

Research Division

Contractor: Regents of UC Berkeley

Contract # 07-321

FUNDING FISCAL YEAR	FY 07/08	FY 08/09	FY 09/10	FY 10/11	
TERM	03/15/08-09/15/09	03/15/08-09/15/09	03/15/08-09/15/09	03/15/08-09/15/09	
	03/15/08-09/14/10	03/15/08-09/14/10	03/15/08-09/14/10	03/15/08-09/14/10	
PCA	72360	72360	72360	72360	
LINE ITEM/OBJECT	398	398	398	398	TOTAL

DESCRIPTION	Consulting services				
Contract \$	\$ 70,000.00	\$ 20,000.00	10,000.00	\$	100,000.00
Amd. #1 - Time only (10/14/09 lld)				\$	

Total, Contract	\$ 70,000.00	\$ 20,000.00	\$ 10,000.00	\$	100,000.00
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Payments to Contractor:

Inv. #	Inv. Date	Ser Per		C/S	RETENTION
77716-55046	07/25/08	04/07/08-06/30/08	9,211.28	9,211.28 C080191	11688.61
77716-58045	8/21/08	4/7/08-6/30/09	14,010.82	9,211.28 C080598	9211.28
77716-87054	6/17/2009		9,600.18	9,600.18 C090267	
77716-87056	6/17/2009		18,920.53	18,920.53 C090257	
77716-90883	7/28/2009		9,874.93	9,874.93 C090257	

Total, Payments	\$ 61,617.74	\$	\$	\$	61,617.74
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Balance Available to Pay Contractor	\$ 8,382.26	\$ 20,000.00	\$ 10,000.00	\$	38,382.26
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Balance Must Be Spent By: 6/30/2010 6/30/2011 6/30/2012

Notes:
Contract Manager: Dorothy Shimer

Research Division

**Contractor: Regents of UC Berkeley
Contract # 07-321**

FUNDING FISCAL YEAR	FY 07/08	FY 08/09	FY 09/10	FY 10/11	
TERM	03/15/08-09/15/09	03/15/08-09/15/09	03/15/08-09/15/09	03/15/08-09/15/09	
	03/15/08-09/14/10	03/15/08-09/14/10	03/15/08-09/14/10	03/15/08-09/14/10	
PCA	72360	72360	72360	72360	
LINE ITEM/OBJECT	398	398	398	398	TOTAL
DESCRIPTION	Consulting services				
Contract \$	\$ 70,000.00	\$ 20,000.00	10,000.00	\$	100,000.00
Amd. #1 - Time only (10/14/09 lld)				\$	-
				\$	-
Total, Contract	\$ 70,000.00	\$ 20,000.00	\$ 10,000.00	\$	100,000.00

Payments to Contractor:

Inv. #	Inv. Date	Ser Per			C/S	RETENTION
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77716-90883	7/28/2009		9,874.93	9,874.93		

Total, Payments	\$ 61,617.74	\$ -	\$ -	\$ -	61,617.74
Balance Available to Pay Contractor	\$ 8,382.26	\$ 20,000.00	\$ 10,000.00	\$	38,382.26
<i>Balance Must Be Spent By:</i>	<i>6/30/2010</i>	<i>6/30/2011</i>	<i>6/30/2012</i>		

Notes:

Contract Manager: Dorothy Shimer

410



University of California Berkeley

Accounting Services
Extramural Funds Accounting

Received by State of California
Air Resources Board
AUG 1 2008
Date: # 77716-55046 B/P#
pgs Amt. Recd \$

Invoice To:

CO80191

Cal EPA Air Resources Board
Research Division
Air Resources Board
P. O. Box 1825
Sacramento, CA 95812

INVOICE NO. 77716 - 55046

Contract/Grant/Agreement/Purchase Order		PI/Director: Horvath, Arpad	
Number: 07-321-7321		Reference:	
Project Title Evaluation of Efficiency Activities in the Industrial Sector Undertaken in Response to Greenhouse Gas Emission Reduction Targets			
	Period Billed		
	4/7/2008 - 6/30/2008		
	Cumulative	Current	
Salaries & Wages	0.00	0.00	
Employee Benefits	0.00	0.00	
Equipment & Facilities	0.00	0.00	
Supplies, Materials, & Services	0.00	0.00	
Travel	0.00	0.00	
Subcontract	21,111.00	21,111.00	
Indirect Cost	2,111.10	2,111.10	
TOTAL	\$23,222.10	23,222.10	
Less Withholding (10.0%):			2,322.21
Amount Now Due			20,899.89
<p>Refer to invoice # 77716 - 55046 and make check payable to: THE REGENTS OF THE UNIVERSITY OF CALIFORNIA Extramural Funds Accounting 2195 Hearst Ave RM 130 MC 1103 Berkeley, California 94720-1103</p> <p>TIN # 94-6002123</p>		<p>It is hereby certified that all expenditures reported (or payment requested) are for appropriate purposes and in accordance with the agreements set forth in the application and award documents.</p> <p style="text-align: right;">less \$11,088.10 <u>Total Due \$9,211.79</u></p> <p style="text-align: right;"><i>[Signature]</i></p>	
Questions regarding this invoice should be directed to:		<p>Jon Mirsky, Award Analyst Phone: (510) 642-0595 FAX: 510-643-8997 Email: mirsky@berkeley.edu</p>	

DS - partial payment - 06-9-2008

PAYMENT APPROVED:

[Signature]
BART E. CROES, P.E.
CHIEF, RESEARCH DIVISION
DATE 9/25/08



University of California Berkeley

Accounting Services
Extramural Funds Accounting

FORM 3000

Invoice To:

0080598

Date: 8/21/2008

Cal EPA Air Resources Board
Research Division
Air Resources Board
P. O. Box 1825
Sacramento, CA 95812

INVOICE NO. 77716 - 58045

Contract/Grant/Agreement/Purchase Order
Number: ~~07-321~~

PI/Director: Horvath, Arpad

Reference:

Project Title: Evaluation of Efficiency Activities in the Industrial Sector Undertaken in Response to Greenhouse Gas
Emission Reduction Targets

	Period Billed	
	4/1/2008 - 6/30/2008	
	Cumulative	Current
Salaries & Wages	0.00	0.00
Employee Benefits	0.00	0.00
Equipment & Facilities	0.00	0.00
Supplies, Materials, & Services	0.00	0.00
Travel	0.00	0.00
Subcontract	21,111.00	21,111.00
Indirect Cost	2,111.10	2,111.10
TOTAL	\$23,222.10	23,222.10

Amount Now Due **23,222.10**

Refer to invoice # 77716 - 58045

and make check payable to:

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
Extramural Funds Accounting
2195 Hearst Ave RM 130 MC 1103
Berkeley, California 94720-1103

TIN # 94-6002123

It is hereby certified that all expenditures reported (or payment requested) are for appropriate purposes and in accordance with the agreements set forth in the application and award documents.

less amount previously paid 9,211.28

~~TOTAL DUE \$14,010.82~~

Questions regarding this invoice should be directed to:

Jon Mirsky, Award Analyst

Phone: (510) 642-0595 FAX: 510-643-8997

Email: mirsky@berkeley.edu

PAYMENT APPROVED:

BART E. CROES, P.E.
CHIEF, RESEARCH DIVISION
DATE 3/18/09

FORM 3000



University of California Berkeley

Accounting Services
Extramural Funds Accounting

UNIVERSITY OF CALIFORNIA

Invoice To:

EMMA PLASENCIA
Air Resources Board, Research Division
1001 "I" Street, Suite 540
Sacramento, CA 95814

Date: 6/17/2009

INVOICE NO. 77716 - 87054

Re: Revision of invoice #
77716-70188

Contract/Grant/Agreement/Purchase Order
Number: ~~07-321~~

PI/Director: Horvath, Arpad

Reference:

Project Title: EVALUATION OF EFFICIENCY ACTIVITIES IN THE INDUSTRIAL SECTOR UNDERTAKEN IN
RESPONSE TO GREENHOUSE GAS EMISSION REDUCTION TARGETS

Period Billed

~~7/1/2008 - 7/31/2008~~

Cumulative

Current

Salaries & Wages

0.00

0.00

Employee Benefits

0.00

0.00

Equipment & Facilities

0.00

0.00

Supplies, Materials, & Services

0.00

0.00

Travel

0.00

0.00

Subcontract

30,322.28

9,211.28

Indirect Cost

2,500.00

388.90

TOTAL

\$32,822.28

9,600.18

Amount Now Due

~~9,600.18~~

Refer to invoice # 77716 - 87054

and make check payable to:

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
Extramural Funds Accounting
2195 Hearst Ave RM 130 MC 1103
Berkeley, California 94720-1103

TIN # 94-6002123

It is hereby certified that all expenditures reported (or payment requested) are
for appropriate purposes and in accordance with the agreements set forth in
the application and award documents.

Questions regarding this invoice should be directed to:

Victorino Soriano, Award Analyst

Phone: (510) 643-6539 FAX: 510-643-8997

Email: vsoriano@berkeley

PAYMENT APPROVED:

BART E. CROES, P.E.
CHIEF, RESEARCH DIVISION
DATE 10/12/09

9,600.18
18,920.53
9,874.93
38,395.64

003

6533-22-12



University of California Berkeley

Accounting Services
Extramural Funds Accounting

FORM 3000A

Invoice To:

EMMA PLASENCIA
Air Resources Board, Research Divisi
1001 "I" Street, Suite 540
Sacramento, CA 95814

Date: 6/17/2009

INVOICE NO. 77716 - 87056

Re: Revision of invoice 77716-78651

Contract/Grant/Agreement/Purchase Order
Number: 07-321

PI/Director: Horvath, Arpad
Reference:

Project Title: EVALUATION OF EFFICIENCY ACTIVITIES IN THE INDUSTRIAL SECTOR UNDERTAKEN IN RESPONSE TO GREENHOUSE GAS EMISSION REDUCTION TARGETS

Period Billed

11/1/2008 - 5/31/2009

Table with 3 columns: Category, Cumulative, Current. Rows include Salaries & Wages, Employee Benefits, Equipment & Facilities, Supplies, Materials, & Services, Travel, Subcontract, Indirect Cost, and TOTAL.

Amount Now Due

18,920.53

Refer to invoice # 77716 - 87056
and make check payable to:
THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
Extramural Funds Accounting
2195 Hearst Ave RM 130 MC 1103
Berkeley, California 94720-1103

TIN # 94-6002123

It is hereby certified that all expenditures reported (or payment requested) are for appropriate purposes and in accordance with the agreements set forth in the application and award documents.

Victorino Soriano

Questions regarding this invoice should be directed to:

Victorino Soriano, Award Analyst
Phone: (510) 643-6539 FAX: 510-643-8997
Email: vsoriano@berkeley.edu

PAYMENT APPROVED:

BART E. CROES, P.E.
CHIEF, RESEARCH DIVISION
DATE 10/12/09

FORM 3000A



University of California Berkeley

Accounting Services
Extramural Funds Accounting

RECEIVED

Invoice To:

EMMA PLASENCIA
Air Resources Board, Research Divisi
1001 "I" Street, 5th Floor
Sacramento, CA 95814

Date: 7/28/2009

INVOICE NO. 77716 - 90883

Contract/Grant/Agreement/Purchase Order

PI/Director: Horvath, Arpad

Number: ~~07-321~~

Reference:

Project Title: EVALUATION OF EFFICIENCY ACTIVITIES IN THE INDUSTRIAL SECTOR UNDERTAKEN IN RESPONSE TO GREENHOUSE GAS EMISSION REDUCTION TARGETS

Period Billed

~~6/1/2009 - 6/30/2009~~

Salaries & Wages

1,149.02

574.51

Employee Benefits

142.98

71.85

Equipment & Facilities

0.00

0.00

Supplies, Materials, & Services

8.04

4.02

Travel

0.00

0.00

Subcontract

56,766.10

8,237.92

Indirect Cost

3,551.60

986.63

TOTAL

\$61,617.74

9,874.93

Amount Now Due

~~9,874.93~~

Refer to invoice # 77716 - 90883

and make check payable to:

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
Extramural Funds Accounting
2195 Hearst Ave RM 130 MC 1103
Berkeley, California 94720-1103

TIN # 94-6002123

It is hereby certified that all expenditures reported (or payment requested) are for appropriate purposes and in accordance with the agreements set forth in the application and award documents.

Questions regarding this invoice should be directed to:

Victorino Soriano, Award Analyst
Phone: (510) 643-6539 FAX: 510-643-8997
Email: vsoriano@berkeley.edu

PAYMENT APPROVED:

BART E. CROES, P.E.
CHIEF, RESEARCH DIVISION

DATE 10/12/09

10/12/09

STATE OF CALIFORNIA
STANDARD AGREEMENT
 STD 213 (Rev 06/03)

AGREEMENT NUMBER 07-321
REGISTRATION NUMBER 3900080833173

1. This Agreement is entered into between the State Agency and the Contractor named below:

STATE AGENCY'S NAME

Air Resources Board (ARB)

CONTRACTOR'S NAME

The Regents of the University of California, Berkeley (UCB or Contractor)

2. The term of this Agreement is: **March 15, 2008** through **September 15, 2009**
 or upon DGS Approval

3. The maximum amount of this Agreement is: **\$ 100,000**
 One hundred thousand dollars and no cents

4. The parties agree to comply with the terms and conditions of the following exhibits which are by this reference made a part of the Agreement.

Exhibit A - Scope of Work	1 page(s)
Exhibit A - Attachment 1	68 pages
Exhibit B - Budget Detail and Payment Provisions	2 page(s)
Exhibit B - Attachment 1	24 pages
Exhibit C* - General Terms and Conditions	GIA 101
Check mark one item below as Exhibit D:	
<input checked="" type="checkbox"/> Exhibit - D Special Terms and Conditions (Attached hereto as part of this agreement)	1 page(s)
<input type="checkbox"/> Exhibit - D* Special Terms and Conditions	
Exhibit E - Additional Provisions	8 page(s)
Exhibit F - Final Report Format	6 pages

Items shown with an Asterisk (*), are hereby incorporated by reference and made part of this agreement as if attached hereto.
 These documents can be viewed at www.ols.dgs.ca.gov/Standard+Language

IN WITNESS WHEREOF, this Agreement has been executed by the parties hereto.

CONTRACTOR

CONTRACTOR'S NAME (if other than an individual, state whether a corporation, partnership, etc.) The Regents of the University of California, Berkeley	
BY (Authorized Signature) <i>Jyl Baldwin</i>	DATE SIGNED (Do not type) 3/5/08
PRINTED NAME AND TITLE OF PERSON SIGNING Jyl Baldwin	
ADDRESS Sponsored Projects Office 2150 Shattuck Avenue, Suite 313, Berkeley, CA 94704-5940	
STATE OF CALIFORNIA	
AGENCY NAME Air Resources Board	
BY (Authorized Signature) <i>Socorro Watkins</i>	DATE SIGNED (Do not type) 03-17-08
PRINTED NAME AND TITLE OF PERSON SIGNING Socorro Watkins, Chief, Business Management Branch	
ADDRESS P.O. Box 2815, Sacramento, CA 95812	

California Department of General Services Use Only

KW

APPROVED

APR - 7 2008

DEPT OF GENERAL SERVICES

Kyates

Exempt per:

5/14/08

EXHIBIT A

SCOPE OF WORK

1. The Regents of the University of California, Berkeley (UCB, University, or Contractor) agrees to provide the following services for the project entitled "Evaluation of Efficiency Activities in the Industrial Sector Undertaken in Response to Greenhouse Gas Emission Reduction Targets," which is attached hereto as Attachment 1 and made a part of this Agreement.
2. The project representatives during the term of this agreement will be:

Requesting Agency: ARB	Providing Agency: The Regents of the University of California, Berkeley
Name: Dorothy Shimer	Name: Arpad Horvath
Section/Unit: Research Division	Section/Unit: Dept. of Civil & Enviro Engineering
Address: 1001 "I" Street, 5 th Floor Sacramento, CA 95814	Address: University of California, Berkeley 215B McLaughlin Hall Berkeley, CA 94720-1712
Phone: (916) 323-1503	Phone: (510) 642-7300
Fax: (916) 323-1045	Fax: (510) 643-8919
Email: dshimer@arb.ca.gov	Email: Horvath@ce.berkeley.edu

The ARB Contract Administrator is:

The University's Contract Administrator is:

Requesting Agency: ARB	Providing Agency: The Regents of the University of California, Berkeley
Name: Emma Plasencia	Name: Jyl Baldwin
Section/Unit: Research Division	Section/Unit: Sponsored Projects Office
Address: 1001 "I" Street, 5 th Floor Sacramento, CA 95814	Address: 2150 Shattuck Avenue, Suite 313 Berkeley, CA 94704-5940
Phone: (916) 323-1524	Phone: (510) 642-8117
Fax: (916) 322-4357	Fax: (510) 642-8236
Email: eplasenc@arb.ca.gov	Email: jlbaldwin@berkeley.edu

TECHNICAL PROPOSAL

Evaluation of Efficiency Activities in the Industrial Sector Undertaken in Response to Greenhouse Gas Emission Reduction Targets

Principal Investigator:
Arpad Horvath

Official Authorized to Bind this Proposal:

Name _____

Signature _____

Prepared for:

State of California Air Resources Board
Research Division
PO Box 2815
Sacramento CA 95812

Prepared by:

Arpad Horvath
Department of Civil and Environmental Engineering
215 McLaughlin Hall
University of California, Berkeley, CA 94720

June 2007

Check if applicable:

Animal subjects _____

Human subjects _____

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1. Statement of Significance

In 2005, Governor Schwarzenegger announced greenhouse gas (GHG) emission reduction targets for California which call for reducing emissions to 2000 levels by 2010, to 1990 levels by 2020, and to 80% below 1990 levels by 2050. The 2020 targets were included in the California Global Warming Solutions Act of 2006. The California Air Resources Board has been given the tasks of adopting a statewide GHG limit for 2020 equivalent to 1990 emissions and to adopt rules, regulations, and market-based compliance mechanisms for achieving the maximum technologically feasible and cost-effective GHG emissions reductions.

Meeting the California Global Warming Solutions Act 2020 target will require action from all sectors of the California economy, including the industrial sector. Many countries around the world have similar national-level GHG reduction or energy-efficiency targets, and comprehensive programs focused on implementation of energy efficiency and GHG emissions mitigation measures in the industrial sector are essential for achieving their goals. A combination of targets and industry-focused supporting programs has led to significant investments in energy efficiency as well as reductions in GHG emissions within the manufacturing sectors in these countries.

The objective of this research is to identify the characteristics of successful industrial sector GHG emissions reduction and energy efficiency programs in other countries in order to provide a summary of lessons learned and make recommendations for specific industrial sector program designs that could be implemented in California in support of the 2020 GHG emissions reduction target outlined in the 2006 Global Warming Solutions Act.

The research will begin with a characterization of the industrial sector in California, determining which industrial sub-sectors are the top energy consumers and largest carbon dioxide emitters. Then industrial sector energy efficiency and GHG emission reduction programs in other countries that focus on the industrial sub-sectors that are most important in California will be examined and key program elements identified. An assessment of the barriers faced when initiating these programs will also be undertaken. Detailed information on specific GHG emission reduction technologies and measures that were undertaken by facilities participating in national level energy efficiency and GHG emissions reduction programs in the top GHG emitting sub-sectors in California will be compiled.

The industrial sector consumes 25% of the energy used in California and emits 28% of CO₂ produced in the state. This project will identify program and policies that have effectively targeted this sector in other countries to achieve real energy and CO₂ savings. Increased energy efficiency and reduced GHG emissions can also lead to cost savings and improved competitiveness for industries, reduced emissions of other air pollutants and particulate matter, reduced water consumption, reduced production of waste and improved product quality.

2. Abstract

This research will identify the characteristics of successful industrial sector GHG emissions reduction and energy efficiency programs in other countries in order to provide a summary of lessons learned and make recommendations for specific industrial sector program designs that could be implemented in California in support of the 2020 GHG emissions reduction target outlined in the 2006 Global Warming Solutions Act. The industrial sector consumes 25% of the energy used in California and emits 28% of CO₂ produced in the state.

California's industrial sector is diverse and encompasses a number of energy-intensive industries such as petroleum refining and cement making as well as many smaller sectors such as textiles, equipment manufacturing, and furniture making. The research will begin with a characterization of the industrial sector in California, determining which industrial sub-sectors are the top energy consumers and largest CO₂ emitters. Five key industrial sub-sectors will be chosen as the sub-sectors to focus on for the remaining project tasks.

Next, industrial sector energy efficiency and GHG emission reduction programs in other countries that focus on the industrial sub-sectors that are most important in California will be examined and key program elements identified. An assessment of the barriers faced when initiating these programs will also be undertaken. Three to five national-level programs that address industries important in California will be chosen for more detailed assessment. For each program identified, the general program design will be described along with an assessment of the level of industry participation and the realized energy savings. Program design elements such as information dissemination related to efficiency options, facility auditing, benchmarking, facility-level target-setting, development of implementation plans, energy management programs, monitoring of progress towards targets and financial incentives will be described.

To the extent possible, detailed information on specific energy efficiency and GHG emission reduction technologies and measures that were undertaken by facilities participating in national level energy efficiency and GHG emissions target-setting reduction programs in the top GHG emitting sub-sectors in California will be compiled. The specific energy efficiency or GHG emission reduction activities undertaken in the chosen programs will be identified and described and, if possible, their implementation costs and estimated annual energy savings (or GHG emission reductions) will be provided. References to literature providing more detail on the energy efficiency or GHG emission mitigation options will be given, as well as references to case studies, if available.

The project report will document the research results and findings from the efforts described above as well as provide a summary of lessons learned from comprehensive industrial energy efficiency or GHG mitigation programs in other countries. Finally, it will make recommendations for specific industrial sector program designs that could be implemented in California in support of the 2020 GHG emissions reduction target outlined in the 2006 Global Warming Solutions Act.

3. Project Objectives

In order to provide a summary of lessons learned and make recommendations for specific industrial sector program designs that could be implemented in California in support of the 2020 GHG emissions reduction target outlined in the 2006 Global Warming Solutions Act, the objectives of this research are as follows: 1) to characterize the industrial sector in California, 2) to identify and describe GHG emission reduction programs in other countries relevant to California, and 3) to identify and describe specific GHG emission reduction technologies and measures that were undertaken in response to GHG emission reduction target-setting programs in other countries.

Objective 1: Characterizing the Industrial Sector in California

California's industrial sector is diverse and encompasses a number of energy-intensive industries such as petroleum refining and cement making as well as many smaller sectors such as textiles, equipment manufacturing, and furniture making. The most recent detailed data on energy consumption by industrial sub-sectors for California is provided for 2000 by the California Energy Balance (CALEB). This data will be updated to the most recent year available in order to have an accurate characterization of California's industrial sector and California's industrial sub-sectors will be ranked in terms of both their energy use and CO₂ emissions in order to choose five key California industrial sub-sectors.

Objective 2: Identifying and Describing GHG Emission Reduction Target-Setting Programs in Other Countries Relevant to California

Numerous GHG emission reduction programs that focus on the industrial sector exist in other countries. These programs will be identified and described and three to five national-level programs that address industrial sectors important in California will be assessed in further detail in order to understand lessons learned regarding program design and delivery as well as applicable elements for possible adoption in California. An assessment of the barriers faced when initiating these programs will be undertaken. For each program identified, the general program design will be described along with an assessment of the level of industry participation and the realized energy savings. Program design elements such as information dissemination related to efficiency options, facility auditing, benchmarking, facility-level target-setting, development of implementation plans, energy management programs, monitoring of progress towards targets and financial incentives will be described.

Objective 3: Identifying and Describing Specific GHG Emission Reduction Technologies and Measures Undertaken in Industrial Target-Setting Programs in Other Countries Relevant to California

To the extent possible, specific actions taken by industrial firms in response to target-setting agreements in other countries will be identified and described in order to more clearly demonstrate how such industries achieve their stated energy efficiency or GHG emissions mitigation goals.

4. Technical Plan

4.1 Research Methods

This project will rely on literature reviews, interviews, and data collection and analysis in order to complete the tasks outlined below.

Literature review will be used to identify energy efficiency or GHG emission reduction programs in other countries that focus on industries relevant to California. Once identified, literature reviews and interviews will be used to understand the key program design elements as well as to identify the specific GHG emission reduction technologies and measures that were undertaken by facilities participating in national level energy efficiency and GHG emissions reduction programs. Literature reviews and interviews will further be used to assess the barriers faced when initiating these programs and how they were overcome.

Data will be collected and analyzed to characterize the industrial sector in California in order to determine which industrial sub-sectors are the largest energy consumers and carbon dioxide emitters. If possible, data will also be collected and analyzed to understand the energy savings and emissions reductions associated with the national level energy efficiency and GHG emissions reduction programs analyzed in this project.

This project will not use test specimens, laboratory animals, or human subjects.

4.2 Tasks

4.2.1 Task 1. Characterization of the Industrial Sector in California

This task involves a characterization of the industrial sector in California, in order to determine which industrial sub-sectors are the top energy consumers and largest CO₂ emitters. The industrial sector includes manufacturing industries (e.g., aluminum, pulp and paper, electronics) and non-manufacturing industries (e.g., agriculture, forestry, construction, and mining for non-energy minerals and metals).

The most recent detailed data on energy consumption by industrial sub-sectors for California is provided for 2000 by the California Energy Balance (CALEB). CALEB provides energy consumption by fuel type (electricity, natural gas, crude oil and petroleum products, and coal) for the following industrial sectors:

Agriculture

- Crop production
- Livestock production
- Irrigation
- Non-specified agriculture

Mining

- Metal mining
- Coal mining
- Nonmetallic minerals

Manufacturing

- Food products
 - Food processing
 - Sugar and confections
 - Non-specified food products

- Tobacco
- Textiles
 - Textile mills
 - Leather
 - Apparel
- Wood and furniture
 - Lumber and wood products
 - Furniture and fixtures
- Pulp and paper
 - Pulp mills
 - Paper mills
 - Paperboard mills
 - Non-specified pulp and paper
- Printing and publishing
- Chemicals and allied products
- Plastics and rubber
 - Plastics
 - Non-specified plastics and rubber
- Stone, clay, glass, cement
 - Flat glass
 - Glass containers
 - Cement
 - Non-specified stone, clay, glass, cement
- Primary metals
- Metal durables
 - Fabricated metal products
 - Computers and office machines
 - Industrial machinery and equipment
- Electric and electronic equipment
 - Telephone and broadcast equipment
 - Semiconductors and related products
 - Non-specified electric equipment
- Transportation equipment
- Instruments and related products
- Construction
- Non-specified industry

These data will be updated to the extent possible given data availability and data limitations in order to have a more recent characterization of California's industrial sector. Data will be collected by fuel type, including electricity, so that GHG emissions can be accurately calculated. If available, an appropriate electricity emissions factor – that accounts for out-of-state electricity imports – will be used in order to calculate CO₂ emissions from electricity. Energy sources consumed as feedstocks in industry will be accounted for using the same assumptions as are used in the California GHG inventory.

Once the data are updated, California's industrial sub-sectors will be ranked in terms of both their energy use and CO₂ emissions. Five key industrial sub-sectors will be chosen in consultation with ARB as the sub-sectors to focus on for the remaining project tasks.

Sources for this data include the California Energy Balance (CALEB) (Murtishaw et al., 2005) and the *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004* (CEC, 2006). Other sources of information, such as the U.S. Geological Survey and Portland Cement Association data on cement energy consumption and production as well as data from investor-owned utilities and local air districts, will also be consulted.

4.2.2 Task 2. Identification and Description of Industrial Sector Energy Efficiency and GHG Emission Reduction Programs in Other Countries Relevant to California

For this task, industrial sector energy efficiency and GHG emission reduction programs in other countries (such as Australia, Canada, Denmark, France, Japan, Netherlands, and UK) that focus on the industrial sub-sectors that are most important in California will be examined. This research will build on programmatic work in other countries and will report their successes or failures, evaluating lessons learned and applicable elements for California. Many countries have had comprehensive industrial sector energy efficiency programs since the 1990s that actively engage a large portion of the industrial sector and that have delivered significant energy savings. The UK's Climate Change Agreement program, for example, which includes industries that are important in California such as semiconductors, food processing, and cement manufacturing, has consistently exceeded the program's GHG emissions reduction goals. A general description of the industrial sector energy efficiency and GHG emissions reduction programs that are examined will be provided, describing the general program design including how the program supports overall national-level goals regarding energy efficiency or GHG emissions mitigation, how targets are established, the level of industry participation, and the realized energy savings or GHG emissions reduction, if available.

From the survey above, three to five national-level programs that address industries important in California will be chosen in consultation with ARB for more detailed assessment. In addition to the information provided above, the design and delivery of program supporting elements such as information dissemination related to efficiency options, facility auditing, benchmarking, facility-level target-setting, development of implementation plans, energy management programs, monitoring of progress toward targets, and financial incentives will be described. Industry participation levels, by industrial sub-sector, will be documented. Program evaluations will be reviewed in order to assess the realized energy savings (by industrial sub-sector if possible). In addition, program managers of the key programs identified in Task 2 will be requested to identify the top barriers faced when initiating the program, both real and perceived by the manufacturers. Discussions with these key program managers will aim at gaining an understanding of how these barriers were addressed within their programs.

The project team researchers has previously reviewed a number of industrial sector energy efficiency and GHG mitigation policies and programs (see Price et al., 2005; Price, 2005; Galitsky et al., 2004) but these reviews did not focus specifically on how policies and programs in other countries are relevant to the key industries in California or the barriers addressed within the program or by the manufacturers. Key sources for this task will include country-specific program descriptions and evaluations, many of which are cited in the reference section of this proposal.

4.2.3 Task 3. Identification of Specific Industrial Energy Efficiency and GHG Emission Reduction Technologies and Measures Undertaken in Programs in Other Countries Relevant to California

The objective of this task is to describe the specific actions taken by industrial firms as participants in energy efficiency and GHG emission reduction programs worldwide in order to more clearly demonstrate how such industries achieve their stated goals.

For each of the three to five key national-level energy efficiency or GHG mitigation programs identified in Task 2, detailed information on specific GHG emission reduction technologies and measures that were undertaken by facilities participating in the programs in the top GHG emitting sub-sectors in California will be compiled to the extent possible. For example, as mentioned, the UK Climate Change Agreements include the semiconductor, food processing, and cement manufacturing industries, all of which are also likely important in California. In order to gain a more complete understanding of the specific energy efficiency improvements or GHG mitigation options employed in these industries in response to the Climate Change Agreements, the UK Climate Change Agreement literature will be reviewed and program managers will be interviewed. If possible, industrial sector associations and/or plant energy managers will also be contacted for additional information. Similar assessments will be done for each of the three to five national-level programs chosen for further evaluation.

To the extent possible, specific energy efficiency or GHG emission reduction activities undertaken in the chosen programs will be identified and described and their implementation costs and estimated annual energy savings (or GHG emission reductions) will be provided. References to literature providing more detail on the energy efficiency or GHG emission mitigation options will be given, as well as references to case studies, if available.

This work will build upon previous research by the project team that assessed a wide range of energy efficiency measures and their energy savings potential in California industries (KEMA, Inc. et al., 2006).

4.2.4 Task 4. Draft Project Report

The draft project report will document the research results and findings from Tasks 1 through 3.

For Task 1, the report will document how the California industrial sector energy consumption data were updated and how California industrial sector GHG emissions were calculated from the updated energy consumption data, including the electricity emissions factor used and other key conversion assumptions. The report will provide a table ranking California industrial sub-sectors by final and primary energy consumption and CO₂ emissions for the most recent year available. The report will also document the five industrial sub-sectors chosen to focus on for the remaining tasks and describe the rationale behind their selection.

For Task 2, the report will provide a brief description of the industrial sector energy efficiency and GHG emission reduction programs in other countries that were initially reviewed and will identify the three to five programs that were chosen to focus on that include industrial sub-sectors that are most important in California. For these

three to five programs, the report will describe the general program design including how the program supports overall national-level goals regarding energy efficiency or GHG emissions mitigation, if applicable, how targets are established, the level of industry participation, how barriers to program implementation and adoption were addressed, and the realized energy savings as documented in program evaluations. The report will describe the design and delivery of program support elements such as information dissemination related to efficiency options, facility auditing, benchmarking, facility-level target-setting, development of implementation plans, energy management programs, monitoring of progress toward targets, and financial incentives.

For Task 3, the report will – to the extent possible – describe the specific energy efficiency or GHG emission reduction mitigation option undertaken and document each option's implementation cost and estimated annual energy savings or GHG emissions reductions. The report will provide references to the literature providing more detail on energy efficiency or GHG emission mitigation options as well as references to case studies.

Overall, the report will provide a summary of lessons learned from comprehensive industrial energy efficiency or GHG mitigation programs in other countries and will make recommendations for specific industrial sector program designs that could be implemented in California in support of the 2020 GHG emissions reduction target outlined in the 2006 Global Warming Solutions Act.

4.2.5 Task 5. Final Project Report

The final project report will be completed following receipt and incorporation of comments by ARB staff.

4.3 Data Management Plan

Data to be collected for the first task of this project include energy consumption data for California industrial sub-sectors, electricity emissions factors for California in-state and imported electricity, and conversion factors for calculating CO₂ emissions from fuels consumed in California.

The second task of this project will involve collecting information via websites of the various program, reports, journal articles, meetings, and telephone calls. All of these sources will be fully documented in the report.

Data to be collected for the third task of this project include the implementation cost of each specific energy efficiency or GHG mitigation measure and the estimated annual energy savings or GHG emissions reduction achieved by each specific energy efficiency or GHG mitigation measure. This data will be collected and analyzed using a pre-designed Excel spreadsheet that includes standardized conversion factors to convert different currencies to US dollars, energy units to joules and British Thermal Units (Btus), and carbon dioxide emissions to units of CO₂.

4.4 Existing Facilities Available for Conducting Proposed Research

The proposed research will be conducted at Lawrence Berkeley National Laboratory within existing office space utilizing available literature, the internet, and

telephone interviews. Additional research may be conducted at University of California libraries.

4.5 References

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Arpad Horvath is the principal investigator and will serve as overall project manager. He will oversee and review the work of the subcontractor, LBNL. He will submit the project quarterly progress reports, the draft report, and the final report.

Lynn Price is the principal investigator for the LBNL project team and will serve as overall project manager. She will oversee the day-to-day research and coordinate the efforts of the technical researchers for each task. She will be responsible for producing the draft and final report and for interacting with ARB staff regarding this project.

Christina Galitsky is a technical researcher on this project who will assist Lynn Price in overall project management. Christina will focus her efforts on research related to Tasks 2 and 3 of this project. Christina will also assist Lynn Price in producing the draft and final report.

Stephane de la Rue du Can is a technical researcher on this project who will focus on Task 1. Stephane will also assist Lynn Price in producing the draft and final report.

Eric Masanet is a technical researcher on this project who will focus on Task 1. Eric will also assist Lynn Price in producing the draft and final report.

This project will be managed and coordinated internally through regular communication including bi-weekly meetings of the research team. The research team has worked together for the nearly three years (or longer in some cases) and is physically located in adjacent offices, so regular communication is already established. Each person will be assigned specific tasks with allocated budget amounts and these will be tracked monthly.

8. Related Research

LBNL research related to the characterization of California's industrial sector has been undertaken through the development of the *California Energy Balances* (CALEB) (Murtishaw et al., 2005), funded by the California Energy Commission. A related LBNL project on *Improving the Carbon Dioxide Emission Estimates from the Combustion of Fossil Fuels in California* is currently being funded by the California Air Resources Board. LBNL has also completed the following reports related to the industrial sector in California:

- Galitsky, C., Worrell, E., Radspieler, A., Healy, P., and Zechiel, S., 2005. *BEST Winery Guidebook; Benchmarking for Energy and Water Savings Tool for the Wine Industry*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL- 3184) (funded by the California Energy Commission).
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 - Coito, F., Worrell, E., Price, L., Masanet, E., Friedmann, R., and Rufo, M., 2005. "California Industrial Energy Efficiency Potential," *Proceedings of the 2005 ACEEE Summer Study on Energy Efficiency in Industry*. Washington, DC: American Council for An Energy-Efficient Economy (funded by Pacific Gas & Electric Company).

Since 2001, LBNL has been funded by the U.S. Energy Star for Industry program to develop energy efficiency guides for industry. The following guides have been published and additional guides on the pulp and paper and petrochemicals industries are currently underway.

- Masanet, E., E. Worrell, and C. Galitsky, 2006. *Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry: An ENERGY STAR® Guide for Energy and Plant Managers*. Lawrence Berkeley National Laboratory, Berkeley, California. LBNL-59289.
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- Galitsky, C. and E. Worrell. 2003. *Energy Efficiency Improvement and Cost Saving Opportunities for the Vehicle Assembly Industry – A Guide for Energy and Plant Managers*, Berkeley, CA: Lawrence Berkeley National Laboratory, January, LBNL-50939.
- Galitsky, C., N. Martin, E. Worrell and B. Lehman. 2003. *Energy Efficiency Opportunities and Potential Cost Savings for Breweries – A Guide for Energy and Plant Managers*, Berkeley, CA: Lawrence Berkeley National Laboratory, May, LBNL-50934.

LBNL research related to the assessment of industrial sector energy efficiency and GHG emissions mitigation policies has produced the following reports and papers:

- Galitsky, C., Price, L., and Worrell, E., 2004. *Energy Efficiency Programs and Policies in the Industrial Sector in Industrialized Countries*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54068) (funded by the U.S. Department of Energy).
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9. Curriculum Vitae and Publications Lists

Arpad Horvath

Associate Professor

Department of Civil and Environmental Engineering
University of California, Berkeley
215B McLaughlin Hall
Berkeley, CA 94720-1712

Telephone: (510) 642-7300, Fax: (510) 643-8919
horvath@ce.berkeley.edu, <http://www.ce.berkeley.edu/~horvath>

CURRENT RESEARCH

Environmental assessment of the materials, services, and processes of infrastructure systems for more informed decision- and policy-making. Life-cycle assessment of products and services. Green engineering and management.

GENERAL RESEARCH INTERESTS

Infrastructure systems and the environment. Environmentally-conscious construction and the built environment. Industrial ecology. Environmental management and policy.

EDUCATION

1997	Ph.D., Civil Engineering Hendrickson)	<i>Carnegie Mellon University</i> (Advisor: Chris T. Hendrickson)
1995	M.S., Civil Engineering Hendrickson)	<i>Carnegie Mellon University</i> (Advisor: Chris T. Hendrickson)
1993	Dipl. Eng. (M.S.), Civil Engineering	<i>Technical University of Budapest, Hungary</i>

EXPERIENCE AND POSITIONS

- Associate Professor, *University of California, Berkeley* (July 2005 – present)
- Assistant Professor, *University of California, Berkeley* (July 1999 – June 2005)
- Director, *Consortium on Green Design and Manufacturing, UC Berkeley* (May 2000 – present)
- Director, “*Engineering and Business for Sustainability*” Certificate Program, *UC Berkeley* (January 2007 – present)
- Research Faculty, *Carnegie Mellon University* (January 1998 – June 1999)
- Postdoctoral Researcher, *Carnegie Mellon University* (July 1997 – December 1997)
- Graduate Research Assistant, *Carnegie Mellon University* (August 1993 – June 1997)
- Engineer-in-Training, *Ministry of Public Works and Transportation, General Office for Roads, Burgos, Spain*, (July 1992)

PROFESSIONAL ACTIVITIES

- Associate Editor, *ASCE Journal of Infrastructure Systems* (May 2002 – present)
- Guest Co-Editor (with H. Scott Matthews), two Special Issues of *ASCE J. of Infrastructure Systems* on Sustainable Development and Infrastructure Systems (September 2004, March 2005)
- Editorial Board Member, *Journal of Industrial Ecology*, the journal of the International Society for Industrial Ecology, MIT Press (March 2005 – present)
- Member, Committee on Environmental Impacts of Wind Energy Projects, National Research Council, The National Academies (August 2005 – May 2007)
- Secretary, Committee on Social and Environmental Concerns in Construction, Construction Institute, American Society of Civil Engineers (2001 – 2005), Member (2005 – present)
- Member, Center for Energy and Environmental Innovation (CEEI), Haas School of Business, UC Berkeley (June 2007 – present)
- Panel Reviewer, National Science Foundation (December 2006, November 2006, May 2005, November 2003, April 2003, November 2002)
- Member, Committee on Waste Management and Resource Efficiency in Transportation ADC60, Transportation Research Board (2000 – 2006)
- Member, Environmental Maintenance Subcommittee A3C01(1), Transportation Research Board (1999 – 2002)
- Corresponding Member, ASCE/TAC Subcommittee on Sustainability, American Society of Civil Engineers (2001 – present)
- Advisory Council Member, American Center for Life Cycle Assessment (2001 – 2006)
- Paper reviewer, *Environmental Science & Technology* (15 manuscripts), *ASCE J. of Construction Engineering and Management* (8), *J. of Industrial Ecology* (6), *ASCE J. of Transportation Engineering* (3), *International J. of Life Cycle Assessment* (4), *Research in Engineering Design* (2), *ASCE J. of Management in Engineering* (2), *Industrial and Engineering Chemistry* (3), *ASCE J. of Architectural Engineering* (2), *Proceedings of the IEEE*, *Ecological Economics* (2), *Environmental Research Letters*, *Environmental Engineering Science*, *J. of Environmental Management*, *J. of Transportation and Statistics*, *European J. of Operational Research*, *Automation in Construction*, *Chemosphere*, *Environmental Impact Assessment Review*, *Resources, Conservation and Recycling* (2), *Environmental Management, Materials and Structures*, *J. of Green Building*, *Greener Management International*, 2005 ASCE Construction Research Congress (17 abstracts, 5 papers), 9th International Conference on Structural Safety and Reliability ICOSSAR 2005 (5), 2007 World Conference on Transport Research, 2007 Conference of the International Society for Industrial Ecology (3 abstracts), 2007 IEEE International Symposium on Electronics and the Environment (6 abstracts), 2006 IEEE International Symposium on Electronics and the Environment (20 abstracts), 2006 American Society for Engineering Education Annual Conference & Exposition, 2007 Transportation Research Board Conference, 2006 Transportation Research Board Conference, 2005 Transportation Research Board Conference (2), 2004 Transportation Research Board Conference (2), 2003 ASME Design and Manufacturing Conference, 2002 Transportation Research Board Conference, 2001 Transportation Research Board Conference, 2001 IEEE International Symposium on Electronics and the Environment, 2000 IEEE International Symposium on Electronics and the Environment, 1997 ASME Design and Manufacturing Conference
- Book reviewer, Wiley (2004), MIT Press (2003), McGraw-Hill (2003), Springer (2002), Prentice-Hall (2001)
- Proposal Reviewer, Science and Technology Foundation (FCT), Ministry of Science, Technology and Higher Education, Portugal (June 2007); Graham Environmental Sustainability Institute, University of Michigan (November 2006); National Science Foundation (July 2006); California Partners for

Advanced Transit and Highways – PATH (March 2006, April 2005); University of Rhode Island Transportation Center – URITC (March 2003); Recycled Materials Resource Center, University of New Hampshire (June 2003)

- **Project Report Reviewer**, California Energy Commission – PIER (December 2004), The Automobile of the 21st Century – AUTO 21, Canada (December 2004)
- **Invited participant**, National Science Foundation Workshop “Research Opportunities for Reducing the Impact of Material Flows in the United States.” National Academies, Washington, DC (June 2004)
- **Co-developer**, first free Web-based life-cycle assessment (LCA) software: www.eiolca.net (1997-99)
- **Co-author**, White Paper of TRB Committee on Waste Management in Transportation A1F07 (1999)
- **Co-organizer**, Distinguished Environmental Lecture Series, Carnegie Mellon University (1998-1999)
- **Consultant**, sample application and exercises for *Advanced Engineering Mathematics – 2/e*, Zill and Cullen, Jones & Bartlett Publishers, Sudbury, MA (1999)
- **Expert reviewer**, *Towards a European Solution for the Management of Waste from Electric and Electronic Equipment*, study for the Environment Committee of the European Parliament, Joint Research Centre, Institute for Prospective Technological Studies, European Commission (1998)
- **Consultant and editor**, *Network Scheduling Techniques for Construction Project Management*, Miklos Hajdu (*Technical University of Budapest, Hungary*), Kluwer Scientific Publishing, Amsterdam, Netherlands (1996)
- **Consultant**, *Michael Baker Co.* (construction), Pittsburgh, PA (September 1996)
- **Editorial assistant**, *Fundamental Principles of Systems Analysis and Decision-Making*, textbook by Paul J. Ossenbruggen, John Wiley & Sons, New York (August - December 1992)

AWARDS

- Laudise Prize “for outstanding achievements in industrial ecology,” International Society for Industrial Ecology (2005)
- AT&T Foundation Industrial Ecology Faculty Fellowship (2004)
- National Science Foundation CAREER award (2001-2006)
- AT&T Foundation Industrial Ecology Faculty Fellowship (2001)
- AT&T Foundation Industrial Ecology Faculty Fellowship (2000)
- Certificate of Appreciation “in recognition of a substantial contribution to the 1999 SAE International Congress & Exposition” (1999)
- NSF-Lucent Technologies Industrial Ecology Fellowship (1998-2000) (shared with C. Hendrickson and L. Lave, Carnegie Mellon University)
- AT&T Foundation Industrial Ecology Faculty Fellowship (1998)

CONFERENCE ORGANIZATION

- **Track chair**, *World Conference on Transport Research*, Berkeley, CA (June 2007)

- **Conference co-chair**, *2007 IEEE International Symposium on Electronics and the Environment*, Orlando, FL (May 2007)
- **Member, Technical Committee**, *4th Conference of the International Society for Industrial Ecology*, Toronto, Canada (June 2007)
- **Program co-chair**, *2006 IEEE International Symposium on Electronics and the Environment*, San Francisco, CA (May 2006)
- **Session chair**, *9th International Conference on Structural Safety and Reliability ICOSSAR 2005*, Rome, Italy (June 2005)
- **Session chair (three sessions)**, *3rd Conference of the International Society for Industrial Ecology*, Stockholm, Sweden (June 2005)
- **Co-chair**, *NSF CAREER Workshop Held in Conjunction with the 2005 Construction Research Congress*, San Diego, CA (April 2005)
- **Session chair (two sessions)**, *ASCE Construction Research Congress*, San Diego, CA (April 2005)
- **Member, Organizing Committee**, *NATO Advanced Research Workshop "Life-cycle Energy and Environmental Implications of Information Technology"*, Budapest, Hungary (September 2003)
- **Session chair (two sessions)**, *ASCE Construction Research Congress*, Honolulu, HI (March 2003)
- **Panel organizer and speaker**, *2002 Gordon Research Conference on Industrial Ecology*, New London, NH (June 2002)
- **Conference co-chair**, *2001 IEEE International Symposium on Electronics and the Environment*, Denver, CO (May 2001)
- **Co-chair**, *2000 UC Berkeley Symposium on Manufacturing and Green Issues in the Electronics Industry*, Berkeley, CA (December 2000)
- **Session chair**, *The Future 500 Conference on Industrial Ecology*, Berkeley, CA (October 2000)
- **Session chair**, *2000 Gordon Research Conference on Industrial Ecology*, New London, NH (June 2000)
- **Conference co-chair**, *2000 IEEE International Symposium on Electronics and the Environment*, San Francisco, CA (May 2000)
- **Co-director**, *NATO Advanced Research Workshop "Green Engineering and Management Methods and Tools for Central and Eastern Europe"*, Budapest, Hungary (May 2000)
- **Short-course organizer and presenter**, *International Colloquium and Exhibit on Environmentally Preferred Advanced Energy Generation – ICEPAG*, University of California, Irvine (April 2000)
- **Program co-chair**, *1999 IEEE International Symposium on Electronics and the Environment*, Danvers, MA (May 1999)
- **Short-course organizer and presenter**, *International Colloquium and Exhibit on Environmentally Preferred Advanced Energy Generation – ICEPAG*, University of California, Irvine (March 1999)
- **Session co-chair**, *Carnegie Mellon University, Carnegie Institute of Technology Research Review* (May 1995)

ACADEMIC ADVISING

University of California, Berkeley:
Ph.D. students graduated:

- Pedro Santos Vieira (graduated in August 2007, "Life-cycle Assessment of Commercial Buildings"), currently with OC&C Consulting, San Francisco
- Cristiano Facanha (graduated in August 2006, "Life-cycle Air Emissions Inventory of Freight Transportation in the United States"), currently with ICF International, San Francisco
- Jennifer Stokes (graduated in May 2004, "Life-cycle Assessment of Alternative Water Supply Systems in California"), currently postdoctoral researcher at UC Berkeley
- Eric Masanet (graduated in May 2004 from Mechanical Engineering, "Environmental and Economic Take-back Planning for Plastics from End-of-Life Computers," co-advisor with D. Dornfeld), currently Principal Scientific Engineering Associate, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory
- Angela Guggemos (graduated in May 2003, "Environmental Impacts of Onsite Construction Processes: Focus on Structural Frames"), currently Assistant Professor, Department of Construction Management, Colorado State University
- Sergio Pacca (graduated in May 2003 from the Energy and Resources Group, "Global Warming Effect Applied to Electricity Generation Technologies," co-advisor with R. Norgaard), currently Assistant Professor, Environmental Management Program, University of Sao Paulo, Brazil
- Erasmia Kitou (graduated in May 2002, "Air Pollution Assessment of Telework: A Design of a Decision-Support Tool"), currently at the European Commission, Environment Directorate General, ENV C. Climate Change and Air Directorate

Current Ph.D. students:

- Mikhail Chester, Ph.D. candidate (August 2004 – present, expected to graduate in May 2008)
- Sebastien Humbert, Ph.D. candidate (August 2004 – expected to graduate in May 2008)
- Nakul Sathaye, Ph.D. student (August 2005 – present, co-advised with Samer Madanat)
- Arman Shehabi, Ph.D. student (January 2004 – present, co-advised with William Nazaroff)
- Nicholas Santero, Ph.D. student (August 2006 – present, co-advised with John Harvey)

Ph.D. exams and committees:

- Ph.D. thesis reader: Taihyeong Lee (CEE, UC Davis, 2006 – present), Sarah Boyd (ME, 2006 – present), Aurora Luscher Sharrard (2007, Carnegie Mellon U.), Chris Cherry (City and Regional Planning, 2007), Ziad Nakat (CEE, 2006), Justin Reginato (CEE, 2005), Agnes Bodnar Lobscheid (Environmental Health Sciences, School of Public Health, 2004)
- Ph.D. "instructor" of Seppo Junnila, Helsinki University of Technology, Finland (September 2002 – September 2004)
- Ph.D. mentor: Michael Toffel, Haas School of Business (Fall 2002 – Spring 2005)
- Chair of Ph.D. qualifying exams: Zofia Rybkowski (2006), Kunhee Choi (2006, 2007), Long Duy Nguyen (2006), Min Liu (2005), Seulkee Lee (2004), Colin Milberg (2003), Thais Alves (2003), Ziad Nakat (2003), Justin Reginato (2003), Jan Elfving (2002), James Choo (1999)
- Member of Ph.D. qualifying exams: Yingchun Yuan (2006, 2007, ME), Sarah Boyd (2006, ME), Sebastien Humbert (2005), Mikhail Chester (2005), Aurora Luscher Sharrard (2005, Carnegie Mellon U.), Pedro Santos Vieira (2004), Cristiano Facanha (2004), Jennifer Stokes (2003), Sergio Pacca (2001), Angela Guggemos (2001), Erasmia Kitou (2000)
- Member of Ph.D. preliminary exams: Nakul Sathaye (2005), Mikhail Chester (2005), Min Chen (2004)

M.S./M.Eng. advising:

- M.S. thesis committee member: Teresa Zhang (ME, 2007), Sarah Boyd (ME, 2007), Asher Ghertner (ERG, 2004), Matthew Dubberley (ME, 2003), Peter Broomes (ME, 2003)
- Advised 5 M.S. students in Fall 2006, 5 in 2005-06, 6 in 2004-05, 6 in 2003-04, 4 in 2002-03, 7 in 2001-02, 7 in 2000-01, 7 in 1999-2000
- Advised 1 M.Eng. student in 2000-02, and 1 in 2000-01

Undergraduate advising:

- Advised 18 undergraduate students in Fall 2006, 18 in 2005-06, 18 in 2004-05, 17 in 2003-04, 17 in 2002-03, 17 in 2001-02, 18 in 2000-01, 27 in 1999-00

Carnegie Mellon University:

- Advised 4 M.S. students in 1998-99
- Diploma thesis advising: Matthias Schoettle (U. of Stuttgart, Germany, 1998), Dieter Schwandner (U. of Karlsruhe, Germany, 1998)

TEACHING

Graduate courses:

- *CE 268E Civil Systems and the Environment* (Spring 2000 – Fall 2006)
- *CE 293A Technology and Sustainability* (Fall 2005 – 2006)
- *CE 292A Technologies for Sustainable Societies* (Fall 2001 – 2004)
- *12-711 Advanced Techniques for Project Management* (Carnegie Mellon University, Spring 1998 – Spring 1999)
- *12-710 Principles and Practices in Environmental Management*, teaching assistant (CMU, Spring 1994)

Undergraduate courses:

- *CE 166 Construction Engineering* (Fall 1999 – 2006)
- *CE 167 Engineering Project Management* (Spring and Fall 2001, Spring 2003 with I. Tommelein, Spring 2002 with A. Guggemos)
- *CE 169A Web-based Systems for Engineering and Management* (Fall 2000 – 2001 with I. Tommelein, Fall 2004 alone)
- *CE 169B Database Systems for Engineering and Management* (Fall 2000 – 2001, Fall 2004)
- *E11 Engineered Systems and Sustainability* (Spring 2006)
- *12-611 Project Management for Construction* (CMU, Fall 1997 with Steven Fenves, and Fall 1998 alone)
- *12-611 Project Management for Construction*, teaching assistant (CMU, Fall 1994 – 1996)

Executive education:

- Life-cycle Assessment, *ITT Industries Jabsco Rule Flojet* (Foothill Ranch, CA, July 2002)
- Environmental Impacts of Infrastructure, *Saudi Strategic Storage Project* (UC Berkeley, August-September 2000)
- Life-cycle Assessment, *Hyundai Engineering* (UC Berkeley, August 2000)
- *Green Engineering and Management* (CMU, July 1995 – 1997)

Continuing education:

- *UC Extension short course "Environmental Management for Companies"* (UC Berkeley, April 2002)
- *UC Extension short course "Life-Cycle Assessment and Engineering"* (UC Berkeley, January 2001)

FACULTY ACTIVITIES

University and College Committee Membership:

- Member, Cal Climate Action Plan Steering Committee (to advise the Chancellor and campus policy, 2006-2007)
- Member, Global Metropolitan Studies Faculty Search Committee (2006)
- Chair, Technology and Sustainability Committee, *College of Engineering* (November 2005 – present)
- Chancellor's Advisory Committee on Sustainability (September 2003 – present)
- Committee on Management of Technology Administration, UC Berkeley (April 2001 – present)

- Environmental Engineering, Energy, and Resources Committee, *College of Engineering*, UC Berkeley (September 2003 – May 2005)
- Selection Committee for the Toxics Substances Research and Training Program's Fellowship Program, UC Berkeley (2001 – 2003)

CEE Departmental Committee Membership:

- Chair, Ecological/Water Resources Engineering Faculty Search Committee (2005 – 2006)
- Strategic Planning Committee (Fall 2004 – present)
- Systems Program Committee (Fall 2002 – present)
- Infrastructure Systems Faculty Search Committee (2003 – 2004)
- Undergraduate Study Committee (Fall 2001 – Spring 2003)
- Committee for Information Technology/Systems Curriculum Development (Fall 2000 – Spring 2001)

Other Faculty Activities:

- ASCE Student Chapter Faculty Advisor, UC Berkeley (2004 – 2006)
- Affiliated Faculty, Energy and Resources Group, UC Berkeley (2000 – present)
- Graduate Admissions Committee, Energy and Resources Group (UC Berkeley, 2001), Civil and Environmental Engineering (Carnegie Mellon University, 1998 – 1999)

CURRENT PEER-REVIEWED JOURNAL SUBMISSIONS

- Horvath, A. (2008), "Life-cycle Assessment." In preparation for *Annual Review of Environment and Resources*, 33.
- Stokes, J., and Horvath, A. (2007), "Uncertainty in Environmental Assessment of Alternative Water Supply Systems." Submitted for review to *Int. J. of Life Cycle Assessment*
- Jones, C. M., Kammen, D. M., and Horvath, A. (2007), "Carbon Labeling and Offsets." Submitted for review to *Science*, ACS.
- Vieira, P. and Horvath, A. (2007), "End-of-Life of Commercial Buildings." Submitted for review to *Environmental Science & Technology*, ACS.
- Vieira, P. and Horvath, A. (2007), "BuiLCA – A Tool for Life-cycle Assessment of Commercial Buildings." Submitted for review to *Int. J. of Life Cycle Assessment*.
- Murray, A., Nelson, K., and Horvath, A. (2007), "A Hybrid Life-cycle and Cost Analysis Approach to Assessing Sewage Sludge Treatment and End-Use Scenarios: A Case Study of Chengdu, China." Submitted for review to *Int. J. of Life Cycle Assessment*.
- Facanha, C., and Horvath, A. (2007), "Evaluation of Life-cycle Air Emissions Factors of Freight Transportation." Submitted for review to *Environmental Science & Technology*, ACS.

PEER-REVIEWED ARCHIVAL PUBLICATIONS (PDF versions:

www.ce.berkeley.edu/~horvath/horvath_pub.html)

1. Kitou, E., and Horvath, A. (2007), "External Air Pollution Costs of Telework." *Int. J. of Life Cycle Assessment*.
2. Cicas, G., Hendrickson, C. T., Matthews, H. S., and Horvath, A. (2007), "Regionalization of the Economic Input-Output Analysis-Based Life-cycle Assessment Model." *Int. J. of Life Cycle Assessment*, DOI: <http://dx.doi.org/10.1065/lca2007.04.318>
3. Humbert, S., Abeck, H., Bali, N., and Horvath, A. (2007), "Leadership in Energy and Environmental Design (LEED): A Critical Evaluation by LCA and Recommendations for Improvement." *Int. J. of Life Cycle Assessment*, Special Issue 12(1), DOI: <http://dx.doi.org/10.1065/lca2006.12.291>

4. Masanet, E., and Horvath, A. (2007), "Assessing the Benefits of Design for Recycling of Plastics in Electronics: A Case Study of Computer Enclosures." *Materials & Design*, 28(6), pp. 1801-1811, DOI: <http://dx.doi.org/10.1016/j.matdes.2006.04.022>
5. Guggemos, A., and Horvath, A. (2006), "Decision-Support Tool for Assessing the Environmental Effects of Constructing Commercial Buildings." *J. of Architectural Engineering*, ASCE, 12(4), pp. 187-195.
6. Stokes, J., and Horvath, A. (2006), "Life-cycle Energy Assessment of Alternative Water Supply Systems." *Int. J. of Life Cycle Assessment*, 11(5), pp. 335-343, DOI: <http://dx.doi.org/10.1065/lca2005.06.214>
7. Facanha, C., and Horvath, A. (2006), "Environmental Assessment of Freight Transportation in the U.S." *Int. J. of Life Cycle Assessment*, 11(4), pp. 229-239, DOI: <http://dx.doi.org/10.1065/lca2006.02.244>
8. Kitou, E., and Horvath, A. (2006), "Transportation Choices and Air Pollution Effects of Telework." *J. of Infrastructure Systems*, ASCE, 12(2), pp. 121-134.
9. Boughton, B., and Horvath, A. (2006), "Environmental Assessment of Shredder Residue Management." *Resources, Conservation and Recycling*, 47(1), pp. 1-25, DOI: <http://dx.doi.org/10.1016/j.resconrec.2005.09.002>
10. Junnila, S., Horvath, A., and Guggemos, A. (2006), "Life-cycle Assessment of Office Buildings in Europe and the U.S." *J. of Infrastructure Systems*, ASCE, 12(1), pp. 10-17.
11. Guggemos, A., and Horvath, A. (2005), "Comparison of Environmental Effects of Steel and Concrete Framed Buildings." *J. of Infrastructure Systems*, ASCE, 11(2), pp. 93-101.
12. Facanha, C., and Horvath, A. (2005), "Environmental Assessment of Logistics Outsourcing." *J. of Management in Engineering*, ASCE, 21(1), pp. 27-37.
13. Horvath, A. (2004), "Construction Materials and the Environment." *Annual Review of Environment and Resources*, 29, pp. 181-204.
14. Toffel, M. W., and Horvath, A. (2004), "Environmental Implications of Wireless Technologies: News Delivery and Business Meetings." *Environmental Science & Technology*, ACS, 38(11), pp. 2961-2970.
15. Suh, S., Lenzen, M., Treloar, G. J., Hondo, H., Horvath, A., Huppes, G., Jolliet, O., Klann, U., Krewitt, W., Moriguchi, Y., Munksgaard, J., and Norris, G. (2004), "System Boundary Selection in Life-cycle Inventories Using Hybrid Approaches." *Environmental Science & Technology*, ACS, 38(3), pp. 657-664.
16. Boughton, B., and Horvath, A. (2004), "Environmental Assessment of Used Oil Management Methods." *Environmental Science & Technology*, ACS, 38(2), pp. 353-358.
17. Junnila, S., and Horvath, A. (2003), "Life-cycle Environmental Effects of an Office Building." *J. of Infrastructure Systems*, ASCE, 9(4), pp. 157-166.
18. Kitou, E., and Horvath, A. (2003), "Energy-related Emissions from Telework." *Environmental Science & Technology*, ACS, 37(16), pp. 3467-3475.
19. Guggemos, A., and Horvath, A. (2003), "Strategies of Extended Producer Responsibility for Buildings." *J. of Infrastructure Systems*, ASCE, 9(2), pp. 65-74.
20. Pacca, S., and Horvath, A. (2002), "Greenhouse Gas Emissions from Building and Operating Electric Power Plants in the Upper Colorado River Basin." *Environmental Science & Technology*, ACS, 36(14), pp. 3194-3200.
21. Matthews, H. S., Hendrickson, C. T., and Horvath, A. (2001), "External Costs of Air Emissions from Transportation." *J. of Infrastructure Systems*, ASCE, 7(1), pp. 111-117.

22. Rosenblum, J., Horvath, A., and Hendrickson, C. T. (2000), "Environmental Implications of Service Industries." *Environmental Science & Technology*, ACS, 34(22), pp. 4669-4676.
23. Hendrickson, C. T., and Horvath, A. (2000), "Resource Use and Environmental Emissions of U.S. Construction Sectors." *J. of Construction Engineering and Management*, ASCE, 126(1), pp. 38-44.
24. Horvath, A., and Hendrickson, C. T. (1998), "Steel vs. Steel-Reinforced Concrete Bridges: Environmental Assessment." *J. of Infrastructure Systems*, ASCE, 4(3), pp. 111-117.
25. Horvath, A., and Hendrickson, C. T. (1998), "A Comparison of the Environmental Implications of Asphalt and Steel-Reinforced Concrete Pavements." *Transportation Research Record*, NRC, No. 1626 (Environmental and Social Effects of Transportation), pp. 105-113.
26. Hendrickson, C. T., Horvath, A., Joshi, S., and Lave, L. B. (1998), "Economic Input-Output Models for Environmental Life-Cycle Assessment." *Environmental Science & Technology*, ACS, 32(4), pp. 184A-191A.
27. Horvath, A., Hendrickson, C. T., Lave, L. B., McMichael, F. C., and Wu, T-S. (1995), "Toxic Emissions Indices for Green Design and Inventory." Cover article, *Environmental Science & Technology*, ACS, 29(2), pp. 86-90.

EDITOR-REVIEWED JOURNAL PUBLICATIONS

- Borg, R. F., Gambatese, J., Haines, Jr., K., Hendrickson, C., Hinze, J., Horvath, A., Koehn, E., Moritz, S. L., Mass, M., and Haughney, R. A. (2003), "Rebuilding the World Trade Center." *Practice Periodical on Structural Design and Construction*, ASCE, 8(3), pp. 137-145.
- Hendrickson, C. T., Horvath, A., Lave, L. B., and McMichael, F. C. (1996), "New Markets for Old Materials." *TR News*, NRC, No. 184, pp. 32-35.

PEER-REVIEWED CONFERENCE PUBLICATIONS

- Horvath, A. (2005), "Incorporating External Cost Valuation into Life-cycle Costing of Office Buildings." *Proceedings of the 9th International Conference on Structural Safety and Reliability (ICOSSAR)*, Rome, Italy.
- Guggemos, A., and Horvath, A. (2005), "Decision Support Tool for Environmental Analysis of Commercial Building Structures." *Proceedings of the 2005 Construction Research Congress*, ASCE, San Diego, CA.
- Stokes, J., and Horvath, A. (2004), "Life-cycle Assessment of a Desalination System in California." *Proceedings of the 2004 A&WMA Annual Meeting*, Indianapolis, IN.
- Guggemos, A., and Horvath, A. (2003), "Framework for Environmental Analysis of Commercial Building Structures." *Proceedings of the 2003 Construction Research Congress*, ASCE, Honolulu, HI.
- Kitou, E., Horvath, A., and Masanet, E. (2002), "Putting in Perspective the Contribution of Transportation to the Environmental Effects of Telework." *81st Transportation Research Board Conference*, Washington, D.C.
- Horvath, A. (2000), "Alternative Fuel Vehicles: Environmental and Economic Effects of Infrastructural Requirements." *Proceedings of the 2000 SAE Total Life Cycle Conference*, Detroit, MI.
- Lave, L., MacLean, H., Lankey, R., Joshi, S., Horvath, A., and Hendrickson, C. (2000), "Life Cycle Inventories of Conventional and Alternative Automobile Fuel/Propulsion Systems: Summary & Conclusions." *Proceedings of the 2000 SAE Total Life Cycle Conference*, Detroit, MI.

- Hendrickson, C. T., Horvath, A., and Matthews, H. S. (1999), "External Environmental Costs of Transportation Equipment, Materials and Services." *78th Transportation Research Board Conference*, Washington, D.C.
- Klausner, M., Grimm, W., and Horvath, A. (1999), "Life Cycle Inventory Combining Input-Output Techniques and Conventional Process Models – A Case Study of a Fuel-Injection System." *1999 SAE Conference & Exposition*, Detroit, MI.
- McMichael, F. C., Hendrickson, C. T., Horvath, A., and Lave, L. B. (1998), "A Comparison of Direct and Indirect Environmental Effects of Critical Industries." *Proceedings of the 1998 A&WMA Annual Meeting*, San Diego, CA.
- Lave, L. B., Joshi, S., MacLean, H., Horvath, A., Hendrickson, C. T., and McMichael, F. C. (1998), "Environmental Input-Output Life Cycle Analysis: A Summary of Results Including a Comparison with the SETAC Approach." *Proceedings of the 1998 SAE Total Life Cycle Conference*, Graz, Austria.
- Garrett, J. H., Hendrickson, C. T., Horvath, A., Joshi, S., Juarez, O., and McMichael, F. C. (1997), "General Purpose Computer-Aided Engineering Tools for Environmental Software Systems." *IFIP TC5 WG5.11 Second International Symposium on Environmental Software Systems*, Whistler, BC, Canada, published in "Environmental Software Systems Vol. 2," Denzer, R., Swayne, D. A., and Schimak, G., Eds., Chapman & Hall, London.
- Lave, L. B., Cobas-Flores, E., McMichael, F. C., Hendrickson, C. T., Horvath, A., and Joshi, S. (1997), "Measuring the Environmental Impacts and Sustainability of Automobiles." *Proceedings of the Sustainable Individual Mobility - Critical Choices for Government and Industry Conference*, Zurich, Switzerland.
- Horvath, A., Hendrickson, C. T., Lave, L. B., and McMichael, F. C. (1995), "Performance Measurement for Environmentally-Conscious Manufacturing." *Proceedings of the 1995 ASME International Congress and Exposition, Manufacturing Science and Engineering MED-Vol. 2-2/MH-Vol. 3-2*, San Francisco, CA.
- Hendrickson, C. T., Horvath, A., Lave, L. B., and McMichael, F. C. (1994), "Green Design." *National Academy of Engineering Conference "Engineering within Ecological Constraints,"* Washington, D.C.

CONFERENCE PUBLICATIONS WHERE FULL PAPER WAS REVIEWED BY CHAIR

- Weisskoff, R., Englehardt, J. D., Lave, L. B., and Horvath, A. (1998), "An Input-Output Analysis of Ecosystem Restoration: The Missing Piece." Plenary paper, *12th International Input-Output Conference*, New York, NY.
- Lave, L. B., and Horvath, A. (1996), "The Market for Recyclables: Prospects and Problems." *Proceedings of Market Tools for Green Goals Conference*, Chicago, IL.

CONFERENCE PUBLICATIONS WHERE ABSTRACT WAS REVIEWED, FULL PAPER WAS PUBLISHED

- Masanet, E., and Horvath, A. (2006), "Modeling and Reducing the Greenhouse Gas 'Footprint' of Personal Computers." *Proceedings of the 2006 IEEE International Symposium on Electronics and the Environment*, San Francisco, CA.
- Masanet, E., and Horvath, A. (2004), "A Decision-Support Tool for Environmental Planning of Take-Back Strategies for Plastics from End-of-Life Electronics." *Proceedings of the 2004 IEEE International Symposium on Electronics and the Environment*, Scottsdale, AZ.

- Dubberley, M., Agogino, A., and Horvath, A. (2004), "Life Cycle Assessment of Intelligent Lighting System Using a Distributed Wireless 'Mote' Network." *Proceedings of the 2004 IEEE International Symposium on Electronics and the Environment*, Scottsdale, AZ.
- Junnila, S., and Horvath, A. (2003), "Environmental Sensitivity Analysis of the Life-cycle of an Office Building." *2nd International Symposium "Integrated Life Cycle Design of Materials and Structures – ILCDES"*, Kuopio, Finland.
- Kitou, E., Masanet, E., and Horvath, A. (2001), "Web-based Tool for Estimating the Environmental Impacts of Telework." *Proceedings of the 2001 IEEE International Symposium on Electronics and the Environment*, Denver, CO.
- Kitou, E., Horvath, A., and Blazek, M. (2000), "Environmentally Preferable Purchasing: A Survey of the Telecommunications Industry." *Proceedings of the 2000 IEEE International Symposium on Electronics and the Environment*, San Francisco, CA.
- Horvath, A. (1999), "Supply Chain Environmental Assessment of the Telecommunications Sectors." *Proceedings of the 1999 IEEE International Symposium on Electronics and the Environment*, Danvers, MA.
- Klausner, M., Grimm, W., and Horvath, A. (1999), "Integrating Product Takeback and Technical Service." *Proceedings of the 1999 IEEE International Symposium on Electronics and the Environment*, Danvers, MA.
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- "Estimation of Environmental Implications of Construction Materials and Designs Using Life Cycle Assessment Techniques," Unpublished Ph.D. thesis, *Carnegie Mellon University*, June 1997
- "Toxic Emission Indices for Green Design and Inventories," Unpublished M. S. thesis, *Carnegie Mellon University*, January 1995

INVITED PRESENTATIONS

- "Engineering and Management for Sustainability: Ideas for the Way Forward." *CITRIS Research Exchange*, UC Berkeley (January 2007)
- "Byproducts and Industrial Ecology." *2006 Byproducts Beneficial Use Summit*, San Francisco, CA (November 2006)
- "Ecoefficiency in Information and Communication Technology: The State of Knowledge in the United States." *The Seventh International Conference on Ecobalance*, Tsukuba, Japan (November 2006)
- "Roadmaps and Roadblocks: The Present and Future of Infrastructure Materials, Processes, and the Environment." *5th Gordon Research Conference on Industrial Ecology*, Oxford, England (August 2006)
- "Life-cycle Assessment Workshop." *Western Regional Pollution Prevention Network Annual P2 Conference*, Tahoe City, CA (September 2005)
- "Life-cycle Environmental Assessment of Infrastructure Systems." *Institute of Transportation Studies, UC Davis* (February 2005)
- "Life-cycle Assessment." *Bechtel Corporation*, San Francisco (January 2005)
- "Life-cycle Assessment." Departmental Seminar, *Department of Nuclear Engineering, UC Berkeley* (December 2004)
- "Sustainability Education at the University of California, Berkeley." *2003 ASCE Civil Engineering Conference & Exposition*, Nashville, TN (November 2003)
- "Applications of Input-Output Analysis in Industrial Ecology." Panelist, *2nd Conference of the International Society for Industrial Ecology*, Ann Arbor, MI (June 2003)

- "Decision-Support Tool for Life-cycle Assessment of Pavements." *Transportation Research Board Summer Workshop "Beneficial Use, Sustainability, and Pollution Prevention in Transportation Infrastructure,"* Portsmouth, NH (June 2003).
- "Environmental Impacts of Telework." *International Symposium on Information Technology and the Environment,* Tokyo, Japan (September 2002)
- "Sustainable Construction." *Department of Civil and Environmental Engineering, Technical University of Lisbon,* Portugal (July 2002)
- "Hybrid Models for Life-Cycle Assessment." *3rd Gordon Research Conference on Industrial Ecology,* New London, NH (June 2002)
- "Life Cycle Assessment of Civil Infrastructure Systems." General Session address, *2001 Annual Meeting of the Asphalt Emulsion Manufacturers Association and the Asphalt Recycling and Reclaiming Association,* San Diego, CA (February 2001)
- "Life Cycle Assessment of Civil Infrastructure Systems." Keynote address, *Partnerships for Sustainability: A New Approach to Highway Materials Conference,* Houston, TX (October 2000)
- "Life Cycle Assessment of Civil Infrastructure Systems." *Army Environmental Policy Institute,* Atlanta, GA (September 2000)
- "Life Cycle Assessment." *2nd Gordon Research Conference on Industrial Ecology,* New London, NH (June 2000)
- "Life-cycle Economic and Environmental Assessment." *2000 National Manufacturing Week Conference,* Chicago, IL (March 2000)
- "Infrastructure Systems and Environmental Analysis." *Department of Civil and Environmental Engineering, Massachusetts Institute of Technology,* Boston, MA (May 1999)
- "Infrastructure Systems and Environmental Analysis." *Department of Civil and Environmental Engineering, Cornell University,* Ithaca, NY (April 1999)
- "Market Potential for Onboard Data Logs in Passenger Cars." *Bosch GmbH,* Stuttgart, Germany (April 1999)
- "Infrastructure Systems, Construction, and Environmental Analysis." *Department of Civil and Environmental Engineering, University of California,* Berkeley, CA (March 1999)
- "Infrastructure Systems and Environmental Analysis." *Department of Civil and Environmental Engineering, University of Maryland,* College Park, MD (March 1999)
- "Material Flows in the Construction Industry." *1st Gordon Research Conference on Industrial Ecology,* New London, NH (June 1998)
- "Input-Output Analysis-Based Life-Cycle Assessment." *General Electric Corp. Environmental Labs,* Schenectady, NY (February 1998)
- "Materials Embedded in Products." *National Research Council Workshop on Materials Flows Accounting of Natural Resources, Products and Residues,* National Academy of Sciences, Washington, D.C. (January 1998)
- "Life-Cycle Assessment." *AIChE Center for Waste Reduction Technologies, Sustainability Metrics Workshop,* Washington, D.C. (September 1997)
- "Environmental Performance Measurement and Life-Cycle Assessment." *General Electric Corp. Environmental Labs,* Schenectady, NY (February 1997)
- "Environmental Performance Measurement." *1996 IBM Environmental Managers Worldwide Meeting,* Washington, D.C. (March 1996)

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- "Incorporating External Cost Valuation into Life-cycle Costing of Office Buildings." *Proceedings of the 9th International Conference on Structural Safety and Reliability (ICOSSAR)*, Rome, Italy (June 2005)
- "Evaluating Life-cycle Environmental Implications of Water Supply Systems." *3rd Conference of the International Society for Industrial Ecology*, Stockholm, Sweden (June 2005)
- "Life-cycle Environmental Accounting and Decision-Making for Bridge Structures." *2004 ASCE Structures Congress and Exposition*, Nashville, TN (May 2004)
- "Identifying Environmentally and Economically Sound Take-Back Strategies for Plastics from End-of-Life Electronics." *SETAC Europe 14th Annual Meeting*, Prague, Czech Republic (April 2004)
- "Global Warming Effect Assessment in the Electricity Sector Using Hybrid Life-cycle Inventory Assessment." *International Conference on Life Cycle Assessment/Life Cycle Management*, Seattle, WA (September 2003).
- "Integrating Input-Output Analysis and Process Life-Cycle Assessment." *SETAC Europe 12th Annual Meeting*, Vienna, Austria (May 2002)
- "Life-Cycle Assessment of Pavements." *Beneficial Use of Recycled Materials for Transportation Applications Conference*, Washington, DC (November 2001)
- "Environmental Assessment of Asphalt versus Concrete Pavements." *2nd International Symposium on Transportation Infrastructure Management*, Berkeley, CA (October 2001)
- "Life Cycle Assessment for Transportation Applications." *University of Tottori - UC Berkeley Annual Transportation Conference*, Tottori, Japan (June 2001)
- "Life Cycle Assessment in the Service Industries." *AICHE 2000 Annual Meeting*, Los Angeles, CA (November 2000)
- "LCA in the Service Industries: A Case Study of Telecommunications." *U.S. EPA International Conference on Life Cycle Assessment*, Arlington, VA (April 2000)
- "Alternative Fuel Vehicles: Environmental and Economic Effects of Infrastructural Requirements." *2000 SAE Total Life Cycle Conference*, Detroit, MI (April 2000)
- "Hybrid Models for Life-Cycle Assessment." *1999 SETAC Annual Conference*, Philadelphia, PA (November 1999)
- *1999 IEEE International Symposium on Electronics and the Environment*, Danvers, MA (May 1999)
- *77th Transportation Research Board Conference*, Washington, D.C. (January 1998)
- *1996 IEEE International Symposium on Electronics and the Environment*, Dallas, TX (May 1996)
- *75th Transportation Research Board Conference*, Washington, D.C. (January 1996)
- *1995 ASME International Congress and Exposition*, San Francisco, CA (November 1995)

MEMBERSHIPS

- Associate Member, American Society of Civil Engineers
 - Member, Construction Institute, American Society of Civil Engineers
 - Member, Construction Research Council, American Society of Civil Engineers
- Member, International Society for Industrial Ecology

LYNN PRICE

Scientist, Deputy Group Leader
International Energy Studies Group
Energy Analysis Department
Environmental Energy Technologies Division
Lawrence Berkeley National Laboratory

1 Cyclotron Road, MS 90-4000
Berkeley, CA 94720
(510) 486-6519
(510) 486-6996 fax
LKPrice@LBL.gov

Employment

Lawrence Berkeley National Laboratory, Berkeley, California

1990 - Present

Price Associates, Berkeley, California

1989 - 1990

MHB Technical Associates, San Jose, California

1983 -1989

Professional Experience

- Principal investigator, China Sustainable Energy Program project on industrial energy efficiency voluntary agreements and tax and fiscal policy projects in China
- Principal investigator, California Energy Commission project on development of an energy balance for the State of California.
- Principal investigator, California Energy Commission project on optimization of product lifecycle greenhouse gas emissions from products produced in California.
- Principal investigator, California Energy Commission project related to technical analysis in support of the California Climate Action Registry.
- Lead author, Intergovernmental Panel on Climate Change Second Assessment Report, Technical Paper on Technologies, Policies and Measures for Mitigating Climate Change, Special Report on Emissions Scenarios, Third Assessment Report, and Fourth Assessment Report.
- Scientist, U.S. Environmental Protection Agency projects related to development of multi-project (standardized) baselines for evaluation of greenhouse gas mitigation projects in the electricity and industrial sectors, benchmarking of energy-intensive industrial sectors, analysis of the energy-efficiency and greenhouse gas mitigation potential of selected industrial sectors, and quantification of program-related greenhouse gas emissions reductions.
- Scientist, U.S. Department of Energy project related to the assessment of international experience in industrial sector energy efficiency policies and programs.

- Scientist, U.S. Agency for International Development project related to development of standardized baselines for evaluation of greenhouse gas mitigation projects in the electricity and industrial sectors in Central America.

Professional Service

Co-Chair, 2003 American Council for an Energy-Efficient Economy's Summer Study on Energy Efficiency in Industry

Advisor for two students in the Master in Public Policy Program, John F. Kennedy School of Government, Harvard University

Reviewer for *Energy*, *The International Journal*, *Energy Policy*, *Journal of Industrial Ecology*, *Environmental Science & Technology*, and the ACEEE 2003 Summer Study on Energy Efficiency in Industry

Host and advisor for international guests in the International Energy Studies Group at Lawrence Berkeley National Laboratory

Education

University of Wisconsin – Madison, Institute For Environmental Studies

Master of Science in Land Resources, May 1982
Phi Kappa Phi Honor Society

University of Wisconsin - Madison
Bachelor of Arts in Geography, May 1980
Graduation with Distinction

Selected Publications

Price, L. and Wang, X., forthcoming. "Constraining Energy Consumption of China's Largest Industrial Enterprises Through the Top-1000 Energy-Consuming Enterprise Program," *Proceedings of the 2007 ACEEE Summer Study on Energy Efficiency in Industry*. Washington, DC: American Council for An Energy-Efficient Economy.

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Price, L., Bartholomew, E., and Mulholland, D., 2004. "Taking Credit for GHG Emissions Reduction Activities of the EPA's State and Local Capacity Building Branch," *Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings*. Washington, DC: American Council for an Energy-Efficient Economy (LBNL-55920).

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Price, L., Marnay, C., Sathaye, J., Murtishaw, S., Fisher, D., Phadke, A., and Franco, G., 2002. "Development of Methodologies for Calculating Greenhouse Gas Emissions from Electricity Generation for the California Climate Action Registry," *11th International Emission Inventory Conference*, Atlanta, GA, April 15-18, 2002 (LBNL-50250).

Marnay, C., Fisher, D., Murtishaw, S., Phadke, A., Price, L., and Sathaye, J., 2002. *Estimating Carbon Dioxide Emissions Factors for the California Electric Power Sector*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-49945).

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Worrell, E., Price, L., and Ruth, M., 2001. "Policy Modeling for Energy Efficiency Improvement in US Industry," *Annual Review of Energy and Environment* 26: 117-43 (LBNL-49096)

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Christina Galitsky

Experience

**Lawrence Berkeley National Laboratory (LBNL), International Energy Analysis
Berkeley, CA 2001-present
Principal Research Associate**

Coordinated and aided governmental and non-governmental (NGO) organizations, local utilities, industry personnel and local inhabitants around the world in programs to increase energy efficiency, mitigate climate change and improve local environments. Designed, managed and conducted research programs, developed user-interfaced tools and led training workshops. Enjoyed traveling up to 60,000 miles/year to conferences, field sites and workshops. Coauthored 28 articles and reports, 2 computer tools, 3 book chapters and managed 8 people.

Sudan

- Co-developed and initiated a fuel efficient stove program in refugee camps in Darfur.
- Refugee camp fieldwork: led demonstrations for hundreds of women and camp leaders; designed and conducted surveys; worked effectively through translators; collected (and later analyzed) data from 50 families; interfaced with national and local Sudanese and U.S. government officials, refugees and NGO staff.
- Determined culturally and environmentally appropriate stove characteristics based on observations and interviews. Successfully raised follow-on funding for large scale roll out.

China

- Helped design workshops, chaired symposiums, and presented my research and tools (lead author) at several national-level workshops throughout China for government, industrial, financial, and NGO staff.
- Established long-term working relationship with Chinese experts in government institutes.
- Visited industrial sites to collect data and amass contacts for future LBNL projects.

Bangladesh

- Operational manager for developing a new, ultra-low cost method for purifying lethally contaminated drinking water (arsenic) in Bangladesh. Coordinated laboratory effort and shaped direction of experimental work.

Central America

- Co-authored a greenhouse gas mitigation and carbon trading decision making tool for the worldwide cement industry. Coordinated and co-wrote Spanish version. Led training session at USAID workshop in Guatemala.

U.S./Worldwide

- Official U.S. observer to Asia Pacific Partnership on Clean Development and Climate; attended meetings in China and the US. Presented my benchmarking methodology for potential adoption in Action Plan.
- Provided technical support for the EPA and California Energy Commission industry programs. Researched and modeled energy and water use and conservation in 10 industries. Developed a first of its kind, award-winning benchmarking tool for California wineries; currently used in 9 countries. Led training sessions sponsored by utility company and featured on local television news.
- Compiled and analyzed best practice programs, products and delivery mechanisms for industrial energy-efficiency programs in industrialized countries. Collaborated with experts in 12 OECD countries.
- Co-chaired Data Analysis Panel at American Council for an Energy Efficient Economy Conference 2005.

Fund-raising and Development

- Co-authored several funding proposals including 6 successful ones for grants totaling over \$600k.
- Helped form new focus team within my (500-person) division, which raised over \$600k in first year.

Eisenberg, Olivieri and Associates (EOA), Inc.
Oakland, CA
Environmental Consultant

1999-2000

Provided analysis and developed risk assessment tools for water quality and drinking water alternatives. Managed stormwater best practice programs.

- Conducted risk assessment on drinking water alternatives for a California water district. Organized extensive data using MS Excel and Access; performed statistical analyses to determine risk to 2.7 million constituents; met with clients, Health Department and Water Board representatives; assisted writing final technical report. Project enabled the client to reduce annual water supply purchase by 20% (over 13 million gallons per year).
- Performed microbial risk assessment for a 1.7 million person residential water supply. Co-developed a new MS Excel Add-In tool and technical report for microbial risk assessments in urban water environments.
- Initiated EOA's first effective company-wide recycling program.

Education

University of California at Berkeley
Berkeley, CA

1999

Master of Science in Chemical Engineering with Thesis

- Research Assistantship: full tuition and stipend for three years.
- Created a new flow cell for my research group that extended the functionality of existing apparatus and made possible thousands of new experiments. Determined the reversibility of adsorption of two proteins.
- Captain of the Berkeley Ultimate Frisbee team. Led 20-woman team to rank 6th in nation.

University of Pennsylvania
Philadelphia, PA

1996

Bachelor of Science and Engineering in Chemical Engineering; minor in Mathematics

- Cumulative GPA: 3.5/4.0 (3.7/4.0 in major); Graduated Cum laude.
- Personally financed over 80% of college education; worked 10 to 20 hours/week in research laboratories.

Awards

- **2006** Technology Review's Humanitarian of the Year Award
- **2006** Technology Review's TR35 Award honoring the 35 Top Innovators in the World under age 35
- **2005** State of California's Flex Your Power Award for Excellence in Energy Efficiency for work on Winery tool

- **2005** LBNL Outstanding Performance Award (1st of ~7 given per year in 500 person division) for Wine Project
- **2005** LBNL Outstanding Performance Award (2nd of ~7 given per year) for work on Arsenic Removal Project
- **2004** Nominated by employer for R&D Magazine R&D 100 Award (honoring top 100 technologies globally)
- **2004** UC Berkeley's Technology Break-through Challenge Award, placing #1 for highest social impact
- **2003** LBNL discretionary award for unfunded proof of concept work on arsenic purification technology
- **2003** Nominated for National Engineer's week New Faces of Engineering Award for young engineers
- **1996** University of Pennsylvania's most outstanding chemical engineer in the 1996 Class, chosen by faculty

Skills & Interests

- Intermediate Spanish skills. Participated in immersion program in San Andrés, Guatemala in April 2003.
- Computer: Excellent modeling skills. Proficient in MS Word, Excel (including Crystal Ball and VBA), PowerPoint, Publisher, Access; Sigma Plot; FORTRAN, ASPEN Plus.
- Avid traveler. Backpacked across Africa, Asia, Central America and Mexico for several months each.
- Intermediate climbing skills; NAUI (SCUBA) certified

Sample Interviews and Local Press

Interview on BBC and KGBH's *The World* regarding TR35 and Humanitarian of the Year Awards and work in Darfur – "Darfur Cookstove Interview" Listen here:
<http://www.theworld.org/?q=node/4795>

Related Article - "Engineering a Better World" by Betsy Mason, *Contra Costa Times*. Read here: <http://www.contracostatimes.com/mld/cctimes/email/news/15827108.htm>

Live Interview on KCBS regarding work in Darfur – "Refugee Stoves". Listen here:
http://www.kcbs.com/topic/yahoo_search.php?page=1&query=galitysky&x=0&y=0&scope=media

Article on my work – Massachusetts's Institute of Technology Technology Review "Simple Technologies Save energy and Lives," by Douglas McGray. Read here:
<http://www.technologyreview.com/TR35/Profile.aspx?TRID=469>

Publications

Master's Thesis

Galitsky, C. 1999. Dynamics of Protein Adsorption at Fluid/Fluid Interfaces as Studied by the Sessile Drop Technique. Berkeley, CA: University of California at Berkeley Chemical Engineering, May.

Reports and Journal Articles

Soller, J. A., D. M. Eisenberg, A. W. Olivieri, and C. Galitsky. 2000. Orange County Water District Orange County Sanitation District Groundwater Replenishment System Water Quality

Evaluation, revised draft final report. Oakland, CA: Eisenberg, Olivieri and Associates, September.

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Galitsky, C. and E. Worrell. 2003. Energy Efficiency Improvement and Cost Saving Opportunities for the Vehicle Assembly Industry – A Guide for Energy and Plant Managers, Berkeley, CA: Lawrence Berkeley National Laboratory, January, LBNL-50939.

Galitsky, C., N. Martin, E. Worrell and B. Lehman. 2003. Energy Efficiency Opportunities and Potential Cost Savings for Breweries – A Guide for Energy and Plant Managers, Berkeley, CA: Lawrence Berkeley National Laboratory, May, LBNL-50934.

Galitsky, C. and E. Worrell. 2003. Energy Efficiency Improvements and Cost Saving Opportunities in the Corn Wet Milling Industry. Proceedings 25th Annual Industrial Energy Technologies Conference, Houston, TX, May 13-16: 191-200.

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Worrell, E. and C. Galitsky. 2004. Energy Efficiency Improvement Opportunities for Cement Making, An ENERGY STAR Guide for Energy and Plant Managers. Berkeley, CA: Lawrence Berkeley National Laboratory, January, LBNL-54036.

Worrell, E. and C. Galitsky. 2004. Profile of the Petroleum Refining Industry in California: California Industries of the Future Program. Berkeley, CA: Lawrence Berkeley National Laboratory, March, LBNL-55450.

Worrell, E., L. Price and C. Galitsky. 2004. Emerging Energy-Efficient Technologies in Industry: Technology Characterizations for Energy Modeling, prepared for the National Commission on Energy Policy. Berkeley, CA: Lawrence Berkeley National Laboratory, May, LBNL-54828.

Galitsky, C. and E. Worrell. 2004. Profile of the Chemicals Industry in California: California Industries of the Future Program. Berkeley, CA: Lawrence Berkeley National Laboratory, June, LBNL-55450.

Galitsky, C. and E. Worrell. 2004. Energy Efficiency Improvements and Cost Saving Opportunities in the Corn Wet Milling Industry. Corn Utilization and Technology Conference Proceedings, Indianapolis, IN, June 7-9.

Galitsky, C., L. Price and E. Worrell. 2004. Energy Efficiency Programs and Policies in the Industrial Sector in Industrialized Countries. Berkeley, CA: Lawrence Berkeley National Laboratory, June, LBNL-54068.

Worrell, E. and C. Galitsky. 2005. Energy Efficiency Improvement and Cost Saving Opportunities for Petroleum Refineries: An ENERGY STAR Guide for Energy and Plant Managers. Berkeley, CA: Lawrence Berkeley National Laboratory, February, LBNL-56183.

Galitsky, C. and A. Radspieler of Lawrence Berkeley National Laboratory, E. Worrell of Ecofys and P. Healy and S. Zechiel, Fetzer Vineyards. 2005. Benchmarking and Self-Assessment in the Wine Industry, Proceedings of the American Council for an Energy Efficient Economy (ACEEE) Summer Study on Energy Efficiency in Industry 2005. Washington, D.C. July 19-22.

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Galitsky, C., E. Worrell and A. Radspieler of LBNL and P. Healy and S. Zechiel of Fetzer Vineyards. 2005. BEST Winery Guidebook: Benchmarking and Energy and Water Savings Tool for the Wine Industry. Berkeley, CA: Lawrence Berkeley National Laboratory, May, LBNL 3184.

Price, L., C. Galitsky, J. Sinton, E. Worrell, W. Graus. 2005. Tax and Fiscal Policies for Promotion of Industrial Energy Efficiency: A Survey of International Experience. Berkeley, CA: Lawrence Berkeley National Laboratory, September, LBNL-58128.

Galitsky, C., S. Chang, and E. Worrell. 2005. Energy Efficiency Improvement and Cost Saving Opportunities for the Pharmaceutical Industry: An ENERGY STAR Guide for Energy and Plant Managers. Berkeley, CA: Lawrence Berkeley National Laboratory, September, LBNL-57260.

Galitsky, C, A. Gadgil, M. Jacobs and Y. Lee. 2006. Fuel Efficient Stoves for Darfur Camps of Internally Displaced Persons: Report of Field trip to North and South Darfur. Berkeley, CA: Lawrence Berkeley National Laboratory, March, LBNL 59540.

Galitsky, C., E. Worrell, E. Masanet, and S. Chang. (2006). Improving Energy Efficiency in Pharmaceutical Manufacturing Operations, Part I: Motors and Drives, and Compressed Air Systems. February 2006: 50-54.

Galitsky, C., E. Masanet, E. Worrell, and S. Chang. (2006). Improving Energy Efficiency in Pharmaceutical Manufacturing Operations, Part II: HVAC, Boilers and Cogeneration. Pharmaceutical Manufacturing, May 2006: 40-43.

Murtishaw S, Sathaye J, Galitsky C, and Dorion K, 2006. Baselines for Greenhouse Gas Mitigation Projects in Central America. Mitigation and Adaptation Strategies for Global Change 11 (3): 645-665.

Price, L. K. and C. Galitsky. 2006 (forthcoming). Opportunities for Improving Energy and Environmental Performance of China's Cement Kilns. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-60638).

Worrell, E., C. Galitsky, E. Masanet, and W. Graus. 2006 (forthcoming). Energy Efficiency Improvement and Cost Saving Opportunities for the Glass Industry - An ENERGY STAR® Guide for Energy and Plant Managers. Berkeley, CA: Lawrence Berkeley National Laboratory, LBNL-57335.

Masanet, M., E. Worrell, W. Graus, and C. Galitsky. 2006 (forthcoming). Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry - An ENERGY STAR® Guide for Energy and Plant Managers. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-59289).

Book Chapters

Worrell, E., C Galitsky and G. Hawkins. 2004. "Energy Efficiency Improvement" (Chapter 6.5), Innovations in Portland Cement Manufacturing, Skokie, IL: Portland Cement Association.

Price, L., Galitsky, C., and Worrell, E. 2006 (forthcoming). End - Use Technologies, Main Drivers, and Patterns of Future Demand: Industry, Future Technologies for a Sustainable Electricity System. Cambridge, UK: Cambridge University Press.

Price, L., Galitsky, C., and Worrell, E. 2006 (forthcoming). "Industry," Future Electricity Technologies and Systems. Cambridge, UK: Cambridge University Press.

Computer Tools

Murtishaw, S, C. Galitsky, E. Worrell, J. Sathaye, L. Price and M. Lefranc. 2003. MBase: Cement 1.0-beta test. MBase Cement Industry GHG Benchmarking Tool. Available online at <http://ies.lbl.gov/iespubs/ieupubs.html>. Berkeley, CA: Lawrence Berkeley National Laboratory, May, LBNL-5486.

Galitsky, C. and E. Worrell. 2005. BEST Winery Tool, An Excel-based Benchmarking and Water and Energy Savings Tool for the Wine Industry. Available online at <http://best-winery.lbl.gov>. Berkeley, CA: Lawrence Berkeley National Laboratory, May.

Stephane de la Rue du Can
Sr Research Associate
Energy Analysis Department
Lawrence Berkeley National Laboratory
510 486 7762
sadelarueducan@lbl.gov

EDUCATION

- 1998 **PARIS IX - Université Paris Dauphine**
DEA Diplôme d'étude approfondie in Economics
(equivalent to Master's degree)
- 1997 Maîtrise in International Economics
(equivalent to Bachelor's degree)
- 1995 **STRASBOURG - Université Louis Pasteur**
DEUG
- 1993 **STRASBOURG - Lycée Notre Dame**
Baccalauréat Série D. Option biology

WORK EXPERIENCE

Sept. 2003 **BERKELEY – Lawrence Berkeley National Laboratory -**
www.lbl.gov

Senior Research Associate

Main tasks:

I work on several topics such as energy and CO₂ emissions accounting methodologies, energy savings opportunities in the industrial sector, state and local climate change initiatives. Drawing from my experience in the Energy Statistics Division at the International Energy Agency, I established the methodological framework in which data are organized in order to construct an energy balance for the state of California that is internationally comparable. I also extended this methodology to calculate CO₂ emissions. Currently, I am working on a historical decomposition of energy use in California as well as a project for the IPCC, disaggregating global energy use forecasts into end-use scenarios for different regions of the world.

Mar. 2000
to Aug. 2003

PARIS - OECD - International Energy Agency - www.iea.org

Responsible for Non-OECD country Energy Balances

I worked in a team of five people to produce two annual publications, *Energy Statistics of Non-OECD Countries* and *Energy Balances of Non-OECD countries*.

Main tasks:

- developing co-operation with national ministries from non-OECD countries
- gathering energy supply and demand information, and processing this information in order to produce annual energy balances,
- creating methodology reports on new processes in the energy sector that impact energy balance and CO₂ accounting,
- programming routine to improve data collection quality

Sept. 1999
to Feb. 2000

LONDON - PDE - Decision Economics - www.pdeeco.com

Junior economist

Assisted a senior economist in his economics researches and analyses.

Keys accomplishments:

- responsible for weekly forecasts of select economic indicators (GDP, CPI)
- draft of a calendar with the main economics events of the week
- brought together pertinent figures for long-term analysis

July 1996

CLERMONT-FERRAND (France) - M.C.TECHNOLOGIES

Economist

Wrote a research paper on the EU Founding of the CAP (Common Agricultural Policy) in order to forecast European subsidies.

FOREIGN LANGUAGES AND COMPUTING

Languages: French Native
 English Fluent
 Spanish Basic

Computing: Good knowledge of PC and Macintosh environments and applications

- Microsoft Office (Word, Excel, PowerPoint) and Access.
- Extensive experience with relational databases and with programming (IEA in house database based on SQL language and Visual Basic for Excel).
- Econometric software (E-views)
- HTML notions

PUBLICATIONS

Price, L., de la Rue du Can, S., Sinton, J., and Worrell, E., forthcoming. Sectoral Trends in Global Energy Use and Greenhouse Gas Emissions. Berkeley, CA: Lawrence Berkeley National Laboratory LBNL-56144

Sathaye, J., de la Rue du Can, S., Holt E. C., 2005. Overview of IPR Practices for Publicly-funded Technologies. Berkeley, CA: Lawrence Berkeley National Laboratory LBNL- 59072

Sathaye, J., Price L.K., De La Rue Du Can S. , FridleyD., 2005. Assessment of Energy Use and Energy Savings Potential in Selected Industrial Sectors in India. Berkeley, CA: Lawrence Berkeley National Laboratory LBNL- 57293

Murtishaw, S., L. Price, S. de la Rue du Can, E. Masanet, E. Worrell, J. Sathaye. 2005. *Development of Energy Balances for the State of California*. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2005-068.

Masanet E., Worrell E., Price L.K., De La Rue Du Can S. (2005), "Reducing California's Greenhouse Gas Emissions through Product Life-cycle Optimization," 2005 ACEEE Summer Study on Energy Efficiency in Industry, West Point, New York, July 2005.

Energy Statistics of Non-OECD Countries, 2000, 2001 and 2002 editions. OECD/International Energy Agency: Paris, France.

Energy Balances of Non-OECD Countries, 2000, 2001 and 2002 editions. OECD/International Energy Agency: Paris, France.

ERIC MASANET

EDUCATION

- Ph.D. **University of California, Berkeley**
Mechanical Engineering, May 2004
Specialization: Environmentally-Conscious Product Design and Manufacturing
- M.S. **Northwestern University**
Mechanical Engineering, December 1996
- B.S. **University of Wisconsin - Madison**
Mechanical Engineering, August 1994

PROFESSIONAL EXPERIENCE

- **Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division**
Principal Scientific/Engineering Associate, June 2005 - Present
Senior Scientific/Engineering Associate, October 2004 - May 2005
- **University of California, Berkeley, College of Engineering**
Program Manager, Engineering and Business for Sustainability Program, Dec. 2006 - present
Lecturer, Department of Civil and Environmental Engineering, August 2006 - December 2006
- **University of California, Berkeley, Consortium on Green Design and Manufacturing**
Postdoctoral Researcher, May 2004 - June 2005
Graduate Student Researcher, August 1999 - May 2004
- **Seagate Technology, Environment, Health, and Safety Division, Scotts Valley, California**
Product Design for Environment Consultant (project-based), July 2003 - May 2005
- **Apple Computer, Hardware Engineering Division, Cupertino, California**
Product Design for Environment Engineer (part-time), June 2001 - January 2003
- **Sun Microsystems, Environment, Health, and Safety Division, Mountain View, California**
Product Design for Environment Engineer (part-time), February 2000 - October 2000
- **Caterpillar Incorporated, Large Wheel Loaders Division, Aurora, Illinois**
Senior Design Engineer, April 1996 - August 1999

SELECTED AWARDS AND HONORS

- **U.S. Delegate, British Council International Young Scientist Climate Change Summit, Bern, Switzerland, November 2005**
- **Best Student Paper Award, IEEE International Symposium on Electronics & the Environment, Boston, Massachusetts, May 2003**
- **Best Student Paper Award, IEEE International Symposium on Electronics & the Environment, San Francisco, California, May 2002**
- **University of California Toxic Substances Research & Training Graduate Fellowship, 2000-2002**
- **UC Berkeley Teaching Effectiveness Award for Graduate Student Instructors, 2001**
- **Santa Fe Institute Complex Systems Modeling Summer School Fellowship, 2001**
- **UC Berkeley Outstanding Graduate Student Instructor Award, 2000**
- **Northwestern University Walter P. Murphy Graduate Research Fellowship, 1994-1995**
- **Pi Tau Sigma Mechanical Engineering Honor Society, 1994**

PROFESSIONAL SERVICE

- **Member, Life-Cycle Assessment Trans-Boundary Impacts Task Force**
United Nations Environment Programme/SETAC Life-Cycle Initiative, August 2004 - Present
- **Cover Editor**
Journal of Industrial Ecology, April 2006 - Present
- **Co-Chair, Conference Education Program**
IEEE International Symposium on Electronics and the Environment, August 2004 - June 2006
- **Vice President**
Student Chapter of the International Society for Industrial Ecology, June 2002 - May 2004
- **Chair, Materials Environmental Issues Session**
IEEE International Symposium on Electronics and the Environment, Scottsdale, AZ, May 2004

- **Co-Chair, Design for Environment Session**
2nd International Society for Industrial Ecology Conference, Ann Arbor, MI, July 2003
- **Chair, Life-Cycle Assessment Session**
IEEE International Symposium on Electronics and the Environment, Boston, MA, May 2003
- **Chair, Student Conference Program**
1st International Society for Industrial Ecology Conference, Leiden, NL, November 2001
- **Co-Founder**
Student Chapter of the International Society for Industrial Ecology, June 2000
- **Ad-Hoc Reviewer (ongoing)**
International Journal of Industrial Ecology
Resources, Conservation, and Recycling
Energy - The International Journal
Ecological Economics
Journal of the Air & Waste Management Association
Environmental Science & Technology
Journal of Infrastructure Systems

PROFESSIONAL MEMBERSHIPS

International Society for Industrial Ecology (ISIE)
American Society of Mechanical Engineers (ASME)

REFEREED ARCHIVAL JOURNAL PUBLICATIONS

1. Masanet, E., and A. Horvath (2006). "Assessing the Benefits of Design for Recycling for Plastics in Electronics: A Case Study of Computer Enclosures." *Materials & Design*, in press.
2. White C.D., E. Masanet, C. Rosen, and S. Beckman (2003). "Product Recovery With Some Byte: An Overview of Management Challenges and Environmental Consequences in Reverse Manufacturing for the Computer Industry." *Journal of Cleaner Production*, 11(4): 445-458.

REFEREED CONFERENCE PUBLICATIONS

1. Masanet, E., and A. Horvath (2006), "Enterprise Strategies for Reducing the Environmental Impacts of Personal Computers." *Proceedings of the 2006 IEEE International Symposium on Electronics & Environment*, San Francisco, California, IEEE.

2. Lung, R.B., E. Masanet, and A. McKane (2006). "The Role of Emerging Technologies in Improving Energy Efficiency: Examples from the Food Processing Industry." *Proceedings of the Industrial Energy Technologies Conference*, New Orleans, Louisiana.
3. Masanet, E., L. Price, S. de la Rue du Can, and E. Worrell (2005). "Reducing California's Greenhouse Gas Emissions through Product Life-Cycle Optimization." *Proceedings of the 2005 ACEEE Summer Study on Energy Efficiency in Industry*, West Point, New York, ACEEE.
4. Friedmann, R., F. Coito, E. Worrell, L. Price, E. Masanet, and M. Rufo (2005). "California Industrial Energy Efficiency Potential." *Proceedings of the 2005 ACEEE Summer Study on Energy Efficiency in Industry*, West Point, New York, ACEEE.
5. Masanet, E., and A. Horvath (2004), "A Decision-Support Tool for the Take-Back of Plastics from End-of-Life Electronics." *Proceedings of the 2004 IEEE International Symposium on Electronics & Environment*, Scottsdale, Arizona, IEEE.
6. Masanet, E., and A. Horvath (2004). "Identifying Environmentally and Economically Sound Take-Back Strategies for Plastics from End-of-Life Electronics." Abstract. *SETAC Europe 14th Annual Meeting*, Prague, Czech Republic, SETAC.
7. Masanet, E., M. Newton, and R. Auer (2003). "Practical Aspects of the Materials Declaration Process." *Proceedings of the 2003 IEEE International Symposium on Electronics & Environment*, Boston, Massachusetts, IEEE.
8. Masanet, E., and A. Horvath (2003). "A Systems-Based, Economic and Environmental Design for Recycling Advisor for Engineering Thermoplastics in Electronic Equipment." Abstract. *2003 International Society for Industrial Ecology Conference*, Ann Arbor, Michigan, ISIE.
9. Kitou, E., A. Horvath, and E. Masanet (2002). "Putting in Perspective the Contribution of Transportation to the Environmental Effects of Telework." *81st Transportation Research Board Conference*, Washington, D.C., TRB.
10. Masanet, E., R. Auer, D. Tsuda, T. Barillot, and A. Baynes (2002). "An Assessment and Prioritization of 'Design for Recycling' Guidelines for Plastic Components." *Proceedings of the 2002 IEEE International Symposium on Electronics & Environment*, San Francisco, California, IEEE.
11. Masanet, E. (2002). "Assessing Public Exposure to Silver-Contaminated Groundwater from Lead-Free Solder: An Upper Bound, Risk-Based Approach." *Proceedings of the 2002 IEEE International Symposium on Electronics & Environment*, San Francisco, California, IEEE.

12. Kitou, E., A. Horvath, and E. Masanet (2001). "Environmental Implications of Telework." Abstract. *2001 International Society for Industrial Ecology Conference*, Leiden, The Netherlands, ISIE.
13. Kitou E., E. Masanet, and A. Horvath (2001). "Web-Based Tool for Estimating the Environmental Impacts of Telecommuting." *Proceedings of the 2001 IEEE International Symposium on Electronics & Environment*, Denver, Colorado, IEEE.

NON-REFERRED JOURNALS, BOOKS, REPORTS, AND PROCEEDINGS

1. Masanet, E., and A. Horvath (2006). "An Analysis of Measures for Reducing the Life-Cycle Energy Use and Greenhouse Gas Emissions of California's Personal Computers." University of California Energy Institute Technical Report, Berkeley, California.
2. Potting, J., P. Preiss, J. Seppälä, J. Struijs, J. Wiertz, M. Blazek, R. Heijungs, N. Itsubo, E. Masanet, B. Nebel, Y. Nishioka, J. Payet, V. Becaert, C. Basset, and O. Jolliet (2006). *Current Practice in Life Cycle Impact Assessment of Transboundary Impact Categories*. United Nations Environment Programme, Paris.
3. Masanet, E. and E. Worrell (2006). "Promoting Energy Efficiency in the U.S. Food Processing Industry: The U.S. EPA ENERGY STAR Program." *Compressed Air Best Practices*, October.
4. Worrell, E. and E. Masanet (2006). "Promoting Energy Efficiency in the U.S. Cement Industry: The U.S. EPA ENERGY STAR Program." *Compressed Air Best Practices*, November.
5. Galitsky, C., E. Masanet, E. Worrell, and C.S. Chang (2006). "Improving Energy Efficiency in Pharmaceutical Manufacturing Operations, Part 2: Heating, Ventilation, and Air Conditioning Systems and Co-Generation." *Pharmaceutical Manufacturing Magazine*, May.
6. Galitsky, C., E. Worrell, E. Masanet, and C.S. Chang (2006). "Improving Energy Efficiency in Pharmaceutical Manufacturing Operations, Part 1: Motors and Drives, Pumps, and Compressed Air Systems." *Pharmaceutical Manufacturing Magazine*, February.

LBNL REPORTS

1. Neelis, M., E. Worrell, and E. Masanet (2007). *Energy Efficiency Improvement and Cost Saving Opportunities for the Petrochemical Industry: An ENERGY STAR® Guide for Energy and Plant Managers*. Lawrence Berkeley National Laboratory, Berkeley, California. Draft.
2. Masanet, E., E. Worrell, and C. Galitsky (2006). *Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry: An*

ENERGY STAR® Guide for Energy and Plant Managers. Lawrence Berkeley National Laboratory, Berkeley, California. LBNL-59289.

3. Masanet, E., L. Price, S. de la Rue du Can, R. Brown, and E. Worrell (2005). *Optimization of Product Life Cycles to Reduce Greenhouse Gas Emissions in California.* California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2005-110.
4. Galitsky, C., E. Worrell, and E. Masanet (2005). *Energy Efficiency Improvement and Cost Saving Opportunities for the Glass Industry: An ENERGY STAR® Guide for Energy and Plant Managers.* Lawrence Berkeley National Laboratory, Berkeley, California. LBNL-57335.
5. Galitsky, C., C. Sheng-chieh, E. Worrell, and E. Masanet (2005). *Energy Efficiency Improvement and Cost Saving Opportunities for the Pharmaceutical Industry: An ENERGY STAR® Guide for Energy and Plant Managers.* Lawrence Berkeley National Laboratory, Berkeley, California. LBNL-57260.
6. Murtishaw, S., L. Price, S. de la Rue du Can, E. Masanet, E. Worrell, and J. Sathaye (2005). *Development of Energy Balances for the State of California.* California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2005-068.

THESES

1. Masanet, E. (2004). "Environmental and Economic Take-Back Planning for Plastics from End-of-Life Computers." Ph.D. Thesis, Department of Mechanical Engineering, University of California, Berkeley.
2. Masanet, E. (1996). "Experimental and Theoretical Support for the Hydrodynamic Effect in Low-Speed Sheet Metal Forming Operations." M.S. Thesis, Department of Mechanical Engineering, Northwestern University, Evanston, IL.

INVITED PRESENTATIONS

1. Platform presentation, California League of Food Processors Exposition, Sacramento, California, January, 2007: "Energy Efficiency and Cost Savings Opportunities in Fruit and Vegetable Processing."
2. Platform presentation, Food Industry Energy Research Conference, University of California, Davis, September, 2006: "Benchmarking and Energy Savings Tool for California Wineries."
3. Panel member, International Young Scientist Climate Change Summit, Bern, Switzerland, November, 2005: "Climate Change and Cities."

4. Seminar, American Council for an Energy-Efficient Economy, Washington, D.C., October, 2005: "Reducing Energy Consumption and Greenhouse Gas Emissions via Product Life-Cycle Optimization."
5. Seminar, Computer Aided Life Cycle Engineering Center, University of Maryland, October, 2005: "Application of Life Cycle Assessment to Greenhouse Gas Mitigation Policies for Personal Computers."
6. Platform presentation, 2nd Annual Climate Change Research Conference and 1st Scientific Conference, West Coast Governors' Global Warming Initiative, Sacramento, California, September, 2005: "Estimation of Greenhouse Gas Emissions from Products Manufactured in California."
7. Platform presentation, U.S. Commercial Service Pollution Prevention and Energy Efficiency (P2E2) Conference, Hong Kong, May, 2005: "Benchmarking for Energy Efficiency Improvement in Industry."
8. Seminar, Centre of Urban Planning and Environmental Management, University of Hong Kong, May, 2005: "Optimization of Product Life Cycles to Reduce Greenhouse Gas Emissions in California."
9. Presentation to the California Energy Commission, Sacramento, California, April 2005: "Modeling the Life-Cycle Greenhouse Gas Emissions of Products Manufactured in California."
10. Seminar, Department of Mechanical Engineering, Massachusetts Institute of Technology, April, 2004: "Environmentally-Conscious Design of Take-Back Systems for Plastics from End-of-Life Electronics."
11. Seminar, Department of Civil and Environmental Engineering, Northwestern University, Evanston, Illinois, April, 2004: "Analyzing the Environmental Impacts of E-Waste Recycling."

MEDIA COVERAGE

1. "Shredding Changes Electronics Recycling." *Recycling Today*, June 2002.
2. "Study Cites Setbacks from Molded-in Metal." *Plastics News*, May 2002.

LANGUAGE SKILLS

English (mother tongue)
German (advanced)
Spanish (basic)

EXHIBIT B

BUDGET DETAIL AND PAYMENT PROVISIONS

1. Invoicing

- A. For services satisfactorily rendered in accordance with this agreement and upon receipt and approval of the invoices which properly detail all charges the Air Resources Board agrees to compensate the Regents of the University of California, Berkeley for actual expenditures incurred in accordance with the rates specified herein or attached hereto.
- B. Invoices shall include the Agreement Number and shall be submitted in triplicate not more frequently than quarterly in arrears to Ms. Emma Plasencia at the address stated in Exhibit A, Article 2.
- C. University may rebudget funds up to a maximum of ten percent between major budget categories with prior notice to ARB's Contract Manager.
- D. Upon mutual agreement, ARB will give consideration to requests to rebudget funds in excess of ten percent, however, no rebudgeting in excess of ten percent and no rebudgeting of funds into the travel category may be performed without Research Division Chief approval. The total agreement cost will remain unchanged.

2. Budget Contingency Clause

- A. It is mutually agreed that if the Budget Act of the current year and/or any subsequent years covered under this Agreement does not appropriate sufficient funds for the program, this Agreement shall be of no further force and effect. In this event, the State shall have no liability to pay any funds whatsoever to Contractor or to furnish any other considerations under this Agreement and Contractor shall not be obligated to perform any provisions of this Agreement.
- B. If funding for any fiscal year is reduced or deleted by the Budget Act for purposes of this program, the State shall have the option to either cancel this Agreement with no liability occurring to the State, or offer an agreement amendment to Contractor to reflect the reduced amount.

3. Payment

- A. Costs for this Agreement shall be computed in accordance with State Administrative Manual Sections 8752 and 8752.1.

- B. Nothing herein contained shall preclude advance payments pursuant to Article 1, Chapter 3, Part 1, Division 3, Title 2 of the Government Code of the State of California.
- C. ARB shall withhold payment equal to ten percent of the total Agreement cost until completion of all work and submission to ARB by University of a final report (including computer diskette copy) approved in accordance with Exhibit F, by ARB. It is University's responsibility to submit an invoice in triplicate with the revised final report for ten percent withheld.
- D. University will be paid for the payment period completed upon receipt, by ARB, of an invoice and progress report satisfying the requirements of this Agreement. The invoice and progress report must be deemed by ARB to reflect reasonable work performed in accordance with the Agreement.
- E. The amount to be paid to University under this Agreement includes all sales and use taxes incurred pursuant to this Agreement. University shall not receive additional compensation for reimbursement of such taxes and shall not decrease work to compensate therefore.

Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal: Evaluation of Efficiency Activities in the Industrial Sector Undertaken in Response to Greenhouse Gas Emission Reduction Targets

Total Budget Requested: \$100,000

Period Covered (months): 18 months

University: UC Berkeley

Address: 2150 Shattuck Avenue, Suite 313

Name of person authorized to bind this bid: Jyl Baldwin (jbaldwin@berkeley.edu)

Title: Contracts & Grants Analyst

Phone: (510) 642-8117

Signature of person authorized to bind this bid: _____

Budget Summary

Budget details must be supplied on pages 3-11 and on additional pages if necessary.
Instructions and definitions of terms are provided in Attachment 1 of the Guidelines for Proposals.

NOTE: Totals in categories in this summary are automatically updated from pages 3-11 when using Excel file.

Direct Costs

1.	Labor & Employee Fringe Benefits	\$2,273
2.	Subcontractor(s)/Consultant(s)	\$95,000
3.	Equipment	\$0
4.	Travel & Subsistence	\$0
5.	Electronic Data Processing	\$0
6.	Photocopying & Printing	\$0
7.	Mail, Telephone, and Fax	\$0
8.	Materials & Supplies	\$0
9.	Analyses	\$0
10.	Miscellaneous	\$0
Total Direct Cost		\$97,273

Indirect Costs

11.	Overhead	\$2,727
Total Indirect Cost		\$2,727

Total Direct and Indirect Cost:	\$100,000
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Budget Detail

I. Direct Costs

1a. Labor Charges for Universities and Other State Agencies

Note: Total Salary Requested cells automatically calculate when using Excel file.

	Individual's Name	Work Title	Mo. Salary	Est. Months	% of Effort or % of Salary	Total Salary Requested
A.	Horvath, Arpad	P.I.	\$10,849.00	0.186	100.00%	\$2,017
B.						\$0
C.						\$0
D.						\$0
E.						\$0
F.						\$0
G.						\$0
H.						\$0
I.						\$0
<i>(use additional page if necessary)</i>						

Subtotal:	\$2,017
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Cost justifications. Describe exactly why each individual listed in the Budget Detail is needed in this project (i.e., their role in the project), why this particular person was chosen for this role, and why their proposed level of effort is necessary. Describe, for each position listed, why the specified rate is reasonable or competitive. (Use additional page if necessary).

1b. Fringe Benefits

Note: COST cells automatically calculate when using Excel file.

	Individual's Name	BASE (\$)	RATE (%)	COST
A.	Horvath, Arpad	\$2,017	12.70%	\$256
B.				\$0
C.				\$0
D.				\$0
E.				\$0
F.				\$0
G.				\$0
H.				\$0
I.				\$0

(use additional page if necessary)

Subtotal:	\$256
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Cost justifications. Provide the Basis for the Fringe Benefit Rates. (Use additional page if necessary).

2. Subcontractors & Consultants

List all subcontractors and consultants. Also submit separate Budget Submittal Form for each subcontractor and consultant.

	Subcontractor or consultant	Cost
A.	Lawrence Berkeley National Laboratory	\$95,000
B.		
C.		
D.		

(use additional page if necessary)

Subtotal: \$95,000

Cost justifications. Describe exactly why each subcontractor is needed in this project (i.e., their role in the project). Describe, for each subcontractor, why the specified rate is reasonable or competitive. (Use additional page if necessary).

3. Equipment (Itemize)

	Item	Cost
A.		
B.		
C.		
D.		

Subtotal: \$0

Cost justifications. Describe exactly why each listed equipment item is needed in this project, and why the cost is reasonable. (Use additional page if necessary). (Refer to Exhibit E, page 19)

4. Travel and Subsistence (Itemize). Use State Rates (Appendix IV). NO FOREIGN

TRAVEL ALLOWED.

Description	Cost
A.	
B.	
C.	
D.	

Subtotal: \$0

Cost justifications. Describe the purpose and duration of each trip and explain why the travel is necessary. (Use additional page if necessary).

5. Electronic Data Processing (Itemize)

Description	Cost
A.	
B.	
C.	
D.	

Subtotal: \$0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

6. Photocopying & Printing (Itemize)

Description of product	Cost
A.	
B.	

Subtotal: \$0

*Cost justifications. Explain the need for the expenditure and the basis for the costs.
(Use additional page if necessary).*

7. Mail, Telephone & Fax (Itemize)

Item	Cost
A.	
B.	
C.	

Subtotal: \$0

*Cost justifications. Explain the need for the expenditure and the basis for the costs.
(Use additional page if necessary).*

8. Materials & Supplies (Itemize)

Item	Cost
A.	
B.	
C.	
D.	
E.	
F.	
G.	
H.	
I.	

Subtotal:	\$0
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Cost justifications. Describe exactly why each item listed above is needed in this project. Explain why the proposed cost is reasonable. (Use additional page if necessary).

9. Analyses (Itemize)

Description	Cost
A.	
B.	
C.	
D.	
E.	
F.	
G.	
H.	
I.	

Subtotal:	\$0
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Cost justifications. Describe the purpose of each different analysis and explain why it is needed in this project. Explain why the proposed rate is reasonable. (Use additional page if necessary).

10. Miscellaneous (Itemize)

Item	Cost
A.	
B.	
C.	
D.	

Subtotal:	\$0
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Cost justifications. Justify all costs not included in the categories above. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

Total Direct Costs (add subtotals for categories 1-10):	\$97,273
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II. Indirect Costs

11. Overhead and Other Indirect Costs

	Base (Salaries, total direct costs, etc.) (\$)	Rate (%)	Cost
A.	\$27,273	10.00%	\$2,727
B.			\$0
C.			\$0
D.			\$0
E.			\$0

Subtotal: \$2,727

Total Indirect Cost: \$2,727

Total Project Cost: \$100,000

Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal: Evaluation of Efficiency Activities in the Industrial Sector Undertaken in Response to Greenhouse Gas Emission Reduction Targets

Total Budget Requested: \$95,000

Period Covered (months): 18 months

University: Lawrence Berkeley National Laboratory

Address: Mailcode: 90R2000, 1 Cyclotron Road, Berkeley, CA 94720

Name of person authorized to bind this bid: Rick Inada (RMIrada@lbl.gov)

Title: Sponsored Projects Officer

Phone: (510 486-5882

Signature of person authorized to bind this bid: _____

Budget Summary

Budget details must be supplied on pages 3-11 and on additional pages if necessary.
Instructions and definitions of terms are provided in Attachment 1 of the Guidelines for Proposals.

NOTE: Totals in categories in this summary are automatically updated from pages 3-11 when using Excel file.

Direct Costs		
1.	Labor & Employee Fringe Benefits	\$47,746
2.	Subcontractor(s)/Consultant(s)	\$0
3.	Equipment	\$0
4.	Travel & Subsistence	\$2,500
5.	Electronic Data Processing	\$0
6.	Photocopying & Printing	\$0
7.	Mail, Telephone, and Fax	\$0
8.	Materials & Supplies	\$0
9.	Analyses	\$0
10.	Miscellaneous	\$3,404
Total Direct Cost		\$53,650

Indirect Costs		
11.	Overhead	\$41,350
Total Indirect Cost		\$41,350

Total Direct and Indirect Cost:	\$95,000
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Budget Detail

I. Direct Costs

1a. Labor Charges for Universities and Other State Agencies

Note: Total Salary Requested cells automatically calculate when using Excel file.

	Individual's Name	Work Title	Mo. Salary	Est. Months	% of Effort or % of Salary	Total Salary Requested
A.	Price, Lynn	P.I./Scientist	\$10,856.00	2.2597	100.00%	\$24,531
B.	Galitsky, Christie	Staff Research Associate	\$7,373.00	1.0837	100.00%	\$7,990
C.	Masanet, Eric	Principal Engineering Associate	\$8,755.00	0.1729	100.00%	\$1,514
D.	DeLaRueduCan, Stephane	Principal Research Associate	\$6,348.00	0.5072	100.00%	\$3,220
E.						\$0
F.						\$0
G.						\$0
H.						\$0
I.						\$0

(use additional page if necessary)

Subtotal:	\$37,255
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Cost justifications. Describe exactly why each individual listed in the Budget Detail is needed in this project (i.e., their role in the project), why this particular person was chosen for this role, and why their proposed level of effort is necessary. Describe, for each position listed, why the specified rate is reasonable or competitive. (Use additional page if necessary).

1b. Fringe Benefits

Note: COST cells automatically calculate when using Excel file.

	Individual's Name	BASE (\$)	RATE (%)	COST
A.	Price, Lynn	\$24,531	28.16%	\$6,908
B.	Galitsky, Christie	\$7,990	28.16%	\$2,250
C.	Masanet, Eric	\$1,514	28.16%	\$426
D.	DeLaRueduCan, Stephane	\$3,220	28.16%	\$907
E.				\$0
F.				\$0
G.				\$0
H.				\$0
I.				\$0

(use additional page if necessary)

Subtotal: \$10,491

Cost justifications. Provide the Basis for the Fringe Benefit Rates. (Use additional page if necessary).

2. Subcontractors & Consultants

List all subcontractors and consultants. Also submit separate Budget Submittal Form for each subcontractor and consultant.

Subcontractor or consultant	Cost
A. B. C. D.	
(use additional page if necessary)	

Subtotal: \$0

Cost justifications. Describe exactly why each subcontractor is needed in this project (i.e., their role in the project). Describe, for each subcontractor, why the specified rate is reasonable or competitive. (Use additional page if necessary).

3. Equipment (Itemize)

Item	Cost
A. B. C. D.	

Subtotal: \$0

Cost justifications. Describe exactly why each listed equipment item is needed in this project, and why the cost is reasonable. (Use additional page if necessary). (Refer to Exhibit E, page 19)

4. Travel and Subsistence (Itemize). Use State Rates (Appendix IV). NO FOREIGN TRAVEL ALLOWED.

	Description	Cost
A.	Air transportation	\$1,000
B.	Ground transportation	\$500
C.	Per diem or subsistence	\$1,000
D.	Other (Lodging & Parking)	

Subtotal: \$2,500

Cost justifications. Describe the purpose and duration of each trip and explain why the travel is necessary. (Use additional page if necessary).

5. Electronic Data Processing (Itemize)

	Description	Cost
A.		
B.		
C.		
D.		

Subtotal: \$0

Cost justifications. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

6. Photocopying & Printing (Itemize)

	Description of product	Cost
A.		
B.		

Subtotal: \$0

*Cost justifications. Explain the need for the expenditure and the basis for the costs.
(Use additional page if necessary).*

7. Mail, Telephone & Fax (Itemize)

	Item	Cost
A.		
B.		
C.		

Subtotal: \$0

*Cost justifications. Explain the need for the expenditure and the basis for the costs.
(Use additional page if necessary).*

8. Materials & Supplies (Itemize)

	Item	Cost
A.		
B.		
C.		
D.		
E.		
F.		
G.		
H.		
I.		

Subtotal:	\$0
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Cost justifications. Describe exactly why each item listed above is needed in this project. Explain why the proposed cost is reasonable. (Use additional page if necessary).

9. Analyses (Itemize)

	Description	Cost
A.		
B.		
C.		
D.		
E.		
F.		
G.		
H.		
I.		

Subtotal:	\$0
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Cost justifications. Describe the purpose of each different analysis and explain why it is needed in this project. Explain why the proposed rate is reasonable. (Use additional page if necessary).

10. Miscellaneous (Itemize)

	Item	Cost
A.	Other project expenses include miscellaneous costs such as telephone, copy	\$3,404
B.		
C.		
D.		

Subtotal: \$3,404

Cost justifications. Justify all costs not included in the categories above. Explain the need for the expenditure and the basis for the costs. (Use additional page if necessary).

Total Direct Costs (add subtotals for categories 1-10): \$53,650

II. Indirect Costs

11. Overhead and Other Indirect Costs

	Base (Salaries, total direct costs, etc.) (\$)	Rate (%)	Cost
A.	\$47,746.00	17.50%	\$8,355
B.	\$2,500.00	14.00%	\$350
C.	\$61,455.00	5.35%	\$3,288
D.	\$58,955.00	48.20%	\$28,416
E.	\$94,059.00	1.00%	\$941

Subtotal: \$41,350

Total Indirect Cost: \$41,350

Total Project Cost:

\$95,000

LBNL Budget Justification

1. PERSONNEL

This project will take place during FY 2007 through FY 2009; rates are based on actual salaries for the period and are escalated at a rate of 3%.

2. FRINGE BENEFITS

The scientific staff fringe benefit average rate for FY07 through FY09 is 28.16% for career staff. These rates are standard to all projects and are approved by DOE.

3. TRAVEL

Travel costs include international air transportation, ground transportation, and travel-related costs for a research trip to conduct interviews in one or more target countries.

4. OTHER

Miscellaneous costs include other project expenses include costs such as telephone, copy costs, computer use and fax costs. Shared administrative support and electricity are included in this category.

Organization burden is charged at the rate of 17.5% on salary and fringe benefits only. The rate is standard to all projects and is approved by DOE.

Travel burden is 14% of total travel cost.

General Overhead at 48.2% of Total Direct Costs. G&A funds the general management and administration of the Lab.

LDRD is 5.20% of total direct costs and burdens, minus subcontract cost and minus total unoverheaded direct costs. Laboratory Directed Research and Development (LDRD) are indirect costs that are allocated to all direct programs at the laboratory for independent research and development activities in conformance with the guidelines contained in DOE Order 5000.4A.

IGPP is .15% of total direct costs and burdens, minus subcontract cost and minus total unoverheaded direct costs. Institutional General Plant Project (IGPP) are new construction projects (cost of less than \$5M) of a general institutional nature benefiting multiple cost objectives and required for general-purpose site-wide needs. IGPP does not include construction projects that can be directly attributed to benefit a specific or single program.

Securities and Safeguards is a 1% charge on the project's total cost. S&S is the recovery of safeguards and security costs on non-DOE projects.

A Federal Administrative Charge of 3% on the total is charged to non-DOE sponsor. We will request a waiver of this charge on the basis that the sponsor is a state agency.

LBNL Budget Justification (continued)

4. OTHER (continued)

a. Explanation of Line #11. Overheads and Other Direct Costs – Line C

Line C basis of \$61,455 is the sum of:

\$37,255 (effort)

\$10,491 (fringe)

\$8,355 (organization burden)

0 (equipment)

0 (subcontract amount with burdens)

0 (purchases with burdens)

\$2,850 (travel with burden)

\$2,504 (miscellaneous expenses)

The basis is then multiplied by the combined LDRD and IGPP rate of 5.35%

b. Explanation of Line #11. Overheads and Other Direct Costs – Line D

Line D basis of \$58,955 is the result of Line C (\$61,455) minus equipment (\$0), minus subcontract Cost (\$0), minus purchases (\$0), minus raw travel amount (\$2,500) = (\$61,455 - \$2,500).

The basis is then multiplied by the general overhead rate of 48.20%

EXHIBIT D

SPECIAL TERMS AND CONDITIONS

1. Termination

- A. This Agreement may be canceled at any time by either party, upon thirty (30) days written notice to the other party.
- B. In the case of early termination, the performing agency will submit an invoice in triplicate and a report in triplicate covering services to termination date, following the invoice and progress report requirements of this Agreement. A copy and description of any data collected up to termination date will also be provided to ARB.
- C. Upon receipt of the invoice, progress report, and data, a final payment will be made to the performing agency. This payment shall be for all ARB-approved, actually incurred costs in accordance with Exhibits A and B, and shall include labor, and materials purchased or utilized (including all noncancellable commitments) to termination date, and pro rata indirect costs as specified in the proposal budget.

2. Disputes

- A. ARB reserves the right to issue an order to stop work in the event that a dispute should arise, or in the event that the ARB gives the performing agency a notice that this Agreement will be terminated. The stop-work order will be in effect until the dispute has been resolved or this Agreement has been terminated.
- B. Any dispute concerning a question of fact arising under the terms of this Agreement which is not disposed of within a reasonable period of time by agency employees normally responsible for the administration of this agreement, shall be brought to the attention of the Executive Officer or designated representative of each agency for joint resolution.

3. Amendments

ARB reserves the right to amend this agreement for additional time and/or additional funding.

EXHIBIT E

ADDITIONAL PROVISIONS

1. Equipment Provisions

- A. Equipment is defined as movable articles of nonexpendable property that meet the following requirements:
1. have a normal useful life (including extended life due to repairs) of at least one year;
 2. have a unit acquisition cost of at least \$5,000 for other than land and structures (for example, identical assets costing \$3,000 each for a \$12,000 total would not meet the requirements); and
 3. be used to conduct work under this contract, and/or
 4. any and all EDP equipment used to conduct work under this contract.
- B. The cost of equipment includes the purchase price plus all costs to acquire, install, and prepare equipment for its intended use.
- C. The ARB reserves the right to purchase total equipment whose cost is greater than \$25,000 and any and all EDP equipment for this contract, through the State procurement process. Contractor's proposed cost of this equipment will be deducted from the total amount payable to the Contractor. The equipment provided by ARB will be equivalent to Contractor's specifications, as described in Contractor's proposal.
- D. In the event Contractor purchases with ARB funds, procures, uses, or otherwise takes possession of equipment owned by ARB to perform work under this contract, title to such equipment shall remain with ARB and such equipment shall become ARB's equipment upon delivery thereof into the Contractor's control or possession.
- E. Contractor shall obtain written approval from ARB prior to the purchase of equipment that is not specifically identified and listed in the approved budget and which is valued at more than \$5,000. The contract funding shall be adjusted for any equipment or supplies furnished by ARB.
- F. ARB reserves the right to full and adequate access to ARB equipment.
- G. Contractor shall maintain and administer a program for the utilization, maintenance, repair, protection, and preservation of ARB equipment, whether acquired from the ARB or purchased with ARB funds from a third party, so as to assure its full availability and usefulness for performance of this contract or as long as this equipment remains in the control or possession of the Contractor. The Contractor will install upon each item of equipment a tag identifying the

equipment as belonging to the ARB and will maintain location records of all equipment. The Contractor shall take steps to comply with all appropriate directions or instructions that the ARB may prescribe for the protection of ARB equipment.

- H. Contractor shall provide to ARB, with the final invoice, a final equipment inventory. The final invoice shall contain an itemization of equipment purchased with ARB funds or procured through the State procurement process, including the type of equipment, manufacturer, serial number, and cost. All ARB equipment shall be returned to the ARB at ARB's expense in full operating condition upon termination of this contract, unless ARB approves a different disposition in writing. Disposition of the equipment shall be in accordance with the instructions from ARB, to be issued after receipt of the final inventory.

2. Reports and Data Compilations

- A. ***With respect to each invoice period, University shall forward to the ARB Contract Administrator, one (1) electronic copy of the progress report and mail one (1) copy of the progress report along with each invoice. (Do not use Express Mail). When emailing the progress report, the "subject line" should state the contract number and the billing period. Each progress report will begin with the following disclaimer:***

The statements and conclusions in this report are those of the University and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

- B. Each progress report will also include:
1. A brief narrative account of project tasks completed or partially completed since the last progress report;
 2. A brief discussion of problems encountered during the reporting period and how they were or are proposed to be resolved;
 3. A brief discussion of work planned, by project task, before the next progress report; and
 4. A graph or table showing allocation of the budget and amount used to date.
 5. A graph or table showing percent of work completion for each task.

- C. If the project is behind schedule, the progress report must contain an explanation of reasons and how the University plans to resume the schedule.
- D. Six months prior to Agreement termination date, University will deliver to ARB twenty (20) bound copies of a draft final report. The reports may be stapled or spiral bound, depending on size. The draft final report will conform to Exhibit F.
- E. Within forty-five (45) days of receipt of ARB's comments on the draft Final Report (Exhibit F), University will deliver to ARB's Contract Manager two (2) copies of the Final Report incorporating all reasonable alterations and additions requested by ARB. Upon approval of the amended final report approved by ARB in accordance to Exhibit F, University will within two (2) weeks, deliver to ARB two (2) camera ready UNBOUND originals of a Final Report incorporating all final alterations and additions. The final report will conform to the Contract Final Report Format, Exhibit F.
- F. Together with the final report, University will deliver a copy of the report on diskette/CD, using any common word processing software (please specify the software used) and a set of all data compilations as specified by the ARB Contract Manager.
- G. University's obligation under this Agreement shall be deemed discharged only upon submittal to ARB of an acceptable final report in accordance to Exhibit F, report diskette/CD, all required data compilations, and any other project deliverables.
- H. Prior to completion of this Agreement, University shall be entitled to release or make available reports, information, or other data prepared or assembled by it pursuant to this Agreement, in scientific journals and other publications and at scientific meetings, provided however, that a copy of the publication be submitted to ARB for review and comment 45 days prior to such publication. Further, University shall place the disclaimer statement in a conspicuous place on all such reports or publications. Health related reports should include an acknowledgment to the late Dr. Friedman. Nothing in this provision shall be construed to limit the right of State to release information obtained from the University or to publish reports, information, or data in State publications.

3. Copyrightable Materials

In recognition of the policy of ARB and University to promote and safeguard free and open inquiry by faculty, students and the members of the public and in furtherance of such policy, both parties agree to the following with respect to rights in data and copyrights under this Agreement:

- A. The term "Subject Data" shall mean all original and raw research data, notes, computer programs, writings, sound recordings, pictorial reproductions, drawings or other graphical representations, and works of any similar nature, produced by University in performance of this Agreement, but specifically excluding "Reports," as defined in this Agreement. Subject Data also excludes financial reports, cost analyses, and similar information incidental to contract administration.
- B. The term "Reports" shall have the meaning assigned to it in this Exhibit F of this Agreement.
- C. Ownership of all Subject Data and copyrights arising from Subject Data shall be vested in University while ownership of all Reports and copyrights arising from the Reports delivered under this Agreement shall be vested in ARB. University agrees to make available to the public for public benefit, to the extent the University shall have the legal right to do so, without license or fee, any scholarly articles which are published from the Subject Data.
- D. Nothing in this exhibit or Agreement shall be construed to limit the right of University faculty, students or staff to publish the Subject Data in the form of scholarly articles in academic journals nor to affect, abrogate or limit the right of University faculty, staff or students to make use of the Subject Data.

4. **Travel & Per Diem**

- A. Any reimbursement for necessary travel and per diem shall be at the University's approved travel rates.
- B. No foreign travel shall be reimbursed unless prior written authorization is obtained from ARB.

5. **Meetings**

- A. **Initial meeting.** Before work on the contract begins, the Principal Investigator and key personnel will meet with the ARB Contract Manager and other staff to discuss the overall plan, details of performing the tasks, the project schedule, items related to personnel or changes in personnel, and any issues that may need to be resolved before work can begin.
- B. **Progress review meetings.** The Principal Investigator and appropriate members of his or her staff will meet with ARB's Contract Manager at quarterly intervals to discuss the progress of the project. This meeting may be conducted by phone.

- C. Technical Seminar. The Contractor will present the results of the project to ARB staff and a possible webcast at a seminar at ARB facilities in Sacramento or El Monte.

6. **Confidentiality**

- A. It is understood that in the course of carrying out this Agreement, State may wish to provide University with proprietary or confidential information of State (Proprietary Information). University agrees to use its best efforts to hold proprietary information in confidence and shall return it to State upon the completion of the project.
- B. This obligation shall apply only to proprietary information that is designated or identified as such in writing by State prior to the disclosure thereof. All proprietary information shall be sent only to the Principal Investigator. Moreover, this obligation shall not apply to any proprietary information which: a) is or becomes publicly known through no wrongful or negligent act on the part of University; b) is already known to University at the time of disclosure; c) independently developed by University without breach of this agreement; or d) is generally disclosed to third parties by State without similar restrictions on such third parties.

7. **Studies Involving Human or Animal Subjects**

A copy of the Institutional Review Board (IRB) approval must be submitted to ARB upon receipt by the investigator.

8. **Patent Provisions**

A. **Definitions**

1. "Invention" means any discovery or product of creative imagination, thought, mental synthesis, or purposeful experimentation conceived or first reduce to practice in the course of or under this Agreement. The term "invention" includes, but is not limited to, any art, method, process, device, machine, manufacture, design, or composition of matter, or any new and useful improvement or application thereof, or any variety of plant, that is or may be patentable under the patent laws of the United States of America.
2. "Agreement" means any legally enforceable agreement, covenant, compact grant, or other arrangement or subcontract setting forth terms and conditions to do or not to do something and entered into by or for the benefit of the State where a purpose of the agreement is the conduct of experimental, developmental, or research work.
3. "Subcontract" means an agreement under or subordinate to a previous or prime agreement, including this Agreement.

4. "Subcontractor" means an individual or firms that contracts with Contractor to perform part or all of the prime Contractor's work under this Agreement.
5. "To bring to the point of practical application" means to manufacture in the case of a composition or product, to practice in the case of a process, or to operate in the case of a machine, device, or system and, in each case, under such conditions as to establish that the invention is being worked, operated, or utilized, and that its benefits are reasonable accessible to the public.

B. Rights Granted to the State

Subcontractor agrees to grant to State all right, title, and interest in and to each invention discovered, conceived, or first reduced to practical application during performance of the Subcontract, subject to the reservation of a non-exclusive paid-up worldwide license to Subcontractor.

C. Invention Disclosures and Reports

With respect to each invention, Subcontractor shall furnish to ARB:

1. A written disclosure of each invention within six (6) months after conception or first actual reduction to practice, whichever occurs first under the Subcontract, sufficiently complete in technical detail to convey to one skilled in the art to which the invention pertains a clear understanding to the nature, purpose, and operation, and the physical, chemical, and electrical characteristics of the invention;
2. A final report listing all inventions, including all those previously disclosed, or certifying that there are no inventions prior to final payment under this Subcontract.
3. Information in writing, as soon as is practicable, of the date and identity of any public use, sale, or publication of any such invention made by or known to Subcontractor, or of any contemplated publication by Subcontractor;
4. Upon request, such duly executed instruments and other papers as deemed by ARB necessary to vest in State the rights granted it under this patent provision and to enable State to apply for and prosecute any patent application in any country covering such invention where State has the right under this patent provision to file such application; and

5. Upon request, an irrevocable power of attorney to inspect and make copies of any United States patent application filed by or on behalf of Subcontractor. This demand may also be made under subdivision 8.

D. **License Granted by Subcontractor to Others Subject to State's Rights**

Subcontractor recognizes that State may contract for property or services with respect to which the vendor may be liable to Subcontractor for royalties for the use of an invention on account of such a contract. Subcontractor further recognizes that it is the policy of State not to pay, in connection with its agreements, charges for use of patents in which the State holds title. In recognition of this policy, Subcontractor agrees to participate in and make appropriate arrangements for the exclusion of such charges from such agreements or for the refund of amounts received by Subcontractor with respect to any such charges not so excluded.

E. **Subcontracts**

1. Contractor shall, unless otherwise authorized or directed by State, include a patent rights clause containing all the terms of this patent provision in any Subcontract hereunder where the purpose of the subcontract is the conduct of experimental, developmental, or research work. In the event of refusal by a Subcontractor to accept this patent provision, Contractor:
 - (1) shall promptly submit a written report to the State setting forth the Subcontractor's reasons for such refusal or the reasons Contractor is of the opinion that the inclusion of this clause would be unacceptable, and other pertinent information that may expedite disposition of this matter; and
 - (2) shall not proceed with the Subcontract without the written authorization of State.
2. Contractor shall not, in any Subcontract or by using such a Subcontract as consideration thereof, acquire any rights to inventions for its own use (as distinguished from such rights as may be required solely to fulfill its agreement obligations to State in the performance of this Agreement).
3. Contractor, at the earliest practicable date, shall also notify State in writing of any Subcontract containing a patent rights clause, furnish to State a copy of such Subcontract, and notify State when such Subcontract is completed. It is understood that State is a

third party beneficiary of any Subcontract clause granting rights to State in inventions, and Contractor hereby assigns to State all the rights that Contractor would have to enforce the Subcontractor's obligations for the benefit of State with respect to inventions. Contractor shall not be obligated to enforce the agreements of any Subcontractor to State with regard to inventions.

F. **Right to Disclose Inventions**

State may duplicate and disclose reports and disclosures of inventions required to be furnished by Subcontractor pursuant to this patent provision.

G. **Forfeiture of Rights in Unreported Inventions**

Subcontractor shall forfeit to State all rights in any invention which Subcontractor fails to report to State, at or prior to the time Subcontractor (1) files or causes to be filed a United States or foreign application thereon, or (2) submits the final report required by 3., B of this patent provision, whichever is later, provided that Subcontractor shall not forfeit rights in an invention if (a) contending that the invention is not an invention, it nevertheless reports the invention and all the facts pertinent to Subcontractor's contention to State, the time specified in 3. A above, or (b) Subcontractor establishes that the failure to report was due entirely to causes beyond Subcontractor's control and without Subcontractor's fault or negligence. Subcontractor shall be deemed to hold any such forfeited invention and the patent applications and patent pertaining thereto, in trust for State pending written assignment of the invention. The right accruing to State under this paragraph shall be in addition to and shall not supersede any other rights State may have in relation to unreported inventions.

H. **Examination of Records Relating to Inventions**

State shall, until the expiration of three years after final payment under this agreement, have the right to examine any books, records, documents, and other supporting data of Subcontractor that State shall reasonably deem directly pertinent to the discovery or identification of inventions or to compliance by Subcontractor with the requirements of this patent provision.

EXHIBIT F

RESEARCH FINAL REPORT FORMAT

The research contract Final Report (Report) is as important to the contract as the research itself. The Report is a record of the project and its results, and is used in several ways. Therefore, the Report must be well organized and contain certain specific information. The ARB's Research Screening Committee (RSC) reviews all draft Final Reports, paying special attention to the Abstract and Executive Summary. If the RSC finds that the Report does not fulfill the requirements stated in this Appendix, the document will not be approved for release, and final payment for the work completed may be withheld. This Appendix outlines the requirements that must be met when producing the Report.

Note: In partial fulfillment of the Final Report requirements, the Contractor shall submit a copy of the Report on a CD in PDF format and in a word-processing format, preferably in Word - Version 6.0 or later. This is in addition to the submission of any paper copies required. The diskette shall be clearly labeled with the contract title, ARB contract number, the words "Final Report", and the date the report was submitted.

Legibility. Each page of the approved Final Report must be legible and camera-ready.

Binding. The draft Report, including its appendices, must be either spiral bound or stapled, depending on size. The revised Report and its appendices should be spiral bound, except for two unbound, camera-ready originals.

Cover. Do not supply a cover for the Report. The ARB will provide its standard cover.

One-sided vs. two-sided. To conserve paper, both the draft Report and the revised Report, except for the unbound camera-ready copies, should be printed on both sides of the page. The unbound camera-ready copies must be printed on only one side of the page.

Title. The title of the Report should exactly duplicate the title of the contract unless a change is approved in writing by the contract manager.

Spacing. In order to conserve paper, copying costs, and postage, please use single or one-line (1) spacing.

Page size. All pages should be of standard size (8 1/2" x 11") to allow for photo-reproduction.

Large tables or figures. Foldout or photo-reduced tables or figures are not acceptable because they cannot be readily reproduced. Large tables and figures should be presented on consecutive 8 1/2" x 11" pages, each page containing one portion of the larger chart.

Color. Color presentations are not acceptable; printing shall be black on white only.

Corporate identification. Do not include corporate identification on any page of the Final Report; except the title page.

Unit notation. Measurements in the Reports should be expressed in metric units. However, for the convenience of engineers and other scientists accustomed to using the British system, values may be given in British units as well in parentheses after the value in metric units. The expression of measurements in both systems is especially encouraged for engineering reports.

Section order. The Report should contain the following sections, in the order listed below:

Title page
Disclaimer
Acknowledgment (1)
Acknowledgment (2)
Table of Contents
List of Figures
List of Tables
Abstract
Executive Summary
Body of Report
References
List of inventions reported and copyrighted materials produced
Glossary of Terms, Abbreviations, and Symbols
Appendices

Page numbering. Beginning with the body of the Report, pages shall be numbered consecutively beginning with "1", including all appendices and attachments. Pages preceding the body of the Report shall be numbered consecutively, in ascending order, with small Roman numerals.

Title page. The title page should include, at a minimum, the contract number, contract title, name of the principal investigator, contractor organization, date, and this statement: "Prepared for the California Air Resources Board and the California Environmental Protection Agency"

Disclaimer. A page dedicated to this statement must follow the Title Page:

The statements and conclusions in this Report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

Acknowledgment (1). Only this section should contain acknowledgments of key personnel and organizations who were associated with the project. The last paragraph of the acknowledgments must read as follows:

This Report was submitted in fulfillment of [ARB contract number and project title] by [contractor organization] under the [partial] sponsorship of the California Air Resources Board. Work was completed as of [date].

Acknowledgment (2). Health reports should include an acknowledgment to the late Dr. Friedman. Reports should include the following paragraph:

This project is funded under the ARB's Dr. William F. Friedman Health Research Program. During Dr. Friedman's tenure on the Board, he played a major role in guiding ARB's health research program. His commitment to the citizens of California was evident through his personal and professional interest in the Board's health research, especially in studies related to children's health. The Board is sincerely grateful for all of Dr. Friedman's personal and professional contributions to the State of California.

Table of Contents. This should list all the sections, chapters, and appendices, together with their page numbers. Check for completeness and correct reference to pages in the Report.

List of Figures. This list is optional if there are fewer than five illustrations.

List of Tables. This list is optional if there are fewer than five tables.

Abstract. The abstract should tell the reader, in nontechnical terms, the purpose and scope of the work undertaken, describe the work performed, and present the results obtained and conclusions. The purpose of the abstract is to provide the reader with useful information and a means of determining whether the complete document should be obtained for study. The length of the abstract should be no more than about 200 words. Only those concepts that are addressed in the executive summary should be included in the abstract.

Example of an abstract:

A recently developed ground-based instrument, employing light detecting and ranging (lidar) technology, was evaluated and found to accurately measure ozone concentrations at altitudes of up to 3,000 meters. The novel approach used in this study provides true vertical distributions of ozone concentrations aloft and better temporal coverage of these distributions than other, more common methods, such as those using aircraft and ozonesonde (balloon) techniques. The ozone and aerosol measurements from this study, in conjunction with temperature and wind measurements, will provide a better characterization of atmospheric conditions aloft and the processes involved in the formation of unhealthy ozone concentrations than can be achieved with traditional ground-based monitors.

Executive Summary. The function of the executive summary is to inform the reader about the important aspects of the work that was done, permitting the reader to understand the research without reading the entire Report. It should state the objectives of the research and briefly describe the experimental methodology[ies] used, results, conclusions, and recommendations for further study. All of the concepts brought out in the abstract should be expanded upon in the Executive Summary. Conversely, the Executive Summary should not contain concepts that are not expanded upon in the body of the Report.

The Executive Summary will be used in several applications as written; therefore, please observe the style considerations discussed below.

Limit the Executive Summary to two pages, single spaced.

Use narrative form. Use a style and vocabulary level comparable to that in Scientific American or the New York Times.

Do not list contract tasks in lieu of discussing the methodology.

Discuss the results rather than listing them.

Avoid jargon.

Define technical terms.

Use passive voice if active voice is awkward.

Avoid the temptation to lump separate topics together in one sentence to cut down on length.

The Executive Summary should contain four sections: Background, Methods, Results, and Conclusions, described below.

THE BACKGROUND SECTION. For the Background, provide a one-paragraph discussion of the reasons the research was needed. Relate the research to the Board's regulatory functions, such as establishing ambient air quality standards for the protection of human health, crops, and ecosystems; the improvement and updating of emissions inventories; and the development of air pollution control strategies.

THE METHODS SECTION. At the beginning of the Methods section, state what was done in general, in one or two sentences.

The methodology should be described in general, nontechnical terms, unless the purpose of the research was to develop a new methodology or demonstrate a new apparatus or technique. Even in those cases, technical aspects of the methodology should be kept to the minimum necessary for understanding the project. Use terminology with which the reader is likely to be familiar. If it is necessary to use

technical terms, define them. Details, such as names of manufacturers and statistical analysis techniques, should be omitted.

Specify when and where the study was performed, if it is important in interpreting the results.

The findings should not be mentioned in the Methods section.

THE RESULTS SECTION. The Results section should be a single paragraph in which the main findings are cited and their significance briefly discussed. The results should be presented as a narrative, not a list. This section must include a discussion of the implications of the work for the Board's relevant regulatory programs.

THE CONCLUSIONS SECTION. The Conclusions section should be a single short paragraph in which the results are related to the background, objectives, and methods. Again, this should be presented as a narrative rather than a list. Include a short discussion of recommendations for further study, adhering to the guidelines for the Recommendations section in the body of the Report.

Body of Report. The body of the Report should contain the details of the research, divided into the following sections:

INTRODUCTION. Clearly identify the scope and purpose of the project. Provide a general background of the project. Explicitly state the assumptions of the study.

Clearly describe the hypothesis or problem the research was designed to address. Discuss previous related work and provide a brief review of the relevant literature on the topic.

MATERIALS AND METHODS. Describe the various phases of the project, the theoretical approach to the solution of the problem being addressed, and limitations to the work. Describe the design and construction phases of the project, materials, equipment, instrumentation, and methodology. Describe quality assurance and quality control procedures used. Describe the experimental or evaluation phase of the project

RESULTS. Present the results in an orderly and coherent sequence. Describe statistical procedures used and their assumptions. Discuss information presented in tables, figures and graphs. The titles and heading of tables, graphs, and figures, should be understandable without reference to the text. Include all necessary explanatory footnotes. Clearly indicate the measurement units used.

DISCUSSION. Interpret the data in the context of the original hypothesis or problem. Does the data support the hypothesis or provide solutions to the research problem? If appropriate, discuss how the results compare to data from similar or related studies. What are the implications of the findings? Identify innovations or development of new techniques or processes. If appropriate, discuss cost projections and economic analyses.

SUMMARY AND CONCLUSIONS. This is the most important part of the Report because it is the section that will probably be read most frequently. This section should begin with a clear, concise statement of what, why, and how the project was done. Major results and conclusions of the study should then be presented, using clear, concise statements. Make sure the conclusions reached are fully supported by the results of the study. Do not overstate or overinterpret the results. It may be useful to itemize primary results and conclusions. A simple table or graph may be used to illustrate.

RECOMMENDATIONS. Use clear, concise statements to recommend (if appropriate) future research that is a reasonable progression of the study and can be supported by the results and discussion.

References. Use a consistent style to fully cite work referenced throughout the Report and references to closely related work, background material, and publications that offer additional information on aspects of the work. Please list these together in a separate section, following the body of the Report. If the Report is lengthy, you may list the references at the end of each chapter.

List of inventions reported and publications produced. If any inventions have been reported, or publications or pending publications have been produced as a result of the project, the titles, authors, journals or magazines, and identifying numbers that will assist in locating such information should be included in this section.

Glossary of terms, abbreviations, and symbols. When more than five of these items are used in the text of the Report, prepare a complete listing with explanations and definitions. It is expected that every abbreviation and symbol will be written out at its first appearance in the Report, with the abbreviation or symbol following in parentheses [i.e., carbon dioxide (CO₂)]. Symbols listed in table and figure legends need not be listed in the Glossary.

Appendices. Related or additional material that is too bulky or detailed to include within the discussion portion of the Report shall be placed in appendices. If a Report has only one appendix, it should be entitled "APPENDIX". If a Report has more than one appendix, each should be designated with a capital letter (APPENDIX A, APPENDIX B). If the appendices are too large for inclusion in the Report, they should be collated, following the binding requirements for the Report, as a separate document. The contract manager will determine whether appendices are to be included in the Report or treated separately. Page numbers of appendices included in the Report should continue the page numbering of the Report body. Pages of separated appendices should be numbered consecutively, beginning at "1".