power than a home is consuming. During these times, there are several options for what can happen to this excess electricity. On a scale of 1 to 8, how positive or negative are you to the following three options? ***[For each option, please circle one response.]***

	Very negative							Very positive	Don't know
1. The utility automatically credits me for any excess electricity I put on the grid at the same rate the utility charges me for electricity.............	1	2	3	4	5	6	7	8	☐
2. The utility credits me for any electricity I put on the grid at the same rate that the utility pays its other wholesale electricity providers	1	2	3	4	5	6	7	8	☐
3. The utility takes the electricity and does not reimburse me, but donates the excess electricity I produce to assist low-income households	1	2	3	4	5	6	7	8	☐

Assume that you were considering purchasing a grid-tied PV system. On a 1 to 10 scale, how important would the following information be to you in making your decision? ***[For each type of information, please circle one response.]***

	Not at all important									Very important	Don't know
1. General basic information on PV for homes (I don't know that much about it yet)	1	2	3	4	5	6	7	8	9	10	☐
2. Availability of financing for the PV system from my utility company	1	2	3	4	5	6	7	8	9	10	☐
3. Availability of financial incentives to help pay for the PV system	1	2	3	4	5	6	7	8	9	10	☐
4. Savings on my utility bill................................	1	2	3	4	5	6	7	8	9	10	☐
5. Buyback rates for excess electricity fed back to the utility grid ...	1	2	3	4	5	6	7	8	9	10	☐
6. Payback period for a PV system purchase	1	2	3	4	5	6	7	8	9	10	☐
7. Sizes and brands of PV systems available	1	2	3	4	5	6	7	8	9	10	☐
8. Description of system components	1	2	3	4	5	6	7	8	9	10	☐
9. Technical information on how the system works.............	1	2	3	4	5	6	7	8	9	10	☐
10. Options available, such as maintenance agreements and warranties on equipment and installation	1	2	3	4	5	6	7	8	9	10	☐
11. Amount of electricity the PV system will provide.............	1	2	3	4	5	6	7	8	9	10	☐
12. Battery costs, maintenance, and disposal...................	1	2	3	4	5	6	7	8	9	10	☐
13. Government policies and programs on PV and utility restructuring	1	2	3	4	5	6	7	8	9	10	☐
14. Benefits to my community and state	1	2	3	4	5	6	7	8	9	10	☐
15. Benefits to the nation and the world.......................	1	2	3	4	5	6	7	8	9	10	☐

Now that you have thought a little more about grid-tied PV for homes, on a 1 to 10 scale, how favorable are you about the idea of using it on **your own** home? ***[Please circle one response.]***

Very unfavorable	1	2	3	4	5 Neutral	6	7	8	9	10	Very favorable	Don't know ☐

Do you feel that you presently know enough about grid-tied PV systems to make an informed decision about buying one for your home? ***[Please circle one response.]***

No, definitely not	1	2	3	4	5	6	7	8	9	10	Yes, definitely	Don't know ☐

On a scale of 1 to 10, how likely are you to look for more information about PV in the near future? ***[Please circle one response.]***

Very unlikely	1	2	3	4	5	6	7	8	9	10	Very likely	Don't know ☐

THE NEXT QUESTION DEALS WITH SOURCES OF INFORMATION ABOUT GRID-TIED PV.

Listed here are some sources of information about grid-tied PV systems. Please indicate how likely it is that you would contact or use each source for information. ***[For each source, please circle one response.]***

	Very unlikely									Very likely	Don't know
1. Friends, neighbors, acquaintances, and relatives	1	2	3	4	5	6	7	8	9	10	☐
2. People who already own PV systems	1	2	3	4	5	6	7	8	9	10	☐
3. Environmental organizations	1	2	3	4	5	6	7	8	9	10	☐
4. Consumer protection organizations	1	2	3	4	5	6	7	8	9	10	☐
5. Lobbying organizations	1	2	3	4	5	6	7	8	9	10	☐
6. PV manufacturers/suppliers	1	2	3	4	5	6	7	8	9	10	☐
7. Utility companies	1	2	3	4	5	6	7	8	9	10	☐
8. Financial institutions (banks, lenders)	1	2	3	4	5	6	7	8	9	10	☐
9. Home builders	1	2	3	4	5	6	7	8	9	10	☐
10. Local contractors	1	2	3	4	5	6	7	8	9	10	☐
11. Home supply stores	1	2	3	4	5	6	7	8	9	10	☐
12. Public libraries	1	2	3	4	5	6	7	8	9	10	☐
13. Colleges and universities	1	2	3	4	5	6	7	8	9	10	☐
14. State and local government agencies	1	2	3	4	5	6	7	8	9	10	☐
15. Federal government agencies and national labs	1	2	3	4	5	6	7	8	9	10	☐
16. Green power marketing companies	1	2	3	4	5	6	7	8	9	10	☐
17. The Internet	1	2	3	4	5	6	7	8	9	10	☐
18. Radio and television	1	2	3	4	5	6	7	8	9	10	☐
19. Books, journals, and reports about PV	1	2	3	4	5	6	7	8	9	10	☐
20. Magazines and newspapers	1	2	3	4	5	6	7	8	9	10	☐
21. Brochures	1	2	3	4	5	6	7	8	9	10	☐
22. Demonstration building or model home with PV	1	2	3	4	5	6	7	8	9	10	☐
23. Event (such as home and garden show, solar home tour)	1	2	3	4	5	6	7	8	9	10	☐
24. Seminars, workshops, or classes	1	2	3	4	5	6	7	8	9	10	☐
25. Other *[Please specify]* ________________	1	2	3	4	5	6	7	8	9	10	☐

Assume you made the decision to purchase a PV system for your home. On a 1 to 10 scale, how likely would you be to consider purchasing it from. . .? ***[For each source, please circle one response]***

	Very unlikely									Very likely	Don't know
1. Your electric utility company or your utility's PV contractor	1	2	3	4	5	6	7	8	9	10	☐
2. Local area PV contractors/businesses (suppliers, installers)	1	2	3	4	5	6	7	8	9	10	☐
3. Retail home improvement center (Home Depot, Hugh M. Woods, etc.)	1	2	3	4	5	6	7	8	9	10	☐
4. PV manufacturer	1	2	3	4	5	6	7	8	9	10	☐
5. Renewable energy/energy efficiency specialty supplier	1	2	3	4	5	6	7	8	9	10	☐
6. Other *[Please specify]* ________________	1	2	3	4	5	6	7	8	9	10	☐

THINKING NOW ABOUT EVERYONE PAYING FOR GRID-TIED PV...

Assume for the moment that all or part of the cost of grid-tied PV systems on homes are subsidized for a limited time to help introduce PV to consumers. Which way would you prefer to see this accomplished, **assuming that each option listed provided the same financial benefits to PV owners?** ***[Please check the option you feel is best.]***

- ☐ 1. All customers pay a slight increase in electricity rates to cover the cost
- ☐ 2. Federal income tax credit for PV owners (the amount of credit is subtracted from the taxes I owe the government)
- ☐ 3. State income tax credit for PV owners
- ☐ 4. Government-subsidized low-interest financing through my utility company
- ☐ 5. Direct government subsidies to PV manufacturer (reducing PV system cost)
- ☐ 6. I am opposed to subsidizing grid-tied PV electricity, even for a limited time
- ☐ 7. Don't know
- ☐ 8. Other ***[Please specify]*** ______________________________

PLEASE TELL US ABOUT YOUR FAMILIARITY WITH THE FOLLOWING RENEWABLES AND ENERGY EFFICIENCY EQUIPMENT.

The following is a list of equipment that individual homeowners can use to produce or use energy more efficiently. On a 1 to 10 scale, please indicate how familiar you are with each of these. ***[For each type of equipment, please circle or check one response.]***

	Not at all familiar							Very familiar	I owned previously	I own now	Don't know
1. Solar cells (PV) to produce electricity **not tied** to the utility grid	1	2	3	4	5	6	7	8	☐	☐	☐
2. Solar panels to heat water for homes	1	2	3	4	5	6	7	8	☐	☐	☐
3. Solar panels to heat homes.......................	1	2	3	4	5	6	7	8	☐	☐	☐
4. Attached solar greenhouses to heat homes	1	2	3	4	5	6	7	8	☐	☐	☐
5. Wind machines (or windmills) to produce electricity or pump water	1	2	3	4	5	6	7	8	☐	☐	☐
6. Passive solar design (such as using south-facing windows to get heat from sun; using water containers, walls, floors, or ceiling to collect and store the sun's heat, etc.)	1	2	3	4	5	6	7	8	☐	☐	☐
7. Energy-efficient retrofits (such as added insulation double-pane or low-E glass, energy-efficient lighting, energy efficient appliances, etc.)...................	1	2	3	4	5	6	7	8	☐	☐	☐
8. Solar panels to heat swimming pools, hot tubs, or spas	1	2	3	4	5	6	7	8	☐	☐	☐
9. Wood stoves to heat homes	1	2	3	4	5	6	7	8	☐	☐	☐
10. Other ***[Please specify]*** ______________	1	2	3	4	5	6	7	8	☐	☐	☐

If you have ever owned or lived with any of these types of equipment, on a 1 to 10 scale, how would you characterize the overall nature of that experience? ***[Please circle or check one response.]***

Very negative				Mixed (negative and positive)					Very positive	Don't know	Have not owned or lived with
1	2	3	4	5	6	7	8	9	10	☐	☐

Why do you feel this way?______________________________

____

____

PLEASE TELL US ABOUT YOURSELF AND YOUR HOUSEHOLD ***[If two people have completed the questionnaire together, please select one head of household for answering the questions on this page and the following page. Please circle or fill in the appropriate response.]***
Reminder: All information will be kept anonymous

I am:

1 Male 2 Female

My age is:

1 24 years or under
2 25 to 49 years
3 50 to 64 years
5 65 years or older

I am:

1 Never married or no longer married
2 Married

Which best describes your household composition?

1 One adult
2 Two adults
3 Two adults and children
4 One adult and children
5 Three or more adults
6 Three or more adults and children

Which of the following best describes the rural area, town, or city where you currently live?

1 Farm
2 Rural area, but not a farm
3 Small town, city, or suburb with less than 10,000 people
4 City or suburb with 10,000 to 100,000 people
5 City or suburb with more than 100,000 people
6 Other *[Please specify]* ____________________
7 Don't know

In which area of Colorado do you live?

1 Greater Denver/Boulder area
2 Greater Colorado Springs area
3 Ft. Collins/Loveland/Greeley area
4 Grand Junction area
5 Other Western slope
6 Greater Pueblo area
7 Eastern plains

What is your zip code?

____ ____ ____ ____ ____

Which best describes your highest level of education?

1 Elementary school through some high school
2 High school graduate or equivalent
3 Some college but no degree
4 A.A. degree
5 Trade or technical school certificate
6 Bachelors degree
7 Some graduate work but no degree
8 Master's degree
9 Work beyond the masters, but no degree
10 Doctoral degree

Which best describes your annual household income before taxes?

1 Under $15,000
2 $15,000 to 24,999
3 $25,000 to 49,999
4 $50,000 to 74,999
5 $75,000 to 99,999
6 $100,00 to 150,000
7 Over $150,000

Regardless of your party identification, how would you rate yourself politically on a 1 to 10 scale, from very conservative to very liberal?

Very conservative									Very liberal
1	2	3	4	5	6	7	8	9	10

What is the primary fuel used to heat your home?

1 Natural gas
2 Electricity
3 Propane
4 Wood
5 Solar
5 Fuel oil
6 Other *[Please specify]* ______________
7 Don't know

What is the name of your electric utility company?

____

Which best describes the primary occupation of the chief wage earner in your household? ***[Please circle only one.]***

1 Clerical or office worker
2 Farm foreman, farm laborer, or farm helper
3 Farmer (farm owner, farm manager)
4 Homemaker
5 Laborer other than farm (construction worker plumber assistant, other physical work
6 Local government employee who provides services for the community (police officer, firefighter, city or county official)
7 Manager, executive, or official (in business, government agency, or other organization)
8 Professional worker (lawyer, doctor, scientist, teacher, systems analyst, musician, etc.)
9 Retired
10 Sales professional or retail sales (real estate, manufacturer's representative, other retail or wholesale sales)
11 Self-owned business (with one or more employees)
12 Service worker (assembly line worker, truck driver taxi driver, waitperson, etc.)
13 Skilled trade or craft worker (machine operator, technician, printer, baker, plumber, mechanic carpenter, hairdresser, etc.)
14 Student
15 Unemployed
16 Other ***[Please specify]*** ____________________

How likely is it that you will be moving to another house in the next few years? ***[Please circle one response.]***

Very unlikely	1	2	3	4	5	6	7	8	9	10	Very likely	Don't know ☐

Please indicate whether you agree or disagree with the following statements. ***[For each statement, please circle one response.]***

	Strongly disagree							Strongly agree	Don't know
1. I am willing to accept modifications to my lifestyle if it helps the environment . .	1	2	3	4	5	6	7	8	☐
2. I buy environmentally-friendly products, even if they cost somewhat more	1	2	3	4	5	6	7	8	☐
3. I like to be as independent as possible so I don't have to rely upon others to meet my needs	1	2	3	4	5	6	7	8	☐
4. I like to experiment with new ways of doing things	1	2	3	4	5	6	7	8	☐
5. I am seen as a leader in my work life, social life, or volunteer activities	1	2	3	4	5	6	7	8	☐

From which source do you think most of the electricity used in Colorado is currently produced? ***[Please check one.]***

☐ 1. Oil
☐ 2. Nuclear energy
☐ 3. Coal
☐ 4. Wind
☐ 5. Solar
☐ 6. Natural gas
☐ 7. Hydropower
☐ 8. Other ***[Please specify]*** ______________________________

PLEASE USE THIS SPACE FOR ANY FURTHER COMMENTS YOU MIGHT HAVE

THANK YOU VERY MUCH FOR YOUR PARTICIPATION IN THIS STUDY!

Please fold your questionnaire in half, put it in the blank envelope, and seal the envelope. Then put the sealed envelope in the postage-paid, business reply envelope and drop it in the mail.

SOURCES OF INFORMATION ABOUT GRID-TIED PV:

- Karen Renshaw, Executive Director
  Colorado Solar Energy Industries Association (COSEIA)
  2170 S. Parker Road, #263
  Denver, CO 80231
  Phone: (303) 750-9764 or (800) 633-9764
  FAX: (303) 750-0085
  E-mail: seiacolo@aol.com
  Website: www.coseia.org

- Marc Roper
  Colorado Office of Energy Conservation
  1675 Broadway, Suite 1300
  Denver, CO 80202-4613
  Phone: (303) 620-4292 or (800) OEC-6662
  FAX: (303) 620-4288
  E-mail: oec@csn.net
  Website: www.state.co.us/gov_dir/oec3/index.html

- Energy Efficiency and Renewable Energy Clearinghouse (EREC)
  U.S. Department of Energy
  Phone: (800) 363-3732

- Energy Efficiency and Renewable Energy Network (EREN)
  http://www.eren.doe.gov/consumerinfo/

FOR INFORMATION ABOUT THIS STUDY, PLEASE CONTACT:

Dr. Barbara C. Farhar
Bureau of Sociological Research
Department of Sociology
Campus Box 327
University of Colorado
Boulder, CO 80309-0327
(303) 384-7376

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB NO. 0704-0188*

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE September 2000	3. REPORT TYPE AND DATES COVERED Technical Report

4. TITLE AND SUBTITLE
A Market Assessment of Residential Grid-Tied PV Systems in Colorado

5. FUNDING NUMBERS
PV00.8201

6. AUTHOR(S)
Barbara C. Farhar and Timothy C. Coburn

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

8. PERFORMING ORGANIZATION REPORT NUMBER
NREL/TP-550-25283

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

NREL Technical Monitor: NA

12a. DISTRIBUTION/AVAILABILITY STATEMENT
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
This report presents research done in response to a decision by the Colorado Governor's Office of Energy Conservation and Management (OEC) and Colorado utility companies to consider making residential grid-tied photovoltaic (PV) systems available in Colorado. The idea was to locate homeowners willing to pay the costs of grid-tied PV (GPV) systems without batteries—$8,000 or $12,000 for a 2- or 3-kilowatt (kW) system, respectively, in 1996. These costs represented two-thirds of the actual installed cost of $6 per watt at that time and assumed the remainder would be subsidized. The National Renewable Energy Laboratory (NREL) and OEC partnered to conduct a market assessment for GPV technology in Colorado. The study encompassed both qualitative and quantitative phases. The market assessment concluded that a market for residential GPV systems exists in Colorado today. That market is substantial enough for companies to successfully market PV systems to Colorado homeowners. These homeowners appear ready to learn more, inform themselves, and actively purchase GPV systems. The present situation is highly advantageous to Colorado's institutions—primarily its state government and its utility companies, and also its homebuilders—if they are ready to move forward on GPV technology.

14. SUBJECT TERMS
Market assessment; photovoltaics; grid-tied photovoltaics; residential systems

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102