

Duplicate

Research Division
Contractor: UC Berkeley
Contract # 07-322

FUNDING FISCAL YEAR	FY 07/08	FY 08/09	FY 09/10	
TERM	12/01/07-06/30/10	12/01/07-06/30/10	12/01/07-06/30/10	
PCA	72350	72350	72350	
LINE ITEM/OBJECT	398	398	398	TOTAL
DESCRIPTION				

Contract \$	\$ 185,601.00	\$ 53,029.00	26,514.00	\$ 265,144.00
				\$
				\$

Total, Contract	\$ 185,601.00	\$ 53,029.00	\$ 26,514.00	\$ 265,144.00
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Payments to Contractor:

Inv. #	Inv. Date	Ser Per		C/S
77695-58121	8/26/2008	4/1-6/30/08	2752.74	2,752.74 C080133
77695-70184	1/14/2009	7/1-7/31/08	3,805.94	3,805.94 C080589
77695-78648	4/10/2009	1/1-3/31/09	14,872.41	14,872.41
77695-90880	7/28/2009		17,112.59	17,112.59 C090131
100904	10/13/2009	7/1 - 9/30/09	64,552.70	64,552.70 C090323

Total, Payments	\$ 103,096.38	\$ -	\$ -	103,096.38
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Balance Available to Pay Contractor	\$ 82,504.62	\$ 53,029.00	\$ 26,514.00	\$ 162,047.62
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Balance Must Be Spent By: 6/30/2010 6/30/2011 6/30/2012

Notes:

Contract Manager: Stephen Storelli

41



University of California Berkeley

Accounting Services
Extramural Funds Accounting

RCVD AUG 27 '08

Invoice To:

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

Date: 8/26/2008.

INVOICE NO. 77695 - 58121

CO80133

Contract/Grant/Agreement/Purchase Order
Number: 07-322

PI/Director: Horvath, Arpad
Reference:

Project Title Retail Climate Change Mitigation: Life-Cycle Emission and Energy Efficiency Labels and Standards

Period Billed

4/1/2008 - 6/30/2008

Salaries & Wages
Employee Benefits
Equipment & Facilities
Supplies, Materials, & Services
Travel
Subcontract
Indirect Cost

Cumulative	Current
2,299.13	2,299.13
293.50	293.50
0.00	0.00
9.20	9.20
0.00	-99.34
0.00	0.00
260.18	250.25
TOTAL	2,752.74

Amount Now Due

2,752.74

Refer to invoice # 77695 - 58121
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

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.

TIN # 94-6002123

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 8/28/08

UCB Form 3000A



University of California Berkeley

Accounting Services
Extramural Funds Accounting

6533-22-12

Invoice To:

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

W80589

Date: 1/14/2009

INVOICE NO. 77695 - 70184

Table with columns: Contract/Grant/Agreement/Purchase Order Number, PI/Director, Reference, Project Title, Period Billed, Cumulative, Current. Includes categories like Salaries & Wages, Employee Benefits, etc.

Amount Now Due 3,805.94

Refer to invoice # 77695 - 70184
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.

[Signature]

Questions regarding this invoice should be directed to: Jon Mirsky, Award Analyst
Phone: (510) 642-0595
Email: mirsky@berkeley.e

PAYMENT APPROVED:

[Signature]
BART E. CROES, P.E.
CHIEF, RESEARCH DIVISION
DATE 3/10/09

0 *
3,805.94 +
19,941.68 +
23,747.62 * +

6533-22-12



University of California Berkeley

Accounting Services

Extramural Funds Accounting

COS 0711

Invoice To:

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

Date: 4/10/2009

INVOICE NO. 77695 - 78648

Contract/Grant/Agreement/Purchase Order Number: 007-322		PI/Director: Horvath, Arpad	
Project Title: RETAIL CLIMATE CHANGE MITIGATION: LIFE-CYCLE EMISSION AND ENERGY EFFICIENCY LABELS AND STANDARDS		Reference:	
		Period Billed 1/1/2009 - 3/31/2009	
		Cumulative	Current
Salaries & Wages		18,585.83	13,411.97
Employee Benefits		652.36	0.00
Equipment & Facilities		0.00	0.00
Supplies, Materials, & Services		29.32	0.00
Travel		215.30	108.40
Subcontract		0.00	0.00
Indirect Cost		1,948.28	1,352.04
TOTAL		\$21,431.09	14,872.41

Amount Now Due

14,872.41

Refer to invoice # 77695 - 78648

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

should be directed to:

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

000

0-006-

PAYMENT APPROVED:

Bart E. Croes
BART E. CROES, P.E.
CHIEF, RESEARCH DIVISION
DATE 4/27/09

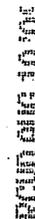
002

FORM 3000



University of California Berkeley

Accounting Services
Extramural Funds Accounting



Invoice To:

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

Date: 7/28/2009

INVOICE NO. 77695 - 90880

Contract/Grant/Agreement/Purchase Order		PI/Director: Horvath, Arpad	
Number: 07-322		Reference:	
Project Title: RETAIL CLIMATE CHANGE MITIGATION: LIFE-CYCLE EMISSION AND ENERGY EFFICIENCY LABELS AND STANDARDS			
		Period Billed 4/1/2009 - 6/30/2009	
		Cumulative	Current
Salaries & Wages		29,888.38	11,302.55
Employee Benefits		795.34	142.98
Equipment & Facilities		0.00	0.00
Supplies, Materials, & Services		37.36	8.04
Travel		215.30	0.00
Subcontract		4,103.33	4,103.33
Indirect Cost		3,503.97	1,555.69
TOTAL		\$38,543.68	17,112.59

Amount Now Due

17,112.59

Refer to invoice # 77695 - 90880
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:

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

DATE: 8/24/09

8/24/09 10:56:28 AM



University of California Berkeley

Accounting Services
Extramural Funds Accounting

RCVD OCT 19 '09

Invoice To:

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

Date: 10/13/2009

INVOICE NO. 77695 - 100904

RCVD NOV 10 2009

Contract/Grant/Agreement/Purchase Order

PI/Director: Horvath, Arpad

Number: 07-322

Reference:

Project Title: RETAIL CLIMATE CHANGE MITIGATION: LIFE-CYCLE EMISSION AND ENERGY EFFICIENCY LABELS AND STANDARDS

Table with columns: Period Billed (7/1/2009 - 9/30/2009), Cumulative, Current. Rows include Salaries & Wages, Employee Benefits, Equipment & Facilities, Supplies, Materials, & Services, Travel, Subcontract, Indirect Cost, and TOTAL.

Amount Now Due

64,552.70

Refer to invoice # 77695 - 100904

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 11/3/09

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

AGREEMENT NUMBER 07-322
REGISTRATION NUMBER 3900808 33179

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

STATE AGENCY'S NAME

Air Resources Board (ARB or State)

CONTRACTOR'S NAME

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

2. The term of this Agreement is: **December 1, 2007 through June 30, 2010**
or upon DGS approval

3. The maximum amount of this Agreement is: **\$265,144.00**
(Two hundred sixty-five thousand one hundred forty-four 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
Exhibit A, Attachment 1 – Technical Proposal	26 pages
Exhibit B – Budget Detail and Payment Provisions	2 pages
Exhibit B, Attachment 1 – Budget Summary	19 pages
Exhibit C* – General Terms and Conditions (GIA -101)	On-line
Exhibit - D Special Terms and Conditions	1 page
Exhibit E – Additional Provisions	8 pages
Exhibit F – Research Final Report Format	7 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)

DATE SIGNED (Do not type)

JYL Baldwin
 PRINTED NAME AND TITLE OF PERSON SIGNING
JYL BALDWIN

11/21/07

ADDRESS

Sponsored Projects Office
 2150 Shattuck Ave, Room 313, Berkeley, CA 94720-5940

STATE OF CALIFORNIA

AGENCY NAME

Air Resources Board

BY (Authorized Signature)

DATE SIGNED (Do not type)

Socorro Watkins
 PRINTED NAME AND TITLE OF PERSON SIGNING
SOCORRO WATKINS, Chief, Business Management Branch

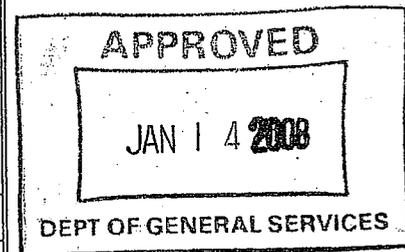
11/29/07

ADDRESS

P.O. Box 2815
 Sacramento, CA 95812

California Department of General Services Use Only

KMM



Exempt per:

[Signature]

EXHIBIT A
Interagency Agreement

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 "Retail Climate Change Mitigation: Life-Cycle Emission and Energy Efficiency Labels and Standards;" 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: Air Resources Board	Providing Agency: Regents of the University of CA, Berkeley
Name: Stephen Storelli	Name: Arpad Horvath
Air Resources Board	UCB
Research Division	Dept. of Civil and Environmental Engineering
Phone: (916) 324-0595	Phone: (510) 654-7300
Fax: (916) 322-4357	Fax: (510) 643-8919
Email: storell@arb.ca.gov	Email: Horvath@ce.berkeley.edu

The ARB Contract Administrator is:

The University's Contract Administrator is:

Requesting Agency: Air Resources Board	Providing Agency: Regents of the University of CA, Berkeley
Name: Ms. Emma Plasencia	Name : Ms. Jyl Baldwin
Division: Research Division	Division: Sponsored Projects Office
Asdress: 1001 "I" Street, 5 th Floor	Address: 2150 Shattuck Ave., Suite #313
Sacramento, CA 95814	Berkeley, CA 94704-5940
Phone: (916) 323-1524	Phone: (510) 642-8117
Fax: (916) 322-4357	Fax:
Email: eplasenc@arb.ca.gov	Email:

TECHNICAL PROPOSAL

Retail Climate Change Mitigation: Life-Cycle Emission and Energy Efficiency Labels and Standards

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

July 30, 2007

Check if applicable:

Animal subjects _____

Human subjects _____

Table of Contents

1. Statement of Significance	3
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1. Statement of Significance

It has been estimated that up to 80% of the annual GHG "footprint" of the average U.S. consumer is attributable to the purchase, use, and disposal of retail products (Matthews 1999; Jones 2006). While California has a strong track record of policies aimed at reducing the operational energy use and GHG emissions of retail products (e.g., appliance efficiency standards), little attention has been paid to reducing the GHG emissions across the entire retail product life cycle (i.e., production, use, and disposal).

Of the annual GHG emissions attributable to retail products in the United States, roughly two-thirds is typically due to product manufacture (i.e., so-called "embedded" product GHG emissions) (Matthews 1999; Jones 2006). The ongoing disposal of retail products is also a significant source of GHG emissions (Masanet et al. 2005). Thus, the GHG emissions associated with the manufacture and disposal of California's retail products might represent a vast untapped source of potential GHG emissions reductions for the state. For example, for personal computers (PCs) in California, Masanet and Horvath (2006) identified manufacturing- and disposal-phase opportunities that could reduce the GHG emissions of California's PCs by roughly 2.5 million metric tons of CO₂ per year.

Therefore, the objective of this research project is to assess opportunities for reducing California's greenhouse gas (GHG) emissions through the application of life-cycle GHG emissions labels and standards to retail products consumed by Californians.

We have designed a research plan that will allow the ARB to understand the potential for reducing the life-cycle GHG emissions of California retail products through labels and standards. There is a critical need for exploratory research to (1) develop credible estimates of the potential for in-state GHG emissions reductions associated with the full life-cycle of California's retail products, and (2) analyze the extent to which the identified GHG emissions reductions might be realized through retail product GHG emissions labels and standards in the state.

First, we will create a life-cycle assessment (LCA) model for California so that it is possible to model the life-cycle GHG emissions of products and services consumed by Californians. The California LCA model will be based on the most comprehensive LCA model available for the United States—Carnegie Mellon University's Economic Input-Output Life-Cycle Assessment model (EIO-LCA)—and will calculate the life-cycle GHG emissions that occur both inside and outside of California. Second, we will use the California LCA modeling approach to estimate the life-cycle GHG emissions associated with feasible "low-GHG" versions of 20-30 key retail products consumed by Californians. The "low-GHG" version of a product represents the minimum life-cycle GHG emissions that will likely be realistic for a given product under future California retail labels and standards programs. Third, we will analyze the potential GHG emissions reductions achievable through the adoption of life-cycle GHG emissions labels and standards policies for retail products in California over the next five years.

The creation of total life-cycle GHG emissions labels and standards for retail products could help the state tap into this additional, possibly enormous potential for GHG emissions reduction. Such labels and standards could provide manufacturers with significant incentives for minimizing the life-cycle GHG emissions of retail products purchased by Californians.

2. Abstract

It has been estimated that up to 80% of the annual GHG "footprint" of the average U.S. consumer is attributable to the purchase, use, and disposal of retail products (Matthews 1999; Jones 2006). While California has a strong track record of policies aimed at reducing the operational energy use and GHG emissions of retail products (e.g., appliance efficiency standards), little attention has been paid to reducing the GHG emissions across the entire retail product life cycle (i.e., production, use, and disposal).

The objective of this research project is to assess opportunities for reducing California's greenhouse gas (GHG) emissions through the application of life-cycle GHG emissions labels and standards to retail products consumed by Californians.

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3. Project Objectives

The objective of this research project is to assess opportunities for reducing California's greenhouse gas (GHG) emissions through the application of life-cycle GHG emissions labels and standards to retail products consumed by Californians.

However, the extent to which such labels and standards for retail products could lead to GHG emissions reductions in California is not yet clear. Analytical methods and policy initiatives related to product life-cycle GHG emissions labels and standards are still emerging, so there are few (if any) case study data to draw upon to measure the effectiveness of such programs. Moreover, robust analytical methods to quantify the in-state GHG emissions of California's retail products across their entire life cycle are currently lacking. There is also little direct guidance available to California to design and manage life-cycle GHG emissions labeling and standards programs as such initiatives are just now beginning to enter the global policy debate (see, for example, EC (2007)).

In order for the California Air Resources Board (ARB) to fully assess the opportunities associated with life-cycle GHG emissions labels and standards in relation to the state's AB 32 targets, there is a critical need for exploratory research to (1) develop credible estimates of the potential for in-state GHG emissions reductions associated with the full life-cycle of California's retail products, and (2) analyze the extent to which the identified GHG emissions reductions might be realized through retail product GHG emissions labels and standards in the state.

We propose a comprehensive research plan to address these critical research needs. Our research team is exceptionally qualified to conduct this study, having over 50 years of collective experience and over 50 published articles and reports in research areas pertinent to this study. Our research team is also currently conducting a number of synergistic research projects that can be leveraged to inform and improve the proposed study.

4. Technical Plan

We have designed a research plan that will allow the ARB to understand the potential for reducing the life-cycle GHG emissions of California retail products through labels and standards as well how such programs might be designed and implemented within the state. Our research plan is divided into five major tasks, which are discussed below.

We note that the research team of Masanet, Matthews, and Horvath developed the Masanet et al. (2005) method for estimating the life-cycle GHG emissions of retail products in California, which is referenced in the ARB's request for proposals (RFP). Thus, our research team is well positioned to efficiently leverage this previous work in the proposed study. However, while the RFP suggests that this method may be ready for application to policy analysis in California, we note that only a preliminary, limited method was developed in Masanet et al. (2005). Thus, significant work remains before this method can be applied to provide credible estimates of the life-cycle GHG emissions reductions attainable through retail product labels and standards in California as requested in the RFP. However, we have proposed a research plan in Tasks 1 and 2 that will allow us to further develop our preliminary method and employ best available data sources so that the method can be used for credible GHG emissions analyses of a wide range of retail products in California. Thus, the modeling work in Tasks 1 and 2 will enable the most realistic and meaningful policy analyses in Task 3 (which was requested in the RFP).

Task 1: Estimation of life-cycle GHG emissions attributable to retail products in California

The purpose of this task will be to develop best-available estimates of the annual life-cycle GHG emissions attributable to retail products purchased by Californians. We propose to develop a comprehensive California LCA model that will calculate the life-cycle GHG emissions of retail products, both inside and outside the state. This task will be carried out in four phases.

Task 1.1: Development of a California Economic Input-Output LCA (EIO-LCA) model for estimating the embedded GHG emissions of retail products

In this task, we will further develop the preliminary California EIO-LCA presented in Masanet et al. (2005). The preliminary California EIO-LCA was based on a comprehensive and well-tested national-level LCA model (Carnegie Mellon University's Economic Input-Output LCA), which was created in 1994 by a team of researchers that includes three of this project's researchers: Hendrickson, Horvath, and Matthews (Hendrickson et al. 1998; Matthews et al. 1999). The U.S. EIO-LCA model is available freely on the web (<http://www.eiolca.net>), and has a large body of users (more than 1.3 million users worldwide to date). The U.S. EIO-LCA model allows one to estimate the nationwide environmental impacts from producing a certain dollar amount of any of 491 commodities or services in the United States. The model is based on the 1997 commodity/commodity input-output (IO) matrix of the U.S. economy as developed by the U.S. Department of Commerce (U.S. BEA 2007) and is capable of estimating the embedded GHG emissions of products (at the national level) on a tons of GHG emission per dollar of production basis (tons of GHG/\$). The model does this by coupling the IO matrix with sector-level data on energy use from the U.S. Department of Energy (e.g., the U.S. DOE Manufacturing Energy Consumption Survey (U.S. DOE 2007)) and the U.S. Census Bureau (e.g., the Annual Survey of Manufactures (U.S. Census Bureau (2007)) and with GHG emissions data from the U.S. Environmental Protection Agency (U.S. EPA 2006a, 2006b).

The preliminary California EIO-LCA developed in Masanet et al. (2005) modified the U.S. EIO-LCA model so that it could estimate the GHG emissions occurring inside and outside of California for two case study products: semiconductors and pharmaceuticals. A preliminary 1997 IO matrix of the California economy was developed from U.S. Far West Region IO matrix (U.S. BEA 2007) by using 1997 sector-level economic data for California from the U.S. Census Bureau (2007). Sector-level energy use in California for the sectors relevant to pharmaceutical and semiconductor manufacture was estimated by adjusting the national-level data from the U.S. EIO-LCA model on a value added basis by sector. The result was a preliminary model that could serve as a first-order approximation of embedded GHG emissions inside and outside of California for only the two case study products. However, to perform the comprehensive policy analyses requested in the RFP, we propose to develop a more robust California EIO-LCA model that characterizes the embedded GHG emissions of all retail products in California, based on the best and most recent data available.

In developing a more robust California EIO-LCA model, we propose several important advancements. First, we will update the underlying U.S. and California 491-sector IO matrices to 2002, which are the most recent economic IO data available from the U.S. Department of Commerce (and were just made available in 2007). This update will ensure that the embedded GHG emissions estimates calculated by the California EIO-LCA model are based on the most recent data available on the structure of the U.S. and California economies.

Second, we will leverage recent IO modeling capabilities at Carnegie Mellon University to estimate the IO relationships between California, the rest of the United States, and the rest of the world. The 2002 491-sector IO matrices for California and the United States will be modified to account for foreign imports into California using detailed commodity trade data from the U.S. Census Bureau (U.S. Census Bureau

2005). This modification will allow the California EIO-LCA model to estimate the embedded GHG emissions of retail products emitted inside and outside the state. We note that his approach has been recently employed at the national level by our project team at Carnegie Mellon University to account the embedded GHG emissions balance of imports and exports between the United States and its major trading partners (Weber and Matthews 2007).

Third, we will update the sector-level estimates of energy use and GHG emissions for each of the 491 sectors in the California and U.S. economies. This update will allow the California EIO-LCA model to estimate the embedded GHG emissions of retail products emitted inside and outside the state using the most recent and geographically-specific data available. In-state energy use and GHG emissions data will be taken from LBNL's California Energy Balances (CALEB) Database (Murtishaw et al. 2005), which contains the most comprehensive and recent (as late as 2004) sector-level data on California energy use to date (see for example Chen 2005). The data in CALEB are based on sector-level fuel (including coal, petroleum, natural gas, nuclear, and renewable sources) and electricity use statistics gathered by the California Energy Commission, the U.S. Department of Energy's Energy Information Administration, the U.S. Geological Survey, and the California Air Resources Board. Electricity-related GHG emissions in CALEB are calculated using a California-specific GHG emissions factor, which accounts for California electricity imports (Marnay et al. 2002). The CALEB database has been used in the past to support the generation of the California State GHG Inventory by the California Energy Commission, and more recently in GHG emissions characterization efforts by the California Air Resources Board.¹ Energy use and GHG emissions data for the United States will be updated to be current with the most recent data available in CALEB, and will be compiled from the U.S. sources cited on the previous page.

The more robust California EIO-LCA model developed in this task will allow average embedded GHG emissions for any retail product purchased by Californians to be calculated on a (tons of GHG/\$) basis, and will further disaggregate embedded GHG emissions by source of origin (i.e., in-state versus out-of-state). It will therefore provide the ARB with an indication of how effective different policies might be at reducing in-state GHG emissions for various retail products. It will also provide the ARB with a means to estimate the GHG emissions "leakage" associated with various policies. Depending on the interest of the ARB, we can further disaggregate out-of-state embedded GHG emissions by specific geographic region (e.g., various U.S. states, national, or foreign emissions). We point out that the California EIO-LCA model will be the most comprehensive and accurate LCA model developed for California to date, and could be updated to include other important environmental emissions in the state for future tradeoff analyses (e.g., criteria air pollutants or toxic emissions).

Task 1.2: Estimation of total annual embedded GHG emissions of retail product in California

We propose to estimate the total annual embedded GHG emissions of California's retail products by employing a two step process developed by Matthews (1999). First, we will estimate the total annual purchases of retail products in California using U.S. Bureau of Labor Statistics Consumer Expenditure Survey data (U.S. BLS 2007), which contains detailed estimates on retail purchases by U.S. consumers by region for a wide range of retail products. The Consumer Expenditure Survey consists of two surveys collected for the Bureau of Labor Statistics by the Census Bureau — the quarterly Interview survey and the Diary survey — that provide information on the buying habits of American consumers, including data on their expenditures for a wide range of items, including groceries (meats, dairy, fruits and vegetables, etc.), clothing, appliances, housing, furniture, transportation, and utilities, to name a few. These data are reported in dollars of expenditure for each item on an annual basis for the average household in a given

¹ See, for example, two recent LBNL proposals that are pending ARB funding: "Disaggregated Estimate of Energy-related Carbon Dioxide Emissions for California," and "Evaluation of Efficiency Activities in the Industrial Sector Undertaken in Response to Greenhouse Gas Emissions Reduction Targets."

U.S. geographical or metropolitan region. We will estimate the total aggregate retail purchases of Californians using the Consumer Expenditure Survey data for the most recent year available (2005) based on the California metropolitan regions captured in the survey (which include the Los Angeles, San Francisco, and San Diego metropolitan statistical areas) and data on the number of households in California by region from the California Department of Finance (e.g., California DOF 2007). Second, we will multiply the statewide purchases of retail products by the appropriate product sector (tons of GHG/\$) multipliers from the California EIO-LCA model developed in Task 1.1 to estimate the total annual embedded GHG emissions of retail products purchased by Californians. As discussed above, the total embedded GHG emissions estimates will be broken down into GHG emissions occurring both inside and outside of the state.

Task 1.3: Estimation of use phase GHG emissions of select retail products in California

Based on the results of Tasks 1.1 and 1.2, we will, with input from the ARB, select 20-30 retail products of greatest interest to the ARB for estimation of full life-cycle GHG emissions (i.e., embedded, use-phase, and disposal-phase GHG emissions). The 20-30 retail products selected are expected to represent a significant fraction of the annual life-cycle GHG emissions associated with retail products consumed in California. For these 20-30 products, we will estimate the total annual use-phase GHG emissions occurring in California using publicly available data sources. A lower and upper bound calculation (in addition to the expected value) will be performed in order to indicate the uncertainty range. Key data sources for this task will include recent comprehensive LCAs conducted for a variety of retail products in California (Masanet et al. 2005) and the European Union (EC 2007). Additional data sources will include use-phase estimates of GHG emissions from appliance energy consumption surveys (e.g., the U.S. DOE Residential Energy Consumption Survey and LBNL's Home Energy Saver (<http://hes.lbl.gov/>)), transport energy consumption statistics (e.g., the U.S. DOE Transportation Energy Data Book), products-specific LCA studies conducted by the project team (e.g., LCAs of electronic equipment conducted by Masanet and Horvath (2006)), and commercially-available LCA software packages available to the project team (e.g., SimaPro (<http://www.pre.nl/simapro/>) and Gabi (<http://www.gabi-software.com/>)).

Task 1.4: Estimation of disposal-phase GHG emissions of select retail products in California

For the 20-30 products considered in Task 1.3, we will also estimate the disposal-phase GHG emissions associated with retail product waste management processes in the California. Disposal-phase emissions were estimated using LCA data for municipal solid waste collection and landfill equipment operations (McDougall et al. 2001; Franklin Associates 1994; BUWAL 1998) as well as landfill gas emissions (generated from biodegradable waste) estimates based on California landfill tipping and operations data from the California Integrated Waste Management Board (e.g., CIWMB 2004). Disposal-phase emissions for product recycling were estimated in Masanet et al. (2005) using product mass composition data from various sources (e.g., manufacturer data) coupled with data on average recycling GHG emissions "credits" from McDougall et al. (2001) and commercially-available LCA software packages. A lower and upper bound calculation (in addition to the expected value) will be performed in order to indicate the uncertainty range.

While the methods developed in Tasks 1.1 and 1.2 can easily be applied to estimate the embedded GHG emissions of literally hundreds of different retail products in California, we limit our estimates of full life-cycle GHG emissions in Tasks 1.3 and 1.4 to 20-30 select products to manage the complexity of the policy analysis tasks in this study. Moreover, given the preliminary nature of the proposed research, a focus on 20-30 select retail products is sufficient to yield the desired insights and results of this study.

Task 2: Estimation of life-cycle GHG emissions reductions attainable for retail products in California

The purpose of this task will be to estimate the life-cycle GHG emissions associated with feasible "low-GHG" versions of each of the 20-30 products analyzed in Task 1. The "low-GHG" version of a product represents the minimum life-cycle GHG emissions that are currently realistic for a given product, and is meant to approximate the "best in class" products that may appear on the market in response to California life-cycle GHG emissions labeling and standards programs. Such "low-GHG" products could be the result of a manufacturer's aggressive pursuit of energy efficiency improvements to product manufacturing methods (e.g., the pursuit of ENERGY STAR plant labels) and product operating characteristics (e.g., the pursuit of ENERGY STAR appliance labels), and the use design for recycling techniques. The establishment of "low-GHG" estimates will enable us to estimate the potential for GHG emissions savings in the various policy scenarios discussed in Task 3.

We propose to estimate the life-cycle GHG emissions associated with "low-GHG" versions of our selected 20-30 products using best available data from a variety of sources. To estimate the minimum manufacturing-phase GHG emissions associated with each product, we will draw upon LBNL's extensive analyses of manufacturing energy efficiency and GHG emissions improvement potentials developed for various sectors for the U.S. EPA's ENERGY STAR for Industry program (see for example Masanet et al. 2006) and California utilities (Friedmann et al. 2005). To estimate the minimum use-phase GHG emissions associated with each product (where applicable), we will identify "best in class" energy efficiency performance levels through a review of the literature and applicable appliance labels worldwide. Lastly, we will employ the basic method outlined in Masanet et al. (2005) to determine the minimum end-of-life phase GHG emissions associated with optimal disposal (e.g., recycling). The "low-GHG" estimates will also incorporate the data uncertainty ranges for each product identified in Task 1.3 to derive lower and upper bounds on all GHG emissions estimates.

Task 3: Analysis of policy scenarios for retail product labeling and standards programs in California

In this task, we will perform a preliminary analysis of the life-cycle GHG emissions reductions achievable through the adoption of life-cycle GHG emissions labels and standards for retail products in California. We propose to perform policy scenario analyses to project possible GHG emissions reductions over a five-year future time period (i.e., 2010 - 2015, which is five years after the targeted completion date of this project). We will use the results from Tasks 1 and 2 to project possible GHG emissions reductions that are achievable both inside and outside of California over this time period, to provide the ARB with an indication of how effective different policies might be at reducing in-state GHG emissions (as opposed to reducing national or foreign GHG emissions).

In our scenario analyses, we propose to first project two future scenarios to establish maximum achievable GHG emissions reductions. First, we will construct a "business as usual" scenario, which will project the growth in average annual life-cycle GHG emissions of our selected 20-30 products based on current trends in California population growth (California DOF 2007) and retail product consumption (U.S. BLS 2007). The purpose of the "business as usual" scenario will be to estimate the life-cycle GHG emissions that will likely occur in the absence of retail product labels and standards programs in California. Then, we will construct a "minimum GHG emissions" scenario, which will project the annual life-cycle GHG emissions of our selected 20-30 products assuming that 100% of purchased products will be of the "low-GHG" variety (as established in Task 2). The difference between the "business as usual" and "minimum GHG emissions" scenarios will provide the ARB with an estimate of the maximum achievable GHG emissions reduction potential associated with labels and standards programs in California.

We will further project two scenarios to estimate the GHG emissions reductions that might be achieved through different policy approaches in California. First, we propose to estimate the GHG emissions

reductions that might be realized via natural market mechanisms by requiring retail products sold in California to carry a life-cycle GHG emissions label. We propose to project manufacturer participation rates and consumer demand elasticities for our 20-30 selected products using historical analyses of the U.S. EPA ENERGY STAR appliance labeling program (performed by colleagues of Masanet at LBNL). The ENERGY STAR appliance labeling program provides arguably the most relevant and comprehensive case study data that can be used for estimating the market transformations achievable via product GHG emissions labels in California. Second, we propose to project a scenario in which maximum life-cycle GHG emissions for our selected 20-30 products are set by California retail product standards. In this scenario, we propose to derive our hypothetical product standards based on manufacturer standards for energy efficiency in various sectors as designated by the U.S. EPA ENERGY STAR Appliance and Industry programs (in which Masanet is a collaborator) (U.S. EPA 2007). However, we are willing to work with the ARB to choose different policy scenarios for analysis based on the interests of the ARB staff (for example, a scenario that considers low-GHG purchasing policies at California agencies).

Given that the analytical tools and policy instruments associated with product GHG emissions labels and standards are still emerging, we feel that detailed cost/benefit analyses of the above policies cannot yet be performed with reasonable uncertainty due to lack of reliable data on the costs of program implementation. Thus, we recommend that the ARB consider such cost/benefit analyses after the results of this and similar studies become available to better characterize program infrastructure needs.

Task 4: Recommendations for future work

Given that the proposed project will be the first preliminary analysis of GHG emissions labels and standard programs for the State of California, an important outcome will be a summary of "lessons learned" and recommendations for future work in this important area. In this task, we will identify opportunities for improving and expanding the analytical framework (including a discussion of the uncertainties in our analyses), identify data gaps in our analyses that could be filled through future work, and develop recommendations for next steps and future research that could be pursued by the ARB (or other California agencies) to build capacity in the area of product GHG emissions labels and standards.

Task 5. Draft project report

The draft project report will document the research results and findings from Tasks 1 through 4:

Task 6. Final project report and modeling data

The contractor will write a final report describing the methods, assumptions, data, and results associated with each research task outlined above. The final report will reflect the comments of the ARB on the draft report. The contractor will also provide the underlying modeling and data files that were used in the analyses described in the report for further use and development by the ARB. These files will include a MATLAB file of the California EIO-LCA model and MS Excel spreadsheet files containing the use-phase data, disposal-phase data, and policy scenario modeling framework and results. A basic user's manual will be developed to assist the ARB in using the MATLAB and Excel files. The user's manual will provide the ARB with step-by-step instructions on how to run the models, generate results, and manipulate model data and assumptions. The contractor will also conduct an in-person demonstration with ARB staff to illustrate the use of the files and user's manual and to answer questions.

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5. Project Schedule

- Task 1. Estimation of life-cycle GHG emissions attributable to retail products in California
- Task 2. Estimation of life-cycle GHG emissions reductions attainable for retail products in California
- Task 3. Analysis of policy scenarios for retail product labeling and standards programs in California
- Task 4. Recommendations for future work
- Task 5. Draft project report

Task 6. Final project report

MONTH	1	3	5	7	9	11	13	15	17	19	21	23	25	27
TASK														
1														
2														
3														
4														
5														
6														
	m	p	p		p	p		p	p		p	d		f
								m				m		m

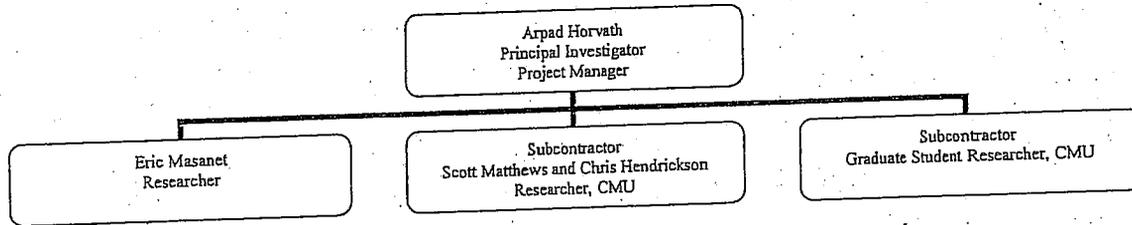
- p = Quarterly progress report
- d = Deliver draft final report (to be submitted 6 months prior to contract expiration)
- f = Deliver final report
- m = Meeting with ARB staff

6. Project Management Plan

We have assembled the best possible team for this project. Collectively, our team has over 50 years of experience and has published over 100 articles and reports in the areas of product LCA, regional policy analysis, industrial energy efficiency and GHG mitigation, regional input-output LCA, and product life-cycle optimization. Our research has spanned nearly all major sectors of the U.S. economy, and several recent analyses have specifically focused on product- and sector-related energy efficiency and GHG reduction opportunities for the State of California. Brief CVs of the principal researchers are appended, and key qualifications are highlighted below.

Horvath is currently serving on the National Research Council's committee studying the environmental impacts of wind energy, and directs UC Berkeley's Consortium on Green Design and Manufacturing and Engineering and Business for Sustainability Certificate Program. Hendrickson, Matthews and Horvath have been the key developers of the EIO-LCA model since 1994, and are co-authors of recent book on the EIO-LCA method (Hendrickson et al. 2006). Matthews has been the principal developer and maintainer of the web-based version of EIO-LCA, the only comprehensive LCA tool accessible free on the web. Matthews and Hendrickson have also performed extensive research in the area of regional input-output LCA, including quantification of emissions "leakage" through outsourcing of product manufacturing (Weber and Matthews 2007). The team of Masanet, Matthews, and Horvath were the principal researchers behind the preliminary California LCA approach developed in Masanet et al. (2005), which was referenced in the ARB's call for pre-proposals on this theme. Masanet has extensive experience analyzing energy efficiency and GHG mitigation opportunities for industrial sectors through work with the U.S. EPA's ENERGY STAR for Industry program. Masanet also has extensive experience analyzing product-related GHG mitigation opportunities, with a specific focus on California.

The principal investigator and project manager for this project is Arpad Horvath. The most hours in this research will be put in by Eric Masanet (Lawrence Berkeley National Laboratory) and the subcontractor, Carnegie Mellon University. Within the CMU team, Scott Matthews and Chris Hendrickson will oversee the research of a graduate student. The organizational chart shows the relationships of the project participants.



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

Eric Masanet is the technical researcher on this project who will focus on all technical tasks, and will also assist Arpad Horvath in producing the draft and the final reports.

Scott Matthews, Chris Hendrickson, and a graduate student researcher will comprise the subcontractor team from Carnegie Mellon University. The two professors will have primary responsibility for development of the life-cycle GHG modeling approach in Task 1, will participate in estimating the GHG emissions for the selected group of products in Task 2 and in the analysis of policy scenarios in Task 3, and will help write the draft and the final project reports. The graduate student will assist the entire project team in all tasks.

This project will be managed and coordinated through regular communication of the entire team via email and phone conferencing. Horvath and Masanet will meet in person bi-weekly. Horvath, Hendrickson, and Matthews have worked together for 14 years (Hendrickson was the Ph.D. advisor of both), Horvath and Masanet, for 8 years (Masanet was supervised by Horvath as a Ph.D. student), so regular communication is already established.

Table 1 shows the hours each project participant will spend on this project.

Task	1	2	3	4	5	6	Total Hours
Project personnel:							
Horvath	80	60	32	16	40	17	245
Masanet	360	300	240	250	200	32	1366
Matthews	96	64	40		40	10	250
Hendrickson	64	32	16		8	6	126
Graduate student	880	480	400	160	320	240	2480
Total	1480	936	728	426	608	305	4483

Table 1. Hours spent by project participants on the proposed project.

Table 2 shows the estimated cost by task.

Task	Labor	Subcontractor	Equipment	Travel, Subsidence	ED P	Copy/Print	Mail Phone Fax	Matr and Supplies	Analysis	Misc.	Employee Fringe Benefits	Overhead	Fee or Profit	Total
1	24,926	46,000		988			8			100	9,232	6,025		87,279
2	20,320	26,063		868			8			81	7,636	2,891		57,867
3	15,172	18,680		120			4			61	5,971	2,133		42,141
4	14,629	5,385		120			4			58	6,070	2,088		28,356
5	13,546	14,989					4			54	5,090	1,870		35,551
6	2,885	9,631		120			2			12	906	393		13,950
	\$104,699	\$135,000	\$0	\$2,216	\$0	\$0	\$34	\$0	\$0	\$419	\$ 40,359	\$17,273	\$0	
													Grand Total:	\$265,144

Table 2. Estimated cost by task.

7. Related Research by Applicants

In addition to our qualifications, the project team can offer a number of synergistic research projects underway that can be leveraged as valuable sources of methods and data for the proposed study.

- Masanet is leading a study funded by the California Energy Commission (CEC) Public Interest Energy Research (PIER) program to quantify the life-cycle GHG emissions associated with consumer lifestyles in California. Data compiled in this study can help in modeling the life-cycle GHG emissions of California retail products in Task 1.
- Hendrickson, Horvath and Matthews have an in-press article in the *International Journal on Life Cycle Assessment* on regional environmental assessment using economic input-output analysis, national economic data, and regional environmental data. The experiences from that research should come valuable in the CA-specific LCA modeling in Task 1.
- Matthews is leading a National Science Foundation (NSF) project analyzing the environmental life-cycle effects of consumption of goods and services in the United States. This project is quantifying international leakage flows of GHG emissions and energy due to outsourced production of components and services around the world. The data and methods of this NSF study can help in building the life-cycle model and characterizing GHG emissions "leakage" in Tasks 1 and 3.
- Masanet is co-leading a study funded by the CEC PIER program to quantify the potential for energy efficiency improvements to California's industrial sector and continues to author U.S. EPA ENERGY STAR energy efficiency improvement studies for U.S. industries. Data from these studies can be applied to estimate the potential for a variety of "low-GHG" product options in Task 2.
- Matthews is participating in a project with the Washington State Department of Ecology to develop an indicator of life-cycle energy and environmental impacts of consumption for the State of Washington. This project is also developing a long-term environmental impact tracking tool for the state. The data and methods developed in this study can be leveraged in modeling the life-cycle GHG emissions of California retail products in Task 1.
- Masanet is co-leading a report to the U.S. Congress on future energy efficiency policy scenarios for U.S. data centers. Scenario modeling and forecasting methods from this study may be applied to the policy scenario analyses in Task 3.

8. Brief Curriculum Vitae and Relevant Publications Lists

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PROFESSIONAL PREPARATION

Technical University of Budapest (Hungary)	Civil Engineering	Dipl. Eng. (M.S.), 1993
Carnegie Mellon University, Pittsburgh, PA	Civil and Enviro. Engineering	M.S., 1995
Carnegie Mellon University, Pittsburgh, PA	Civil and Enviro. Engineering	Ph.D., 1997

APPOINTMENTS

- January 2007 – present: **Director**, “Engineering and Business for Sustainability” Certificate Program, UC Berkeley (January 2007 – present)
- November 2005 – present: **Chair**, Technology and Sustainability Committee, College of Engineering, UC Berkeley
- August 2005 – May 2007: **Member**, Committee on Environmental Impacts of Wind Energy Projects, National Research Council, The National Academies
- July 2005 – present: **Associate Professor**, UC Berkeley
- May 2005 – present: **Editorial Board Member**, *J. of Industrial Ecology* (Int. Soc. Industr. Ecology)
- September 2003 – present: **Member**, Chancellor’s Advisory Committee on Sustainability, UC Berkeley
- May 2002 – present: **Associate Editor**, *ASCE J. of Infrastructure Systems*
- 2001 – 2005: **Secretary**, Committee on Social and Environmental Concerns in Construction, Construction Institute, American Society of Civil Engineers (ASCE)
- May 2000, 2001, 2007: **Conference co-chair**, *IEEE International Symposium on Electronics and the Environment*
- May 1999, 2006: **Program co-chair**, *IEEE International Symposium on Electronics and the Environment*,
- May 2000 – present: **Director**, Consortium on Green Design and Manufacturing (CGDM), UCB
- 2000 – 2006: **Member**, Transportation Research Board Committee on Waste Management in Transportation A1F07
- July 1999 – June 2005: **Assistant Professor**, UC Berkeley
- January 1998 – June 1999: **Research Faculty**, Carnegie Mellon University
- July 1997 – December 1997: **Postdoctoral Researcher**, Carnegie Mellon University

SELECTED RELEVANT PEER-REVIEWED JOURNAL PUBLICATIONS (of 27 total)

(PDF versions: www.ce.berkeley.edu/~horvath/horvath_pub.html)

Facanha, C., and Horvath, A. (2006), “Environmental Assessment of Freight Transportation in the U.S.”
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- 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.
- 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.
- Hendrickson, C. T., Horvath, A., Joshi, S., and Lave, L. B. (1998), "Economic Input-Output Models for Environmental Life-Cycle Assessment." *Envir. Sci. & Technol.*, 32(4), pp. 184A-191A.
- 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, *Envir. Sci & Technol*, 29(2), pp. 86-90.

SYNERGISTIC ACTIVITIES

- 2007: Leading the development of "Engineering and Business for Sustainability" certificate program at UC Berkeley (<http://sustainable-engineering.berkeley.edu>)
- 2005: Laudise Prize "for outstanding achievements in industrial ecology," International Society for Industrial Ecology
- 2005: Co-development of the course *CE 293A Technology and Sustainability* at UC Berkeley
- 2000: Development of the course *CE 268E Civil Systems and the Environment* at UC Berkeley
- 1995 – present: Participated in development of the life-cycle assessment (LCA) model based on economic input-output analysis (EIO-LCA), the first free Web-based life-cycle assessment (LCA) software (www.eiolca.net)
- 1995: Development of a toxicity-based emissions metric, CMU-Equivalent Toxicity, based on occupational health values

Ph.D. STUDENT ADVISING: 6 completed, 7 current

ERIC MASANET, Ph.D.

Principal Scientific/Engineering Associate
Environmental Energy Technologies Division
Lawrence Berkeley National Laboratory
1 Cyclotron Road, Building 90R4000, Berkeley, California 94720
Phone: (510)486-6794 Email: ermasanet@lbl.gov

EDUCATION

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

PROFESSIONAL AND RESEARCH EXPERIENCE

Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division
Principal Scientific/Engineering Associate, Oct. 2004 - present

University of California, Berkeley, College of Engineering
Program Manager, Engineering and Business for Sustainability Certificate Program, Jan. 2007 – present
Lecturer, Department of Civil and Environmental Engineering, Aug. 2006 – Dec. 2006

University of California, Berkeley, Consortium on Green Design and Manufacturing
Postdoctoral Researcher, May 2004 - June 2005
Graduate Student Researcher, August 1999 - May 2004

Apple Computer, Cupertino, California
Product Environmental Engineer (part-time while pursuing Ph.D.), June 2001 - Jan. 2003

Caterpillar Incorporated, Large Wheel Loaders Division, Aurora, Illinois
Senior Design Engineer, May 1998 - Aug. 1999; Design Engineer, Apr. 1996 - Apr. 1998

RECENT RELEVANT PUBLICATIONS

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

CHRIS T. HENDRICKSON, Ph.D.

Duquesne Light Co. Professor of Engineering
Department of Civil and Environmental Engineering
Carnegie Mellon University
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cth@cmu.edu

PROFESSIONAL PREPARATION

- BS, General Engineering (Resources Strategy); Stanford University, 1973
- MS, Civil Engineering; Stanford University, 1973
- B. Phil. (now renamed Master of Philosophy), Economics; Oxford University, 1975
- Ph.D., Civil Engineering; Massachusetts Institute of Technology, 1978

APPOINTMENTS

1996-2006	Head, Department of Civil and Environmental Engineering, Carnegie Mellon University
1996-present	Duquesne Light Company Professor of Engineering, Carnegie Mellon University
1991-1996	Assoc. Dean for Academic Affairs, Engineering (CIT), Carnegie Mellon University
1987-1996	Professor, Department of Civil and Environmental Engineering, Carnegie Mellon
1989-1996	Education Director, Engineering Design Research Center, Carnegie Mellon University
1983-1987	Associate Professor, Department of Civil Engineering, Carnegie Mellon University
1978-1983	Assistant Professor, Department of Civil Engineering, Carnegie Mellon University

FIVE RELEVANT PUBLICATIONS

1. Hendrickson, Chris T., Lester B. Lave, H. Scott Matthews, Arpad Horvath, Satish Joshi, Francis C. McMichael, Heather MacLean, Gyorgyi Cicas, Deanna Matthews and Joule Bergerson, 'Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach,' Resources for the Future, 2006.
2. Hawkins, Troy, Chris Hendrickson, Cortney Higgins, H. Scott Matthews and Sangwon Suh, 'A Mixed-Unit Input-Output Model for Environmental Life-Cycle Assessment and Material Flow Analysis,' ES&T, 2007, <http://dx.doi.org/10.1021/es060871u>
3. C. T. Hendrickson, G. Cicas, and S. Matthews, "Transportation Sector and Supply Chain Performance and Sustainability", Transportation Research Board Conference, January 2006.
4. Cliff Davidson, Chris Hendrickson, and H. Scott Matthews, "Sustainable Engineering: A Sequence of Courses at Carnegie Mellon", International Journal of Engineering Education, 2005.
5. Hawkins, Troy, H. Scott Matthews and Chris Hendrickson, 'Closing the Loop on Cadmium: An Assessment of the Material Cycle of Cadmium in the U.S.,' International Journal of Life-Cycle Assessment, 11(1), pp. 38-48, 2006

FIVE OTHER PUBLICATIONS

1. Hendrickson, Chris T., Lester B. Lave, H. Scott Matthews, Arpad Horvath, Satish Joshi, Francis C. McMichael, Heather MacLean, Gyorgyi Cicas, Deanna Matthews and Joule Bergerson, 'Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach,' Resources for the Future, 2006.
2. Fenves, S., U. Flemming, C. Hendrickson, M. Maher, R. Quadrel, M. Terk, and R. Woodbury,

- Concurrent Computer-Integrated Building Design, Prentice-Hall, 1993. (Reviewed in ASCE J. of Architectural Engineering, Sept. 1995).
3. Hendrickson, C. and T. Au, Project Management for Construction, Prentice-Hall, New York, 1989. Other Editions and Authorized Translations:
 - a. Hendrickson, C.T., Project Management for Construction, (2nd edition), <http://www.ce.cmu.edu/PMBook/>, 2000.
 - b. Chinese Translation: Higher Education Press, 2005.
 - c. Farsi Translation: M.T. Bankie, 1995
 - d. Spanish Translation: Diego Arturo L. de Ortigosa, 1994.
 4. Zozaya-Gorostiza, C., C. Hendrickson and D. Rehak, Knowledge Based Process Planning for Construction and Manufacturing, Academic Press, Cambridge, MA, 1989.
 5. Wohl, M. and C. Hendrickson, Transportation Investment and Pricing Principles, John Wiley and Sons, New York, 1984.

SYNERGISTIC ACTIVITIES

- The Economic Input-Output Life Cycle Assessment software (www.eiolca.net) developed by Chris Hendrickson and his colleagues is widely used for education and research of supply chain and life cycle environmental impacts. Over 200,000 uses of the software have been logged and the site was named among the Top 10 Green Business Web Sites by The Green Business Letter, 2001.
- Dr. Hendrickson chaired the task force that re-designed the Carnegie Mellon College of Engineering curriculum in 1989/90.
- Dr. Hendrickson was a member of the Body of Knowledge Committee of the Task Committee on Academic Prerequisites for Professional Practice, "Civil Engineering Body of Knowledge for the 21st Century," American Society of Civil Engineers, January, 2004.
- Teaching Awards: Outstanding Professor of the Year Award, ASCE Pittsburgh Section, 1990, and Benjamin Richard Teare Teaching Award, Carnegie Institute of Technology 1987
- Hendrickson, C. and T. Au, *Project Management for Construction*, Prentice-Hall, New York, 1989. New edition (2000) of this textbook published and available free on the Internet at: <http://www.ce.cmu.edu/PMBook/>

H. SCOTT MATTHEWS, Ph.D.

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Department of Engineering and Public Policy
Director of Research, Green Design Institute
Carnegie Mellon University
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Phone: (412) 268-6218 Fax: (412) 268-7357
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PROFESSIONAL PREPARATION

- Ph.D., Economics; Carnegie Mellon University, 1999
- M.S., Economics; Carnegie Mellon, 1996
- B.S., Computer Engineering and Engineering and Public Policy, Carnegie Mellon, 1992

APPOINTMENTS

- Aug 2002-2006: Asst. Professor, Civil & Environmental Engineering / Engineering & Public Policy
- Jan. 2000-Present: Director of Research, Green Design Institute
- July 2000-July 2002: Research Assistant Professor, Carnegie Mellon University, Pittsburgh, PA
- Jan. 1999-June 2000: Assistant Head, Department of Engineering and Public Policy, Carnegie Mellon

SELECTED RELEVANT PUBLICATIONS (of 38 total)

- Heather Wakeley, Michael Griffin, Chris Hendrickson, and H. Scott Matthews, "Alternative Transportation Fuels: Distribution Infrastructure for Hydrogen and Ethanol in Iowa", in press, ASCE Journal of Infrastructure Systems, 2007.
- Christopher Weber and H. Scott Matthews, "Quantifying the Global and Distributional Aspects of American Household Environmental Impact", accepted, Ecological Economics, 2007.
- Paulina Jaramillo, W. Michael Griffin, H. Scott Matthews, Comparative Life Cycle Air Emissions of Coal, Domestic Natural Gas, LNG, and SNG for Electricity Generation, Environmental Science and Technology, in press, 2007.
- Christopher Weber and H. Scott Matthews, Embodied Emissions in U.S. International Trade: 1997-2004, in press, Environmental Science and Technology, 2007.
- Barbara Karn (EPA) and H. Scott Matthews, "Nanotechnology: Emerging Challenges for Electronics and the Environment", IEEE Spectrum, in press, 2007.
- Cortney Higgins, H. Scott Matthews, Chris Hendrickson, and Mitchell Small, "Lead Demand of Future Vehicle Technologies", Transportation Research Part D, in press, 2007.
- Troy Hawkins, Chris Hendrickson, Cortney Higgins, H. Scott Matthews and Sangwon Suh, "A Mixed-Unit Input-Output Model for Environmental Life-Cycle Assessment and Material Flow Analysis", Environmental Science and Technology, Vol. 41, No. 3, pp. 1024 - 1031, 2007. DOI: [10.1021/es060871u](https://doi.org/10.1021/es060871u).
- Gyorgyi Cicas, C. T. Hendrickson, Arpad Horvath, and H. S. Matthews, "Development of a Regional Economic and Environmental Input-Output Model of the US Economy", International Journal of Life Cycle Assessment, 2007, [dx.doi.org/10.1065/lca2007.04.318](https://doi.org/10.1065/lca2007.04.318).
- Aurora L. Sharrard, H. Scott Matthews, and Michael Roth, "Economic and Environmental Implications of Construction Energy Use and Generation under New EPA Emission Standards", in press, Journal of Construction Engineering and Management, 2006.

- Cliff Davidson, Chris Hendrickson, and H. Scott Matthews, "Sustainable Engineering: A Sequence of Courses at Carnegie Mellon", International Journal of Engineering Education, Vol. 23, No. 2, pp. 287-293, 2007.
- Melissa Bilec, Robert Ries, H. Scott Matthews, "Sustainable Development and Green Design – Who is Leading the Green Initiative?", in press, ASCE Journal of Professional Practice, 2006.
- Melissa Bilec, Robert Ries, H. Scott Matthews, and Aurora Sharrard, "An Example of a Hybrid Life Cycle Assessment of Construction Processes", ASCE Journal of Infrastructure Systems, Vol. 12, No. 4, December 2006, pp. 207-215, (doi 10.1061/(ASCE)1076-0342(2006)12:4(207)).
- Chris T. Hendrickson, Gyorgyi Cicas, and H. S. Matthews, "Transportation Sector and Supply Chain Performance and Sustainability", Transportation Research Record No. 1983, 2006.
- William R. Morrow, W. Michael Griffin, and H. Scott Matthews, "Modeling Cellulosic Ethanol Production and Distribution in the US", Environmental Science and Technology, Vol. 40, No. 9, 2006, pp. 2877-2886.
- Hawkins, Troy, H. Scott Matthews and Chris Hendrickson, 'Closing the Loop on Cadmium: An Assessment of the Material Cycle of Cadmium in the U.S.', International Journal of Life Cycle Assessment, 11(1), pp. 38-48, 2006, <http://dx.doi.org/10.1065/lca2006.01.234>.
- Joe Marriott and H. Scott Matthews, "Environmental Effects of Interstate Power Trading on Electricity Consumption Mixes", Environmental Science and Technology, Vol. 39, No. 22, pp. 8585-8590, 2005. DOI: <http://dx.doi.org/10.1021/es0506859>.
- Paulina Jaramillo and H. Scott Matthews, "Landfill Gas to Energy Projects: An Analysis of Private and Social Benefits", Environmental Science and Technology, Vol. 39, No. 19, pp. 7365-7373, 2005. <http://dx.doi.org/10.1021/es049325w>
- Eric Williams and H. Scott Matthews, "Telework Adoption in the US and Japan", ASCE Journal of Infrastructure Systems, Vol. 11, No. 1, March 2005, pp. 21-30, (doi 10.1061/(ASCE)1076-0342(2005)11:1(21))
- Shannon M. Lloyd, Lester B. Lave, and H. Scott Matthews, "Life Cycle Benefits of Using Nanotechnology To Stabilize Platinum-Group Metal Particles in Automotive Catalysts", Environmental Science and Technology, 39(5); pp.1384-1392, 2005. DOI: 10.1021/es049325w
- H. Scott Matthews, Gyorgyi Cicas, and Luis Aguirre, "Evaluation of Residential Fixed Solar Photovoltaic Systems in the US", ASCE Journal of Infrastructure Systems, Vol. 10, No. 3, September 2004, pp. 105-110, (doi 10.1061/(ASCE)1076-0342(2004)10:3(105))
- H. Scott Matthews, "Thinking Outside 'the Box': Designing a Packaging Take-Back System", California Management Review, Winter 2004.
- H. Scott Matthews, Chris Hendrickson, Lester Lave, "The Economic and Environmental Implications of Centralized Stock Keeping," Journal of Industrial Ecology, Vol. 6, No. 2, pp. 71-81, 2003.
- H. Scott Matthews, E. Williams, T. Tagami, and C. T. Hendrickson, "Energy Implications of Online Book Retailing in the United States and Japan", Environmental Impact Assessment Review, Volume 22, Issue 5, 2002, pp. 493-507.
- Luis Ochoa, Chris T. Hendrickson, and H. Scott Matthews, "An Aggregate Life Cycle Assessment of Residential Buildings", ASCE Journal of Infrastructure Systems, Vol. 8 No.4, pp. 132-138, 2002.
- H. Scott Matthews, Lester Lave, and Heather MacLean, "Life Cycle Impact Analysis: A Challenge for Risk Analysis", Risk Analysis, Vol. 22, No.5, pp. 853-860, 2002.
- H. Scott Matthews, "Use versus Manufacturing Life Cycle Energy and Environmental Impacts for Tape Drives", Resources, Conservation, and Recycling, 36 (2002), pp. 187-196.
- H. Scott Matthews, Chris T. Hendrickson, and Denise L. Soh, "Environmental and Economic Effects of E-Commerce: A Case Study of Book Publishing and Retail Logistics", Transportation Research Record No. 1763, pp. 6-12, 2001.

- H. Scott Matthews, Chris T. Hendrickson, and Arpad Horvath, "External Costs of Air Emissions from Transportation," ASCE Journal of Infrastructure Systems, Vol., 7 No. 1, March 2001.
- H. Scott Matthews and Mitchell Small, "Extending the Boundaries of Life Cycle Assessment Through Environmental Economic Input-Output Models," Journal of Industrial Ecology, Vol. 4. No. 3, 2000, pp. 7-10.
- H. Scott Matthews and Lester B. Lave, "Applications of Environmental Valuation for Determining Externality Costs," Environmental Science and Technology, Vol. 34, No.8, pp. 1390-1395, 2000.
- H. Scott Matthews, Chris T. Hendrickson, Francis C. McMichael, and Deanna J. Hart, "Disposition and End-of-Life Options for Personal Computers", Green Design Initiative Technical Report #97-10, July 1997.
- Lester B. Lave and H. Scott Matthews, "It's Easier to Say Green than Be Green", Technology Review, Nov/Dec 1996, pp. 70-71. [Reprinted in Technology Review Italian Edition, December 1996, pp.6-7]

SYNERGISTIC ACTIVITIES

- Development of Economic Input-Output Life Cycle Assessment Internet Model, <http://www.eiolca.net/>, January 1999.
- Development and Publication of Green Design Educational Modules, 1998-2001 (<http://gdi.ce.cmu.edu>)
- IEEE International Symposium on Electronics and the Environment, Finance Chair (2001-2005), Conference Chair (2004), Program Chair (2006).
- ASCE Journal of Infrastructure Systems – Editorial Board; Co-edited 2 special issues on sustainable infrastructure
- Journal of Industrial Ecology – Associate Editor, Input-output life cycle assessment

Total Graduated Students: 12

EXHIBIT B
Interagency Agreement

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's 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.

EXHIBIT B
Interagency Agreement

- 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: Retail Climate Change Mitigation: Life-cycle Emission and Energy Efficiency Labels and Standards

Total Budget Requested: \$265,144

Period Covered (months): December 1, 2007 through June 30, 2010, or 30 months

Business or Institution: UC Berkeley, Sponsored Project Office

Address: 2150 Shattuck Ave., Suite #313, Berkeley, CA 94704-5940

Name of person authorized to bind this bid: Jyl Baldwin

Title: Contract Officer

Phone: (510) 642-8117

Signature of person authorized to bind this bid: _____

Budget Summary

Budget details must be supplied on pages 7-16 and on additional pages if necessary.

Instructions and definitions of terms are provided on pages 1-4.

NOTE: Totals in categories in this summary must match totals for categories on pages 7-16.

<u>Direct Costs</u>	
1. Labor & Employee Fringe Benefits	\$ 126,384
2. Subcontractor(s)/Consultant(s)	\$ 120,748
3. Equipment	\$ 0
4. Travel & Subsistence	\$ 2,216
5. Electronic Data Processing	\$ 0
6. Photocopying & Printing	\$ 0
7. Mail, Telephone, and FAX	\$ 30
8. Materials & Supplies	\$ 0
9. Analyses	\$ 0
10. Miscellaneous (GAEL insurance)	\$ 366
Total Direct Cost	\$ 249,744
<u>Indirect Costs</u>	
11. Overhead	\$ 15,400
12. General & Administrative Expenses	\$
13. Other Indirect Costs	\$
14. Fee or Profit	\$ 0
Total Indirect Cost	\$ 15,400

Total Direct and Indirect Cost:	\$ 265,144
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Budget Detail

I. Direct Costs

1a. Labor Charges for Universities and Other State Agencies

Individual's Name	Work Title	Mo. Salary	Est.	% of Effort or Months Requested	% of Salary
A. Horvath, Arpad, P.I., UC Berkeley		10,849	1.576		17,102
B. Masanet, Eric, Researcher, LBNL		8,665	8.596		74,485
C.					
D.					
E.					
F.					
G.					
H.					
I.					

(use additional page if necessary)

Subtotal: 91,587

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

Horvath is the Principal Investigator, responsible for overall project management. His salary rate is the summer salary rate current as of July 1, 2007.

Masanet has recognized expertise in the research methods necessary for the successful completion of this project. He will maintain a Multi-location Appointment (MLA) on campus while working on this project. His salary rate is his actual salary rate current as of June 1, 2007.

1b. Fringe Benefits

	BASE (\$)	RATE (%)	COST
A. Horvath, Arpad	17,102	12.7	2,172
B. Masanet, Eric	74,485	43.8	32,625
C.			
D.			
E.			
F.			
G.			
H.			
I.			

(use additional page if necessary)

Subtotal:	34,797
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Cost justifications. Provide the Basis for the Fringe Benefit Rates. (Use additional page if necessary).

The University's standard fringe benefit rate for faculty summer salary is 12.7%.

The fringe benefit rate for Masanet is based on his MLA appointment on campus, which carries a rate of 43.8%.

These rates are standard to all projects.

2. Subcontractors & Consultants

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

Subcontractor or consultant	Cost
A. Carnegie Mellon University,	\$120,748
B.	
C.	
D.	

(use additional page if necessary)

Subtotal:
120,748

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)

Equipment (itemize)	Cost
A. Item	
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).

4. Travel and Subsistence (itemize). Use State rates (Appendix IV). NO FOREIGN TRAVEL ALLOWED.

Description	Cost
A. Air transportation	920
B. Ground transportation	200
C. Per diem or subsistence	616
D. Trips to ARB (Berkeley – Sacramento – Berkeley)	480

Subtotal: 2,216

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

The travel budget includes:
 - 4 trips by car to visit the ARB for meetings, including private car mileage reimbursement, tolls, parking, and lunch for 2 persons,
 - 2 trips to visit the subcontractor in Pittsburgh, PA, including (for 1 person) airfare (\$460), ground transportation (\$100), and per diem (\$154, current GSA rate for lodging and M&IE).

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.	Mail, telephone and fax	30
B.		
C.		

Subtotal: 30

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

Mail, telephone and fax charges for this project are necessary in order to maintain communication with the ARB, and between the project team and the subcontractor.

8. Materials & Supplies (itemize)

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

Subtotal: 0

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.		

Subtotal: 0

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.	GAEL insurance	366
B.		
C.		
D.		

Subtotal: 366

Cost justifications. Justify all costs not included in the categories above. Explain the need for the item and why the cost is reasonable. (Use additional page if necessary).

The University-mandated General and Employment Liability (GAEL) insurance rate is 0.4% of the labor charges.

Total Direct Cost (add subtotals for categories 1-10): 249,744

II. Indirect Costs

11. Overhead and Other Indirect Costs

	Base (Salaries, total direct costs, etc.)	Rate	Cost
A.	Modified total direct costs 153,996	10%	15,400
B.			
C.			
D.			
E.			

Subtotal: 15,400

Total Indirect Cost: 15,400

Total Project Cost: 265,144

Budget Submittal Form

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

PLEASE TYPE OR PRINT:

Title of Proposal: Retail Climate Change Mitigation: Life-cycle Emission and Energy Efficiency Labels and Standards

Total Budget Requested: \$120,748

Period Covered (months): December 1, 2007 through June 20, 2010 or 30 months

Business or Institution: Carnegie Mellon University

Address: 5000 Forbes Avenue Pittsburgh, PA 15213

Name of person authorized to bind this bid: Susan Burkett

Title: Associate Provost

Phone: (412) 268-8746

Signature of person authorized to bind this bid: _____

Budget Summary

Budget details must be supplied on pages 7-16 and on additional pages if necessary.

Instructions and definitions of terms are provided on pages 1-4.

NOTE: Totals in categories in this summary must match totals for categories on pages 7-16.

<u>Direct Costs</u>	
1. Labor & Employee Fringe Benefits	\$ 104,359
2. Subcontractor(s)/Consultant(s)	\$ 0
3. Equipment	\$ 0
4. Travel & Subsistence	\$ 0
5. Electronic Data Processing	\$ 5,411
6. Photocopying & Printing	\$ 0
7. Mail, Telephone, and FAX	\$
8. Materials & Supplies	\$
9. Analyses	\$ 0
10. Miscellaneous – GAEL insurance	\$ 0
Total Direct Cost	\$ 109,771
<u>Indirect Costs</u>	
11. Overhead	\$ 10,977
12. General & Administrative Expenses	\$
13. Other Indirect Costs	\$
14. Fee or Profit	\$ 0
Total Indirect Cost	\$ 10,977

Total Direct and Indirect Cost:	\$ 120,748
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Budget Detail

I. Direct Costs

1a. Labor Charges for Universities and Other State Agencies

Individual's Name	Work Title	Mo. Salary	Est.	% of Effort or Months Requested	% of Salary
A. Matthews, H. Scott	Assoc Prof	10,071	1.6398		16,515
B. Hendrickson, Chris T	Professor	20,257	0.8191		16,592
C. Graduate Student		N/A	25		62,247
D.					
E.					
F.					
G.					
H.					
I.					

(use additional page if necessary)

Subtotal: 95,354

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

Matthews has expertise in environmental life cycle assessment, the EIO-LCA model, and consumption.

Hendrickson has recognized expertise in the research methods necessary for the successful completion of this project, as well as specific expertise on greenhouse gas emissions.

A Carnegie Mellon graduate student assistant will help with managing data and models in support of Task 1 (and Task 2), and will assist in documentation of project and writing of final report.

1b. Fringe Benefits

	BASE (\$)	RATE (%)	COST
A. Matthews, H. Scott	16,515	27.2	4,492
B. Hendrickson, Chris T.	16,592	27.2	4,513
C.			
D.			
E.			
F.			
G.			
H.			
I.			

(use additional page if necessary)

Subtotal: 9,005

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

Using non-federal fringe benefit rate for Carnegie Mellon University. The University's fiscal year runs July 1 June 30. Fringe benefits for faculty and staff are 27.2%, and do not apply to graduate stipends.

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).

4. **Travel and Subsistence (itemize). Use State rates (Appendix IV). NO FOREIGN TRAVEL ALLOWED.**

Description	Cost
A.	
B.	

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. Computing Services	\$4,905
B. Printing Services	\$157
C. Information Services	\$350
D.	

**Subtotal:
\$5,411**

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

The costs above are estimated based on previous research projects, but will be charged based on actual expenses. They are based on the following percentages of salaries and fringe benefits:

Computing Services 4.7%

Printing Services 0.34%

Information Services (including republication expenses) 0.15%

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	Cost
A.			
B.			
C.			
D.			
E.			
F.			

Subtotal: 0

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.		

Subtotal: 0

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

Cost justifications. Justify all costs not included in the categories above. Explain the need for the item and why the cost is reasonable. (Use additional page if necessary).

Total Direct Cost (add subtotals for categories 1-10): 109,771

II. Indirect Costs

11. Overhead and Other Indirect Costs

	Base (Salaries, total direct costs, etc.)	Rate	Cost
A. MTDC	109,771	10%	10,977
B.			
C.			
D.			
E.			

Subtotal: 10,977

Total Indirect Cost: 10,977

Total Project Cost: 120,748

EXHIBIT D
Interagency Agreement

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
Interagency Agreement

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.

EXHIBIT E Interagency Agreement

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;
4. A graph or table showing allocation of the budget and amount used to date; and
5. A graph or table showing percent of work completion for each task.

EXHIBIT E Interagency Agreement

- 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

EXHIBIT E Interagency Agreement

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.

EXHIBIT E Interagency Agreement

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

These provisions apply only to non-state entity subcontractors that may be a part of this Agreement.

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.

EXHIBIT E
Interagency Agreement

4. "Subcontractor" means an individual or firms that contract 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.

EXHIBIT E
Interagency Agreement

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.

EXHIBIT E
Interagency Agreement

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
Interagency Agreement

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 ½" x 11") to allow for photo-reproduction.

EXHIBIT F Interagency Agreement

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"

EXHIBIT F Interagency Agreement

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

EXHIBIT F Interagency Agreement

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.

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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.

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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.

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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".