Historically Embedded

Embodied Energy's Place in Building Retrofits

Troy Hideki Okimoto

Submitted towards the fulfillment of the requirements for the Doctorate of Architecture degree, December 2011

University of Hawai‘i at Mānoa School of Architecture
Doctorate Project Committee: Kristopher Palagi, Chairperson;
Charles Lehuakona Isaacs Jr.; and William R. Chapman

Historically Embedded

Embodied Energy's Place in Building Retrofits

Troy Hideki Okimoto
December 2011

We certify that we have read this Doctorate Project and that, in our opinion, it is satisfactory in scope and quality in partial fulfillment for the degree of Doctor of Architecture in the School of Architecture, University of Hawai'i at Mānoa.

____

Kristopher M. Palagi, Chairperson

____

Charles Lehuakona Isaacs Jr.

____

William R. Chapman

What we need is continuity...
Historic preservation is not sentimentality but a psychological necessity.
We must learn to cherish history and to preserve worthy old buildings...
We must learn how to preserve them,
Not as pathetic museum pieces,
But by giving them new uses.

- Ada Louise Huxtable
  Lessons in Healing the City's Scars

Our economy is still based upon cheap fossil fuel
And a constant growth of gross national product...
Old knowledge and established technical solutions are combined...
With new sustainable technology.

- Anders Nyquist
  Green Building and Planning: Experiences and Visions

Many of the root processes at work in natural ecologies and our economics
are amazingly similar, and we can learn much about success and failure
in our own arrangements by noticing, for example, that the more niches
that are filled in a given natural ecology...
the more efficiently it uses the energy it has at its disposal,
and the richer it is in life and means of supporting life.
Just so with our own economies:
the more fully their various niches are filled,
the richer they are in means of supporting life.

- Jane Jacobs
  Cities and the Wealth of Nations

Historically Embedded: Embodied Energy's Place in Building Retrofits

Table Of Contents

Foreword

Design and research are the solution to allow buildings, civilization, and the natural environment to live cohesively and responsively with one another. Our society must change its behavior. To do so, we must integrate ideas from eco-psychology, personal development, scientific research, mentoring, monitoring, and leadership. Although large scale changes in public and private behaviors have been on governmental and non-governmental organization agendas, there is often no understanding of the connections between the economic and the environmental, or the psychological and physical dimensions of the problems. The reuse of existing structures can promote a more social, economical, and environmental way of life that is holistically integrated. An understanding of the ethical theories behind decisions to reinvent rather than to demolish may give a developer the justification to pursue a renewal project. Adjusting a building's dilapidated existing state to an energy efficient, high performing future state through quantitative and qualitative comparative scenarios can help the existing building stock.

The recent economic crisis has put new construction at a standstill. The American Institute of Architects (AIA) forecasted steep declines in nonresidential construction spending through 2010: "Spending is projected to decrease by 16% in 2009 and another 12% in 2010."[1] With the flow of money to new construction at an all time low, we can raise the public's awareness through policy, stimulus program spending, and the creation of a typology of building tectonics through architecture. Design strategies can help mediate the retrofitting of existing buildings and provide answers to the chaos and economic hardships of new construction. If the United States of America retrofitted 40% of the nation's residential and commercial building stock, we could create 625,000 jobs in 10 years and generate $64 billion per year in cost savings for U.S. energy ratepayers (about $300 to $1,200 per family).[2]

---

[1] Kermit Baker, "*Consensus Construction Forecast: Steep Downturns in Nonresidential Construction*

[2] Murley, Susan. *The DOE's Solar Decathlon Prepares Graduates for Green Jobs.* September 13, 2011. http://www.huffingtonpost.com/susanna-murley/terps-charged-up-for-the-_b_960031.html?ir=College (accessed September 15, 2011).

Acknowledgements

The most important and influential people in my life are my parents and family. I could not have gotten through the struggles of life without them. Thank you for your encouragement and making me believe that the impossible can be achieved. This is for you.

This project is a collaboration that involved many individuals. A culmination of data, literature, and research has made this project unique and could not have been possible without the mentorship, guidance, and manaʻo of my committee members: Kristopher Palagi, Charles Lehuakona Isaacs Jr., and Dr. William R. Chapman.

The inspiration for this research was my involvement and colleagueship with the Environmental Research and Design Lab under the direction of Dr. Stephen Meder at the University of Hawaiʻi at Mānoa School of Architecture. My experience at the Environmental Lab made me aware of the environmental impact that buildings have.

My practicum experience with Zimmer Gunsul Frasca Architects LLP in the spring of 2011 in Portland, Oregon was also noteworthy. I would like to personally thank Robert Packard, Ronald Gronowski, David Grigsby, Janet Hull, and Chris Flint Chatto. Thank you for your guidance and mentorship.

List of Figures

List of Tables

Topics

Historic Preservation (Heritage Preservation) is defined by The Secretary of the Interior's Standards for the Treatment of Historical Properties, 1995:

as the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project.

Sustainability (Green Building) is defined by The Office of the Federal Environmental Executive's Commitment to Green Building: Experiences and Expectations, 2003:

as the practice of 1) increasing the efficiency with which buildings and their sites use energy, water, and materials, and 2) reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and removal – the complete building life cycle.

Embodied Energy (Embedded Energy) is defined by Graham J. Treloar from the Australia Architectural Science Association and database expert in embodied energy, 1994:

The quantity of energy required by all of the activities associated with a production process, including the relative proportions consumed in all activities upstream to the acquisition of natural resources and the share of energy used in making equipment and in other supporting functions (i.e. direct energy + indirect energy).

District Scale Sustainability (EcoDistrict) is defined by The Sustainable Cities Institute, 2011:

a highly integrated and planned neighborhood or district that is resource efficient. The thoughtful planning of the project is home to a range of transportation options and helps to capture, manage and reuse all energy, water and waste on the site. One of the most important aspects of an EcoDistrict is that it enhances community engagement and wellbeing, while providing a rich diversity of habitat and open space, even within an urban city.[3]

Embodied Carbon (Embedded Carbon) is defined by Patrice Frey from the National Trust for Historic Preservation, like embodied energy, as:

the amount of carbon emitted through building construction, including the carbon emitted in transporting materials, and carbon emitted assembling a building.

[3] Sustainable Cities Institute. *District Scale Sustainability* . August 9, 2011. http://www.sustainablecitiesinstitute.org/view/page.basic/buzz_topics/content.buzz_topic/Buzz_DirectScale_Sustainability_2011_08_09 (accessed September 7, 2011).

Abstract

Older buildings, buildings over 50 years in age, comprise more than half of the existing buildings in the United States. The importance of reusing buildings and reinvesting in older buildings is the subject of this paper, as well as the rationale for retrofitting the existing building stock. Retention and reuse of these buildings preserves the materials, embodied energy, and human capital already expended in their construction. The recycling of buildings is a beneficial "green" practice, and stresses the importance and values of historic preservation in the overall promotion of heritage and sustainability.

My Doctorate of Architecture project will explore many facets of renewal due to Hawai‘i's isolation from the rest of the world. An analytical intervention will be applied to Gartley Hall on the University of Hawai‘i at Mānoa campus' quad area. The Gartley model will examine and quantify the embodied energy at various phases of building retrofits.

Society has become increasingly aware of our impact on the natural environment. This awareness is due in part to the rising cost of oil and the basic cost of living. Being cognizant of our impact on the environment will help mediate economic inflation and preserve Hawai‘i's beauty for future generations. Hawai‘i was one of the last places on earth settled by man due to its complete isolation in the Pacific Ocean. This isolation has created one of the world's most unique environments and lifestyles; minimizing each person's carbon footprint will help preserve our islands' natural beauty.

My project demonstrates the implications and methods of choices a designer, developer, contractor, and building-user make to achieve sustainability in retrofitting existing buildings through an analysis that covers the embodied energy of existing buildings and their potential future uses. This project will analyze and compare the energy and materials previously expended on a building and at various levels of remodel. My conclusions are drawn from precedents, quantitative embodied energy data, and regional transportation variables (Hawai‘i's isolation). The final portion of the project identifies the problems and metrics associated with one of the oldest buildings on the University of Hawai‘i at Mānoa campus through a lifespan model that considers phasing retrofits, transportation costs, and existing embodied energy.

KEYWORDS: Embodied Energy, Sustainability, Preservation, Retrofitting, Existing Building

Historically Embedded

Embodied Energy's Place in Building Retrofits

Troy Hideki Okimoto
December 2011

We certify that we have read this Doctorate Project and that, in our opinion, it is satisfactory in scope and quality in partial fulfillment for the degree of Doctor of Architecture in the School of Architecture, University of Hawai'i at Mānoa.

Kristopher M. Palagi, Chairperson

Charles Lehuakona Isaacs Jr.

William R. Chapman

Historically Embedded

Embodied Energy's Place in Building Retrofits

INTRODUCTION

Hawai'i has one of the world's most unique environments due to its isolation from the rest of the world. This isolation has led to several issues including our state's reliance on imported fossil fuels, the overfilling and violations at our state landfills, gentrification of historic districts, and the mindset to demolish rather than **reuse** or **retrofit**.[4]

Hawai'i's isolation has made the cost of living here one of the highest in the United States due to shipping, the state's reliance on imported fossil fuels, and the continued rise of electrical costs. As shown in Figure 1.1, the Hawaiian Island chain is located almost 2,400 miles from California; 3,800 miles from Japan; and 2,400 miles from the Marquesas Islands.[5] This isolation is one of the reasons Hawai'i was one of the last places on earth to be settled by explorers and justification for Hawai'i residents to reduce needs, reuse, recycle, and rely on renewable resources as much as possible; to minimize sending construction waste to our landfills; and to minimize imported products.

[4] A note on terminology: By **REUSE** of buildings, I mean the act of keeping an existing building in service rather than demolishing or abandoning the structure. **RETROFIT** refers not just to reusing a building – but improving its energy performance and reducing other negative environmental impacts associated with the building.

[5] Fischer, John. *Only in Hawaii Part 1: Islands Unique in all the World* . July 23, 2010, http://gohawaii.about.com/cs/onlyinhawaii/a/only_in_hawaiia.htm (accessed November 23, 2010).

Utilizing the embodied energy already within existing buildings and infrastructure can help mediate this issue. Retrofitting existing buildings to be energy efficient and to use available renewable resources can aid our reliance on importing construction products and exporting construction waste.

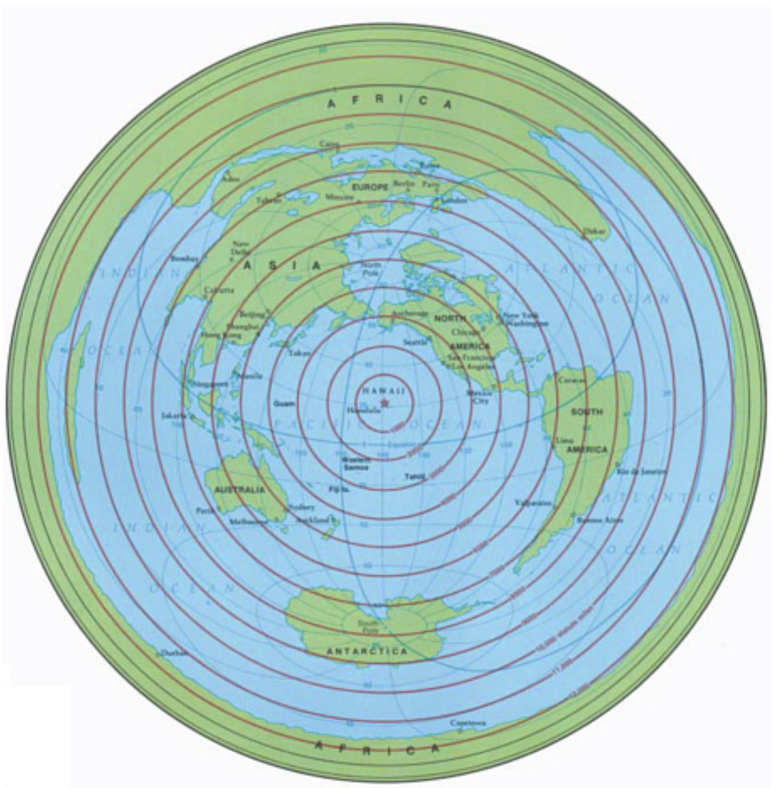


FIG 1.1 Hawai'i's Isolation in the Pacific

Source: National Academy of Sciences Press

The United States of America has always been ahead in technological advancements. The United States, which has only 5 percent of the world's population, is responsible for 22 percent of the world's greenhouse gas emissions.[6] Although transportation – cars, trucks, trains, airplanes – account for 32 percent of America's

[6] Wadhams, Emily. "Introduction." *Forum Journal: National Trust for Historic Preservation*, March 2009: 8.

carbon emissions; 43 percent of America's total carbon emissions come from the operation of buildings, and this does not include the carbon generated by extracting, manufacturing, and transporting building materials (embodied energy).[7]

My project is focused on how precious recycled building materials are, along with the importance of **embodied energy** in Hawai'i's building retrofit potential.[8] Seeing existing buildings as a reusable form or material for future use is the goal. I also want to educate people and help them realize that demolition is not always the solution. Historic **preservation** is a powerful way to reduce societies' dependence on non-renewable energy and to look forward toward a **sustainable future**. Chapter 1 discusses the three highlighted ideas and concludes with a comprehensive vision of how they can all work together.

Chapter 2 discusses the challenges the world and Hawai'i are facing politically and economically. The policies and programs put in place by our judicial system help to bring stability to the chaotic ups, downs, and bursts of the fragile economy and ecosystem. Presently, we are living in one of the worse economic depressions the United States has seen since the early twentieth century. Job opportunities through building retrofits are usually greater than with new construction, and putting the American people to work with green collar jobs may benefit today's economy. Susanna Murley from the

---

[7] Ibid

[8] A note on terminology: **Embodied Energy** refers to the: SOURCING, MANUFACTURING, TRANSPORTING, CONSTRUCTING, OPERATING, MAINTAINING, DECONSTRUCTING, REPLACING of anything previously constructed.

Department of Energy (DOE) Solar Decathlon Committee said, "If we retrofitted 40% of the nation's residential and commercial building stock, we could create 625,000 jobs in 10 years and generate $64 billion per year in cost savings for U.S. energy ratepayers (about $300 to $1,200 per family)."[9] Retrofitting buildings will create jobs in design, analysis, construction labor, and maintenance operations.

The American Institute of Architects (AIA) forecasted steep declines in nonresidential construction spending through 2010: "Spending is projected to decrease by 16% in 2009 and another 12% in 2010, as shown in Fig. 1.2. With less money flowing through the industry, architects, builders and regular folk are opting for retrofits with more practical design. Turning our backs to this issue is not the solution."[10] McGraw-Hill Construction also reported "steep declines in nonresidential construction projects...(2009). The commercial and institutional building sectors have seen this large decline."[11] With the flow of money to new construction at an all time low, we can raise the public's awareness of the potential of retrofitting through policy, stimulus program spending, and the creation of a typology of innovative architecture. Design strategies can

---

9 Murley, Susan. *The DOE's Solar Decathlon Prepares Graduates for Green Jobs.* September 13, 2011. http://www.huffingtonpost.com/susanna-murley/terps-charged-up-for-the-_b_960031.html?ir=College (accessed September 15, 2011).

10 Baker, Kermit. *Consensus Construction Forecast: Steep Downturns in Nonresidential Construction Projected Through 2010.* July 10, 2009. http://info.aia.org/aiarchitect/thisweek09/0710/0710b_consensus.cfm (accessed April 15, 2010).

11 Ibid

help mediate the retrofitting of existing buildings and respond to the chaos and economic hardships of new construction.

McGraw-Hill Construction Bob Murray 781-430-2201 Construction starts (billions of 2000$)	2008 $	FORECAST 2009 % change	 2010
Nonresidential Total	146.7	-20.6	-3.8
Commercial Total	55.4	-30.2	-3.8
Office	18.0	-20.6	-2.2
Retail/Other Comm.	28.3	-31.1	-2.8
Hotel	9.2	-46.0	-12.3
Industrial Total	14.7	-37.9	-19.1
Institutional Total	76.5	-10.3	-1.7
Health	14.9	-16.4	-1.6
Education	33.5	-11.4	-2.2
Religious	2.8	-2.7	-5.7
Public Safety	8.1	4.5	1.9
Amusement/ Recreation	9.0	-14.7	-4.3

TABLE 1.2 AIA Economics Consensus Forecast

Source: McGraw-Hill Construction Bob Murray

The importance of public infrastructure like "streets and highways, bridges, water and sewer lines, and conservation projects [is] significant..."[12] but unlike those for infrastructure, the funds for buildings are much more modest. Residential and nonresidential buildings are significantly limited to stimulus project funds that are estimated to total "$35 to $40 billion over the next two years,…in a $400 billion a year sector..."[13] The private side of the building sector sees an unfortunate side effect of this situation because retrofits are not a popular way to bring revenue to a building developer and/or owner.

Chapter 3 discusses precedent studies of retrofitted buildings and Chapter 4 discusses the metrics of embodied energy brought into the analysis. Researching and retrofitting buildings to make them 'responsive' to any climate and 'sensible' to the environment can

[12] Ibid

[13] Ibid

help bring people together in identifying their urban city.[14] My examination of the role building retrofits play in reshaping the diversity of the built environment in cities revealed both positive and negative effects in the social, economic, and cultural revitalization of cities. My research investigates how new meanings and values are negotiated for recently obsolete, derelict, and abandoned structures. Countless books have been published that cover the design and construction of sustainable building. However, sustainability is an extremely broad, misused, and washed term. For the purposes of this project, retrofitted reuse of existing buildings helps to preserve energy already expended (embodied) at the building site and embedded within construction materials. Building maintenance and post-occupancy evaluations help to maintain a level of energy efficiency after renovation. Chapters 3 and 4 will explain how embodied energy and retrofits are analyzed through specific precedents.

The inflation of oil and the cost of living in Hawaiʻi have increased awareness of the importance of saving money by reducing, reusing, and recycling. As a future architect, it is my responsibility to preserve the built environment rather than demolish it. Renovating a structure to be green, healthy, and attractive to current and future tenants who share a commitment to preservation, stewardship of the natural environment, and a healthy indoor environment is my top priority. In Chapters 5 and 6, I use Gartley Hall on

[14] Nyquist, Anders. "Green Building and Planning: Experiences and Visions." In *Green Building and Planning: Experiences an Visions*, by Anders Nyquist, 13. Njurunda: Anders Nyquist Arkitektkontor AB Pramviken, 2010.

the University of Hawaiʻi at Mānoa campus as a study to educate people on the process of retrofits and the metrics of embodied energy.

Re-evaluating the paradigms of both the building and the user, one must ask how each impacts the political structure, indigenous tradition and culture, and the natural ecological geology. Ensuring a balanced relationship between the environment, buildings, and the citizens occupying them, challenges designers to create an innovative building typology. The new building type's use of policy and programs, quantitative embodied energy data, and case studies can set leadership standards and establish collaboration and support from the public and professionals. Leading by example from the top down would help us to better understand, identify, and analyze the measures necessary to reduce greenhouse gas emissions.

Hawaiʻi's isolation from the mainland United States heightens the importance of taking active steps toward promoting a greener understanding of the reuse of existing buildings. Action has been taken in the mainland United States because "existing buildings are responsible for more than 43 percent of carbon emissions and account for about 75 percent of our electricity use."[15] Hawaiʻi's situation is different from the mainland's because the importance of awareness and educating people to harness the already expended embodied energy within materials is due largely to our state's isolated environment.

---

[15] Wadhams, Emily. "Introduction." *Forum Journal: National Trust for Historic Preservation*, March 2009: 5.

1 Ideology

PRESERVATION IDEOLOGY

SUSTAINABLITY IDEOLOGY

EMBODIED ENERGY IDEOLOGY

Preservation Ideology

The National Register of Historic Places is the bedrock of historic preservation in the United States. The National Historic Preservation Act of 1966 was a major partnership between the state and federal sectors. The National Park Service (NPS) is a federal agency that manages all national parks, monuments, and other conservation and historical properties. There are districts, sites, buildings, structures, and objects, tangible and intangible, that are significant to American history, architecture, archaeology, engineering, and culture. Preserving these resources contributes to a greater understanding of our nation's history and culture.[16]

Chapter 6E of the Hawai‘i Revised Statutes is the state's historic preservation law. The State Department of Land and Natural Resources (DLNR) enforces the rules, and a historic preservation review process is required for redevelopment of land in the State of Hawai‘i. The State Historic Preservation Division manages and finances all future nominations at the state level. The National Register translates and interfaces with preservation on a more local level through the State Historic Preservation Officer (SHPO), also known as the State Liaison Officer. There is one officer per state within the United States that oversees the archival research for historic sites. At the state level, the SHPO ensures that the National Register's standards for evaluating the significance of properties are enforced. The criteria for evaluation are enforced as a guide for state and

[16] National Park Service, "National Historic Preservation Act of 1966."

local governments, as well as federal agencies, to help retain a nomination's historical integrity. A nomination's significance and integrity are a high priority to the SHPO, so there must be collaboration between the owner and SHPO.

It is often believed that there are conflicts between green building practices and technologies and the Secretary of the Interior's Standards. Interviews with State Historic Preservation Offices, architects, property owners, and developers were conducted in preparation for this paper to examine the relationship between green building and the Secretary of the Interiors Standards. I believe that the conflicts that do exist are not insurmountable, and these problems are small in relation to the entire building project. Those interviewed believed that designers and preservationists could overcome most potential conflicts through creative design.

Some SHPOs find that reviewing projects that incorporate green features takes longer and requires more in-depth review. Despite this longer process, SHPOs and owners can usually work through conflicts and compromise on solutions. For example, "a group of homeowners in a Maryland historic district had high goals for efficiency in their homes, and they were content with the compromises that they made with their local review board. Through negotiations with the board, owners were allowed to complete almost all of their proposed components with the exception of some features that were visible from the public right-of-way and that were not in keeping with the character of the house."[17]

Our environment yields abundant resources but is often taken for granted. Society today has become more aware of rapid resource depletion, world population growth, and the ever-growing abuse of the environment. The Historic American Buildings Survey (HABS) started in 1933, and the National Historic Preservation Act (NHPA) in 1966. Both the survey and the act provided the research and laws to secure historic preservation as the first inherently sustainable practice, before sustainability became a movement in the nineties. In 2007, the National Trust for Historic Preservation launched its Sustainability Initiative in order to steer the conversation towards an understanding of the value of conserving our existing resources rather than consuming more. The National Trust's Sustainability Initiative is guided by four core principles of stewardship:

> First the reuse of our existing buildings reduces the amount of demolition and construction waste deposited in landfills, lessens the unnecessary demand for new energy and other resources needed to construct a new building, and conserves the energy originally expended to create the structures (embodied energy). Reinvestment in older and historic communities also has numerous environmental benefits. Older and historic communities tend to be centrally located, dense, walkable, and are often mass-transit accessible – qualities

[17] Friends of the National Center for Preservation Training and Technology and the National Trust for Historic Preservation, "Sustainability and Historic Preservation - Making Policy. Green Building Practices and the Secretary of the Interior's Standards for Historic Preservation." (Pocantico Symposium, November 2008).

> promoted by Smart Growth advocates. Reinvestment in these communities also preserves the energy expended in creating the existing infrastructure, such as roads, water systems and sewer lines. Retrofits of historic buildings can and should be undertaken to extend building life and better capture the energy saving available through new technologies. Finally, respect for our existing built environment is an important component of the Sustainability Initiative's strategy.[18]

The principles of historic preservation are the foundation of sustainable principles today. It is important to understand the practice of preserving history to have a clearer understanding of the deep roots from which sustainability grew. Although there has been disconnect between the two principles, a correlation remains within the study of embodied energy and retrofits.

---

[18] Frey, Patrice. *Building Reuse: Finding a Place on American Climate Policy Agendas.* Sustainability Research , Washington D.C.: National Trust of Historic Preservation, 2008.

Sustainability Ideology

Buildings are substantial CO_2 emitters and a major contributor to climate change. According to the US Energy Information Administration, buildings account for "76% of fossil fuel consumption, transportation 1%, and industry 23%."[19] This argument is based on the large environmental footprint of buildings, especially when considering the high reliance on resources due to an increased acceptance of air conditioning and heating (HVAC).[20] Stakeholders, building owners, tenants, and property appraisers (values) are linked to the level of energy consumption (carbon footprint) of a building. The problem lies with how the level of energy consumption of a building due to rating tools can potentially play a major role in the way buildings are operated, maintained, and designed.

[19] U.S. Energy Information Administration . *Architecture 2030.* January 1, 2010. www.architecture2030.org (accessed April 1, 2010).

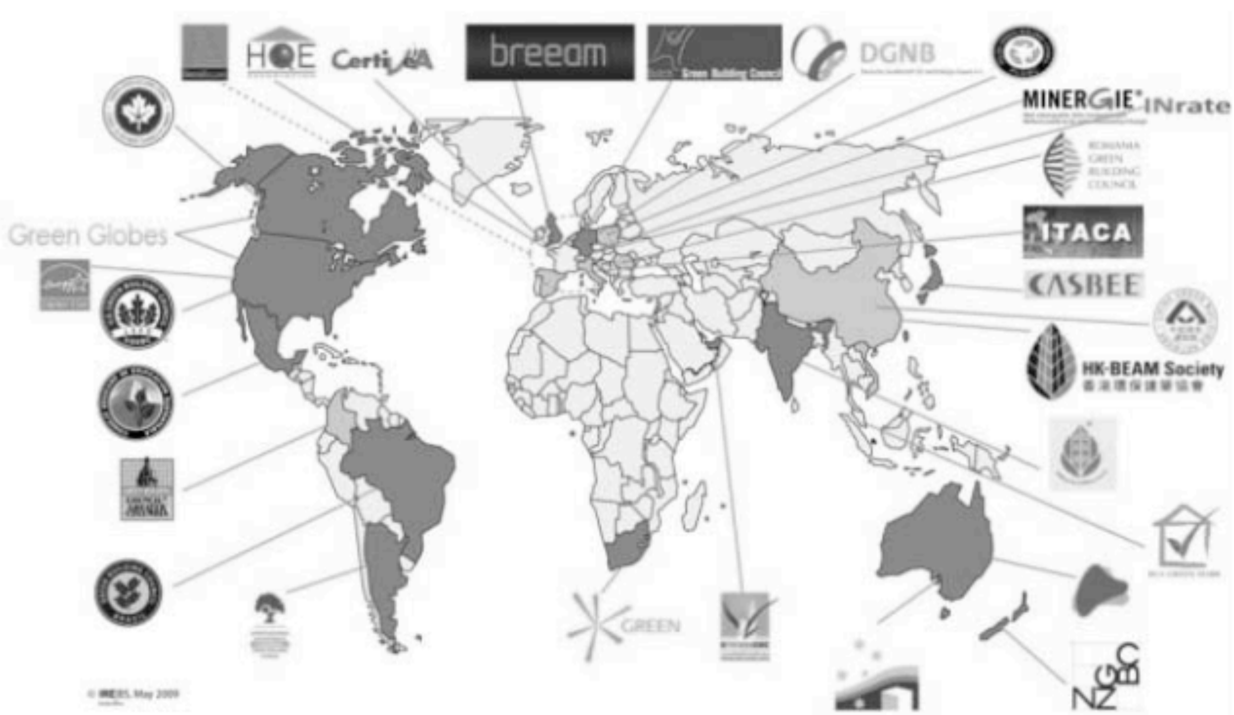
[20] Ibid

U.K. and Europe	Americas	Rest of the World
BREEAM (inc Eco-homes)	LEED (U.S. & Canada)	Green Star (Australia)
The Green Guide to Specification	U.S. DOE (U.S. Department of Energy) Design Guide (U.S.)	BEAM (Hong Kong)
Office Scorer	WBDG (Whole Building Design Guide) (U.S.)	LEED (China and India)
ENVEST	HOK Sustainable Design Guide (U.S.)	Greenmark (Singapore)
Sustainability Checklists (e.g. SEEDA; BRE)	BREEAM Canada (Canada)	GBTool (South Africa)
Environmental Impact Assessment (EIA)	Green Globes (U.S. & Canada)	
Strategic Environmental Assessment (SEA)		

Note: The sources are RICS (2007) and Green Globes (2009).

FIG 2.1 International Rating Tools

Source: JOSRE



Countries have introduced new rating tools over the past few years in order to improve knowledge about the level of sustainability in the building sector. Consideration is given to the different rating tools for sustainable buildings in each country. These rating tools have evolved over time, and countries and their rating tools have contributed to seeking and providing insight into building's positive and negative effects on society. The various rating systems, as shown in Fig. 2.1 in Appendix, indicates the main rating tool implemented and where it is located.[21]

The World Green Building Council (WGBC) has the largest global coverage, with worldwide links in the United States, Canada, some parts of Europe, Japan, Australia, and South Africa. The Leadership in Energy and Environmental Design (LEED) and BRE Environmental Assessment Method (BREEAM) building rating systems are both moving toward an internationally accepted rating tool. "It is reported that three of the most common rating tools, namely BREEAM, LEED, and Green Star, are seeking to develop common metrics that will help international stakeholders compare buildings in different cities using an 'international language.'"[22]

The international rating system is a great tool to implement and drive green building strategies into the minds of designers, contractors, stakeholders, and social thinkers. The location of a project is considered due to each locale's climate change

---

[21] Reed, Richard, Anita Bilos, Sara Wilkinson, and Karl-Werner Schulte. "International Comparison of Sustainable Rating Tools." *JOSRE* 1 (2009)

[22] Reed, Richard, Anita Bilos, Sara Wilkinson, and Karl-Werner Schulte. "International Comparison of Sustainable Rating Tools." *JOSRE* 1 (2009): 6.

issues. Australia's lack of water and drought, and the United Kingdom's flooding issues are evidence that climate change is real and must be addressed. The individual characteristics of each country must not be overlooked, and at times, a universal rating tool may not work for every country. Overall, the rating tool system has positive and negative effects and can help to change people's ways of thinking about their everyday activities and their effects on the environment.

Older buildings[23] comprise more than half of the existing buildings in the United States. Retention and adaptive reuse of these buildings preserves the materials, embodied energy, and human capital already expended in their construction. The recycling of buildings is one of the most beneficial "green" practices, and stresses the importance and values of historic preservation in the overall promotion of sustainability.

LEED for Existing Buildings (LEED-EB), launched in 2004, looks at actual building performance, and in 2006, the U.S. Green Building Council (USGBC) announced that buildings certified under LEED for New Construction (LEED-NC) would have the option of being enrolled at no charge in LEED-EB. Rick Fedrizzi, CEO of the USGBC, recently wrote in the Huffington Post that "there are about 120 million existing homes in the U.S., and about 5 million commercial buildings comprising more than 71 billion square feet of space. And virtually every one of them is an energy hog." Renovating historic buildings in order to address energy efficiency and climate disruption is a challenging puzzle that also represents great opportunities. There are occasions when

[23] A note on terminology: Any building older than 50 years is considered older.

reusing existing buildings and retrofitting them to be more energy efficient has a higher payback than new construction.

The Preservation Green Lab in Seattle, Washington is an initiative of the National Trust for Historic Preservation. The lab is focused on developing public policy and building codes to solve historic retrofit challenges, and to demonstrate solutions with pilot projects. According to an article by a director of the Association for Preservation Technology International, buildings constructed before 1920 on average consume less energy per square foot than those built in any decade since.

LEED EB-O&M (Operations and Maintenance) is one of the newest rating systems developed by the USGBC. The LEED EB-O&M documentation is designed to be completed by operations and maintenance staff, and focuses on actual building performance data and improvements. The advantage of measuring specific loads in existing buildings is that it enables operations staff to implement more effective building energy efficiency measures based on actual occupant use patterns.[24] The USGBC's LEED EB-O&M tracks and measures carbon emissions and reductions. Monitoring the energy load, demand, and reduction of retrofitted buildings provides the level of metrics needed to properly determine the success or failure of a project.

The USGBC's Leadership in Energy and Environmental Design (LEED) rating system is a persuasive and powerful tool to promote energy efficiency in buildings. My

[24] Driedger, Michael. "Choosing the Right Green Building Rating System." *Perkins + Will Research Journal* 01.01 (2009): 22-41.

project came to life because of the impact regionalism has on the "materials and resources" section in LEED. I feel LEED should take "point" consideration of projects that reuse verses projects that demolish. This could be assigning points or simply offering a better regional rating for Hawai'i's isolation. The varied regions throughout the United States, for example Oregon verses Hawai'i, are another consideration that should be addressed by LEED. Hawai'i is a unique case that should have the transportation of construction materials and construction/demolition waste factored in the "materials and resources" section in LEED.

Embodied Energy Ideology

The concept of embodied energy (i.e. Life Cycle Assessment, Embedded Energy) originated in the late 1960's when it became clear that the only sensible way to examine industrial systems was to examine their performance, starting with the extraction of raw materials from the earth and tracing all operations until the final disposal of these materials as wastes back into the earth.[25] "Cradle-to-grave" refers to this lifecycle of a particular material from production to demolition. During the late 1960's, the cradle-to-grave concept concentrated mainly on energy and raw materials, but now with modern methods, it takes into account air emissions, water emissions, and solid waste.

The Athena EcoCalculator and the Waste Reduction Model (WARM) are two tools that help to calculate embodied energy. The Athena EcoCalculator tool looks at the entire cradle-to-grave process and calculates total embodied energy in particular building systems. The WARM tool looks at transportation and waste management scenarios, and compares various waste management practices. Alternate scenarios help to better manage the transportation and management of construction/demolition waste.

There are two forms of embodied energy in buildings that I will be focusing on in this paper: initial embodied energy and recurring embodied energy.

---

[25] Boustead Consulting (BCL). *LCAs and LCIs.* June 22, 2011. http://www.boustead-consulting.co.uk/introduc.htm (accessed October 24, 2011).

The initial embodied energy in buildings represents the non-renewable energy consumed in the acquisition of raw materials, their processing, manufacturing, transportation to site, and construction. This initial embodied energy has two components, direct and indirect energy. Direct energy is the energy used to transport building products to the site, and then to construct the building. Indirect energy is the energy used to acquire, process, and manufacture the building materials, including any transportation related to these activities.[26]

The recurring embodied energy in buildings represents the non-renewable energy consumed to maintain, repair, restore, refurbish or replace materials, components or systems during the life of the building. As buildings become more energy-efficient, the ratio of embodied energy to lifetime consumption increases. Clearly, for buildings claiming to be "zero-energy" or "autonomous", the energy used in construction and final disposal takes on a new significance.

---

[26] Canadian Architect. *Measures of Sustainability.* January 1, 2011. http://www.canadianarchitect.com/asf/perspectives_sustainibility/measures_of_sustainablity/measures_of_sustainablity_embodied.htm (accessed November 1, 2011).

2 Challenges

POLITICAL CHALLENGE

HAWAI‘I CHALLENGE

POLICIES AND PROGRAMS

Political Challenge

The common perception is that historic buildings are energy hogs, and that the environmental costs of demolition and new construction are far outweighed by the energy saved by the operation of more high performance, energy efficient buildings. Research suggests that many historic and older buildings are actually more energy efficient than recently constructed buildings because of their greater potential for site sensitivity, quality of construction, and use of passive heating and cooling.

Bringing change to established standards requires a top-down approach, starting with high governmental officials and a proposed policy backed by the public, researchers, and hard-fact data that is quantified and monitored accurately. The Kyoto Protocol (1997) has been a standard for monitoring and reducing greenhouse gas emissions globally, but a proposal and accurate up-to-date database that helps to monitor and reduce embodied energy in buildings has not been updated since the 1980’s. The embodied energy database that does exist is nowhere near the level of policy that the Kyoto Protocol is at currently. It has the potential to become a globally used database backed by international policy.

Typically, one would employ six criteria to evaluate policy proposals: “environmental outcome, dynamic efficiency, cost effectiveness, equity, flexibility in the presence of new information, and incentives for participation and compliance. At times there may be tensions among several of the evaluative criteria, such as between environmental outcome and efficiency, and between cost effectiveness and incentives for participation and compliance."[27] Such tensions may cause participation, one of the objective requirements, to get off track. Regaining direction during this time of tension is common; although the stringent goals need to be met, targets are of little or no environmental benefit if participation is low or if parties fail to cooperate.

The Kyoto Protocol (1997) is taking the lead in greenhouse gas emission reduction globally; Kyoto (1997) proposed three means of meeting targets by way of market-based mechanisms. "(1) emissions trading – known as 'the carbon market,' (2) the clean development mechanism (CDM), and (3) joint implementation (JI)."[28] Although the Kyoto Protocol has gained international acceptance, there are many criticisms regarding the mechanisms being used to stimulate green investment and allowing parties to meet their emission targets in a cost effective way. Kyoto has been described as "too little, too fast," by Barrett and Stavins.[29] Table 2, as shown in Appendix 7, describes alternative international policies for global climate change in an easy to read chart. The "too little, too fast" criticism of the Kyoto Protocol was given because it asks for "excessively costly short-term reductions in emissions, without

---

[27] Aldy, Joseph E., Scott Barrett, and Robert N. Stavins. "Thirteen Plus One: A Comparison of Global Climate Policy Architectures." *Climate Change Modeling and Policy*, 2003: Summary.

[28] United Framework Convention on Climate Change (UNFCCC). *Kyoto Protocol.* http://unfccc.int/kyoto_protocol/items/2830.php (accessed April 1, 2010).

[29] Aldy, Joseph E., Scott Barrett, and Robert N. Stavins. "Thirteen Plus One: A Comparison of Global Climate Policy Architectures." *Climate Change Modeling and Policy*, 2003: Summary.

determining what should be done over a longer timeframe."[30] A longer timeframe will allow for more credibility and better incentives for private corporations to make long-term investments.

A next-generation monitoring, assessment, and control system will aid the public in understanding the importance of monitoring energy consumption. Future control centers should be intuitive, publicly available, and fully automated in an easy to understand system. The system will allow the public to access a monitoring based measurement of their greenhouse gas emission and carbon consumption, and to thereby set attainable goals. "Real-time monitoring and control for state estimation and contingency analysis was initially developed in the 1960s."[31] The availability, implementation, control, and enforcement of future smart control systems will need to start from high government policy. Future work may lie in research and demonstration of the feasibility of the proposed concept of future smart control centers, including monitoring functions, assessment functions, and controllability. The technology of the twenty-first century can make future control centers a reality today.

Emily Wadhams is the vice president for public policy and directs the National Trust for Historic Preservation's Sustainability Program. Through federal policy, the National Trust for Historic Preservation is addressing issues such as climate change, the

---

[30] Aldy, Joseph E., Scott Barrett, and Robert N. Stavins. "Thirteen Plus One: A Comparison of Global Climate Policy Architectures." *Climate Change Modeling and Policy*, 2003: 478.

[31] Li, Fangxing, Pei Zhang, and Navin Bhatt. "Next Generation Monitoring and Control Functions for Future Control Centers." *North American Power Symposium NAPS*, 2008: 1.

energy crisis, green incentives, state and local policies, and an innovative program called "preservation green lab." Refer to Appendix 5 for more details on these positive actions.

The challenges facing global climate change are hard to quantify and monitor, but basically, they involve funding and tracking carbon emissions. Policy in a top-down democratic society like the United States affects building design and can help to bring order and action to a society seeking a clean energy future. Looking at Hawai‘i's political challenges from a state level will help to identify specific issues and ways to help mediate the energy crisis.

Hawai‘i's primary means of managing solid waste has been disposal in landfills. Table 2.1 indicates that the average American produces 4.6 pounds of solid waste daily, and residential waste comprises almost two-thirds of municipal solid waste. In 2006, the United States generated 251 million tons of trash.[32] This number will continue to grow with our nation's population.

[32] Sustainable Cities Institute. *Materials Management.* January 1, 2007. http://www.sustainablecitiesinstitute.org/view/page.basic/class/tag.topic/materials_management (accessed September 30, 2011).

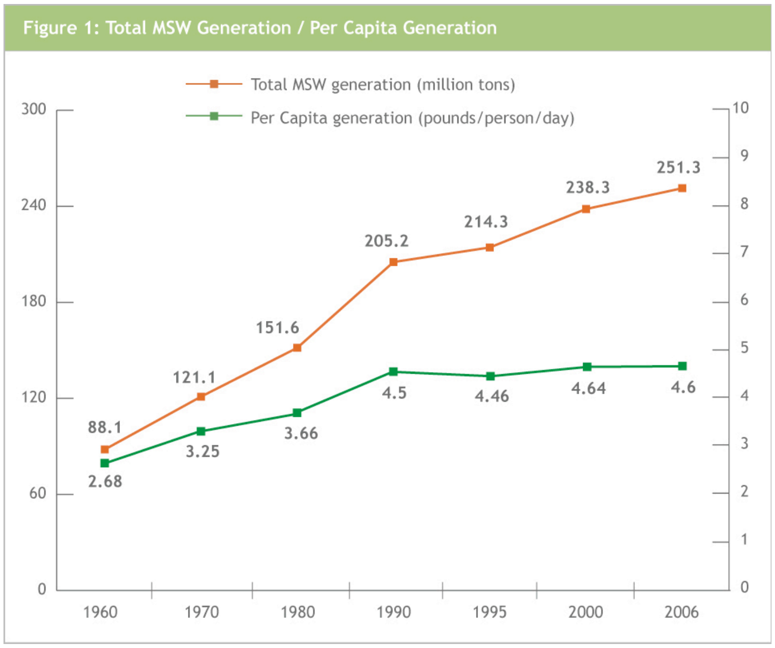


TABLE 2.1 America's Total Municipal Solid Waste Generation

Source: Sustainable Cities Institute

The shortage of landfills and the overall size of Hawai'i make it difficult to manage the waste generated by the population. However, by going back to the basics; using construction and demolition waste reduction programs; and educating the public, businesses, developers, contractors, and architects on how to use less, we can improve our management of construction and demolition waste. When designers and builders understand the negative impacts that waste has on the environment, they can be more proactive in reducing them.

The volume of construction and demolition waste continues to grow as older buildings are demolished to make way for new ones. The proper assessment of existing buildings is a way to help minimize construction and demolition waste.

Hawai‘i Challenge

Hawai‘i’s Energy Objectives

Hawai‘i’s energy policy is seeking to ensure dependable, efficient, and economical energy. Increasing self-sufficiency and decreasing our reliance on imported fossil fuels will result in greater energy security and reduce greenhouse gas emissions. In addition to greenhouse gas reductions, keeping energy production methods in Hawai‘i will help to control embodied energy. Hawai‘i’s energy objectives are described in the Hawai‘i Revised Statutes, Chapter 226-18, “Objectives and policies for facility systems – energy,” as amended:

> Planning for the State's facility systems with regard to energy shall be directed toward the achievement of the following objectives, giving due consideration to all:
>
> 1. Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;
> 2. Increased energy self-sufficiency where the ratio of indigenous to imported energy use is increased;
> 3. Greater energy security in the face of threats to Hawai‘i’s energy supplies and systems; and
> 4. Reduction, avoidance, or sequestration of greenhouse gas emissions from energy supply and use."[33]

[33] Hawaii Department of Business Economic Development and Tourism. *Energy, Resource, and Technology Division.* http://hawaii.gov/dbedt/info/energy/ (accessed April 2010).

Some of the reasons Hawai‘i is more efficient than the mainland average include high-energy prices that discourage energy use, little requirement for space heating, few energy-intensive industries, and short driving distances. Current solar power needs to be regulated due to the lack of grid supportability. “From the 1960’s to the late 1980’s oil was being used and reached its peak in 1989, accounting for 92% of total energy use.”[34] Since the 1990’s, H-power and more alternative and renewable resources have become more readily available and affordable. “Energy security includes supply security, price security or stability, and economic security.”[35] “Supply security” ensures that energy is available despite market disruptions elsewhere. Price stability is sought to protect against price fluctuations, which reduce economic security. Physical damage to energy infrastructure (i.e. natural disasters, terrorism) is possible due to modern technologies. Upkeep and proper maintenance are also extremely important to properly run an energy supply system. “ACT 234 established the State’s policy framework and requirements to lower Hawai‘i’s greenhouse gas emissions cost effectively by January 2020.”[36] Hawai‘i’s goal is to lower greenhouse gas emissions from 1990 to equal or lesser values by 2020 through the promotion of renewable and alternative resources, and lowered dependence on imported fossil fuels.

---

[34] Hawaii Department of Business Economic Development and Tourism. *Energy, Resource, and Technology Division.* http://hawaii.gov/dbedt/info/energy/ (accessed April 2010).

[35] Ibid

[36] Ibid

The impact of the service life and operating efficiency of a building are best illustrated in Table 2.2 below.[37] Although this project is being compared in Sydney, Australia and Ann Arbor, Michigan, the intent of comparing two separate regions is apparent. For a standard efficiency building, over a 100-year service life, the approximate percentage of the total carbon footprint of a building attributable to the embodied energy of materials is 15 percent, the other 85 percent being attributed to operations and maintenance. A shorter service life, in addition to increasingly more efficient buildings (as represented in the green line), has an inversely proportional impact of increasing the importance of embodied energy while decreasing the importance of operational energy to the total carbon footprint. As the USGBC embraces the 2030 challenge and buildings move to zero net carbon (rather than zero net energy as the buildings will always use energy), the embodied energy of the building materials may well surpass the operational energy footprint.[38]

---

[37] Reiner, Mark, Mark Pitterle, and Michael Whitaker. "How Do You Define Green?: Embodied Energy Considerations in Existing LEED Credits." *Symbiotic Engineering.* September 1, 2007. http://www.symbiotic-engineering.com/includes/content/publications/embodied_energy_considerations_in_existing_leed_credits.pdf (accessed November 20, 2010).

[38] Ibid

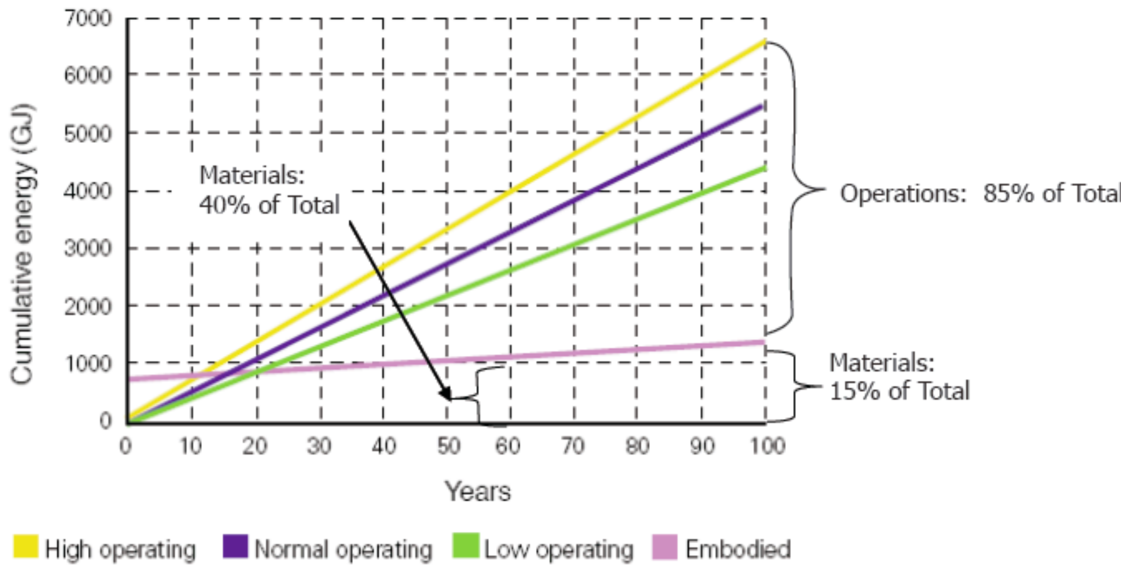


TABLE 2.2 Impact of Service Life and Operating Efficiency of Buildings

Source: Symbiotic Engineering

According to the Hawai'i County Integrated Resource and Solid Waste Management Plan, lumber accounts for 10 percent or more of materials disposed of in Hawai'i's county landfills. The wasteful mentality associated with construction and demolition needs to be re-evaluated and managed more efficiently. Materials are the heart and soul of building. Most of the building materials used in the construction of buildings in Hawai'i come from the United States west coast. While importing building materials to Hawai'i, we are shipping construction and demolition waste to landfills on the west coast to alleviate our state's overfilled landfills.

Hawai'i's Reliance on Importing Products

In the continued future and beyond, most of the nation's energy demands will still be met with fossil fuels and nuclear fission. In turn, fossil fuels are fast becoming a scarce world commodity due to the increasing demand for them. "Petroleum provides up to 75% of Hawai'i's energy needs. All of the petroleum products used in the State must be imported to the State."[39] Under normal circumstances, an estimated thirty-day supply of most petroleum products is stored at the oil terminals and tank farms on the island of O'ahu. The island's energy needs and economy could be in a catastrophic situation if a disaster were to occur.

Hawai'i has less than a seven-day supply of many foods, especially perishables. Some 90 percent of our food is still imported. Hawai'i will never be totally self-sufficient – the goal is to produce food for the local market efficiently enough to replace most imports. Hopefully, it will be done based on a philosophy of self-efficacy, sustainability, and stewardship reflecting "aloha 'āina" – love of the land.[40] The County of Hawai'i must decrease its energy costs and vulnerability. To do so, the county must combine efforts to achieve energy conservation efficiency and the development of natural renewable energy alternatives that reduce dependence on imported fossil fuels and increase energy efficiency. Looking at building retrofits and embodied energy is a step towards mediating logistics and our reliance on importing.

---

[39] County of Hawai'i. *ENERGY-County of Hawai'i.* January 1, 2011. www.co.hawaii.hi.us/general_plan_rev/revision/energy.doc (accessed October 26, 2011).

[40] Clements, Tom. *Alternative Hawai'i: Hawai'i's Agriculture Facing the Future.* February 1, 2005. http://www.alternative-hawaii.com/agriculture/index.htm (accessed September 22, 2011).

Hawai'i's Transportation Crisis

Hawai'i's isolation from the United States makes our reliance more pronounced. Importing construction products and exporting construction and demolition waste can create a burden on our state's economy and adds to the embodied energy of materials. Horizon Lines, Inc. is the nation's leading domestic ocean shipping and integrated logistics company.[41] The company offers three weekly, fixed-day direct sailings from Tacoma, Washington; Oakland, California; and Los Angeles, California to Hawai'i. Most of Hawai'i's products are shipped via freight container ships and/or barges from the United States west coast. "Freight shipping is one of the world's leading sources of carbon dioxide emissions that contribute to global climate change."[42] Shipping costs play a big role in bringing new construction materials to either build new buildings or retrofit existing ones.

Although Hawai'i's environment is one of the most unique in the world, we do not play much of a role in supplying the United States with nonfuel minerals. As seen in Appendix 15, nonfuel minerals add value to the U.S. gross domestic product (GDP) by supporting major industries that consume processed mineral materials.[43] Appendix 16 outlines the values of nonfuel mineral production in the United States and the principal nonfuel minerals produced in 2010 by Hawai'i. Hawai'i is ranked 46/50 and supplies

[41] Horizon Lines, Inc. *Horizon Lines Hawai'i.* January 1, 2010. http://www.horizonlines.com/Ocean-Services/Hawaii.aspx (accessed October 26, 2011).

[42] Ibid

[43] Major consuming industries of processed mineral materials are construction, durable goods manufacturing, and some nondurable goods manufacturers. The value of shipments for processed materials cannot be directly related to gross domestic product.

only 0.17 percent of U.S. crushed stone, construction sand and gravel, and natural gemstones. Although some of the crushed stone and construction sand and gravel could be kept on the island, most of the other construction materials (e.g. Portland cement, steel, gypsum, paints, and chemicals) need to be imported from the mainland U.S.

To help minimize transportation costs, Hawaiʻi needs to find ways to keep existing materials on site rather than continue importing more into the islands. Understanding the energy already expended in existing materials or buildings here can help alleviate our reliance on importing new products.

Policies and Programs

Policies and programs are a strong driving force toward change and participation. A number of current enacted policies provide national leadership and encourage compliance with the desire to conserve our national history and educate future generations. Acts, laws, and policies effectively serve the conservation of historic sites.

U.S. General Services Administration's Legacy Vision Policy

The United States General Services Administration's (GSA) historic preservation program provides technical and strategic expertise to promote the viability, reuse, and integrity of historic buildings. The Legacy Vision Policy is an inventory that the GSA is undertaking to review and file public buildings in a portfolio. The ultimate outcome is to provide quality workplaces, increase customer satisfaction, and enhance the asset value of real estate for the benefit of the taxpayer.[41] The strategies and policies are in place to control the stewardship and trusteeship for future generations to experience the significance the included historic buildings have had in history.

U.S. Federal Tax Incentive Programs

The Federal Historic Preservation Tax Incentives Program has enormous cultural, economic, and social impacts. It promotes the enhancement of the environment and quality of life in communities. As well, it leverages private investment in depressed

[41] LVP (2010). *Legacy Vision Policy: Restructuring the Owned Inventory.* February 19, 2010. http://www.gsa.gov/Portal/gsa/ep/contentView.do? contentType=GSA_BASIC&contentId=17977 (accessed April 19, 2010).

neighborhoods, creates jobs, promotes community preservation, fosters heritage education, enhances state and local tax revenues, and increases property values. Rehabilitation tax credits provide a 10 percent or 20 percent tax credit on the rehabilitation and renovation of old buildings for use as offices, hotels, apartments, etc. Conservation/façade easements offer an income tax deduction for the donation of a specified portion of a historic building. The Mills Act provides property tax relief in exchange for the continued preservation of historic properties. The Investment Tax Credit for Low-Income Housing provides a tax credit for the acquisition, construction, or rehabilitation of low-income housing and can be applied to historic structures. The new markets tax credit, relatively new, provides funding for qualified businesses and economic development activities that benefit low-income neighborhoods.[42]

Tax Reform Act of 1986

Under the provisions of the Tax Reform Act of 1986, a 20% tax credit is available for the substantial rehabilitation of commercial, agricultural, industrial, or rental residential buildings that are certified as historic. Over the past five years, 27,851 low and moderate income housing units were created in the United States, constituting 44 percent of the total number of housing units completed under the historic preservation tax credit program within that same time period. State Historic Preservation Offices and local governments are working with state housing agencies to encourage greater allocation of low income housing funds for rehabilitation rather than new construction of

[42] Los Angeles Planning and Zoning. *Adaptive Reuse Ordinance.* http://www.ladbs.org/rpt_code_pub/Ordinance.pdf (accessed April 2010).

affordable housing. Federal tax incentives raise equity capital from investors to help finance different kinds of development: affordable housing, economic development, and renovation of historic buildings. A low-income housing tax credit is awarded to developers to help fund the construction or rehabilitation of apartments for low-income renters.

The National Historic Preservation Act of 1966

The National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices created the Act; it was passed into legislation October 15, 1966. "The National Historic Preservation Act of 1966, as amended (16 U.S.C. § 470 et seq.), Executive Order 11593, Executive Order 13006, and Executive Order 13287 directs all Federal agencies to follow strict political laws."[43] The National Historic Preservation Act of 1966 helped to solidify a foundation for historic preservationists to preserve historical and archaeological sites in the United States of America and helps to save our National heritage.

U.S. Retrofit Ramp Up Program

In celebration of Earth Day 2010, the White House promised $452 million in ecoretrofits for homes in twenty-five communities across the U.S. as part of the all-new "Retrofit Ramp Up" program. The program is expected to "ramp up" energy efficiency in U.S. homes, create green collar jobs, and save Americans millions in utility bills. As part of the program, homeowners are eligible for rebates of up to $3,000 for their

---

[43] General Services Administration (GSA). *ADM 1020.2 Procedures for Historic Properties* . http://www.gsa.gov/Portal/gsa/ep/contentView.do?contentType=GSA_BASIC&contentId=12228 (accessed April 19, 2010).

ecoefforts.[44] With the help of the Retrofit Ramp Up Program, green collar jobs can help put Americans back to work and could offer more jobs in the construction/building sector.

Hawai'i County Integrated Resource and Solid Waste Management Plan

The 2009 County of Hawai'i Integrated Resources and Solid Waste Management Plan (IRSWMP) Update has been prepared in compliance with the Hawai'i Revised Statutes (HRS) Chapter 342G, which requires counties in Hawai'i to update and revise their solid waste management plans every five years. The last update to the plan was completed in 2002. Revision of the plan began in early 2008 and involved the participation of a Solid Waste Advisory Committee (SWAC), the County of Hawai'i Environmental Management Commission, the public, the business community, the County of Hawai'i Department of Environmental Management (DEM), the Office of the Mayor, the Solid Waste Division (SWD), the County Council, and numerous other stakeholders. The following executive summary comes from the December 2009 IRSWMP update from the State of Hawai'i:[45]

> This IRSWMP update includes an evaluation of waste management practices in the County, including waste reduction practices and programs, opportunities for implementation of zero waste policies and

---

[44] Biden, Joe (Vice President, 2010). *Remarks by the Vice President Announcing Recover Act "Retrofit Ramp Up" Awards on Even of Earth Day.* April 21, 2010. http://www.whitehouse.gov/the-press-office/remarks-vice-presidentannouncing- recovery-act-retrofit-ramp-awards-eve-earth-day (accessed April 22, 2010).

[45] State County of Hawai'i . *County of Hawai'i Integrated Resource and Solid Waste Management Plan.* Executive Summary, Honolulu: State County of Hawai'i , 2009.

practices, the status of both active and closed landfills, and potential options for expanding and extending the capacity of the South Hilo Sanitary Landfill (SHSL). The results are organized by section in accordance with HRS 342G. Each section contains a description of the existing conditions, a summary of the 2002 Integrated Solid Waste Management Plan (ISWMP) update recommendations and status of implementation of those recommendations, a description of options available to the County for improvement of the solid waste management program, and recommendations for implementation of selected options. The recommendations in this Plan are projected to increase the County's current recycling rate of 29 percent to a rate of 44 percent by the end of the planning period (FY 14-15).

County of Hawai'i Energy Plan

See Appendix 18 "County of Hawai'i – Energy."

3 Building Precedent Studies

JEAN VOLLUM NATURAL CAPITAL CENTER

KING STREET STATION REHABILITATION

BISHOP MUSEUM’S HAWAIIAN HALL

CITY OF LOS ANGELES ADAPTIVE REUSE ORDINANCE

Building Precedent Studies

Case Study: Jean Vollum Natural Capital Center

721 NW 9th Avenue, Portland, Oregon

Architecture Firm:

Holst Architecture

Building Date:

1895

Restoration Completion Date:

2001

Project Size (sf/site acreage):

79,000 SF

Project Use:

Office, Retail & Restaurant Space

Project Location:

Portland, Oregon

Budget ($/sq Ft, optional):

$183 /sq Ft or $12.8 million

Historic Preservationist:

Heritage Consulting Group

General Contractor:

Walsh Construction Co.

Owner:

Ecotrust

The Jean Vollum Natural Capital Center is an ideal model because it is a historic renovation located in a city that prides itself on progressive, sustainable-minded thinking, and that is used as a tool to open people's minds to sustainable design. It is located in the River District, or Pearl District, in northwest Portland, an old industrial area of warehouse buildings and thirty-four acres of rail yards. The River District is currently undergoing rapid development into high-density urban residential neighborhoods with art galleries, retail shops, restaurants, and green spaces, serviced by new Portland Streetcar lines.

The original building was a warehouse built in 1895 to store building supplies. The building is a classic example of Richardsonian Romanesque style architecture.[46] Ecotrust, the owner and a non-profit group, supports sustainability in the Pacific Northwest. Ecotrust added space and earned a LEED Gold rating, but it had less success convincing the National Park Service that it had followed the Secretary of Interior's Standards. The steps to register the building were addressed too late in the design process to obtain a spot on the National Register of Historic Places. Refer to Appendix 4 and 7 to see a more detailed breakdown of LEED categories and materials.

The Jean Vollum Natural Capital Center sets a high standard for other projects implementing green building in historic preservation. The progressive Portland setting at the public and private levels, although not absolutely required for success as can be proven in other case studies, does aid tremendously in promoting sustainable development and smart growth at an urban scale. Collaboration and understanding amongst the project players is essential; however, so is a clearly defined project mission at the outset. It certainly helps when all those involved strongly believe in the project concept, particularly when dealing with sustainable design applied to a historic nominated building. The goals and intentions of such projects should carry more than simple physical and economic goals; they should reflect a common belief and mindset in the stewardship of the built and natural environments.

---

[46] DiNola, Ralph. "Historic Preservation and Green Building: A Lasting Relationship." *Environmental Building News*, January 1, 2007: 6.

Case Study: Portland Center Stage Armory

128 Eleventh Avenue, Portland, Oregon

Architecture Firm:

GBD Architects

Building Date:

1891

Restoration Completion Date:

2006

Project Size (sf /site acreage):

56,000 SF

Project Use:

Performance Facility & Theater

Project Location:

Portland, Oregon

Budget ($/sq Ft, optional):

$675/sq Ft or $38.7 million

Historic Preservationist:

Heritage Consulting Group, John Tess

General Contractor:

Hoffman Construction

Owner:

Gerding Edlen Development

Oregon is one of the leaders in promoting the concept of sustainable design when it comes to building renewal. This is due to the progressive public, private, and governmental sectors collaborating to achieve a cohesive built and natural environment.

The Portland Armory is a nineteenth century building in the heart of Portland's Pearl District where the past and future have been incorporated in a seamless design. From its intended use as the first armory in Portland for the National Guard, it has been transformed into a performing arts center, a community space, and shining example of twenty-first century sustainable design. Over the decades, the building has served as an annex and drilling ground for the Portland Armory, a public events venue, and a retail space.[47] Today, through a unique public-private partnership and a million dollar project, the Portland Family of Funds and Portland Center Stage renovated the armory into a state of the art performance facility. In addition to funding the project, there were numerous other problems to solve, including, seismic upgrades; creating 56,000 square feet of space within a 20,000 square foot footprint; and maintaining the old growth Douglas fir trusses.

Portland, Oregon has been a hub for "smart development" and "sustainable practice" through governmental policies and public involvement. Despite the technology added to the building, it is listed on the National Register of Historic Places with a LEED Platinum rating. This case goes to show that there can be compromise between getting a building listed on the National Register and LEED certified.

The Gerding Theater at the Armory attracts more than 150,000 people annually for all manners of events. The theater hosts numerous delegations of architects and city planners interested in preservation, offering guided tours, media displays, and lecture series. Educating and involving the community has contributed significantly to the success of the Portland Armory project."[48] Refer to Appendix 2 for a more detailed breakdown of the LEED categories.

---

[47] Architectural Heritage Center. *Gerding Theater at the Armory Case Study.* April 15, 2008. http://www.visitahc.org/content/gerding-theater-armory-case-study (accessed November 23, 2010).

[48] Architectural Heritage Center. *Gerding Theater at the Armory Case Study.* April 15, 2008. http://www.visitahc.org/content/gerding-theater-armory-case-study (accessed November 23, 2010).

Case Study: Bishop Museum's Hawaiian Hall

1525 Bernice Street, Honolulu, Hawai'i

Architecture Firm:
Mason Architects Inc.
Building Date:
1889
Restoration Completion Date:
2009
Project Size (sf /site acreage):
56,000 SF
Project Use:
Museum
Project Location:
Honolulu, Hawai'i
Budget ($/sq Ft, optional):
$21 million
Interior Designer:
Ralph Appelbaum and Associates
Owner:
Charles Reed Bishop

The Bishop Museum's Hawaiian Hall is a special place within the Bishop Museum complex because it houses a rare collection of Hawaiian artifacts found nowhere else in the world. Hawaiian Hall is also a rare example of a Victorian museum, originally designed by C.W. Dickey and Ripley in 1903. The architectural firm handling the restoration project won a 2010 American Institute of Architects (AIA) Honolulu Award.

Mason Architects designed the Phase I restoration and improvement of the historic Hawaiian Hall Complex. The complex was built in three stages, from 1888 to 1903, by Charles Reed Bishop, who created a museum to house the collection of Hawaiian artifacts owned by his wife, Princess Bernice Pauahi Bishop, who died in 1884. Mason Architects' Historic Structures Report documented the building's significance and history of alterations, and recommended guidelines for its preservation. Originally, skylights and double-hung windows provided all the lighting and ventilation for the complex, but over the years, many of these openings were filled in, sometimes to the detriment of the building's appearance and environmental sustainability.[49]

Ralph Appelbaum has worked on numerous new and restored museums around the world, from the American Museum of Natural History to the new United States Holocaust Memorial Museum.[50] Working with the museum staff and exhibit designer, Ralph Appelbaum and Associates, and Mason Architects, brought the complex up to state of the art museum standards without compromising its historic integrity.

The three floors of Hawaiian Hall take visitors on a journey through the different realms of Hawaiʻi. The first floor is the realm of Kai Ākea, which represents the Hawaiian gods, legends, beliefs, and the world of pre-contact Hawaiʻi. The second floor, Wao Kanaka, represents the realm where people live and work, focusing on the importance of the land and nature in daily life. The third floor, Wao Lani, is the realm inhabited by the gods; here, visitors learn about the aliʻi and key moments in Hawaiian history.[51]

[49] Mason Architects Inc. *Hawaiian Hall Complex.* June 1, 2009. http://www.masonarch.com/projects/museum/hawaiian_hall.html (accessed November 23, 2010).

[50] Leidermann, Mike. *Bishop Museum's Extreme Makeover.* January 7, 2007. http://the.honoluluadvertiser.com/article/2007/Jan/07/il/FP701070320.html (accessed November 23, 2010).

[51] The Bishop Museum. *Main Exhibit Hall: Hawaiian Hall.* April 1, 2010. http://www.bishopmuseum.org/exhibits/continuing.html (accessed November 23, 2010).

***Case Study: City of Los Angeles Adaptive Reuse Ordinance*[52]**

The state of California has one of the strictest building codes and greatest support for minimizing global climate change. California's climate plan involves a number of key strategies such as a "cap-and-trade program, Pavley standards, tax benefits and incentives, and monitoring systems."[53] The following case study analyzes California's adaptive reuse of existing buildings as a means of remedying energy consumption and global climate change.

In 1999, the City of Los Angeles adopted landmark legislation to encourage the conversion of its downtown's mostly historic office buildings into lofts, apartments, and hotels. The legislation applies to non-residential buildings including industrial buildings. The Adaptive Reuse Ordinance (ARO) is applicable to the reuse of historically designated buildings, both local and national landmarks. Attention is also paid to existing industrial uses. The ordinance notes that an adaptive reuse site must not be detrimental to the safety and welfare of future residents and that a reuse project will not displace existing industrial uses.

The ARO's mission was to revitalize downtown's cultural resources to attract residents and visitors who would bring vitality to the urban core, while addressing the

---

[52] Citywide Adaptive Reuse Ordinance, Section 12.24 X 1. Excerpt from the Los Angeles Municipal Code. Adopted by Ordinance No. 172,571, effective June 3, 1999. Amended by Ordinance No. 174,315, effective December 20, 2001. Amended by Ordinance No. 175,588, effective December 1, 2003.

[53] State of California Energy Commission. *California Climate Change Policy & Programs: California's Climate Plan.* April 1, 2009. http://www.climatechange.ca.gov/policies/2010-01-27_FACT_SHEET_SCOPING_PLAN.PDF (accessed April 23, 2010) 1.

city's housing crisis. The ARO works by significantly reducing the time required to obtain a building permit. Adapting an industrial or a commercial building for residential use traditionally required compliance with numerous rules and regulations. The ordinance cut through this 'red tape.' The advantage has been significant, enabling the city to leverage an extraordinary amount of private sector investment with a minimum of public subsidy. The provisions streamline the application process and provide significantly more flexibility in meeting building code and zoning requirements. Many non-compliant site conditions (including building height, parking, floor area, and setbacks) are permitted without requiring a variance. Residential density requirements are also waived. See Appendix 3 for the changes and successes of this particular project.

Developers, design professionals, owners, and other team members face many regulatory and financial barriers when undertaking the adaptive reuse of a historic industrial building. Issues range from contamination to historic preservation design review to securing funds to designing a new use. There are, however, countless tools and incentives available to aid the adaptive reuse field, and they are increasingly geared specifically to aiding the growing industrial conversion movement.

There are several types of aforementioned tax incentives, which can help preserve historic buildings. Other construction-based incentives offer additional flexibility in meeting building code requirements, which can make potential projects significantly more affordable.

The adaptive reuse process will continue to evolve and become less regulated as innovations become mainstream and the reuse of buildings becomes a more integral component of smart growth and revitalization strategies. It is only a matter of time before the aesthetic, historic, revitalizing, and sustainable advantages of adaptive reuse are truly valued and favored.

4 Metric Precedent Studies

JOSEPH VANCE BUILDING

PORTLAND CENTER STAGE ARMORY

FIFTH + COLUMBIA TOWER

UNIVERSITY OF SAN DIEGO CALIFORNIA EXISTING BUILDING RELOCATION

Metric Precedent Studies

Case Study: Joseph Vance Building

1402 Third Avenue, Seattle, Washington

Architecture Firm:

Zimmer Gunsul Frasca Architects LLP

Building Date:

1929

Restoration Completion Date:

2007

Project Size (sf /site acreage):

138,000 SF

Project Use:

Office & Retail

Project Location:

Seattle, Washington

General Contractor:

Turner Construction Company

Structural Engineer:

Magnusson Klemencic Associates

Mechanical Engineer:

ARUP

Owner:

Jonathan Rose Companies, LLC

The Joseph Vance Building in downtown Seattle, Washington is an example of the renewal of an existing building. The building's original intentions paid close attention to energy efficiency even though it was first built in the early twentieth century. The term "sustainability" has been around for a long time and is just the basis of energy efficient design. The new owner of the building wanted to bring it up to current office standards, provide an environmentally friendly environmental project, and eliminate the desire to demolish and rebuild.

The owner had a vision to utilize as much existing material as possible and to minimize construction waste coming from the site. Seattle is in an area with a number of fabricators; manufacturers; and reclaimed, recycled, and renewable materials. The embodied energy, especially in terms of transportation cost, is substantially lower since all of these resources are nearby. Local materials and resources reduce the overall carbon footprint of the life of a building. Regional location plays a role that is hard to quantify, and LEED needs to clearly identify these regional issues.

The Joseph Vance Building is located in a "smart growth" location for its ability to provide sustainable office space near bus and light rail lines. The building is among the first in a portfolio of investments by this developer that focus on buildings near mass transit for green renovation purposes.

Company founder Jonathan F.P. Rose said, "The building's location near the bus tunnel fits the fund's philosophy of making investments in 'smart growth' spots such as downtowns and 'walkable Main Streets' rather than in suburban settings that depend on parking lots. The strategy is 'environmentally right' because it gives tenants options for commuting to work." Rose added, "but also we think it gives better economic returns."[54]

With these goals in mind, the candidate was a natural candidate for LEED for Existing Buildings (LEED-EB), a newer policy-based rating system developed by the USGBC, which helped drive some of the major building retrofits. "The project is currently on track to earn LEED-EB Gold certification, and earned an Energy Star score

---

[54] American Institute of Architects (AIA). *What Makes it Green?* January 14, 2007. http://wmig.aiaseattle.org/node/151 (accessed November 16, 2010).

of 97 (putting it in the top 4% of its peers)."[55] Refer to Appendix 1, to see greater detail of the LEED-Existing Buildings breakdown of categories.

The renovation of the fourteen-story historic office building in downtown Seattle focused on restoring the building's original materials and passive sustainable design functions such as high ceilings, terrazzo floors, operable windows, and floor plan layouts designed to maximize natural light. Since completion of the renovation, occupancy has increased from 68% pre-renovation to over 90%, the building earned LEED-EB Gold certification and an Energy Star Score of 96, and the project team continues to examine and fine-tune building performance through energy monitoring, post-occupancy surveys and a current re-greening effort.

Table 4.1, a summary from the Athena EcoCalculator, breaks down the building's existing assembly systems (foundation, columns and beams, intermediate floors, exterior walls, windows, interior walls, and roof). The Athena EcoCalculator measures the environmental effects of building materials and their related processes. This lifecycle assessment tool accounts for the impacts of a product, material, or process based on the effects of obtaining the raw materials, the processes through which those raw materials go to become usable products, the assembly of those products into a structure, the maintenance and operations required to maintain those products, the effects of disposing

[55] American Institute of Architects (AIA). *What Makes it Green?* January 14, 2007. http://wmig.aiaseattle.org/node/151 (accessed November 16, 2010).

of the product after its useable life, and the transportation impacts that arise between each of those phases.[56]

Joseph Vance Building	Total area	Fossil Fuel Consumption (MJ) TOTAL	Weighted Resource Use (tons) TOTAL	GWP (tons CO2eq) TOTAL	Acidification Potential (moles of H+ eq) TOTAL	HH Respiratory Effects Potential (kg PM2.5 eq) TOTAL	Eutrophication Potential (g N eq) TOTAL	Ozone Depletion Potential (mg CFC-11 eq) TOTAL	Smog Potential (kg NOx eq) TOTAL
Foundations & Footings	9,285	238,292	278	36	11,947	85	6,499	118	122
Columns & Beams	111,428	4,874,934	423	197	85,380	392	345,701	2	520
Intermediate Floors	126,000	7,206,322	3,447	566	177,247	1,075	310,497	764	1,276
Exterior Walls	47,565	6,129,401	777	711	776,124	9,380	252,556	1,297	4,757
Windows	15,855	7,047,810	580	625	1,025,438	8,771	235,396	2,084	5,175
Interior Walls	76,500	2,581,836	318	117	47,583	738	42,312	26	393
Roof	9,285	947,942	414	80	32,640	201	28,142	178	704
TOTALS	-	29,026,537	6,236	2,331	2,156,359	20,643	1,221,102	4,470	12,947

TABLE 4.1 Existing Building's Embodied Energy

Source: Athena EcoCalculator

[56] Athena Sustainable Materials Institute . *EcoCalculator Overview* . January 11, 2011. http://www.athenasmi.org/tools/ecoCalculator/ (accessed September 30, 2011).

Table 4.1A, represents the total existing embodied energy within the Joseph Vance Building. This measurement is the baseline amount of energy within the building before any retrofits or renovations. Fossil Fuel Consumption in megajoules (MJ) and Global Warming Potential (GWP) in tons of carbon dioxide equivalent both measure embodied energy. The results are measurements that take into account resource extraction and processing, product manufacturing, on-site construction of assemblies, all related transportation, maintenance and replacement cycles over an assumed building service life of fifty years, and structural system demolition and transportation to a landfill or recycling center.[57]

Joseph Vance Building	Conversion Factor TOTAL	Units	BEES EE Value (MJ/unit)	Embodied Energy (MJ) TOTAL
Steel	300,000	SF	8.9	2,670,000
Concrete	75,000	tons	160	12,000,000
Grand Total				14,670,000

TABLE 4.1A Building Retrofit's Embodied Energy

Source: BEES

Figure 4.1A, represents the total amount of fossil fuel consumption, in megajoules, of the building's seismic retrofit. Steel and concrete were used for the building's structural piles and reinforced frame to provide a more rigid structure. Adding the existing building's embodied energy (29,026,537 MJ) to its seismic retrofit (14,670,000 MJ), we can now see the current building's total embodied energy (43,696,537 MJ).

[57] Athena Sustainable Materials Institute . *EcoCalculator Overview* . January 11, 2011. http://www.athenasmi.org/tools/ecoCalculator/ (accessed September 30, 2011).

Case Study: King Street Station Rehabilitation

303 S. Jackson Street, Seattle, Washington

Architecture Firm:

Zimmer Gunsul Frasca Architects LLP

Building Date:

1906

Restoration Completion Date:

2011

Project Size (sf /site acreage):

60,000 SF

Project Use:

Public Transportation Hub and Office Space

Project Location:

Seattle, Washington

Budget ($/sq Ft, optional):

$3,333 / sq. Ft. or $200 million

Historic Preservationist:

Artifacts Consulting Inc.

General Contractor:

Sellen Construction

Structural Engineer:

ARUP

Owner:

Seattle Department of Transportation

Constructed in 1906, King Street Station, once a gateway for millions of travelers coming into Seattle and the Pacific Northwest, played a major role in establishing Seattle as a major metropolitan city. But the station, which is on the National Register of Historic Places, had fallen into disrepair with the decline in train travel in the latter half of the century. The sustainable seismic retrofit and renovation of the historic structure not only preserves the building and the materials and energy required to build it, but also respects and restores the craftsmanship of its time and strengthens its role as a regional transportation hub and neighborhood link.

Rehabilitation elements of the project include the iconic twelve-story clock tower, forty-five-foot-high ornamental plaster ceilings and halls, terrazzo and mosaic tile floors, and operable windows. True to the building's original fashion, the white marble wainscoting, decorative sconces, and glass globe chandeliers that were removed during 'modernization' of the station in the 1950s will be replicated and replaced. The rehabilitation also includes significant seismic and structural updates to improve the building's safety and durability, all which will comply with the city's sustainable building standards and the Secretary of the Interior's Standards and Guidelines for Historic Preservation.

A number of sustainable strategies and systems are envisioned to increase building performance including natural ventilation, replacement of all mechanical systems with a new ground-source heat pump, and energy and water efficient lights and fixtures. Energy models predict the building to use 35.8 KBTU/sf/yr, performing 56.4% better than the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) 2007 standards and meeting benchmarks of the 2030 Challenge. The project is anticipated to achieve a LEED Gold certification at minimum.[58] The reuse and improvements to the functions of this historic rail station helped to reduce the building's energy use by 90%.

Bringing together the diverse interests of the City of Seattle, the Seattle Department of Transportation, local businesses, and nearby developers with a common goal, Zimmer Gunsul Frasca Architects' (ZGF) explored opportunities to incorporate district-wide sustainable design strategies while also enhancing existing pedestrian and

---

[58] DiNola, Ralph. "Historic Preservation and Green Building: A Lasting Relationship." *Environmental Building News*, January 1, 2007: 6.

vehicular connections to strengthen the station's relationship to both existing and future developments. Most notably, the station's location at the edge of a proposed 3.85-acre mixed-use redevelopment effort offers an opportunity to share water and energy resources. A rainwater harvesting system will capture runoff to be used for toilet flushing in the building with the potential to expand and share excess resources with adjacent future developments.

The King Street Station Rehabilitation cost options, see Appendix 9, were referenced to determine the embodied energy in the building's rehabilitation retrofit. This project is a unique case in which the retrofit of the building has a higher overall fossil fuel consumption than the existing building's degraded state. This is due to the special manpower and hours required to restore a building over 100 years old, the large quantity of steel and concrete required to seismically retrofit a National Historic Landmark, and the retrofitting technologies used to bring the building up to twenty-first century energy-use standards.

Table 4.2 breaks down the building's existing assembly systems (foundation, columns and beams, intermediate floors, exterior walls, windows, interior walls, and roof).

King Street Station (Phase 2)	Total area	Fossil Fuel Consumption (MJ) TOTAL	Weighted Resource Use (tons) TOTAL	GWP (tons CO2eq) TOTAL	Acidification Potential (moles of H+ eq) TOTAL	HH Respiratory Effects Potential (kg PM2.5 eq) TOTAL	Eutrophication Potential (g N eq) TOTAL	Ozone Depletion Potential (mg CFC-11 eq) TOTAL	Smog Potential (kg NOx eq) TOTAL
Foundations & Footings	50,875	1,305,665	1,523	199	65,463	467	35,612	649	669
Columns & Beams	50,875	3,068,190	1,551	256	92,157	604	201,827	655	721
Intermediate Floors	50,875	3,618,569	1,477	256	85,111	670	130,302	317	635
Exterior Walls	29,000	6,977,110	1,123	522	352,616	2,470	185,972	913	2,139
Windows	14,500	1,953,409	374	332	304,663	4,789	116,054	446	2,271
Interior Walls	15,500	820,857	122	44	17,829	209	11,952	19	139
Roof	50,875	4,309,112	406	200	82,920	537	88,565	18	2,262
TOTALS	-	22,052,911	6,577	1,810	1,000,759	9,747	770,284	3,016	8,837

TABLE 4.2 Existing Building's Embodied Energy

Source: Athena EcoCalculator

Table 4.2A represents the total existing embodied energy within the King Street Station Rehabilitation project.

King Street Station phase 2a	Conversion Factor TOTAL	Units	ICE EE Value (MJ/kg)	BEES EE Value (MJ/unit)	Embodied Energy (MJ) TOTAL
Masonry	7,235	SF		79.6	575,906
Gypsum Board	18,900	SF		29.4	555,660
Steel	716,949	kg	20.1	8.9	14,410,680
Concrete	4,556,730	kg	0.75	160	3,417,548
Wood	95,590	SF		5.03	480,818
Grand Total					19,440,611

King Street Station phase 2b	Conversion Factor TOTAL	Units	ICE EE Value (MJ/kg)	BEES EE Value (MJ/unit)	Embodied Energy (MJ) TOTAL
Masonry	3,947	SF		79.6	314,181
Gypsum Board	2,800	SF		29.4	82,320
Steel	1,199,298	kg	20.1	8.9	24,105,894
Glass/Glazing	2,125	SF		134.72	286,280
Concrete	4,759,435	kg	0.75	160	3,569,577
Wood	6,985	SF		5.03	35,135
Grand Total					28,393,387

TABLE 4.2A Building Retrofit's Embodied Energy

Source: BEES

Table 4.2A represents the total amount of fossil fuel consumption, in megajoules, of the building's seismic retrofit and restoration. Steel and concrete were used for the building's structural piles and reinforced frame to provide a more rigid structure. The other materials – masonry, gypsum board, and wood – were used in the renovation and restoration. The rehabilitation of King Street Station went through three phases of construction; Figure 3.2A encompasses the last two phases, which comprised the majority of the work. Adding the existing building's embodied energy (22,052,911 MJ) to the restoration and seismic retrofit (47,833,998 MJ) yields the current building's total embodied energy (698,886,909 MJ).

***Case Study: Fifth + Columbia Tower**

Fifth Avenue & Columbia Street, Seattle, Washington

Architecture Firm:
Zimmer Gunsul Frasca Architects LLP
Building Date:
Not Built
Project Size (sf /site acreage):
950,000 SF
Project Use:
Office and Retail
Project Location:
Seattle, Washington
Mechanical Engineer:
Syska Hennessy Group
Structural Engineer:
ARUP
Ownership:
Fifth & Columbia Investors, LLC
Development:
Daniels Real Estate, LLC

The tower being planned for this downtown Seattle corner has a unique story, mainly due to the history of the block on which it sits. The new Fifth + Columbia office tower's forty-three-story footprint sits on a quarter of a block in Seattle's downtown financial district. The other three-quarters of the block have been home to the historic Rainier Club, a registered historic landmark, and the First United Methodist Church (FUMC) sanctuary building, a late eighteenth century Byzantine style church. It took nearly twenty-five years of preservation efforts to save the First United Methodist Church from the demolition ball.

The Rainier Club is downtown Seattle's preeminent private club and a historical landmark on the National Register of Historic Places; it was founded in 1888 in what was then the Washington Territory (statehood came the following year).[59] The club became an organization on July 25, 1888, led by civic and business leaders including Judge Thomas Burke (1849-1925), W. A. Peters, and E. M. Carr. The original wing of the club building, located on 820 Fourth Avenue in downtown Seattle, was designed by Kirtland Cutter (1860-1939) and completed in 1904.[60]

The First Episcopal Church Sanctuary was built in 1908 and occupies the northeast corner of the block bounded by Fifth Avenue and Marion Streets in downtown Seattle. The orignal intention for the property was to demolish the sanctuary building and build a thirty-four-story highrise on the half block parcel. In 2008, the preservation battle gained national attention because it pitted the public's right to control zoning over a religious institution's right to freely practice religion. In a 5 to 4 vote, the Washington State Supreme Court ruled in favor of the congregation and allowed for the demolition of the building without city landmark protection. After years of negotiation, an agreement to save the building and construct a new facility for the congreation was reached in 2007.[61]

---

[59] The Rainier Club. *Rainier Club Home Page.* January 1, 2006. http://www.therainierclub.com/ (accessed September 14, 2011).

[60] Crowley, Walt. *HistoryLink.org Essay 2959: Rainier Club (Seattle).* January 27, 2001. http://www.historylink.org/index.cfm?DisplayPage=output.cfm&File_Id=2959 (accessed September 14, 2011).

[61] Kreisman, Larry. *Daniels Recital Hall: History of Building.* January 1, 1984. http://recitalhall.fifthandcolumbia.com/history.html (accessed September 14, 2011).

The FUMC seismic retrofit cost options, see Appendix 8, were referenced to determine the embodied energy in the building's seismic retrofit. The purpose of this project was to quantify the existing building's embodied energy. Saving the FUMC was an important part of the Fifth + Columbia office tower project's site design and green principles. From the beginning, the developers wanted to keep and reuse the adjacent eighteenth century building. The goal to keep the historic building has been achieved, and this metric study of embodied energy shows the environmental savings.

Table 4.3 breaks down the building's existing assembly systems (foundation, columns and beams, intermediate floors, exterior walls, windows, interior walls, and roof).

Fifth + Columbia (FUMC)	Total area
Foundations & Footings	12,420
Columns & Beams	24,840
Intermediate Floors	12,420
Exterior Walls	37,380
Windows	1,500
Interior Walls	3,500
Roof	12,420
TOTALS	-

Fossil Fuel Consumption (MJ) TOTAL	Weighted Resource Use (tons) TOTAL	GWP (tons CO2eq) TOTAL	Acidification Potential (moles of H+ eq) TOTAL	HH Respiratory Effects Potential (kg PM2.5 eq) TOTAL	Eutrophication Potential (g N eq) TOTAL	Ozone Depletion Potential (mg CFC-11 eq) TOTAL	Smog Potential (kg NOx eq) TOTAL
318,749	372	49	15,981	114	8,694	158	163
1,498,061	757	125	44,996	295	98,543	320	352
883,393	361	63	20,778	164	31,810	77	155
4,209,106	1,141	207	112,089	621	45,709	88	1,196
666,775	55	59	97,014	830	22,270	197	490
118,123	15	5	2,177	34	1,936	1	18
1,982,742	1,210	191	65,550	458	60,655	492	1,017
9,676,949	3,910	699	358,586	2,515	269,617	1,334	3,391

TABLE 4.3 Building Assembly Life Cycle Analysis

Source: Athena EcoCalculator

Table 4.3A represents the total existing embodied energy within the First United Methodist Church project.

Fifth + Columbia		Conversion Factor TOTAL	Units	ICE EE Value (MJ/kg)	BEES EE Value (MJ/unit)	Embodied Energy (MJ) TOTAL
Carpet		1,560	SF		75.9	118,404
Gypsum Board		2,000	SF		29.4	58,800
Steel		57,379	kg	20.1	8.9	1,153,327
Concrete		29,393	kg	0.75	160	22,045
Wood		28,460	SF		5.03	143,154
Grand Total						1,495,729

TABLE 4.3A Building Retrofit's Embodied Energy

Source: BEES

Table 4.3A, represents the total amount fossil fuel consumption, in megajoules, of the building's seismic retrofit. Steel and concrete were used for the building's structural piles and reinforced frame to provide a more rigid structure. The remaining materials – carpet, gypsum board, and wood – are being used to renovate the interior. Adding the existing building's embodied energy (9,676,949 MJ) to its seismic retrofit (1,495,729 MJ) yields the current building's total embodied energy (11,172,678 MJ).

Case Study: University of California San Diego Existing Building Relocation

9500 Gilman Drive, La Jolla, California

Architecture Firm:

Zimmer Gunsul Frasca Architects LLP

Building Date:

August 2013

Project Size (sf /site acreage):

196,000 SF

Project Use:

Office, Classroom, Laboratory and Research

Project Location:

La Jolla, California

Budget ($/sq Ft, optional):

$918 / sq. Ft. or $180 million

General Contractor:

McCarthy Building Companies, Inc.

Structural Engineer:

KPFF

Mechanical & Plumbing Engineer:

IBE Consulting Engineers

Electrical Engineer:

Integrated Engineering Consultants

Ownership:

University of California San Diego,

School of Medicine

The University of California San Diego (UCSD) will construct a 196,000 square foot, five-story building consisting of office, research, and classroom space. The new facility will be the called the Health Sciences Biomedical Research Facility 2 (HSBRF2). The building will provide new wet research laboratories, laboratory support space, core labs, offices, and animal facilities for the School of Medicine.

Before the new UCSD School of Medicine HSBRF2 can be built, the three existing buildings will need to be managed to achieve a Materials & Resources, Construction Waste Management LEED credit, and an Innovation in Design, Existing Building Relocation LEED credit.[62] The intent of this Innovation in Design credit is to show that the UCSD School of Medicine HSBRF2 project is extending the lifecycle of existing building stock, conserving resources, and reducing construction waste by relocating two existing buildings from the new project site to another site on campus property for reuse.

The U.S. Green Building Council (USGBC) and LEED have established a precedent in stating that this approach is acceptable and warrants an Innovation and Design credit. As described in the Credit Interpretation Ruling located on the USGBC LEED website:

> *"The relocation of the…structure… warrants an innovation point, as this reuse measure achieves a higher environmental impact than recycling of the materials...alone."*[63]

Public Credit Interpretation Rulings
Credit Interpretation Request: 7/26/2007; Ruling: 8/16/2007

[62] McCarthy Building Companies, Inc. *McCarthy Lands Construction Contract for $90 Million UCSD Health Sciences Biomedical Research Facility.* August 5, 2009. http://www.mccarthy.com/news/2009/08/05/ucsd-health-sciences-biomedical-research-facility/ (accessed September 20, 2011).

[63] Green Building Certification Institute. *Project Credit Interpretation Rulings* . January 1, 2011. http://www.gbci.org/CIRs.aspx (accessed August 20, 2011).

The existing buildings currently on the project site and within the new project LEED boundary total 10,542 GSF: Date Building, 3,639 GSF; Evergreen Building, 4,743 GSF; and Fir Building, 2,160 GSF. The two relocated buildings, Fir and a portion of Evergreen, total 3,540 GSF. Including the demolished building area (7,002 GSF between the remaining portion of Evergreen and Date), the project site includes 10,542 GSF of building area on 1.32 acres (LEED boundary = 57,645 GSF or 1.32 acres).[64] The Figure 4.4 Building Relocation Map shows the existing and new locations of the relocated buildings. The existing location is in the heart of the main University of California San Diego campus, and the new location is located approximately nine miles east on the campus' Elliot Field Station property.

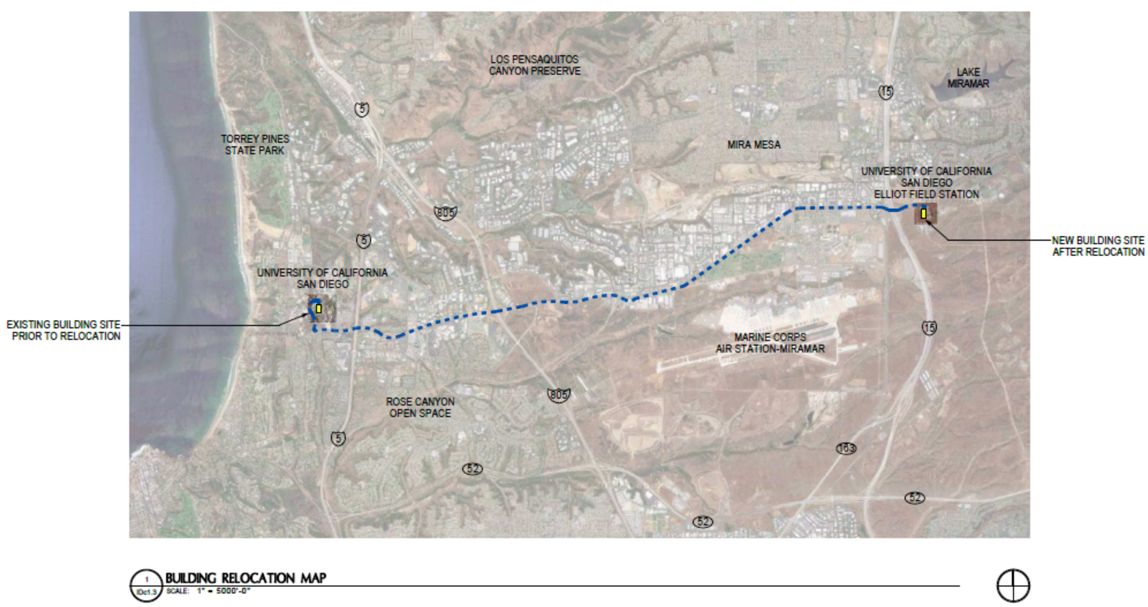


FIG 4.4 Building Relocation Map

Source: UCSD

[64] Zimmer Gunsul Frasca Architects LLP. *Innovation in Design Credit Narrative.* Credit Narrative, San Diego: LEED NCv2.2 Documentation IDc1.3, 2011.

All of the buildings are constructed with the following materials:

- **Roof and ceiling**
  - Metal roofing over plywood sheathing with R-19 thermal insulation between 6” exterior grade solid wood joists
  - Suspended 2x4 acoustical lay-in ceiling in metal grid ceiling system
  - 2x4 lay-in troffer light fixtures
  - 2x2 supply and return air grills
  - (2) 30”x30” skylights operable from interior
- **Exterior walls**
  - 5/8”x4” T1-11 textured wood siding over plywood sheathing on 2x4 exterior grade solid wood studs at 16” o.c. with R-11 insulation and 5/8” painted interior gypsum board extending from floor to roof structure
  - Solid wood fascia, sill and window trim, and baseboards
  - Single-hung, single-pane bronze-tinted windows in anodized aluminum frames with insect screens, fixed spandrel glass panels from finish ceiling to structure, and interior window mini-blinds
  - Aluminum entry door in aluminum frame with ¼” tempered bronze glass
- **Floor structure and finish**
  - ¾” tongue and groove exterior grade plywood over moisture vermin proofing membrane over steel z joists and continuous perimeter steel tubes
  - Carpet throughout with 2-1/2” rubber base
  - Sheet vinyl with integral cove to 48” AFF at toilet room
- **Interior walls and finish**
  - 2x4 solid wood studs at 16” o.c. with 5/8” painted gypsum board on both sides with painted wood trim on all windows
  - Flush, solid core wood doors with metal frames throughout

TOTALS	LN. FT.	SQ. FT.	CU. FT.	WT. (lbs)	WT. (tons)
2 x 6 Dimensional Lumber	5119.76			10239.51	5.119755
2 x 4 Dimensional Lumber	5789.97			8446.85	4.223425
2 x 10 Solid Wood Joist	3052.35			10286.42	5.14321
5/8" Plywood		10703.62		18946.25	9.473125
3/4" Plywood		5668.67		12074.27	6.037135
5/8" Gypsum Board / Drywall		15742.47		40920.41	20.460205
Fiberglass Insulation			139077.75	278155.54	139.07777
Steel	4799.5			44933.72	22.46686
Carpet		5061.99		10123.98	5.06199
Vinyl Tile		107		149.8	0.0749
20 Gauge Metal Decking		5668		14170	7.085
Windows		509.54		4076.32	2.03816

TABLE 4.4A Material Takeoffs and Weight Conversions

Source: UCSD

WARM TOTALS	WT. (tons)
Dimensional Lumber	29.99665
Glass	2.03816
Mixed Metals	29.55186
Carpet	5.06199
Drywall	20.460205
Fiberglass Insulation	139.07777
Vinyl Flooring	0.0749

TABLE 4.4B WARM totals, Weight Conversions & Material Categories

Source: UCSD

Table 4.4A shows a material takeoff summary of each of the three buildings – Fir, Evergreen & Ivy – at the UCSD HSBRF2 site. The takeoffs were taken from CAD drawings to find specific linear, square, or cubic footage. Weight conversions, as seen in Appendix 10, were calculated from these measurements. Table 4.4B shows the material categories and the accompanying weight conversions. The Athena EcoCalculator and Waste Reduction Model (WARM) were used to calculate embodied energy (see Appendices 11 and 12).

The Athena EcoCalculator software tool was used to determine the existing embodied energy of the three buildings on the UCSD HSBRF2 site. Table 4.4C represents the total existing embodied energy within the three buildings on the UCSD HSBRF2 site.

5 Gartley Hall: Hawaiʻi Application

BACKGROUND HISTORY

WHAT IS A MEGAJOULE?

Gartley Hall: Hawai‘i Application

Gartley Hall went up in 1922, making it the third permanent building on campus. It became the new home of chemistry and physics classes. Today, Gartley houses the Psychology Department. The architect of the structure was J. H. Craig; he added a Grecian architectural style to the building. The building was remodeled in 1964 at a cost of $197,968; the legislature had appropriated $142,000 in 1919 for the original building.[65]

Gartley Hall was called the “Laboratory Building” for a few months, but was renamed in 1922 after the first Chairman of the Board of Regents. Alonzo Gartley was a Navy officer who settled in the territory in 1900 and was the manager of Hawaiian Electric Company when he was appointed a regent in 1907. After 1910, Gartley became a vice president of C. Brewer and Co. On February 2, 1922, the regents had planned to name the building after George B. Carter, the territorial governor who had signed the act in 1907 that established the College of Hawai‘i. However, on March 17, 1922, they decided not to because they felt that doing so would antagonize some of the Hawaiians. On July 11, 1922, the Board named it after Gartley who died a year later.[66]

---

[65] Souza, Elsa and Norwood, Charles. "Gartley Hall (1922)." In *Building a Rainbow*, by Victor N. Kobayashi, 35. Honolulu: Hui O Students University of Hawai‘i at Mānoa, 1983.

[66] Ibid

This doctoral thesis is meant to help people understand the retrofitting process and the importance of embodied energy. The materials and methods of construction in 1922 were not as sophisticated as they are today. The main materials used in Gartley Hall were reinforced concrete, steel, plaster, and wood. Table 5.1 breaks down the categories of materials and approximate quantities in Gartley Hall's current condition. Breaking the materials into linear, square, or cubic feet is a typical way to measure embodied energy. A weight conversion can then be applied to each material category. The size and weight of a particular material are key to determining its embodied energy.

TOTALS	LN. FT.	SQ. FT.	CU. FT.	WT. (lbs)	WT. (tons)
Concrete (3,000 PSI)			1523.28	5940773.51	2970.39
Concrete Tile			764.39	458636.40	229.32
Steel Bar Size #3	95148.50			36452.64	18.23
Steel Bar Size #4	6408.00			4681.34	2.34
Steel Bar Size #5	18042.00			18479.87	9.24
Steel Bar Size #7	5865.00			11988.06	5.99
Steel Bar Size #8	168.00			448.56	0.22
Plywood		81818.00		178976.88	89.49
Nominal Wood	38744.00			49592.32	24.80
Windows		2252.00		13512.00	6.76

TABLE 5.1 Categories of Materials and Approximate Quantities

What is a Megajoule (MJ)?

Typically, embodied energy is measured as a quantity of non-renewable energy per unit of building material, component, or system. Embodied energy may be expressed as a megajoule (MJ) or gigajoule (GJ) per unit of weight (kilogram or ton) or area (linear, square, or cubic feet).[67] Gartley Hall's existing building has 7,621,433 MJ of energy expended within it currently. The megajoule measures the estimated amount of fossil fuel energy used in the extraction, processing, transportation, construction, and disposal of each material currently within the building. To provide a rough idea of what a megajoule is, Table 5.2 compares one barrel of oil to various forms of its effects (e.g. emissions, energy, nonrenewables, and calories).

Emissions	
GHG Emissions (MTCO2E)	749
Barrels of Oil	1

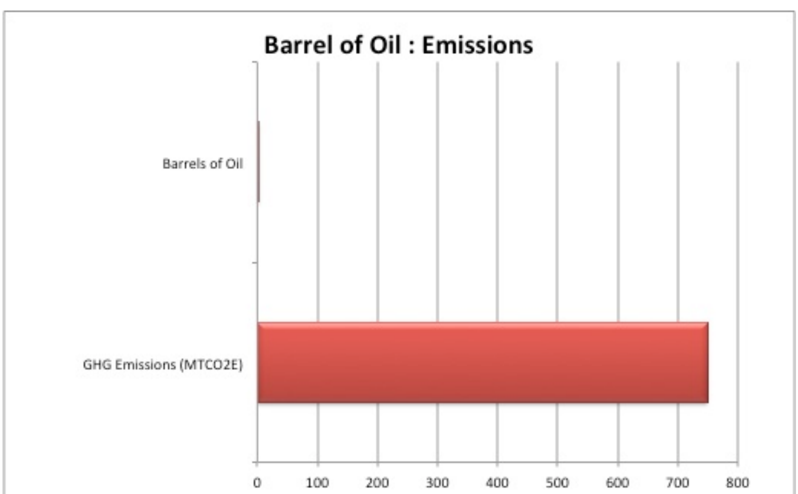


TABLE 5.2 One Barrel of Oil Compared to Emissions

[67] Canadian Architect. *Measures of Sustainability.* January 1, 2011. http://www.canadianarchitect.com/asf/perspectives_sustainibility/measures_of_sustainablity/measures_of_sustainablity_embodied.htm (accessed November 1, 2011).

Energy	
Kilowatt Hour (kWh)	1700
Megajoules (MJ)	6120
Thousand British Thermal Units (kBtu)	5800
Barrels of Oil	1

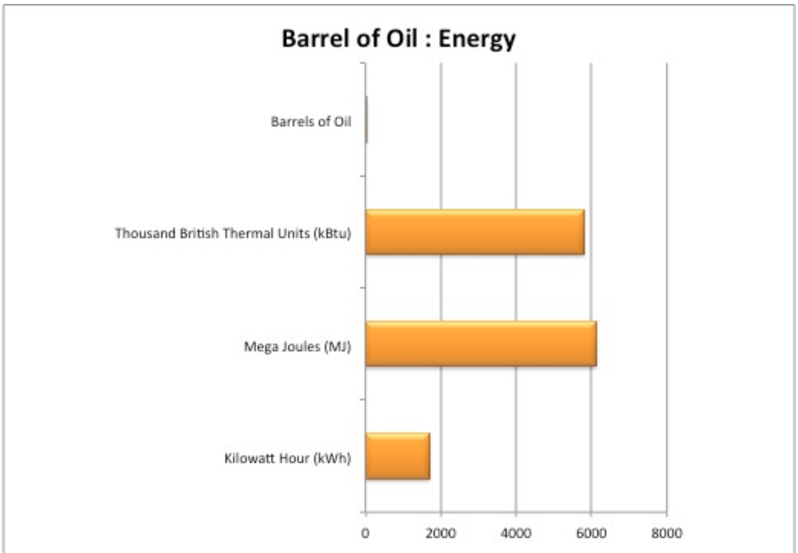


TABLE 5.3 One Barrel of Oil Compared to Energy Equivalents

Nonrenewables	
Therms of Natural Gas	58
5 gallon Cylinder of Propane	1130
Cubic Meters of Natural Gas	160
Gallons of Gasoline	42
Barrels of Oil	1

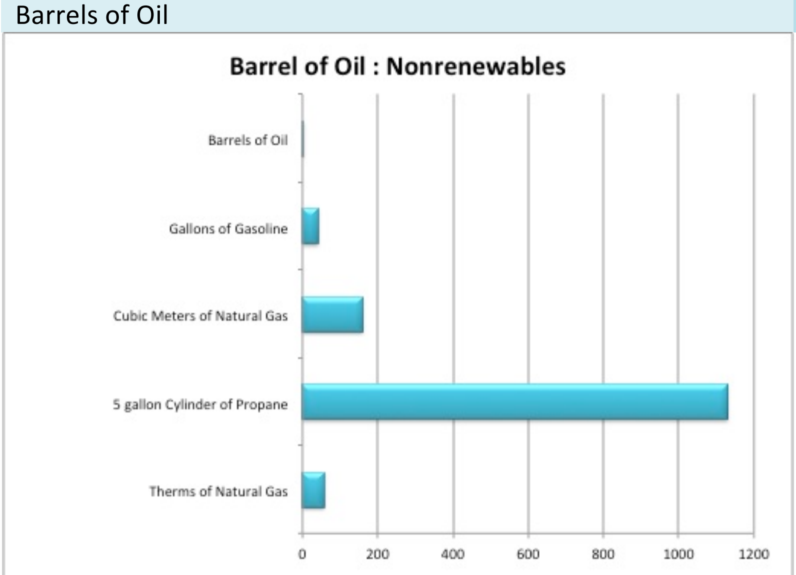


TABLE 5.4 One Barrel of Oil Compared to Nonrenewable Resources

Calories	
Million Calories	1462
Barrels of Oil	1

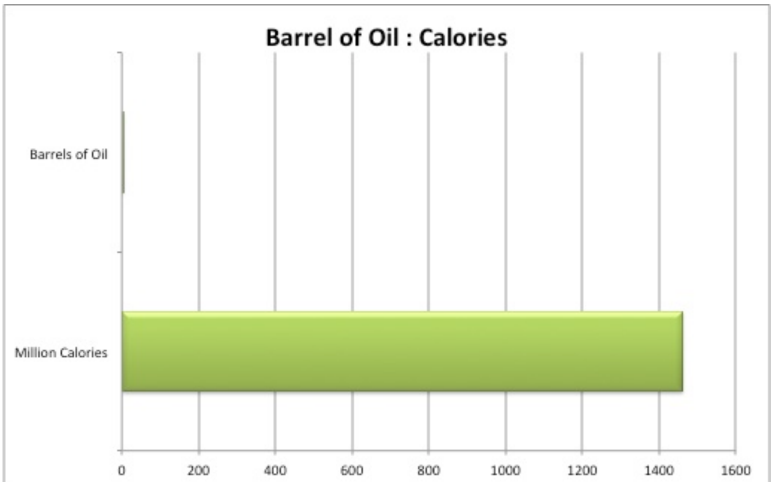


TABLE 5.5 One Barrel of Oil Compared to Calories

6 Gartley Hall Retrofit Phasing

PHASE #1: EXISTING BUILDING

PHASE #2: RETROFIT “A” – LOW-LEVEL

PHASE #3: RETROFIT “B” – MEDIUM-LEVEL

PHASE #4: RETROFIT “C” – HIGH-LEVEL

PHASE #5: RETROFIT “D” – DEMOLITION

Gartley Hall: Hawai‘i Application

The University of Hawai‘i at Mānoa has a building on campus called Gartley Hall as seen in Figure 6.1.

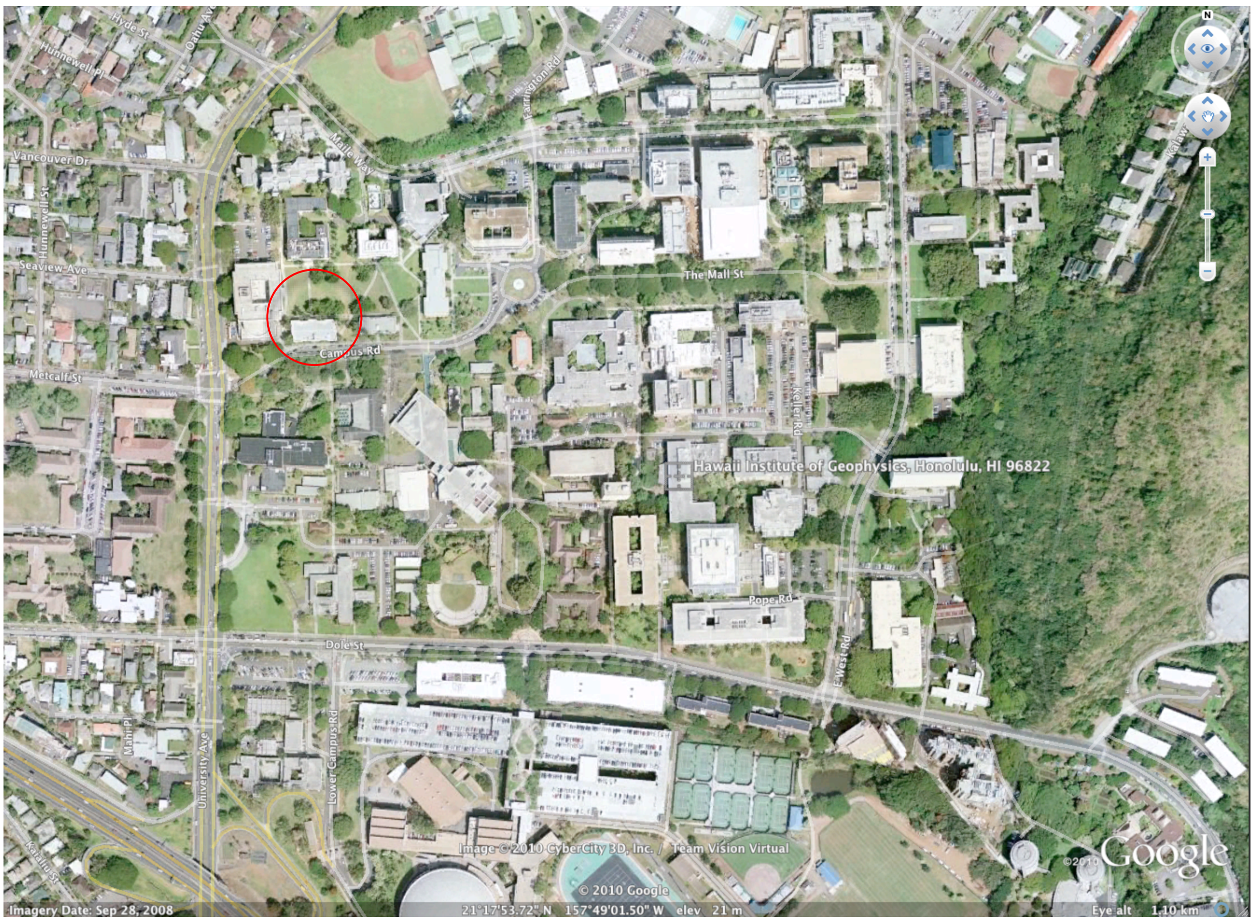


FIG 6.1 University of Hawai‘i at Mānoa Gartley Hall

Source: Google Earth

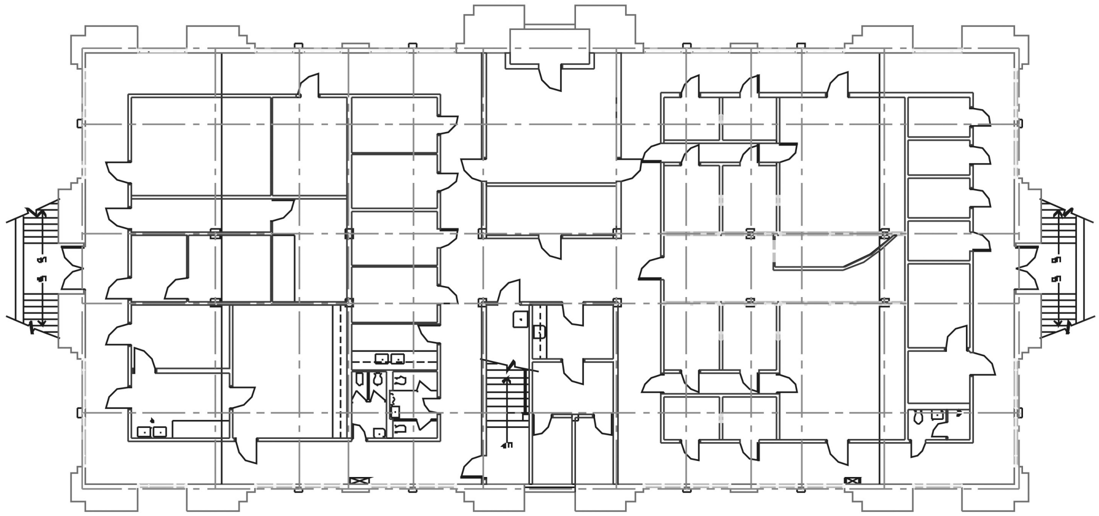


FIG 6.2 University of Hawai'i at Mānoa
Gartley Hall Basement Level Floor Plan

Source: Environmental Research & Design Laboratory

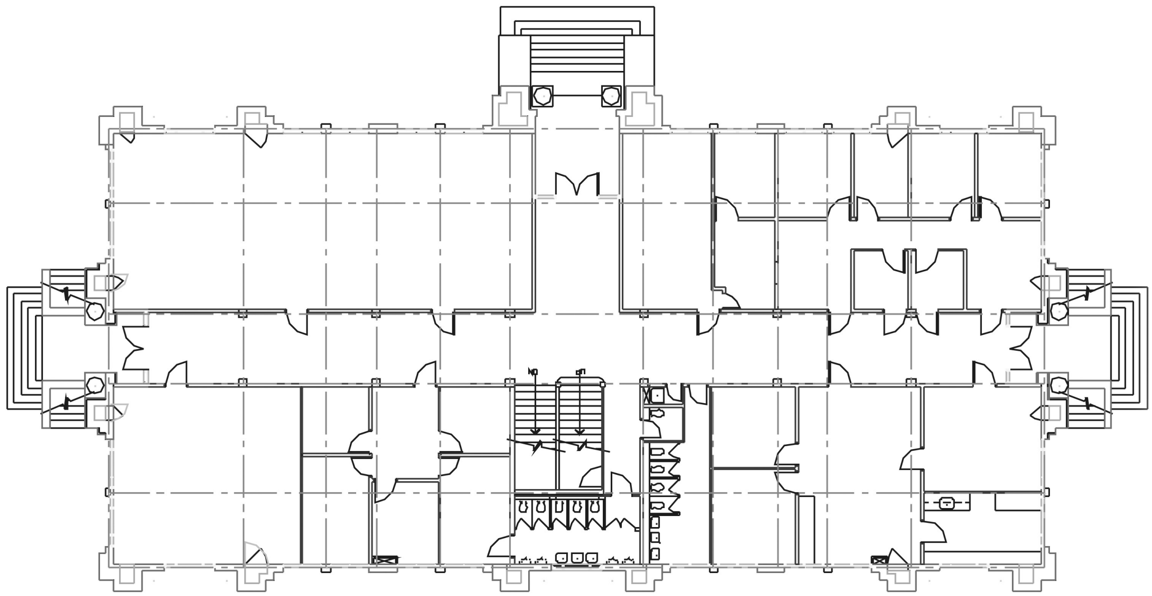


FIG 6.3 University of Hawaiʻi at Mānoa Gartley Hall First Level Floor Plan

Source: Environmental Research & Design Laboratory

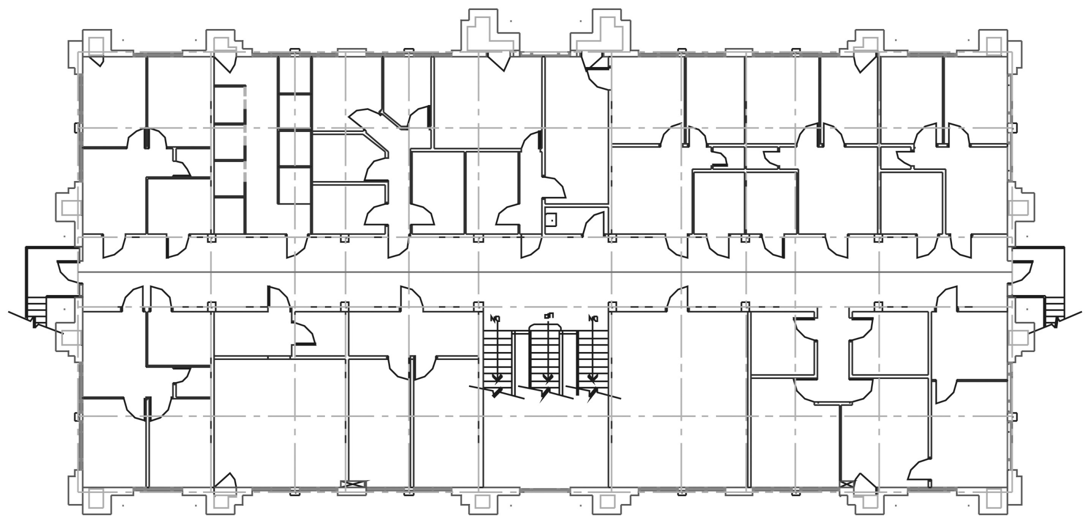


FIG 6.4 University of Hawai'i at Mānoa
Gartley Hall Second Level Floor Plan

Source: Environmental Research & Design Laboratory

FIG 6.5 University of Hawai'i at Mānoa
Gartley Hall East Elevation Rendering

Source: Environmental Research & Design Laboratory

Gartley Hall	Total area
Foundations & Footings	7,880
Columns & Beams	23,640
Intermediate Floors	15,760
Exterior Walls	17,404
Windows	2,252
Interior Walls	31,550
Roof	7880
TOTALS	-

Fossil Fuel Consumption (MJ) TOTAL	Weighted Resource Use (tons) TOTAL	GWP (tons CO2eq) TOTAL	Acidification Potential (moles of H+ eq) TOTAL	HH Respiratory Effects Potential (kg PM2.5 eq) TOTAL	Eutrophication Potential (g N eq) TOTAL	Ozone Depletion Potential (mg CFC-11 eq) TOTAL	Smog Potential (kg NOx eq) TOTAL
202,234	236	31	10,140	72	5,516	100	104
1,425,690	721	119	42,822	281	93,783	304	335
1,534,156	1,442	194	65,728	459	62,890	602	638
1,364,961	828	133	48,583	353	34,627	336	725
402,705	84	45	39,112	561	15,965	68	280
926,027	154	38	17,830	299	7,390	11	155
1,765,659	767	127	45,669	308	37,198	313	2,795
7,621,433	4,232	686	269,884	2,333	257,369	1,735	2,769

TABLE 6.1 Gartley Hall – Existing Building's Embodied Energy

Source: Athena EcoCalculator

Table 6.1 is the embodied energy in Gartley Hall today. The particular number we are looking at the 'Fossil Fuel Consumption (MJ) total,' 7,621,433 MJ. By keeping the entire building on site will help to minimize additional fossil fuel consumption (MJ), labor, and materials to be brought to the site.

TOTALS	LN. FT.	SQ. FT.	CU. FT.	WT. (lbs)	WT. (tons)
Concrete (3,000 PSI)			1523.28	5940773.51	2970.39
Concrete Tile			764.39	458636.40	229.32
Steel Bar Size #3	95148.50			36452.64	18.23
Steel Bar Size #4	6408.00			4681.34	2.34
Steel Bar Size #5	18042.00			18479.87	9.24
Steel Bar Size #7	5865.00			11988.06	5.99
Steel Bar Size #8	168.00			448.56	0.22
Plywood		81818.00		178976.88	89.49
Nominal Wood	38744.00			49592.32	24.80
Windows		2252.00		13512.00	6.76

TABLE 6.2 Gartley Hall – Existing Material Weight Conversions

Keeping the energy expending within an existing building is seen as the right thing to do. Others moral intuition may not see the same as a person who values the environment or someone from a different cultural background. The importance of keeping embodied energy on site may sometimes be outweighed by political costs, environmental logistics, and/or monetary value.

Phase #2: Retrofit "A" – Low-Level

A low-level building retrofit consists of replacing the existing windows with efficient windows. Changing the existing windows makes the U-vales lower, but at the same time, lowers solar radiation transferred through the glass panes. The windows in the building are taken offsite to be reused. The scope of a low-level retrofit means bringing in fans, shading devices, and keeping the building in line with the Secretary of the Interior's Standards for Rehabilitation.

Gartley Hall has the potential to become nominated on the National Register and doing a low-level retrofit will minimize its impact of destroying any historically significant portions of the building. Although the application of a low-level retrofit may sound good in theory, bringing the building's energy efficiency up to current standards may be difficult.

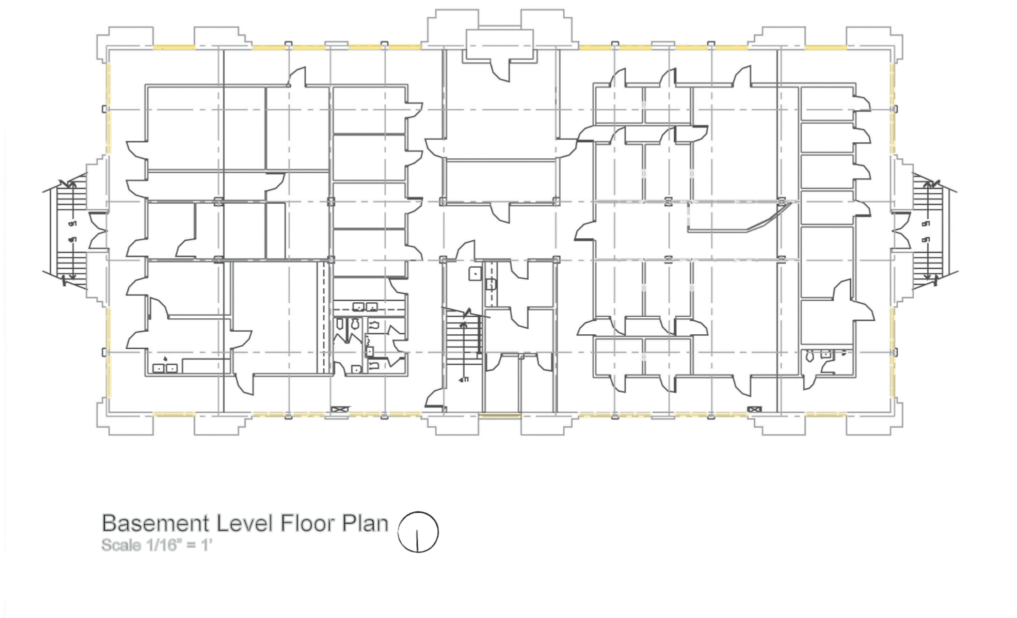


FIG 6.5 University of Hawai'i at Mānoa Gartley Hall Basement Level Floor Plan, Retrofit "A" – Low-Level

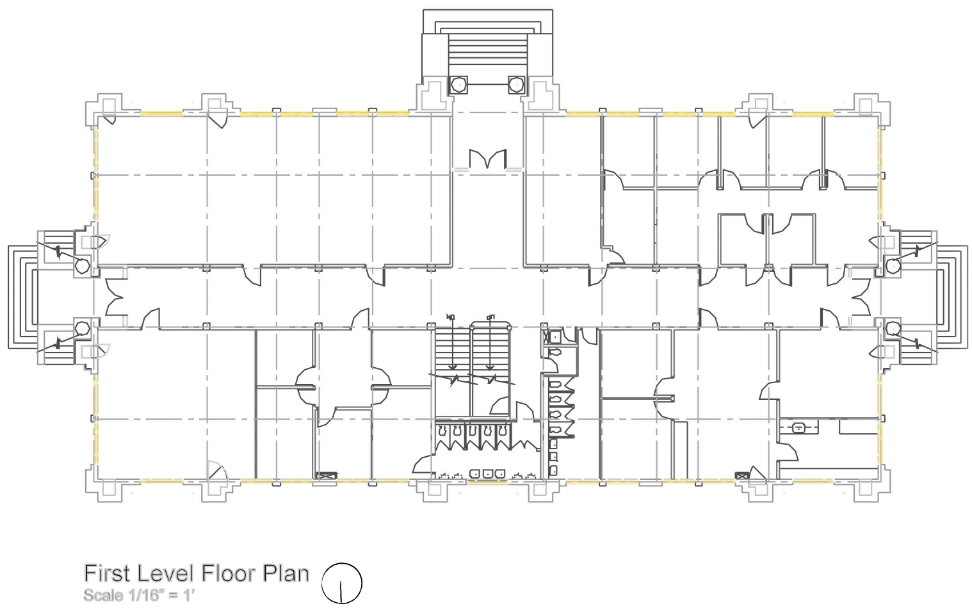


FIG 6.6 University of Hawai‘i at Mānoa Gartley Hall First Level Floor Plan, Retrofit “A” – Low-Level

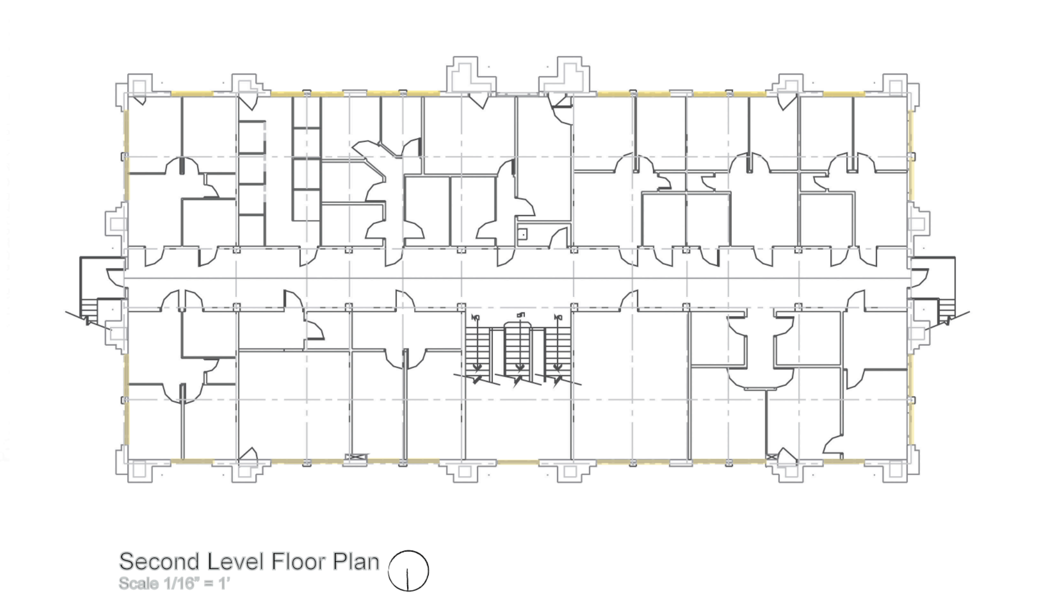


FIG 6.7 University of Hawai'i at Mānoa Gartley Hall Second Level Floor Plan, Retrofit "A" – Low-Level

Gartley Hall - Retrofit "A": Low-Level	Total area
Foundations & Footings	7,880
Columns & Beams	23,640
Intermediate Floors	15,760
Exterior Walls	17,404
Windows	-
Interior Walls	31,550
Roof	7,880
TOTALS	-

Fossil Fuel Consumption (MJ) TOTAL	Weighted Resource Use (tons) TOTAL	GWP (tons CO2eq) TOTAL	Acidification Potential (moles of H+ eq) TOTAL	HH Respiratory Effects Potential (kg PM2.5 eq) TOTAL	Eutrophicatio n Potential (g N eq) TOTAL	Ozone Depletion Potential (mg CFC-11 eq) TOTAL	Smog Potential (kg NOx eq) TOTAL
202,234	236	31	10,140	72	5,516	100	104
1,425,690	721	119	42,822	281	93,783	304	335
1,534,156	1,442	194	65,728	459	62,890	602	638
1,364,961	828	133	48,583	353	34,627	336	725
-	-	-	-	-	-	-	-
926,027	154	38	17,830	299	7,390	11	155
1,765,659	767	127	45,669	308	37,198	313	532
7,218,727	4,148	642	230,772	1,772	241,404	1,666	2,489

TABLE 6.3 Gartley Hall – Low-Level: Retrofit "A" Building's Embodied Energy

Source: Athena EcoCalculator

Table 6.2 shows the embodied energy left in a low-level, "low-tech" retrofit. It keeps all materials except the windows onsite, and the embodied energy left onsite is 7,218,727 MJ.

Phase #3: Retrofit “B” – Medium-Level

Gartley Hall’s present-day closure is due structural issues, settling in the building’s foundation as well as poor construction. The medium level retrofit helps to mend the structural issues and rebuild the interior. A medium-level retrofit consists of renovating the interior. The foundation and footings, windows, and interior walls are taken offsite. New materials being brought to the site replace the interior walls and partitions. The foundation is shored and the exterior load-bearing walls are reinforced with micro piles around the perimeter of the foundation. The steel and concrete taken offsite is recycled and the windows reused.

FIG 6.8 University of Hawai'i at Mānoa Gartley Hall Basement Level Floor Plan, Retrofit "B" – Medium-Level

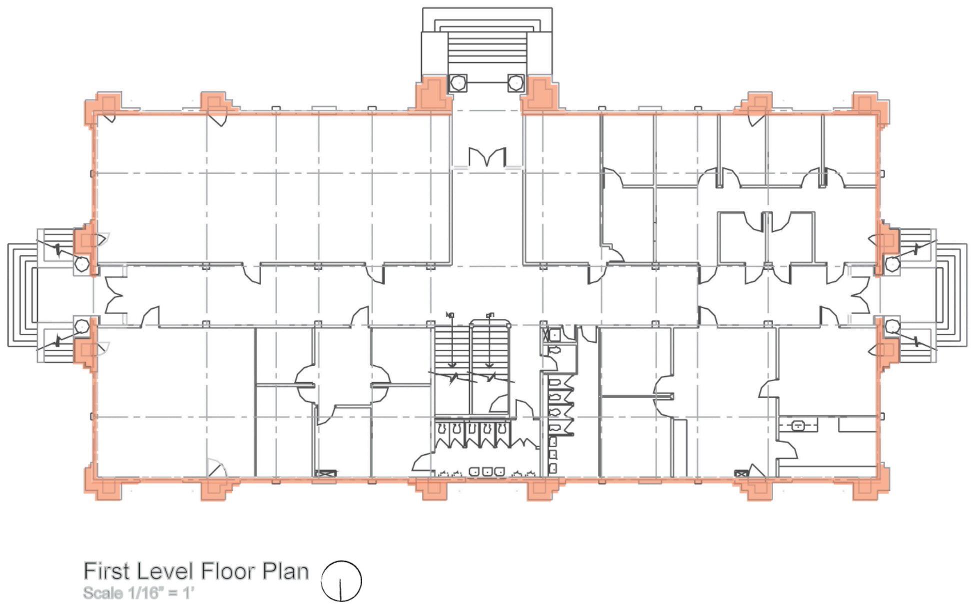
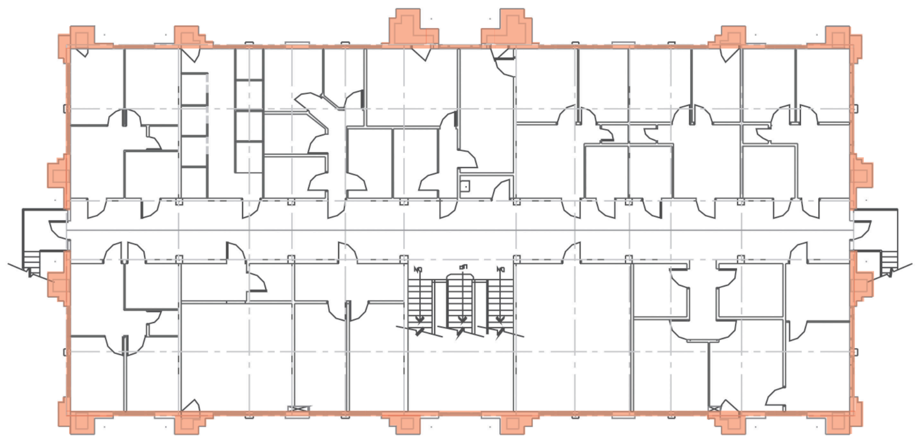


FIG 6.9 University of Hawai‘i at Mānoa Gartley Hall First Level Floor Plan, Retrofit "B" – Medium-Level



Second Level Floor Plan
Scale 1/16" = 1'

FIG 6.10 University of Hawai'i at Mānoa Gartley Hall Second Level Floor Plan, Retrofit "B" – Medium-Level

Gartley Hall - Retrofit "B": Medium-Level	Total area
Foundations & Footings	-
Columns & Beams	23,640
Intermediate Floors	15,760
Exterior Walls	17,404
Windows	-
Interior Walls	-
Roof	7,880
TOTALS	-

Fossil Fuel Consumption (MJ) TOTAL	Weighted Resource Use (tons) TOTAL	GWP (tons CO2eq) TOTAL	Acidification Potential (moles of H+ eq) TOTAL	HH Respiratory Effects Potential (kg PM2.5 eq) TOTAL	Eutrophication Potential (g N eq) TOTAL	Ozone Depletion Potential (mg CFC-11 eq) TOTAL	Smog Potential (kg NOx eq) TOTAL
-	-	-	-	-	-	-	-
1,425,690	721	119	42,822	281	93,783	304	335
1,534,156	1,442	194	65,728	459	62,890	602	638
1,364,961	828	133	48,583	353	34,627	336	725
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
1,765,659	767	127	45,669	308	37,198	313	532
6,090,466	3,758	573	202,802	1,401	228,498	1,555	2,230

TABLE 6.4 Gartley Hall – Medium-Level: Retrofit "B" Building's Embodied Energy

Source: Athena EcoCalculator

Table 6.4 shows the embodied energy in a medium-level interior retrofit. It keeps a majority of the exterior assemblies onsite and removes most of the interior materials. The embodied energy left onsite is 6,090,466 MJ.

Phase #4: Retrofit "C" – High-Level

A high-level retrofit consists of gutting the building and leaving the envelope of the building intact. This type of retrofit is often called "façadism." This is the closest retrofit to demolishing the building because the façade is remains intact for the purposes of building a new structure and interior. The exterior walls and foundation and footings are kept onsite. Everything else is taken offsite to either a landfill or recycle center, or reused. The steel and concrete is recycled and the windows reused.

New materials brought to the site need to replace the columns, beams, intermediate floor slabs, interior walls, windows, and roof. Even though this level of retrofit brings a majority of the building's systems to the site, there is still the façade left on site.

FIG 6.11 University of Hawai'i at Mānoa Gartley Hall Basement Level Floor Plan, Retrofit "C" – High-Level

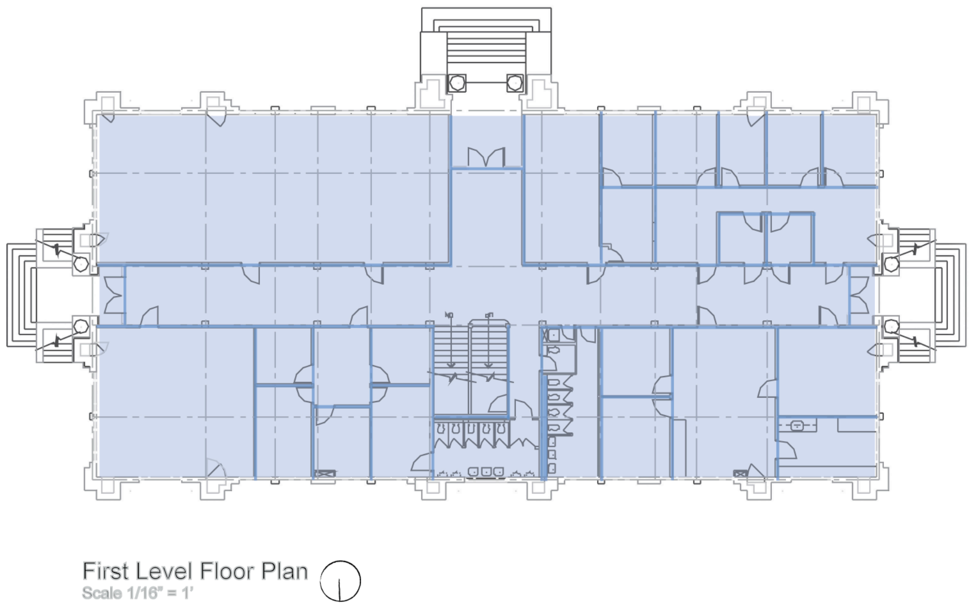


FIG 6.12 University of Hawai‘i at Mānoa Gartley Hall First Level Floor Plan, Retrofit "C" – High-Level

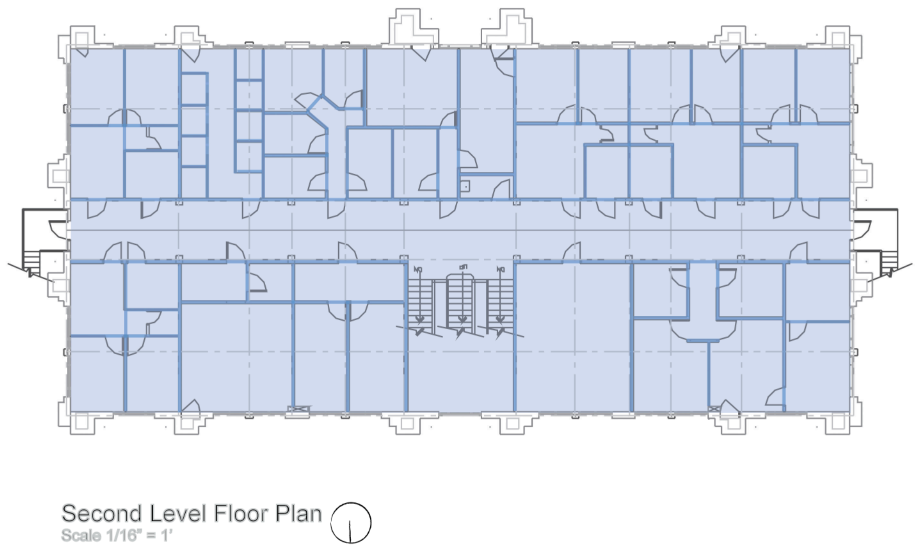


FIG 6.13 University of Hawai'i at Mānoa Gartley Hall Second Level Floor Plan, Retrofit "C" – High-Level

Gartley Hall - Retrofit "C": High-Level	Total area	Fossil Fuel Consumption (MJ) TOTAL	Weighted Resource Use (tons) TOTAL	GWP (tons CO2eq) TOTAL	Acidification Potential (moles of H+ eq) TOTAL	HH Respiratory Effects Potential (kg PM2.5 eq) TOTAL	Eutrophication Potential (g N eq) TOTAL	Ozone Depletion Potential (mg CFC-11 eq) TOTAL	Smog Potential (kg NOx eq) TOTAL
Foundations & Footings	7,880	202,234	236	31	10,140	72	5,516	100	104
Columns & Beams	-	-	-	-	-	-	-	-	-
Intermediate Floors	-	-	-	-	-	-	-	-	-
Exterior Walls	17,404	1,364,961	828	133	48,583	353	34,627	336	725
Windows	-	-	-	-	-	-	-	-	-
Interior Walls	-	-	-	-	-	-	-	-	-
Roof	-	-	-	-	-	-	-	-	-
TOTALS	-	1,567,195	1,064	164	58,723	425	40,143	436	829

TABLE 6.5 Gartley Hall – High-Level: Retrofit "C" Building's Embodied Energy

Source: Athena EcoCalculator

Table 6.5 shows the embodied energy in a high-level retrofit. It keeps all of the exterior walls (façade), foundation, and footings onsite and replaces all other materials and assembly systems. The embodied energy left on site is 1,567,195 MJ.

Phase #5: Retrofit "D" – Demolition

Demolition consists of the entire teardown of an existing building. All of the materials are taken offsite to either a landfill or recycle center, or reused. All parts of the new building have to be brought to the site. Demolition of a building is not the best solution but is often implemented.

The embodied energy left on site is totally lost and is 0 MJ. What makes this level of retrofit alarming is the additional amount of emissions, labor, and materials being brought to the site.

7 Conclusions

Gartley Hall: Conclusions

Buildings over 50 years in age comprise more than half of the existing buildings in the United States. The preexistence of these older building have an effect to the way new buildings are designed today. Each older building's original use and energy efficiency was meant to use less energy, but in the building's current state the use and energy efficiency is considered high.

The metric and building precedents I researched provided the basis for analyzing Gartley Hall. Building precedents help to dissect building retrofits at existing sites and understand the effects of transportation. Metric precedents help to categorize materials and convert cubic yard, square footage, or linear footage (takeoffs) into weight. Each precedent studied identified costs that affected the commissioning of a retrofit project.

The costs related to the construction and design industry are political, private, external, and psychic costs. Each cost is a factor to help answer the question of keeping an older building or demolishing it. Policy can help the State's reliance on importing new construction products and exporting demolition waste. Transportation and the logistics of products raise the monetary value of materials. Finding new ways to keep materials on the islands rather than continuing to import goods help to minimize transportation reliance. Hawai‘i's isolation from the mainland United States and the logistics involved to import and export from the islands help to justify the need for policy and mental change.

Job creation through retrofits involves a number of specialty service industries. Deconstructing existing buildings and supplying reuse warehouses, restoration assistance to repair a historic motif to its original appearance, and consultants specializing in sustainable preservation retrofits.

The moral values and intuitions of each person are diverse. Helping people understand the metrics and importance of embodied energy embedded within existing buildings may be a catalyst to change the mentality of people who may not be aware. The historic significance and heritage of Gartley Hall has to do with it being one of the oldest buildings on the campus, built in 1922. The building has historical significance and could be nominated with the National Register of Historic Places. Gartley Hall's importance to the University of Hawai'i at Mānoa's early stages help to solidify retrofitting as a solution instead of demolishing the historically significant structure.

Bibliography

Aksamija, Ajla. "Comparative Analysis of Flooring Materials: Environmental and Economic Performance." *Perkins + Will Research Jornal* 02.01 (2010): 55-66.

Aldy, Joseph E., Scott Barrett, and Robert N. Stavins. "Thirteen Plus One: A Comparison of Global Climate Policy Architectures." *Climate Change Modeling and Policy*, 2003: Summary.

American Institute of Architects (AIA). *What Makes it Green?* January 14, 2007. http://wmig.aiaseattle.org/node/151 (accessed November 16, 2010).

Architectural Heritage Center. *Gerding Theater at the Armory Case Study.* April 15, 2008. http://www.visitahc.org/content/gerding-theater-armory-case-study (accessed November 23, 2010).

Athena Sustainable Materials Institute . *EcoCalculator Overview* . January 11, 2011. http://www.athenasmi.org/tools/ecoCalculator/ (accessed September 30, 2011).

Athens, Lucia. *Building an Emerald City: A Guide to Creating Green Building Policies and Programs.* Washington D.C.: Island Press, 2010.

Biden, Joe (Vice President, 2010). *Remarks by the Vice President Announcing Recover Act "Retrofit Ramp Up" Awards on Even of Earth Day.* April 21, 2010. http://www.whitehouse.gov/the-press-office/remarks-vice-presidentannouncing-recovery-act-retrofit-ramp-awards-eve-earth-day (accessed April 22, 2010).

Boustead Consulting (BCL). *LCAs and LCIs.* June 22, 2011. http://www.boustead-consulting.co.uk/introduc.htm (accessed October 24, 2011).

Buddenborg, Jennifer Lynn. *Changing Mindsets: Sustainable Design in Historic Preservation* . Thesis, Ithaca, New York: Cornell University , 2006.

Canadian Architect. *Measures of Sustainability.* January 1, 2011. http://www.canadianarchitect.com/asf/perspectives_sustainibility/measures_of_sustainability/measures_of_sustainablity_embodied.htm (accessed November 1, 2011).

Clements, Tom. *Alternative Hawai'i: Hawai'i's Agriculture Facing the Future.* February 1, 2005. http://www.alternative-hawaii.com/agriculture/index.htm (accessed September 22, 2011).

County of Hawai'i. *ENERGY-County of Hawai'i.* January 1, 2011. www.co.hawaii.hi.us/general_plan_rev/revision/energy.doc (accessed October 26, 2011).

Crowley, Walt. *HistoryLink.org Essay 2959: Rainier Club (Seattle).* January 27, 2001. http://www.historylink.org/index.cfm?DisplayPage=output.cfm&File_Id=2959 (accessed September 14, 2011).

DiNola, Ralph. "Historic Preservation and Green Building: A Lasting Relationship." *Environmental Building News*, January 1, 2007: 6.

Driedger, Michael. "Choosing the Right Green Building Rating System." *Perkins + Will Research Journal* 01.01 (2009): 22-41.

Fischer, John. *Only in Hawai'i Part 1: Islands Unique in all the World.* July 23, 2010. http://gohawaii.about.com/cs/onlyinhawaii/a/only_in_hawaiia.htm (accessed November 23, 2010).

Frey, Patrice. *Building Reuse: Finding a Place on American Climate Policy Agendas.* Sustainability Research , Washington D.C.: National Trust of Historic Preservation, 2008.

General Services Administration (GSA). *ADM 1020.2 Procedures for Historic Properties.* http://www.gsa.gov/Portal/gsa/ep/contentView.do?contentType=GSA_BASIC&contentId=12228 (accessed April 19, 2010).

Green Building Certification Institute. *Project Credit Interpretation Rulings* . January 1, 2011. http://www.gbci.org/CIRs.aspx (accessed August 20, 2011).

Hawai'i Department of Business Economic Development and Tourism. *Energy, Resource, and Technology Division.* http://hawaii.gov/dbedt/info/energy/ (accessed April 2010).

Horizon Lines, Inc. *Horizon Lines Hawai'i.* January 1, 2010. http://www.horizonlines.com/Ocean-Services/Hawaii.aspx (accessed October 26, 2011).

Kreisman, Larry. *Daniels Recital Hall: History of Building.* January 1, 1984. http://recitalhall.fifthandcolumbia.com/history.html (accessed September 14, 2011).

LVP (2010). *Legacy Vision Policy: Restructuring the Owned Inventory.* February 19, 2010 . http://www.gsa.gov/Portal/gsa/ep/contentView.do?contentType=GSA_BASIC&contentId=17977 (accessed April 19, 2010).

Leidermann, Mike. *Bishop Museum's Extreme Makeover.* January 7, 2007. http://the.honoluluadvertiser.com/article/2007/Jan/07/il/FP701070320.html (accessed November 23, 2010).

Li, Fangxing, Pei Zhang, and Navin Bhatt. "Next Generation Monitoring and Control Functions for Future Control Centers." *North American Power Symposium NAPS*, 2008: 1.

Los Angeles Conservancy. *Incentives for Preserving Historic Buildings.* http://www.laconservancy.org/preservation/incentives.pdf (accessed April 1, 2010).

Los Angeles Planning and Zoning. *Adaptive Reuse Ordinance.* http://www.ladbs.org/rpt_code_pub/Ordinance.pdf (accessed April 2010).

Nyquist, Anders. "Green Building and Planning: Experiences and Visions." In *Green Building and Planning: Experiences an Visions*, by Anders Nyquist, 13. Njurunda: Anders Nyquist Arkitektkontor AB Pramviken, 2010.

Mumma, Tracy. *Home Energy Magazine Online.* February 15, 1995. http://www.homeenergy.org/archive/hem.dis.anl.gov/eehem/95/950109.html (accessed November 9, 2010).

Murley, Susan. *The DOE's Solar Decathlon Prepares Graduates for Green Jobs.* September 13, 2011. http://www.huffingtonpost.com/susanna-murley/terps-charged-up-for-the-_b_960031.html?ir=College (accessed September 15, 2011).

Mason Architects Inc. *Hawaiian Hall Complex.* June 1, 2009. http://www.masonarch.com/projects/museum/hawaiian_hall.html (accessed November 23, 2010).

McCarthy Building Companies, Inc. *McCarthy Lands Construction Contract for $90 Million UCSD Health Sciences Biomedical Research Facility.* August 5, 2009. http://www.mccarthy.com/news/2009/08/05/ucsd-health-sciences-biomedical-research-facility/ (accessed September 20, 2011).

Pendlebury, John. *Conservation in the Age of Consensus.* New York, NY: Routledge, 2009.

Reed, Richard, Anita Bilos, Sara Wilkinson, and Karl-Werner Schulte. "International Comparison of Sustainable Rating Tools." *JOSRE* 1 (2009): 6.

Reiner, Mark, Mark Pitterle, and Michael Whitaker. "How Do You Define Green?: Embodied Energy Considerations in Existing LEED Credits." *Symbiotic Engineering.* September 1, 2007. http://www.symbiotic-engineering.com/includes/content/publications/embodied_energy_considerations_in_existing_leed_credits.pdf (accessed November 20, 2010).

Romano, Benjamin J. *New Fund High on "Green" Buys Seattle Buildings.* April 14, 2006. http://seattletimes.nwsource.com/html/businesstechnology/2002929494_vance14.html (accessed November 16, 2010).

Sustainable Cities Institute. *District Scale Sustainability .* August 9, 2011. http://www.sustainablecitiesinstitute.org/view/page.basic/buzz_topics/content.buzz_topic/Buzz_DirectScale_Sustainability_2011_08_09 (accessed September 7, 2011).

—. *Materials Management.* January 1, 2007. http://www.sustainablecitiesinstitute.org/view/page.basic/class/tag.topic/materials_management (accessed September 30, 2011).

Sandnes, Jill. *2010 Top Ten Green Awards.* March 19, 2010. http://wmig.aiaseattle.org/node/173 (accessed January 22, 2011).

Schroeder, Bob. *Platinum Performance: The Armory Building, Portland Center Stage.* February 20, 2010. http://www.glumac.com/greenResources/GR_Armory_Building.html (accessed October 25, 2010).

Souza, Elsa and Norwood, Charles. "Gartley Hall (1922)." In *Building a Rainbow*, by Victor N. Kobayashi, 35. Honolulu: Hui O Students University of Hawai‘i at Mānoa, 1983.

State of California Energy Commission. *California Climate Change Policy & Programs: California's Climate Plan.* April 1, 2009. http://www.climatechange.ca.gov/policies/2010-01-27_FACT_SHEET_SCOPING_PLAN.PDF (accessed April 23, 2010).

State of Hawai‘i Department of Land and Natural Resources. *Mission.* January 1, 2011. http://hawaii.gov/dlnr/docare/mission (accessed September 12, 2011).

State County of Hawai‘i . *County of Hawai‘i Integrated Resource and Solid Waste Management Plan.* Executive Summary, Honolulu: State County of Hawai‘i , 2009.

The Bishop Museum. *Main Exhibit Hall: Hawaiian Hall.* April 1, 2010. http://www.bishopmuseum.org/exhibits/continuing.html (accessed November 23, 2010).

The Heritage Foundation. *Issues: Energy and Environment .* July 16, 2010. http://www.heritage.org/Issues/Energy-and-Environment (accessed October 31, 2010).

The Rainier Club. *Rainier Club Home Page.* January 1, 2006. http://www.therainierclub.com/ (accessed September 14, 2011).

Tseckares, Charles N. *A Green Future for Old Buildings.* November 23, 2009. http://www.boston.com/bostonglobe/editorial_opinion/oped/articles/2009/11/23/a_green_future_for_old_buildings/ (accessed November 4, 2010).

U.S. Energy Information Administration . *Architecture 2030.* January 1, 2010. www.architecture2030.org (accessed April 1, 2010).

United Framework Convention on Climate Change (UNFCCC). *Kyoto Protocol.* http://unfccc.int/kyoto_protocol/items/2830.php (accessed April 1, 2010).

Wadhams, Emily. "Introduction." *Forum Journal: National Trust for Historic Preservation*, March 2009: 5.

Worskett, R. "Conservation: The Missing Ethic." *Monumentum*, 1982: 151-161.

Zimmer Gunsul Frasca Architects LLP. *Innovation in Design Credit Narrative.* Credit Narrative, San Diego: LEED NCv2.2 Documentation IDc1.3, 2011.

Appendix

Appendix 1 - Case Study – LEED Breakdown: Joseph Vance Building

Sustainable Sites: "The Joseph Vance Building in Seattle brings the building up to current office standards, provides an environmentally friendly environment and eliminates the desire to demolish and rebuild. It houses 13 floors of offices over ground floor retail with a basement for mechanical equipment and storage. As an existing building that was designed, constructed and operated before sustainability was an issue, the renovated Vance Building has many inherent sustainable aspects. One of these is its location, which is close to a variety of public transit options.

Toward Zero Energy: The original Vance Building is bathed in natural light with views of the mountains and Puget Sound and is naturally ventilated. The renovation sought to restore and improve existing low-energy systems in this L-shaped building. Double-hung windows were restored to provide full operability and maximize natural ventilation. Thermal studies that were conducted indicated that the combination of operable windows and ceiling fans could provide the necessary comfort for occupants of the building. "Light shelves" were added to windows to prevent glare and redirect light and heat to the interior space. Wind guards were also included in the design to allow outside air to cool while not disrupting papers and items left on desktops. The building's original steam system was retained after research showed this heating strategy was the most carbon friendly. The system's commissioning included replacing traps to prevent condensation leaks at individual radiators and installing valves that allowed tenants the ability to regulate their temperature instead of the previous arrangement that had only one temperature control per building façade.[69]

Local and Sustainable Materials: The remodel involved uncovering and restoring the building's original ceilings and terrazzo floors in the main lobbies and hallways, updating the facility using sustainable materials and fixtures, and seismic improvements in a "light touch" strategy that strips the building to its core elements in an effort to reduce unnecessary waste. The 800 SF Property Management Office was designed as a model sustainable tenant space that elegantly includes simple 'green' elements including a conference table custom built from local, reclaimed trees; rapidly renewable plywood cabinets; wind screens for ventilation effectiveness; light shelves for enhanced daylight penetration; and a natural color palette using environmentally friendly paints and finishes. A waste disposal program was instituted, allowing property management the ability to monitor waste outputs. Composting and recycling programs were also introduced. As part of the building management policy, 50% of occupant waste will be recycled.

Sustainable Water: Motion sensor faucets and low flow toilets replaced existing water fixtures in the common area bathrooms. The fixtures installed include a 10 second cycle that uses 0.09 gallons of water, or 0.5 gallons per minute. This is a 64% below the baseline of 0.25 gallons per cycle. A low flow shower was included in the newly built

---

[69] American Institute of Architects (AIA). *What Makes it Green?* January 14, 2007. http://wmig.aiaseattle.org/node/69 (accessed November 16, 2010).

bicycle shower and change facility. To meeting LEED-EB standards, the design for water conservation measures reduces water consumption from between 10% to 20%.[70]

IEQ and Comfort: The original building provided natural ventilation. Most tenant and common spaces had remained naturally ventilated with operable windows, although a few suites had been retrofitted with mechanical systems. In some cases the original sashes had been nailed shut. The design team weighed installing new windows against restoring existing windows. Since operability was key for tenant comfort, the team chose to restore the existing wood windows. Weather stripping was added, as well as custom window treatments that use light shelves to reflect light deeper into the floor plate and mecco shades positioned to allow clerestory light at all hours. Old carpets, which required heavy cleaning in elevator lobbies and corridors, were torn out, revealing original terrazzo floors that are easier to clean. The low drop ceilings in elevator lobbies, corridors and vacant tenant suites were removed to expose the building's original high ceilings and to provide maximum light. Green Operations and Maintenance Programs were adopted that include converting janitorial cleaning practices and products to be environmentally friendly.

Collective Wisdom and Feedback: The Vance Building brings together collective wisdom from an older generation – narrow wings, daylighting and natural ventilation – and applies new sustainable techniques and materials. The project was a natural candidate for LEED for Existing Buildings. LEED-EB allowed the design team to renovate and

---

[70] American Institute of Architects (AIA). *What Makes it Green?* January 14, 2007. http://wmig.aiaseattle.org/node/69 (accessed November 16, 2010).

enhance these systems while using an established, contemporary benchmark and process. Part of the greening effort included the creation of a tenant improvement manual that outlines measures new tenants can follow to make their spaces as green as possible. This was developed through input from the owner and design team members. The Jonathan Rose Companies will use these Sustainable Building Guidelines nationally, as well as for future tenant improvements to the Vance Building. The manual addresses the use of low VOC adhesives and sealants, lighting options, recycled content fabrics and carpets and Energy Star copiers, fax machines and computers.

Social Equity: One of the driving visions of this project was to upgrade an existing building to meet contemporary workplace standards and create a comfortable, pleasant and affordable place for non-profit and environmentally focused organizations. The renovation maintains the historical character of the original Vance Building and improves the neighborhood for merchants, property owners and residents of the surrounding community. By applying green building standards to this renovation project, the owner and design team are promoting a healthy workplace for the tenants that will improve employee retention, reduce absenteeism and increase productivity. The renovation also eliminated the need to demolish and rebuild, saving precious natural resources and improving the environment.[71]

Regional/Community Design: The Jonathan Rose Companies will use the development of the Sustainable Building Guidelines by the design team nationally, as well as for future

---

[71] American Institute of Architects (AIA). *What Makes it Green?* January 14, 2007. http://wmig.aiaseattle.org/node/69 (accessed November 16, 2010).

tenant improvements to the Vance Building. The Guidelines outline ways to create a green TI project by using recycled materials, and other sustainable solutions. It also lists tenant standards, sustainable finishes and materials. The Sustainable Building Guidelines provides a section on 'Creating A Green TI Project', which promotes recycling as much as possible from the existing space. Before remodeling of office space, an inventory is taken to determine what can be reused from the existing space. Carpet is recycled through the Antron Reclamation Program, furniture is either sold or given to local furniture warehouses, and all wood, paper and metal products are recycled. The Green Operations and Maintenance Program engages 'CleanScapes' to maintain the sidewalks and alleyways around the building. CleanScapes also fulfills a social mission by employing men and women in the social service and criminal justice networks. The building is planning on purchasing renewable power and is pursuing an Energy Star rating."[72]

---

[72] American Institute of Architects (AIA). *What Makes it Green?* January 14, 2007. http://wmig.aiaseattle.org/node/69 (accessed November 16, 2010).

Appendix 2 - Case Study – LEED Breakdown: Jean Vollum Natural Capital Center

Sustainable Sites: Alternative transportation and storm water management highlighted this category. Abundant bike parking, a bicycle-sharing program for tenants, on-site locker and shower facilities, two Flexcar[73] hybrid cars parked on-site, employee transportation stipends that promote mass transit use and walking, and two electric vehicle charging stations provide several alternative transportation options. The Portland Streetcar and TriMet bus both have stops at the Ecotrust building block within the Fareless Square, a 330-block area in which all rides on TriMet buses, MAX light rail trains and streetcars are always free.

The storm water management goal was to divert 100 percent of the site's storm water from the city's sewage system through a series of integrated strategies leading from the Ecotrust building to infiltration areas incorporated into the parking lot landscape design. A 6,000 square foot ecoroof on the exposed second story roof provides a permeable surface consisting of two inches of soil and native vegetation. The roof weighs approximately 14 lbs. per square foot when saturated, equal in weight to a conventional gravel roof, and thus required no additional structural, load-bearing upgrades to the historic shell.[74]

The water not absorbed by the ecoroof winds its way down the gutter and downspout system to the ground level landscaping made up of bios-wales containing more native species plantings. The bio-swales act as bio-filters that flush out pollutants

[73] Buddenborg, Jennifer Lynn. *Changing Mindsets: Sustainable Design in Historic Preservation* . Thesis, Ithaca, New York: Cornell University , 2006.
[74] Ibid

from surface runoff water. They consist of a swales, drainage course with sloped sides, filled with plantings, compost or rocks that filter the water and remove contaminants before releasing it to the watershed or sewer.

Parking lot storm water is directed by a gradual landscape slope towards two swales on the western edge of the lot, with notches cut into the curb along the western side to provide more direction. Overflow outlets connected to the city system are situated in each of the four swales. The parking lot itself is made of pavers and permeable asphalt. Pavers are small, square concrete bricks that allow water to seep through the cracks between the blocks and move naturally through the permeable sub-layers to the groundwater. Ecotrust has found that this is not the best design solution for a small area that requires slow vehicular traffic because the permeable asphalt and pavers are easily moved from their spots, creating a messy and jumbled parking surface. However, these combined elements successfully divert at least 95 percent of the site's storm water from the city system.[75]

Energy and Atmosphere: Energy reduction in the Ecotrust building presented several challenges that new building constructions do not face, given its orientation, high ceilings, and historic features. However, by focusing on energy efficiency, embodied energy, green power, and transportation, significant energy savings were achieved. Regional climactic sensitivity was considered in the selection of energy systems in respect to energy efficiency.

---

[75] Buddenborg, Jennifer Lynn. *Changing Mindsets: Sustainable Design in Historic Preservation* . Thesis, Ithaca, New York: Cornell University , 2006.

Several heating and cooling mechanisms were analyzed in regard to their efficiency and impact on the historic structure with the aid of a computer modeling system. Natural gas-fired warm-up boilers provide the heat cycle, with the system preset for 78 degrees Fahrenheit for cooling and 68 degrees Fahrenheit for heating, and tenant comfort control through window operation. A conventional HVAC system controlled by a computerized energy management system that can bring 100 percent of outside air into the building provides the cooling system. Outside and inside air continually mix to maintain a comfortable temperature inside.

Indoor energy use is tempered through the installation of T-5 High Output bulbs, the most efficient available at the time; occupancy sensors in hallways, closets, restrooms, and meeting spaces that monitor light, heating and cooling usage; a Greenhouse Gas Reduction Initiative where tenants voluntarily commit to purchasing renewable energy and offsetting greenhouse gas emissions; and a heavy reliance on daylighting. The strategic interior design orients all workspaces and areas of high traffic around the perimeter of the building to capture the natural light from the windows. Areas that do not garner much use, like closets, were placed in the building interior and are monitored by occupancy sensors. A large skylight above the atrium and 24 smaller skylights scattered throughout the second floor provide ample daylighting, particularly in the center atrium that opens onto the first floor. Lights equipped with photovoltaic sensors in the atrium detect lowering levels of daylight and adjust light levels accordingly.[76] The open, unobstructed interior also allows for ample diffusion of natural

[76] Buddenborg, Jennifer Lynn. *Changing Mindsets: Sustainable Design in Historic Preservation* . Thesis, Ithaca, New York: Cornell University , 2006.

light from the windows and skylights.

Saving the embodied energy of the building through its restoration also falls into this category. The energy savings from reduced material extraction, manufacture and transport are vast. This component is perhaps the most significant in energy savings because it touches upon so many tangential factors, like daylighting and natural ventilation from existing windows, yet it finds no points in this LEED category.

More creative energy savings features are dotted throughout the building. For instance, the tenant Hot Lips Pizza devised a unique oven heat exchanger equipped in a bread oven as opposed to a typical pizza oven. The bread oven, twice the size of a conventional pizza oven, consumes half as much energy to bake larger volumes of pizza. The heat exchanger transfers waste heat from the oven through a series of pipes that lead warm water into the basement hot water heater. This hot water is then used in the restaurant for washing and cleaning.[77] Tenants also share kitchen appliances.

Materials and Resources: By following the mantra "less is more" the Ecotrust project earned ten of the possible 13 Materials and Resources points. A low-finish aesthetic, coupled with ample use of salvaged, recycled, and local materials and resources, and a good dose of creativity, provided the means to success. Priority was given to the use and purchase of materials that were: [1] salvaged from the lot, [2] made with a high percentage of recycled content, [3] easily recyclable, [4] regional, or [5] certified as

---

[77] Buddenborg, Jennifer Lynn. *Changing Mindsets: Sustainable Design in Historic Preservation* . Thesis, Ithaca, New York: Cornell University , 2006.

sustainable, or manufactured by a company committed to sustainable design.[78]

The low-finish aesthetic involved leaving pipes, wires and mechanical equipment exposed, thereby allowing the historic interior of the warehouse to remain intact, and also decreasing additional material usage. The wooden posts, beams and trusses were in good condition and required only a minimal cleaning. The shared, open office plans contributed to this low-finish aesthetic, cutting material use for tenant improvements by half or more, while distributing natural light and fresh air more effectively.[79]

One of the savvy decisions made was to salvage the materials from the deconstruction of the adjacent onsite building to be used in the warehouse restoration. A storage area was created roughly ten blocks from the site, affectionately known as the "boneyard," to temporarily hold all of the materials before their reuse. Stone, wood, diamond plates, old gears and pipes, tongue and groove paneling, doors, hardware, posts and beams were all salvaged. Most of the third floor addition was built with these salvaged materials, including wood for its framing. Freight elevator gears form table bases. Wood, wire, old furniture and nails were used by fine furniture makers to build directories, coat racks, tables, benches, chairs, and other items. Other offsite salvaged materials like donated doors were used for office partitions and desks in the Office of Sustainable Development work space. Engraved benches on 10th Avenue were originally the granite curbs in between the sidewalk and street on NW Johnson. Surplus materials

---

78 Buddenborg, Jennifer Lynn. *Changing Mindsets: Sustainable Design in Historic Preservation* . Thesis, Ithaca, New York: Cornell University , 2006.
79 Ibid

were donated or sold.[80]

The reuse of the building itself offers the most efficient means to conserving materials and resources. The original windows were rehabilitated, many still with their 1895 glass panes. Salvaged lumber from the warehouse demolition was used in the restoration and repair of several of the window sashes. To increase energy efficiency, the windows were weatherized with a ribbed-zinc interlock weatherstrip used in conjunction with neoprene compression pieces to provide a tight seal. The original Douglas-fir plank floor was refinished on the first floor and an environmentally safe floor finish was applied.

Recycled materials are found throughout the building as well. Due to seismic code restrictions, the second floor wood flooring had to be replaced with a plywood sublayer, overlain with interlocking rubber tiles made from post-consumer recycled rubber tires. The tiles did not need an adhesive to hold together, therefore eliminating any toxic substances. The interior paint comes from a latex paint recycling program developed by Metro, Portland's regional government. The initial use and remixing of the paints releases many of the original VOCs.

FSC certified wood was used if salvaged wood could not be used. The third floor interior is laid with FSC certified guariuba flooring, a lesser-known tropical wood chosen to promote forest diversity, while the third floor exterior deck is made of Ipe, an Amazonian hardwood from an FSC certified forest in Bolivia. Because of the strength

---

[80] Buddenborg, Jennifer Lynn. *Changing Mindsets: Sustainable Design in Historic Preservation* . Thesis, Ithaca, New York: Cornell University , 2006.

and durability of Ipe, it does not require a protective finish. The selection of these two non-native species raises the question of sustainability in regard to using locally and regionally produced products. So many factors arise when choosing products in a sustainable manner, and oftentimes trade-offs are made, particularly in a globalized economy. In other words, there is not a definitive right or wrong answer to this question, but is one that must be analyzed on a case-by-case basis.

Indoor Environmental Quality: Nine of 15 points were earned in the Indoor Environmental Quality category. The restored windows and added skylights proved effective not only in energy and materials but also in providing ample daylight, views, and natural ventilation. Low VOC-emitting materials were used in the flooring, furnishings and upholstery, paint, walls and windows, like the use of Glitsa Infinity Non-Flat Water Based Finish on the refinished plank floors. Marbelized linoleum countertops, or Marmoleum, found throughout the building, are made of the following all-natural, non-toxic components: linseed oil, wood flour, pine rosins, and jute fiber. As mentioned in the Materials and Resources section, the recycled paint also had reduced VOC levels due to reuse. Monitoring of carbon dioxide levels and demand-controlled ventilation added to the healthy environment.[81]

Innovation and Design Process: The Ecotrust project surpassed many LEED standards, including the percentage of diverted construction waste and recycled content. As a result, each of these accomplishments earned the project an additional two points within this

---

[81] Buddenborg, Jennifer Lynn. *Changing Mindsets: Sustainable Design in Historic Preservation* . Thesis, Ithaca, New York: Cornell University , 2006.

category. The reuse of a historic building and the educational use of the project itself as a Green Building Demonstration Project garnered another two additional points. To round out the five out of five possible points in the Innovation and Design Process category, the project was also awarded a point for the use of a LEED Accredited Professional.

The fact that LEED awarded a point for the reuse of a historic building shows the recognition of the USGBC in the inherent benefits of preserving not just the embodied energy of a building but its cultural value as well. This point award does appear to be on a case-by-case basis however, as the green restoration of the S.T. Dana Building on the University of Michigan, Ann Arbor campus appealed to LEED for such a credit and was denied.[82]

Ecotrust makes a valiant effort to pass this message on to its tenants and visitors alike in its educational mission. The building is open to visitors to explore, with a Field Guide to lead one throughout the building's three floors. Creating a sense of community was an important, overarching goal of Ecotrust in the design and presentation of the building. It serves not only as a functioning work and retail space but as an educational space as well.

The Green Renovation: An emphasis on passive design, deconstruction and material reuse, and retention of historic character allowed the Ecotrust project to adequately follow the Standards, with the exception of the third floor penthouse and west side steel tower additions that confront Standard Nine. Seismic code upgrades required the

---

[82] Buddenborg, Jennifer Lynn. *Changing Mindsets: Sustainable Design in Historic Preservation* . Thesis, Ithaca, New York: Cornell University , 2006.

construction of the two towers that were structurally tied to the building. These provided seismic stability and stair access between the three floors, but their design was found by the NPS to adversely impact the building's historic integrity.

Other rehabilitation/renovation measures that had to take the Standards into account were the exterior and interior paint stripping; parapet removal and rebuilding; addition of interior structural steel frame, skylights, mechanical and electrical systems, and passenger elevator; use of recycled and salvaged materials; and rehabilitation of wood flooring and windows. The old grey paint on the exterior facades and bases was stripped, returning the building to its original 1895 appearance. Power washing easily removed the paint from the roof trusses and interior brick walls; the paint chip waste fit into three garbage bags. Sections of the parapet walls had advanced mortar deterioration and required their removal and rebuilding.

One of the more unique elements of retaining the historic character of the site is seen in the retention of a one-story piece of the deconstructed building, reinforced with metal, leaving a profile of the roof and visual record of what once stood there. It frames the west side of the lot, hugging the parking lot, creating what can be considered an art form. The preservation of this piece addresses Standard Two in the retention and preservation of the historic character inherent in this given space and environment.[83]

[83] Buddenborg, Jennifer Lynn. *Changing Mindsets: Sustainable Design in Historic Preservation* . Thesis, Ithaca, New York: Cornell University , 2006.

Appendix 3 – Materials Guide to the Jean Vollum Natural Capital Center

Materials Guide to the Jean Vollum Natural Capital Center

The Jean Vollum Natural Capital Center has been awarded gold-level Leadership in Energy and Environmental Design (LEED) certification under the strict standards developed by the U.S. Green Building Council. It is – nationwide – the first restoration of a historic building to earn the LEED gold rating. The certification considers such factors as water efficiency, energy performance, siting, materials, and indoor air quality.

Originally constructed as a warehouse in 1895, the Natural Capital Center building was acquired by Ecotrust in 1998 with the help of an extraordinary gift from philanthropist and founding board member Jean Vollum.

Ecotrust's renovation of the brick and timber building respects the character of the original 1895 structure while incorporating environmentally-innovative materials and techniques. The redevelopment contractor, Walsh Construction, has estimated that more than 98 percent of the construction waste has been recycled or reclaimed, a Portland city record. The building also features an "ecoroof" that, together with street-level landscaping, filters and absorbs almost all of the site's rainwater, eliminating contaminated runoff to the Willamette River.

BUILDING TEAM

OWNER (503) 227-6225
Ecotrust Properties, LLC,
Spencer Beebe and Bettina von Hagen

DEVELOPER (503) 228-0272
Heritage Consulting Group, Robert Naito

ARCHITECT (503) 233-9856
HOLST Architecture P.C., Jeffrey Stuhr

GENERAL CONTRACTOR (503) 222-4375
Walsh Construction Co., Dan Snow and Carrington Barrs

STRUCTURAL ENGINEER (503) 227-3251
KPFF Engineers, Blake Patsy

MECHANICAL ENGINEER (503) 659-6394
Interface Engineering, Andy Frichtl

CIVIL ENGINEER (503) 227-3251
KPFF Engineers, Susan VanDyke

INTERIOR DESIGN (503) 228-5122
Edelman Sojaga Watson, Carol Edelman

SUSTAINABILITY CONSULTANT (503) 823-7725
Greg Acker Architecture, Greg Acker

LANDSCAPE ARCHITECT (503) 227-5802
Nevue Ngan Associates, Bo Nevue

LEED CONSULTANT (503) 603-1661
PGE Green Building Services, Ralph DiNola

PROPERTY MANAGEMENT (503) 233-4048
Ashforth Pacific, Inc., Wade Lange

ecotrust

FOR MORE INFORMATION, CONTACT
BETTINA VON HAGEN | 503.467.0756 | BETTINA@ECOTRUST.ORG
EUGÉNIE FRERICHS | 503.467.0767 | EUGENIE@ECOTRUST.ORG

CONTENTS

Compiled by Eugénie Frerichs

DÉCOR

ARTWORK

FOR MORE INFORMATION ON THE ARTISTS:
PDX Contemporary Art
(503) 222-0063
www.pdxcontemporaryart.com

The large-scale paintings hanging in the Natural Capital Center reflect the work of an eclectic group of successful contemporary artists, many of which are from the Pacific Northwest.

I'm Very Well Protected, Gregory Grenon, 1991 — 2ND FLOOR ECOTRUST RECEPTION AREA
Mother Earth watches closely and takes note of the latest ideas and activities generated in her honor.

Anapurna, Nancy Lorenz, 1998 — 2ND FLOOR STAIRWAY
Working in the style of the optical artists, Nancy Lorenz has created in *Anapurna* a scene of the natural world. Mother-of-pearl inlays shift colors with the passing light from the skylights overhead. They are stars shining in a night sky or reflecting onto deep blue waters, which perhaps harken back to the artist's youth in Japan.

Like Rain, James Lavadour, 1995 — 2ND FLOOR CORRIDOR
James Lavadour, a member of the Walla Walla Tribe, lives on the Umatilla reservation in eastern Oregon. He is a self-taught artist who started painting landscapes in the 1970's. His paintings explore the relationships between earth, flesh, air, and water, and they are a response to the terrain in which he has lived his entire life, the Blue Mountains of eastern Oregon.

Mandala, Mary Henry, 1969 — 2ND FLOOR CORRIDOR
Mary Henry has been painting for decades out of her home in Whidbey Island, north of Seattle, WA. Now in her eighties, she has recently built a new art studio, and continues to paint every day. Her work is also on display at the Portland Art Museum.

MOOSE

DONATION
The Beebe Family

2ND FLOOR ATRIUM

The moose is a donation from Spencer Beebe, Ecotrust founder and president. It was shot by his great grandfather in Alaska near the turn of last century, about the same time the Natural Capital Center was built. "It is a relic of a former age, an heirloom, art, a ghost of the past," says Beebe, and a reminder of a time when many people came here to hunt and fish. It is a reminder that today many people in parts of the Coastal Temperate Rainforest with whom Ecotrust works continue to subsistence hunt and fish.

SIGNAGE

Architectural Signage Northwest
2121 NW York St.
Portland, OR 97210
(503) 227-2121

Anstey Healy Design
1231 NW Hoyt St. Suite 204
Portland, OR 97209
(503) 295-1979
www.ansteyhealy.com

Lee's Better Letters
(503) 232-1448

THROUGHOUT

The goods, ideas, and services created within the walls of the Natural Capital Center leave their mark on the physical space through the signage, stenciled with careful detail by Lee Littlewood and Lee's Better Letters.

The list of donors at the 10th Avenue entrance is encased within the old cover to the McCraken warehouse boiler.

Tenant signage is engraved on Douglas Fir salvaged from the warehouse demolition, and Anstey Healy Design created the template for the additional signage.

ENERGY

APPLIANCES

REFRIGERATOR:
Arctic Air Co.
Broich Enterprises, Inc.
6440 City West Parkway
Eden Prairie, MN 55344
(925) 941-2270
www.arcticairco.com

DISHWASHER:
Kenmore, www.kenmore.com

2ND FLOOR KITCHEN

The refrigerator in the 2nd floor kitchen is certified by the California Energy Commission as an energy-efficient model. Its daily energy consumption is 1.3 kWh.

The dishwasher in the 2nd floor kitchen is a Kenmore Elite Energy Star model. The normal cycle, which varies between 70-90 minutes, 6.5-10.8 gallons, depending on need, meets the energy efficiency standards as defined by the federal Energy Star program.

Both the dishwasher and refrigerator are shared by all tenants on the 2nd floor. Their efficiency contributes greatly to the building's overall energy savings of 23%, as compared to the ASHRAE national energy code.

GREEN POWER

ENROLLMENT INFORMATION:
Portland General Electric
P.O. Box 4404
Portland, OR 97208-9581
(800) 542-8818
www.PortlandGeneral.com

THROUGHOUT

The Natural Capital Center purchases twenty-two blocks, at 100 kWh/block, of Clean Wind and Salmon Friendly power each month through Portland General Electric Company's Renewable Power program. One half of the monthly payment supports construction of new wind power facilities or salmon habitat restoration projects, while the other half supports the higher costs associated with renewable power acquisition.

HOT LIPS PIZZA OVEN

1ST FLOOR

CONTACT:
Dave Yudkin, Hot Lips Pizza
(503) 817-5116
www.hotlipspizza.com

The oven in Hot Lips Pizza is a bread oven typically found in bakeries. At twice the size of a conventional pizza oven, the bread oven consumes half as much energy to bake large volumes of pizza. The oven is equipped with a heat exchanger, which uses heat from the oven to warm water that feeds into the hot water heater in the basement. To further maximize heat efficiency, the oven is lined with over 1000 pounds of insulation.

HVAC SYSTEM

THROUGHOUT

CONTACT:
Hunter Davisson, Inc.
3410 SE 20th Ave.
Portland, OR 97202
(503) 234-0477
www.hunterdavisson.com

The HVAC system for the Natural Capital Center is a variable air volume model, which allows the percentages of fresh and recycled air to vary depending on the existing conditions in the building. It is equipped with carbon dioxide sensors that trigger a flush of fresh air through the building when the air has grown stale. The space temperatures are set at more efficient levels, summer/winter at 76 deg F/68 deg F rather than 74/70, putting less strain on the energy requirements for the building. Consequently, the Natural Capital Center's energy costs are 23% lower than ASHRA's specified standard.

EXTERIOR

ASPHALT

PARKING LOT

PAVERS SUPPLIER:
Mutual Materials
P.O. Box 333
Tualatin, OR 97062-0333
(503) 624-8860

ASPHALT SUPPLIER:
Morse Brothers
www.morsebros.com

INSTALLATION:
Tom Fischer Trucking
53990 W. Lane Rd.
Scappoose, OR 97056
(503) 543-7979

The concrete pavers and semi-permeable asphalt in the Natural Capital Center parking lot are two important components of the Natural Capital Center's stormwater management system.

While traditional concrete is often designed with little to no permeability, sending stormwater runoff into city drains and eventually the closest waterways, these pavers and asphalt are designed to reduce or eliminate stormwater runoff by absorbing the water and returning into the ground below. This recharges the groundwater supply and diverts stormwater from the city's already overloaded stormdrains. Permeable asphalt is best suited for large expanses. In small applications, as is the case here, the material is not applied evenly, leading to premature breaking and crumbling of the material.

BIOSWALES

PARKING LOT

LANDSCAPE ARCHITECT:
Nevue Ngan Associates
Bo Nevue, Landscape Architect
1006 Grand Ave., Suite 250
Portland, OR 97214
(503) 239-0600

INSTALLATION:
Cedar Landscape, Inc.
14145 SW Galbreath Dr.
Sherwood, OR 97140
(503) 625-3700

The long, narrow strips of landscaping in the parking lot are part of the Natural Capital Center's stormwater management system. The swales are bottomless; all of the rainwater they receive from the parking lot and the roof's downspouts will filter through the vegetation and soil to then either evapotranspirate into the atmosphere or seep into the groundwater. The native plants were carefully selected for their ability to tolerate seasonal fluctuations between inundations of water and intense heat. Once established these plants require little maintenance, and will receive irrigation from rainwater alone.

GRANITE BENCHES

10TH AVENUE SIDEWALK

POLISHING AND ENGRAVING:
Great Northwest Granite & Marble
1921 SE Hawthorne
Portland, OR
(503) 238-1905

The polished and engraved granite benches on 10th Avenue were originally the curbs in between the sidewalk and street on NW Johnson. They are inscribed with the words of various harbingers of a conservation economy, such as Wendell Berry, Jane Jacobs, and the Haisla Nation of British Columbia.

RELIC WALL

10TH AVENUE SIDEWALK

DECONSTRUCTION:
Walsh Construction Co.
with training from The Rebuilding Center's Deconstructioin Services
3625 N. Mississippi Ave.
Portland, OR 97227
(503) 331-1877
www.rebuildingcenter.org

At a close distance from the Natural Capital Center's 10th Avenue entrance stands all that remains of the McCraken warehouse annex. At the time of breaking ground for the Natural Capital Center, the annex was not structurally sound, leaving no other option but to painstakingly deconstruct and recycle all of the annex's building material. Salvaged Douglas Fir columns and framing material moved from the annex to the third story penthouse, which was re-engineered to support the historic wood. The annex also provided material for the atrium, where the original timbers coexist with salvaged, re-milled wood. Approximately 98% of the deconstructed material was reused or recycled, a record for the city.

FLATSCREENS

1ST FLOOR ATRIUM

TECHNICAL ASSISTANCE:
Concept to Reality, Tim Canfield
14316 SE River Rd.
Milwaukee, OR 97267
(503) 805-5284

The Tidepool.org computer and its counterpart, the flatscreen, both located in the atrium, are fueling stations for visitors and tenants seeking inspiration and education about the ideas and actions of a conservation economy. Here one can catch up on the bioregion's latest news stories, carefully selected and updated daily by the editors at Tidepool.org. Opposite the Tidepool computer one can view the flatscreen's newest slide show, featuring images and text on various themes of a conservation economy.

FIREPLACE

3RD FLOOR PATIO

Fireside Dist. of Oregon, Inc.
18389 SW Boones Ferry Rd.
Portland, OR 97224
(503) 684-8535

Tenants and visitors can enjoy the city views and fresh air year round thanks to the warmth and comfort of the 3rd floor patio's outdoor fireplace. The fireplace builds on a long tradition in the Pacific Northwest of gathering around the fire to share stories and resolve conflicts.

FLOORING

CARDECKING

1ST FLOOR PUBLIC AREAS

REFINISHING:
Bachelor Hardwood
P.O. Box 852
Welches, OR 97067
(503)-622-7642

The floors on the main level of the Natural Capital Center are the original Douglas Fir planks that were milled for the warehouse over a century ago. In order to restore the wood without jeopardizing its historical integrity, the planks were sanded and refinished with Glitsa Infinity Non-Flat Water Based Finish for wood floors, used in conjunction with Glitsa Infinity Color Control Sealer, products that are low in volatile organic compounds. The joints are filled with colored cork shavings.

CARPET AND CARPET TILE

2ND FLOOR THROUGHOUT

SUPPLIER:
Interface, Inc.
www.ifsia.com

All of the carpets on the 2nd floor are manufactured by Interface, Inc., and meet the requirements of the Carpet and Rug Institute Green Label Indoor Air Quality Test Program. Interface, Inc. is striving to become the world's first sustainable industrial corporation, a goal the company established worldwide in 1994. To achieve their goal, Interface defined a seven-step process: Eliminate waste; Release only benign emissions; Use renewable energy; Close the loop of materials flow; Create resource efficient transportation strategies; Provide a "sensitivity hookup"; Redesign commerce. As a corporation with offices and manufacturing plants worldwide, Interface Inc. is fast becoming a powerful voice for the promotion of a conservation based economy.

COCO-MATS NATURAL FIBER FLOOR COVERINGS

1ST FLOOR INTERIOR ENTRYWAYS

SUPPLIER:
Alison T. Seymour, Inc.
5423 W. Marginal Way S.W.
Seattle, WA 98106
(206) 935-5471
(800) 227-5471

Coco-Mats are made from 100% coconut coir with solid PVC backing. Coconut coir consists of the shredded outer shell of the coconut, which is a widely available, renewable resource that is gaining in popularity in the United States.

CORK FLOORING

1ST FLOOR, PATAGONIA; 3RD FLOOR, SUITE 300

SUPPLIERS:
Natural Cork LLC
1825 Killingsworth Rd.
Augusta, GA 30904
(800) 404-2675

Built-e, Inc.
www.built-e.com

The flooring in the Patagonia reading room and the conference and supply rooms in Suite 300 comes from the bark of the cork tree, Quercus suber, which grows in Mediterranean climates. The cork is harvested from live trees every 10-15 years, which is the length of time necessary for the bark to regenerate. When done responsibly, cork can be harvested from the same tree for up to ten to fifteen cycles.

GUARIUBA HARDWOOD FLOOR

3RD FLOOR LOBBY

SUPPLIER:
Colonial Craft Specialties
2772 Fairview Ave. N.
Roseville, MN 55113
(800) 727-5187
www.colonialcraft.com

The 3rd floor lobby greets visitors with a colorful guariuba (Clarisia racemosa) hardwood floor. FSC certified Guariuba is a "lesser known species" and was selected specifically to encourage responsible forest management. While hundreds of species proliferate in the forest where these trees grow, barely a dozen prosper in the marketplace. Until consumption more closely parallels the diversity of outputs from the forest, there is little incentive to maintain forests in their natural condition. The selection of a lesser-known species sends a signal to the forest land manager that diversity in the forest is a valuable asset.

▼
IPE DECKING — 3RD FLOOR PATIO

SUPPLIER:
EcoTimber/Hayward Lumber
1020 Heinz Ave.
Berkeley, CA 94710
(510) 549-3000

IMPORTER:
Sylvania Certified LLC
(800) 468-6139
www.certifiedwood.com

The wood for the 3rd floor patio is Ipe, an Amazonian hardwood that was grown and harvested sustainably from an FSC certified forest in Bolivia. The decking came in shorter lengths to increase the log utilization, a process which overcomes a serious problem in many Latin American milling operations: wood waste. The decking is an intermediate size in-between the typical 4" and 6" nominal width, which also reduces waste at the mill level. Its sturdiness is such that it does not require any protective finish; the visible color is its natural hue.

▼
MARMOLEUM FLOORING — 2ND FLOOR RESTROOMS & SUPPLY ROOM

SUPPLIER:
Environmental Building Supplies
819 SE Taylor St.
Portland, OR 97214
(503) 222-3881
www.ecohaus.com

MANUFACTURER:
Forbo Linoleum, (800) 842-7839
www.forboLinoleumNA.com

The marbleized linoleum in the 2nd floor bathrooms, supply room, and on various countertops throughout the building, is made from all natural, renewable resources. The primary ingredients in Marmoleum, as it is commonly called, include: Linseed oil (pressed seeds from the flax plant), wood flour (from controlled forestry practices, no tropical hardwoods used), pine rosins (mixed with the oxidized linseed oil), and jute fiber (spun into yarn and applied as backing).

▼
RUBBER FLOORING — 2ND FLOOR PUBLIC AREAS

SUPPLIER:
Atmosphere Recycled
Rubber Flooring
West Coast Services
(800) 465-4605

The black and blue interlocking rubber tiles on the 2nd floor are made from post-consumer, single-ply, non-laminated recycled rubber tires with colored rubber granules. The flooring emits little to no volatile organic compounds and requires no adhesive for installation, further reducing the potential for toxic emissions. Style: Impact; size: 4mm x 38" square.

FURNISHINGS & UPHOLSTERY

▼
ADIRONDACK CHAIRS — 3RD FLOOR PATIO

SUPPLIER:
LWO Corporation
Arboria Garden Furniture
P.O. Box 17125
Portland, OR 97217
(503) 286-5372
www.lwocorp.com

The Adirondack chairs on the 3rd floor patio are made from the South American hardwood Eucalyptus grandis, and are FSC certified. The wood is pre-finished with a rich mahogany colored oil for protection against weathering. The chairs are manufactured for LWO Corporation's Arboria line of garden and patio furniture. LWO Corporation is a Portland-based company "dedicated to seeking out sources of high quality lumber which is grown and harvested using sustainable, environmentally responsible forestry techniques."

▼
CEDAR BENCHES — 3RD FLOOR PATIO

SUPPLIER:
Sarita Furniture
Box 1269
Port Alberni, BC
CANADA V9Y 7M1
(888) 472-7482
www.sarita.net

Sarita Furniture in British Columbia provided the FSC certified Western Red Cedar benches on the 3rd floor patio. Sarita Furniture products are certified through SmartWood, and were the first forest products in British Columbia to receive certification through the SmartWood Forest Certification Program.

▼
ECOTRUST WAITING AREA ARMCHAIRS — 2ND FLOOR ATRIUM

SUPPLIER:
Maharam
(800) 645-3943
www.maharam.com

The fabric for the armchairs in the Ecotrust waiting area contain 78% post-industrial recycled polyester.

▼

HERMAN MILLER FURNISHINGS

SUPPLIER:
Herman Miller
Zeeland, Michigan
(800) 851-1196
www.hermanmiller.com

CONFERENCE ROOM TABLES AND CHAIRS [STYLE: CAPER] — 2ND FLOOR
ECOTRUST OFFICE SYSTEM [STYLE: RESOLVE] — 2ND FLOOR
SUITE 300 OFFICE SYSTEM [STYLE: PASSAGE] — 3RD FLOOR

The furnishings for the Ecotrust and CFPC offices, and the 2nd floor conference center, are from Herman Miller. Herman Miller's corporate environmental goal is, "To become a sustainable business by manufacturing products without reducing the capacity of the environment to provide for future generations." As a manufacturer of office furniture, Herman Miller has taken great strides to achieve their goal. Much of their furniture contains between 40-100% recycled content (by weight) and all steel, aluminum, and polypropylene components are 100% recyclable. The wood desks included in the office system in Suite 300 are FSC certified and include cherry, red and white oak, sugarpine, and hard and soft maple veneers.

▼

THE JOINERY TABLES AND CHAIRS — 1ST FLOOR ATRIUM; 2ND FLOOR RESOURCE LIBRARY

The Joinery
4804 SE Woodstock Blvd.
Portland, OR 97206
(503) 788-8547
www.thejoinery.com

The maple for the tables in the first floor atrium comes from the Collins Companies' forests in Pennsylvania, which have been certified by the Forest Stewardship Council to be sustainably harvested. Sustainably managed forests like these provide most of the wood used at The Joinery. Readily renewable materials: limestone, cork and wood flours, resin and jute comprise the marmoleum surface that tops the tables.

▼

RESOURCE LIBRARY SEATING — 2ND FLOOR

SUPPLIER:
Pendleton Woollen Mills
(800) 760-4844
www.pendleton-usa.com

The benches in the Natural Capital Center Resource Library are upholstered with textiles from Pendleton Woollen Mills. In the early 1900's, as the McCraken warehouse first began to flourish, Pendleton blankets were primarily known as a standard of value for both trade and credit amongst the Nez Perce, Navajo, Hopi, and Zuni nations. Today, as the Natural Capital Center brings new life to the old warehouse, Pendleton Woollen Mills continues to thrive as a family-run business, expanding its products list to include men's and women's clothing, accessories, and upholstery. Style: Sioux Belt fabric

▼

ROBLE & IPE TABLES AND CHAIRS — 3RD FLOOR LOBBY

SUPPLIER:
Sylvania Certified LLC
(800) 468-6139
www.certifiedwood.com

The tables and chairs in the 3rd floor lobby and patio are FSC certified roble and ipe, imported from Bolivia by Sylvania Certified LLC. The roble and ipe trees are both very slow growers; they are harvested after reaching at least 120 years in age, resulting in a naturally durable, stable wood ideal for outdoor conditions. Styles: Julia, Cassatt, Cézanne

▼

SALVAGED MATERIALS — THROUGHOUT

CARPENTERS:
Arlo Manion
6108 SE Stark
Portland, OR 97215

Terry Tebeau
939 SE Alder
Portland, OR 97214
(503) 236-9441

Independent fine furniture makers built several furniture pieces for the Natural Capital Center from salvaged wood. Terry Tebeau, applied artist/designer, made the STOOLS in the atrium, the EVENT CENTER PEDESTALS and PODIUM, 2nd floor BUILDING DIRECTORIES, free-standing COATRACKS and COAT HOOKS, and the TIDE-POOL WORKSTATION, all from salvaged Douglas Fir trusses, scrap plywood, and wainscoting. He also designed the space and built the furniture for the Progressive Investment office, Suite 250. Arlo Manion built the inserts for the CONFERENCE TABLE in the Ecotrust Alder Room and the KITCHEN TABLETOP from salvaged Douglas Fir. The COFFEE TABLE in the Ecotrust waiting area and the stands for the kitchen table were originally gears for the old warehouse freight elevator. Carrington Barrs of Walsh Construction Co. salvaged some old Douglas Fir floor joists for the WOODEN BENCHES in the parking lot and basement locker rooms.

INSULATION

▼

ICYNENE — 3RD FLOOR

SUPPLIER:
Icynene Insulation System
(800) 758-7325
www.icynene.on.ca

In order to better insulate the building, walls and ceilings were sealed from draft and moisture with Icynene, a polyicynene expanding foam insulation. It is applied as a spray foam but does not contain ozone-destroying gases or formaldehyde, making it the only insulation material on the market certified by the Envirodesic Certification Program for healthier indoor air quality. It does not contain any detectable volatile organic compounds.

JANITORIAL SERVICE — BASEMENT OFFICE

▼

Corporate Building Maintenance
16055 SW Walker Rd., Suite 129
Beaverton, OR 97006

CLEANING SUPPLIES:
The Leaf Project
(877) ECO-LEAF
www.leafproject.com

Corporate Building Maintenance, Inc., which provides the janitorial service for the Natural Capital Center, is "committed to eliminating the use of environmentally hazardous products and chemicals associated with the maintenance of commercial facilities." Their cleaning materials, supplied by The Leaf Project, are biodegradable, all natural, phosphate free, and without any animal by-products or perfumes. The proceeds from The Leaf Project cleaning products support environmental education in schools and the work of various environmental organizations. Their work is supported by Rainforest Action Network and the Earth Island Institute.

LIGHTING

▼

CONFERENCE CENTER DECORATIVE FIXTURES — 2ND FLOOR

SUPPLIER:
Louis Poulsen
www.louispoulsen.com
(954) 349-2525

The lighting fixtures in the conference center were custom fabricated to use compact fluorescent lamps with a dimming ballast. These fixtures work as part of a two-tiered lighting design, in conjunction with the fluorescent lamps that hang one level above. The two-tier design provides a wide array of efficient lighting levels, for the multiple needs of a diverse space. Style: PH6 maxi.

▼

FLUORESCENT FIXTURES — 2ND FLOOR THROUGHOUT

SUPPLIER:
Prudential Lighting
(213) 746-0360
www.prulite.com

The fluorescent fixtures visible throughout the building are designed with a dual circuit switch for use of one or two lamps, as needed.

▼

OCCUPANCY SENSORS — THROUGHOUT

Several of the lights throughout the building have occupancy sensors, which turn lights off automatically when a space is not in use, while lights in the atrium brighten or dim automatically depending on the amount of natural light available from the skylights. Such measures have significantly reduced the building's total energy consumption, which is 23% less than that of a conventional building of the same size.

PAINT

▼

METRO PAINTS — INTERIOR THROUGHOUT

PAINT DROP-OFF/ FACTORY DIRECT PRICES:
METRO Household Hazardous Waste Facility
METRO South Station
2001 Washington St.
Oregon City, OR 97405
(503) 650-1384
www.metro-region.org

RETAIL LOCATION:
Environmental Building Supplies
819 SE Taylor
Portland, OR 97214
(503) 222-3881
www.ecohaus.com

The interior paints used throughout the Natural Capital Center came from used cans of latex paint that were collected by METRO, Portland's regional government. METRO's latex paint recycling program strives to keep hazardous waste out of Portland's landfills and waterways. Their recycling facility in Oregon City accepts partially used and unwanted latex paints from homeowners and small businesses. The paints are re-mixed and re-sold in a variety of colors, many of which can be seen throughout the Natural Capital Center.

Lead content: 25 ppm (acceptable maximum: 600 ppm)

Volatile Organic Compounds: 30-100 g/l average (acceptable maximum, 150 g/l).

(Limits set by the Consumer Product Safety Commission.)

ROOFING

▼

ECOROOF — OVER THE 2ND STORY

DISTRIBUTOR:
W.P. Hickman, Inc.
www.wphickman.com

REGIONAL SALES REP:
W.P. Hickman, Paul Fannin
(253) 841-7654

ROOFER:
McDonald & Wetle Roofing
2020 NE 194th St.
Portland, OR 97230
(503) 667-0175

SOIL AND PLANT INSTALLATION:
Green Seasons Landscaping
P.O. Box 583
West Linn, OR 97068
(503) 263-4567

The ecoroof roofing membranes consist of two layers of modified bitumen at a total thickness of 8.2 mm. The bottom membrane provides waterproofing for the roof, while the top layer of bitumen, inlaid with a thin copper film, provides root resistance and drainage. The membranes support two inches of soil and several species of native grasses, wildflowers, and succulents. The ecoroof is an important component of the Natural Capital Center's stormwater management system, through which the majority of the building's stormwater is treated, diverting the water from the city's overloaded stormdrains.

SALVAGED MATERIALS

DOORS
SALVAGED

2ND FLOOR THROUGHOUT

Several doors were salvaged from the warehouse demolition and reused throughout the building. The steel and wood barn-style track doors that divide the conference room originally hung beneath the brick archways on the ground floor. Walsh Construction Co. employees and subcontractors certified their work on the restoration project with their signatures, which cover the old steel door to the catering kitchen in the conference center. ShoreBank Pacific's office space on the 2nd floor is defined by a door-wall, which consists of various hinged doors that were found throughout the warehouse.

FURNISHINGS
CARPENTERS:

Arlo Manion
6108 SE Stark
Portland, OR 97215

Terry Tebeau
939 SE Alder
Portland, OR 97214
(503) 236-9441

THROUGHOUT

Independent fine furniture makers built several furniture pieces for the Natural Capital Center from salvaged wood. Terry Tebeau, applied artist/designer, made the STOOLS in the atrium, the EVENT CENTER PEDESTALS and PODIUM, 2nd floor BUILDING DIRECTORIES, free-standing COATRACKS and COAT HOOKS, and the TIDE-POOL WORKSTATION, all from salvaged Douglas Fir trusses, scrap plywood, and wainscoting. He also designed the space and built the furniture for the Progressive Investment office, Suite 250. Arlo Manion built the inserts for the CONFERENCE TABLE in the Ecotrust Alder Room and the KITCHEN TABLETOP from salvaged Douglas Fir. The COFFEE TABLE in the Ecotrust waiting area and the stands for the kitchen table were originally gears for the old warehouse freight elevator. Carrington Barrs of Walsh Construction Co. salvaged some old Douglas Fir floor joists for the WOODEN BENCHES in the parking lot and basement locker rooms.

WOOD
SALVAGED

THROUGHOUT

Builders used reclaimed wood for STRUCTURAL MEMBERS, CONCRETE FORMWORK, FLOORING, TRIM, FURNITURE, and ARTWORK. Framing for the third story penthouse came from wood salvaged during the deconstruction of the original warehouse annex, the northwestern wall of which still stands at the end of the parking lot. Wood for 60% of the penthouse post and beam structure, and 50% of its purlins, came from the demolition of a site across the street, sold at $.55 per board foot. The handrail around the mezzanine consists of solely reclaimed wood, as does its flooring structure. The vertical wainscot in the 2nd floor hallway was originally 1 x 6 subflooring from the area of the building that is now the atrium. It was refinished with Miller Acriclear, a water-based sealant.

STRUCTURAL STEEL

WESTERN EXTERIOR, THROUGHOUT BUILDING INTERIOR

SUPPLIER:

Seaport Steel
Seattle, WA
(206) 343-0700
www.seaportsteel.com

REBAR:

Cascade Steel Rolling Mills
3200 N. Hwy 99
West P.O. Box 687
McMinnville, OR 97128
(503) 472-4181
www.schn.com

INSTALLATION:

G.T.E. Metal Erectors, Inc.
P.O. Box 877
Canby, OR 97013
(503) 266-6433

All of the structural steel beams in the Natural Capital Center contain 97.5% recycled steel scrap, while the steel rebar contains 95.5% recycled content. Recycling has always been an integral part of the steel manufacturing process. In the year 2000, 70 million tons of steel scrap were recycled. The scrap is re-milled into new steel products which can, in turn, be recycled at the end of their lifespan. For the steel mills, re-using steel scrap greatly lowers manufacturing costs. For the environment, recycling steel reduces the strain on energy and natural resources. When one ton of steel is recycled, 2,500 pounds of iron ore, 1,400 pounds of coal, and 120 pounds of limestone are conserved. (Statistics: www.recycle-steel.org)

TRANSPORTATION

BICYCLE RACKS
SUPPLIERS:

Huntco Bike Racks
St. James, OR.
(800) 547-5909
www.huntco.com

Bike Track, Inc.
P.O. Box 235
Woodstock, VT 05091
(888) 663-8537

PARKING LOT, BASEMENT

The Natural Capital Center offers over fifty parking spaces for bicycles as one way of promoting the use of alternative transportation. While the racks in the parking lot are a standard, locally manufactured design, the Bike Track Mini-Mum racks in the basement are designed for space-efficient, vertical bike parking.

▼
BIKE-SHARE — BASEMENT

Community Cycling Center
1700 NE Alberta
Portland, OR 97211
(503) 288-8864
www.communitycyclingcenter.org

The Natural Capital Center also has a bike-sharing program, through which tenants may check out one of three bicycles, donated by Walsh Construction Co. and the Community Cycling Center, for day use.

▼
ELECTRIC VEHICLE REFUELING STATIONS — PARKING LOT

Electric Vehicle Infrastructure, Inc.
11839 Industrial Court
Auburn, CA 95603
(530) 823-8077
www.evii.com

The parking lot is equipped with the infrastructure to support two electric vehicle charging stations, each designed for charging two vehicles simultaneously. The DS-200-DL Dual Power Control Stations are compatible with vehicles from Ford, Mazda, and Honda.

▼
FLEXCAR — PARKING LOT

Flexcar Portland
620 SW Main St., Suite 228
Portland, OR 97205
503-328-FLEX (3539) (Portland)
360-823-FLEX (Vancouver)
www.flexcar.com

Flexcar purchased and placed two Toyota Prius hybrid sedans specifically for the Natural Capital Center location. Tenants of the building are encouraged to commute to work via bicycle or public transportation, and use Flexcar for any errands or trips taken during the day. The cars are also available for use by all Flexcar members.

WALLS

▼
AQUARIUM — 2ND FLOOR CORRIDOR

SUPPLIER:
Classic Aquariums, Inc.
5809 NE 100th Circle
Vancouver, WA 98686
(503) 231-9577

The aquarium next to The Wild Salmon Center contains several juvenile salmon and steelhead that were born in area hatcheries. Although The Wild Salmon Center's goal is to proactively protect wild populations of salmon and steelhead, the Endangered Species Act prohibits the removal of listed wild or native species from their native habitats, even for educational purposes such as this. While viewing the aquarium, you may see examples of Chinook or Coho salmon, steelhead, cutthroat trout, or sturgeon. The array of species in the aquarium may be predator and prey, with roles shifting quickly. Some of the interactions between the creatures reflect behavior used to partition or maintain habitat. Some of the behavior reflects interactions between prey and predator. You may witness one creature hunting and eating another - do not be alarmed!

▼
CORK TACK PANELS — 2ND FLOOR INTERPRETIVE CORRIDOR; 2ND FLOOR RESOURCE LIBRARY

SUPPLIER:
ContempoCork
175 Dorchester Rd.
River Edge, NJ 07661
(201) 986-7915

Various bulletin boards throughout the 2nd floor are made from dyed cork. Cork comes from Quercus suber, the cork oak tree, which grows in Mediterranean climates. The cork is the actual bark of the oak, and it is harvested from live trees every 10-15 years, which is the length of time necessary for the bark to regenerate. When done responsibly, cork can be harvested from the same tree for up to ten to fifteen cycles.

▼
DIAMOND PLATE — 2ND FLOOR ENTRY TO CONFERENCE ROOM

Salvaged

The steel diamond plate panels that frame the entrances to the conference center were salvaged from the warehouse demolition. The diamond plate was a later addition to the warehouse, installed on the ground floor to distribute the weight of forklifts and heavy machinery evenly over the surface of the wood floors. The diamond plate was cleaned, without any coats of sealer, before reinstallation in the new building as wall covering.

▼
GYPSUM DRYWALL — 3RD FLOOR

SUPPLIER:
USG Corporation
125 S. Franklin St.
Chicago, IL 60606-4678
(800) 874-8870

INSTALLATION:
The Finishers Corp.
19450 SW Mohave Court
Tualatin, OR 97062
(503) 692-4485

The drywall in the Natural Capital Center consists of Sheetrock Brand gypsum, 25% of which is recaptured rather than mined material, sandwiched between sheets of 100% recycled unbleached newsprint. The gypsum used in drywall is either mined or recovered as a byproduct of removing polluting gases from the smoke stacks at fossil-fuel burning power plants. This process is called flue-gas desulfurization. Recapturing gypsum reduces the amount of harmful materials emitted into the atmosphere and cuts back on the mining activities necessary to extract raw gypsum.

▼
IISAAK PANELING — 2ND FLOOR CONFERENCE ROOM

SUPPLIER:
Iisaak Forest Resources Ltd.
P.O. Box 639, 2395 Pacific Rim Hwy.
Volvelet, BC Canada V0R340
(250) 726-2446
www.iisaak.com

The wall panels in the conference center are made of Western Red Cedar from the ancient rainforest of Clayoquot Sound on Vancouver Island. The timber was selectively harvested by Iisaak Forest Resources Ltd. Iisaak is a First Nations led company and a joint venture between the Nu-chah-nulth First Nations of Clayoquot and the Weyerhauser Company. Iisaak Forest Resources is pioneering a new kind of forestry based on ecologically sensitive practices and the protection of treasured First Nations' cultural areas. Their forest management practices have been FSC certified.

▼
INTERPRETIVE NICHES — 2ND FLOOR CORRIDOR

TO RESERVE SPACE CONTACT:
Ecotrust
Kara Orvieto
(503) 227-6225

The interpretive niches dispersed throughout the 2nd floor were constructed with wood and piping salvaged from the warehouse demolition. Equipped with adjustable cork tack panels and electrical outlets for the use of televisions and flatscreens, the interpretive niches are positioned as a simple and effective method for public outreach and education. Topics displayed thus far have included salmon-friendly wine, organic and fair trade coffee, and certified wood. The displays change every two months, and are available to building tenants or other interested organizations in the region.

▼
LODGEPOLE PINE PANELING — 3RD FLOOR, SUITE 300

SUPPLIER:
The Collins Companies
1618 SW 1st Ave., Suite 500
Portland, OR 97201
(800) 329-1219
www.collinswood.com

ASSEMBLY:
Twenty-Four Seven Incorporated
425 NE 9th Avenue
Portland, OR 97232
(503) 222-7999
www.twentyfour7.com

The wall paneling in the Certified Forest Products Council office area is FSC certified CollinsWood lodgepole pine, harvested sustainably in Southern Oregon from the 75,000-acre Collins Lakeview Forest.

▼
PANEL PAVILION — 3RD FLOOR, SUITE 300

SUPPLIER:
Columbia Forest Products
www.columbiaforestproducts.com

ASSEMBLY:
Twenty-Four Seven Incorporated
425 NE 9th Avenue
Portland, OR 97232
(503) 222-7999
www.twentyfour7.com

The Panel Pavilion in the CFPC office area consists of an array of hardwood ply panels from FSC certified EuroPly. Veneers visible on the panel pavilion include cherry, rotary and sliced red and white oak, teak, black walnut, ash and hickory.

▼
RADIUS WALL — 3RD FLOOR RECEPTION

SUPPLIER:
Red Hills Lumber Company
709 Campbell St.
Thomasville, GA 31792
(229) 227-3556
www.redhillslumberco.com

The radius wall behind the reception station is made from heritage grade FSC certified Longleaf Pine donated by Red Hills Lumber in Georgia. Longleaf Pine forests have been systematically replaced by the more commercially viable Southern Yellow Pine species, and concerted efforts are underway to conserve Longleaf Pine forests by establishing greater value its products in the marketplace.

WATER

▼
FLOW FIXTURES — RESTROOM FAUCETS AND BASEMENT SHOWERS

Symmons
(800) 796-6667

Zurn Industries, Inc.
P.O. Box 2767
Sanford, N.C. 27331.
(800) 997-3876

The Natural Capital Center has taken several steps to reduce water consumption. Measures include: Single Handle Lavatory Faucets fitted with 0.5 gallon per minute (gpm) aerators [S-20 series by Symmons]; Flow-restricting washers on shower heads, emitting 2.0 gpm [Symmons part # T-44-2.0]; Exposed Flush Valve on toilets for low consumption, 1.6 gallons per flush [Zurn Z-6000XL-WS1]; Kohler toilets, 1.6 gallons per flush; and Kohler urinals, 1.0 gallons or less per flush. As a result, the building has achieved a 33% overall reduction in water consumption compared to a conventional building of the same size.

▼
"XERIGATION" SYSTEM
Rain Bird , www.rainbird.com

INSTALLATION:
Cedar Landscape, Inc.
14145 SW Galbreath Dr.
Sherwood, OR 97140
(503) 625-3700

PARKING LOT LANDSCAPING

"Xerigation" is a term used to describe water-efficient irrigation. The Natural Capital Center landscaping uses a xerigation system that is a temporary landscape dripline, with pressure compensation, designed for irrigating ground cover, mixed plantings, slope plantings, and hedge rows. The system will be removed once the native plants are established. The flow rate is 0.61–0.92 gallons per hour.

WINDOWS

▼
CUSTOM WINDOWS
Colonial Craft Specialties
2772 Fairview Avenue N.
Roseville, MN 55113
(800) 727-5187
www.colonialcraft.com

The Collins Companies
1618 SW 1st Ave., Suite 500
Portland, OR 97201
(800) 329-1219
www.collinswood.com

The H Window Company
1324 E. Oakwood Dr.
Monticello, MN 55362-9965
(800) 843-4929
www.h-window.com

3RD FLOOR THROUGHOUT

H Windows in Minnesota custom-built the operable windows on the 3rd floor with manufactured parts from Colonial Craft Specialties using FSC certified pine from Oregon's own Collins Companies. The window trim is FSC certified pine, as are the window blinds, both sourced from The Collins Companies.

▼
RESTORED WINDOWS
RESTORATION:
Portland Sash & Door
16460 SW 72nd Ave.
Portland, OR 97224
(800) 660-2905
www.portlandsashanddoor.com

2ND FLOOR THROUGHOUT

Throughout the Natural Capital Center there is evidence of a compromise between old and new building strategies. The operable windows on the second floor, for example, are of the original design, many still with 1895 glass panes. Several of the window sashes had to be restored or repaired with lumber salvaged from the warehouse demolition before re-installing them in the existing frames. The windows were then weatherized with a ribbed-zinc interlock weatherstrip used in conjunction with neoprene compression pieces to ensure a tightly sealed, energy efficient building. The building team chose to retain these single-pane restored windows to conserve both materials and the historical integrity of the building.

▼
WINDOW DRAPERY
SUPPLIER:
Maharam
(800) 645-3943
www.maharam.com

2ND FLOOR CONFERENCE CENTER; ECOTRUST ALDER ROOM

Made from 78% post-industrial recycled polyester, the Apricot-colored curtains create a high-performance space for showing slides, presentations, and films.

Appendix 4 - Case Study: Portland Center Stage Armory

One primary challenge was to install modern mechanical, electrical, plumbing and telecommunications systems in a historical renovation project where visibility to architecture was paramount. Chilled water was extended from the district cooling plant that serves all of the Brewery Blocks. This eliminated the need for unsightly equipment on the visible barrel roof of the building.[84]

Air handlers utilize fan wall technology, which provides multiple smaller fans, providing not only improved acoustical performance but also added redundancy for the owner. Eliminating sound traps and providing electronic filtration minimized pressure drops and reduced motor loads. Electronic filtration minimized pressure drops and provided high levels of air filtration to meet LEED® standards. [85]

The entry lobby has a radiant floor with displacement ventilation, which delivers air at approximately 63€F and at 20 ft. per minute. Computational Fluid Dynamics (CFD) was performed on the building to confirm ventilation effectiveness for the systems. [86]

To achieve the individual temperature control credit for the administrative offices, an underfloor access system was installed to provide not only ventilation air but also distribution of electrical and telecommunications systems. Raised floors typically have 12-24 inches of space, however, only 9 inches was available to the project due to the

---

[84] Schroeder, Bob. *Platinum Performance: The Armory Building, Portland Center Stage.* February 20, 2010. http://www.glumac.com/greenResources/GR_Armory_Building.html (accessed October 25, 2010).
[85] Ibid
[86] Ibid

barrel dome configuration at the perimeter. To supplement cooling and provide heating needs, we utilized chilled beams, which are essentially a horizontal fan coil unit. They also integrate space lighting and provide an attractive ceiling element.[87] A sophisticated energy management system with a full measurement and verification plan to sub-meter the building was installed, and allows for fine-tuning components over time.

Plumbing systems for the building utilize low flow fixtures throughout, and dual flush technology water closets. A rainwater harvesting system was installed on the site to collect rainwater through the drain system and store it in a large concrete tank. Water is filtered and sterilized before being distributed to water closets, urinals and for irrigation use. The tank was sized to accommodate drought contentions in the summer.[88]

The lighting system was designed to evoke a theatrical experience upon entering the space, while highlighting the architectural character of the historic building and working within the structure of the LEED® program. Lobby spaces were treated as extensions of the theatres. Many of the luminaires were specified with colored theatrical gels, creating interesting contrast to the exposed, raw finishes of the space. Track lighting was provided to enable the spaces to be used for a variety of programs, with the intent that the project would be viewed as a community space in addition to a theatre. To ensure energy efficiency and increase lamp life, the lobby spaces were designed with an architectural dimming system that would allow for pre-programmed scene controls and time controls

---

[87] Schroeder, Bob. *Platinum Performance: The Armory Building, Portland Center Stage.* February 20, 2010. http://www.glumac.com/greenResources/GR_Armory_Building.html (accessed October 25, 2010).
[88] Ibid

for the non-emergency lighting. The approach to the office lighting and functional theatre workspaces was to use high efficiency luminaires and efficacious lamps. As mentioned, lighting was integrated with the mechanical chilled beams to minimize ceiling systems. With the aggressive approach to daylighting through the use of skylights, many of the office level luminaires, in open public and workspaces, integrate daylight dimming through photocell input. Individual offices are provided with user controlled dimming, to ensure a productive working environment.[89]

Integrating technology systems such as telecommunications cabling and security systems into the project provided some unique challenges. In addition to the routing of conduits and cables being difficult due to the historic structure of the building, there is a widely varying use for the Armory Theater. There are offices, work areas, rehearsal spaces, stages, event lobbies and function spaces spread across multiple floors, with all of these spaces requiring different types of cabling and equipment needs. With daily business operations on the top floor and the main public entry on the ground floor, security access zones and time-of-day use issues were discussed in detail, as was the video surveillance methodology.[90]

Of particular interest is the video surveillance system that consists of IP-enabled cameras that attach to the Armory's data network in the same manner as a PC. A single network cable transports video streams to a central network-attached server and delivers the power for the cameras. This reduced the overall amount of raw materials, such as copper and

---

[89] Schroeder, Bob. *Platinum Performance: The Armory Building, Portland Center Stage.* February 20, 2010. http://www.glumac.com/greenResources/GR_Armory_Building.html (accessed October 25, 2010).
[90] Ibid

polymers for cabling, by 50%. This approach also allows for access to the video system by the administration staff from any computer with access to their network, such as a home PC or even a handheld PDA.[91]

The security access control system can be used not only to limit access to secure areas, but to provide the building systems controls with information as to what areas of the building are occupied, allowing the lighting and HVAC systems to be controlled accordingly.[92]

---

[91] Schroeder, Bob. *Platinum Performance: The Armory Building, Portland Center Stage.* February 20, 2010. http://www.glumac.com/greenResources/GR_Armory_Building.html (accessed October 25, 2010).
[92] Ibid

Appendix 5 - Case Study: The City of Los Angeles Adaptive Reuse Ordinance

"A great deal of the housing boom associated with downtown Los Angeles is the result of the progressive Adaptive Reuse Ordinance (ARO) passed in 1999 and revised in 2002. Roughly half of the 2,850 new residential units finished between 1999 and 2004 are conversions encouraged by the ordinance. Encouraged by the success in downtown, the City expanded the Adaptive Reuse Ordinance to cover the historic suburbs of Hollywood, Chinatown, Lincoln Heights, and Wilshire Center business districts. New adaptive reuse projects in these areas are already in the works. Effective on December 1, 2003, the ordinance was expanded citywide, providing a streamlined process for revitalizing neighborhoods and providing much needed housing throughout the City of Los Angeles. One of the first projects under the ARO was the conversion of three manufacturing buildings into Santee Court. At the beginning of the twentieth century, Michael J. Connell developed the first garment manufacturing buildings in an area that became and is still known as downtown's Fashion District. Designed by architects Arthur Angel and Carl Leonard, the three buildings, adapted into 165 loft-style apartments, 20 percent of which are affordable, were constructed between 1911 and 1912. All three buildings are locally designated as historic monuments. MJW Investments' conversion of the buildings in Santee Court, the first phase of downtown's largest adaptive reuse project, includes a rooftop garden, a basketball court, and a swimming pool. The buildings are connected by a landscaped, pedestrian promenade (complete with outdoor tables and chairs) that was originally a service alley. The promenade is anchored by Rite

Aid, and features a Subway eatery, other retail tenants will include a market and a food court."[93]

[93] Los Angeles Planning and Zoning. *Adaptive Reuse Ordinance.* http://www.ladbs.org/rpt_code_pub/Ordinance.pdf (accessed April 2010).

<u>Appendix 6 – Policy Hierarchy Breakdown</u>

FEDERAL POLICY

Climate change and energy legislation is taking shape in the 111th Congress. Our sustainability priorities are focused in the following areas:

-**Incentives for owners of homes and commercial buildings** to conserve energy through energy-efficiency retrofits, with a 120 percent bonus for owners of properties listed in or eligible for the National Register of Historic Places.

-**Rehabilitation tax credit amendments** that increase incentives to support certified, substantial rehabilitation projects, including a “green supplement” for buildings that achieve a high level of energy performance.

-**Older and historic building experts** within the federal agency structure to act as liaisons between the Department of Energy, the Environmental Protection Agency, the Advisory Council on Historic Preservation, and the Department of the Interior to conduct research, develop demonstration projects, and address standards for energy conservation and historic preservation.

-**Transportation reauthorization** not only to protect the enhancements program and Section 4(f) but to redirect federal dollars away from road construction that promotes sprawl and toward programs that support reinvestment in older communities.

-**Federal funding for the Historic Preservation Fund** to support the state and tribal public infrastructure that is the foundation of preservation work across the country, including Save America's Treasures and Preserve America grants.

STATE AND LOCAL POLICY

The National Trust hopes to both directly influence state and local policy and to be an information and best practices resource for our Statewide and Local Partners, Main Street communities, state historic preservation officers, and others interested in sustainable development policy across the country.

CENTER FOR STATE AND LOCAL POLICY

Housed within our Public Policy Department in Washington D.C., the Center for State and Local Policy will provide support to the Preservation Green Lab, be an information clearinghouse, provide technical assistance, and disseminate information to our network of partners.

It is more important now than ever that preservationists all over the country pull up our chairs and take a seat at those tables where climate change, economic redevelopment, and job creation funding, programs, and policies are being developed. That means remaining in frequent contact with your congressional representative and senator and encouraging them to include policies favorable for older and historic buildings in upcoming climate change, energy, and transportation legislation. It means attending meetings in your city or county to make sure that preservation has a prominent place in your community's climate action plan."[94]

PRESERVATION GREEN LAB

In March the National Trust launched the Preservation Green Lab (PGL) in Seattle. This is our first regional office with a programmatic focus. The PGL will work with selected cities and states on policies that can serve as models for other communities and states. Initially we will work with the cities of Seattle, San Francisco, and Dubuque, Iowa. The goal is to tackle issues such as energy efficiency and building codes, zoning and climate action plans, or legislation that encourage reuse and retrofitting of buildings and reinvestment in older communities.

[94] Wadhams, Emily. "Introduction." *Forum Journal: National Trust for Historic Preservation*, March 2009: 6-7.

Appendix 7: Table 2

TABLE 2
ALTERNATIVE INTERNATIONAL POLICY ARCHITECTURES
FOR GLOBAL CLIMATE CHANGE

Alternative	Environmental Outcome	Dynamic Efficiency	Cost Effectiveness	Distributional Equity	Flexibility	Incentives for Participation and Compliance
Kyoto Protocol	Probably low, given short-term nature of commitments, and poor incentives for participation and compliance.	Requires reductions that are too large in short run, and silent on reductions required for long run.	Flexible mechanisms help cost effectiveness, but non-participation by key countries reduces cost effectiveness; CDM burdened by transactions costs.	Only industrial countries (ICs) face targets, but developing countries (DCs) help shape rules. DCs receive some adaptation assistance.	Emission ceilings are locked in, but only for five-year periods.	Incentives for participation and compliance are very weak.
Aldy, Orszag, & Stiglitz (2001)	Depends on safety valve price and extent of developing country participation.	Allows for policies that could be consistent with dynamic efficiency.	International emissions trading with a safety valve would likely result in common price for all participants.	Delays mandatory emissions commitments by DCs. Safety valve funds to DCs for abatement efforts.	Commitments and safety valve price adjusted over time in response to new information.	Use of sanctions, especially on trade, to promote compliance. Incentives for developing country participation.
Barrett (2001, 2003)	Depends on the agreed standards.	Technology lock-in may impair efficiency, but increased R&D may also lower costs.	Would not equalize marginal costs across all sectors.	R&D funded according to UN scale. ICs pay for technology adoption by DCs; adaptation funded by ICs.	R&D protocol provides information about technologies to lower costs, but standards may create lock-in.	R&D investment, economies of scale, network externalities, and trade restrictions create incentives for participation. No need to enforce compliance.
Benedick (2001)	Depends on levels for R&D, technology standards, etc.	Technology lock-in may be a problem, but public sector R&D may lower costs.	Would not be a global agreement, and would not equalize marginal costs across all sectors.	ICs to transfer new technologies to DCs. US to show leadership in reducing emissions unilaterally.	R&D would provide more information about new technologies.	Participation deliberately restricted, at least initially and in some areas. No explicit mention of compliance.
Bradford (2002)	Would depend on the magnitude of financial contributions to the central authority.	Could potentially support a dynamically efficient outcome.	Common offer bid for emissions allowances to all countries would insure cost-effectiveness.	Financing obligations would reflect ability to pay and expected benefits from mitigating climate change.	Central authority could adjust emissions allowances purchases with new information over time.	Does not explicitly address enforcement of financing obligations.
Cooper (1998, 2001)	Would depend on the level of the carbon tax.	Could potentially support a dynamically efficient outcome.	Common carbon tax would be cost-effective.	Tax would be uniform, but part of revenue could be redistributed to DCs.	Tax level can be changed, to adjust to new information.	Does not incorporate explicit mechanisms. Relies on a "commitment" to treaty objectives plus transparency.

Table 2 - Alternative International Policy Architectures for Global Climate Change

Alternative	Environmental Outcome	Dynamic Efficiency	Cost Effectiveness	Distributional Equity	Flexibility	Incentives for Participation and Compliance
Hahn (1998)	Depends upon levels at which instruments are set.	Depends upon levels and time paths of instruments.	Could be cost-effective, due to reliance on market-based and related instruments.	Depends upon allocations.	Very flexible; instruments that perform best are continued.	No attention is given to participation and compliance.
McKibbin & Wilcoxen (1997, 2000, 2002)	Relatively low carbon emissions price implies modest near-term emissions reductions.	Could potentially support a dynamically efficient outcome.	Common carbon price across all countries supports cost-effective implementation.	DCs would receive emissions endowments in excess of current emissions.	Decadal negotiations to select carbon price allows for accounting of new information.	Does not substantially address participation or compliance issues.
Nordhaus (1998, 2002)	Relatively low carbon tax implies modest near-term emissions reductions.	Could potentially support a dynamically efficient outcome.	Harmonized carbon tax insures cost-effective implementation among participating countries.	Participation conditional on per capita income. DCs would also likely receive financial transfers.	Periodic international votes allows for adjusting carbon tax to new information.	Promotes compliance through trade measures. Developing country participation supported through financial transfers.
Schelling (1997, 1998)	Would probably have little effect on emissions.	Does not front-load mitigation. Promotes R&D to reduce future mitigation costs.	Would aim to reduce emissions globally.	Financial transfers to DCs.	Emphasizes the need to act, rather than to meet a particular target.	Enforcement of compliance not needed by design.
Schmalensee (1996, 1998)	Little effect in short run, but significant effects in long term.	If targets are sufficient, could be dynamically efficient.	Could be cost-effective, due to reliance on market-based and related instruments.	Little attention given to distributional equity in the cross-section, but could provide intertemporal equity.	Quite flexible, due to focus on beginning with modest targets.	No attention given to participation and compliance issues.
Stavins (2001b)	Abatement would be very modest in the short term, but much more ambitious in the long term.	If targets are sufficient, could be dynamically efficient.	Could be cost-effective, due to reliance on tradable permits, carbon taxes, and hybrid systems.	Addresses cross-sectional distributional equity through allocation of permits and use of growth targets.	Long-term targets are flexible, to allow for effects of learning.	Little attention to participation and compliance, except for incentives for DCs.
Stewart & Wiener (2001)	Would depend on the magnitude of the "headroom" allowances given to DCs.	Dynamic efficiency weakened by participation & compliance problems.	Reliance on an expanded CDM, and participation and compliance problems undermine cost-effectiveness.	Headroom allowances to DCs plus emissions trading provide potential economic gains to poor countries.	Emission commitments would need to be periodically negotiated.	Similar to Kyoto Protocol, with exception of incentives from "headroom" allowances.
Victor (2001)	Similar in targets to KP, but with safety-valve sales of additional permits.	Better than KP in its emission path, but not defined.	Includes flexible mechanisms of Kyoto Protocol; hence, can be cost-effective.	By bringing DCs into set of nations facing binding constraints only as they become more wealthy, equity is addressed.	Subsequent periods would need to be renegotiated.	Compliance is considered through buyer liability scheme, but participation is not addressed.

95

[95] Aldy, Joseph E., Scott Barrett, and Robert N. Stavins. "Thirteen Plus One: A Comparison of Global Climate Policy Architectures." *Climate Change Modeling and Policy*, 2003.

Appendix 8 – First United Methodist Church: Seismic Retrofit Cost Option

DANIELS PERFORMANCE HALL
JTM CONSTRUCTION
FUMC - SEISMIC RETROFIT
CPL DRAWINGS S2.1-S2.7 and S3.1 - Dated 4/7/10

PROJECT:	DANIELS PERFORMANCE HALL	SUB-BASEMENT LEVEL:	2,385
OWNER:	DANIELS DEVELOPMENT	LOWER FLOOR LEVEL:	9,475
ARCHITECT:	RON WRIGHT & ASSOCIATES	MEZZANINE LEVEL:	7,440
ESTIMATOR:	JH / SP / MO	SANCTUARY MAIN FLOOR LEVEL:	10,750
DATE:	4/30/2010	UPPER MEZZANINE LEVEL:	5,500
DRAWINGS:	CPL DRAWINGS S2.1-S2.7 and S3.1 - Dated 4/7/10	**TOTAL BUILDING GROSS AREA:**	**35,550**

ELEMENT		TOTAL	COSTS / SF
EXCAVATIONS AND FOUNDATIONS		NO SCOPE	
SUBSTRUCTURE		NO SCOPE	
SUPERSTRUCTURE (Seismic Upgrade)		$1,232,954	$34.68
EXTERIOR CLOSURE		$1,565,238	
ROOFING & SHEET METAL		$74,848	$2.11
INTERIOR CONSTRUCTION		$266,489	$7.50
SPECIAL CONSTRUCTION		NO SCOPE	
CONVEYING SYSTEMS		NO SCOPE	
MECHANICAL		$17,775	$0.50
ELECTRICAL		$63,811	$1.79
EQUIPMENT		NO SCOPE	
DEMOLITION		$312,191	$8.78
SUBTOTAL:		$3,533,305	$99.39
SUBCONTRACTOR BONDS:	0.50%	$17,667	
GENERAL CONDITIONS:	6.50%	$229,665	
SUBTOTAL:		$3,780,637	$106.35
LIABILITY INSURANCE:	0.92%	$34,782	
EXCISE TAX:	0.471%	$17,807	
CITY TAX:	0.230%	$8,695	
SUBTOTAL:		$3,841,921	$108.07
CONTRACTORS FEE:	5.00%	$192,096	
SUBTOTAL:		$4,034,017	$113.47
ESTIMATING / DESIGN CONTINGENCY:	7.00%	$282,381	
ESCALATION CONTINGENCY:	0.00%	$0	
TOTAL:		**$4,316,398**	**$121.42**

SEISMIC UPGRADE

EXCAVATIONS AND FOUNDATIONS					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
				NO SCOPE	

SUBSTRUCTURE					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
				NO SCOPE	

SUPERSTRUCTURE (Seismic Upgrade)					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
West Elevation					
Concrete In-fill @ West Elevation Openings (windows)	W / EXTERIOR ENCLOSURE RESTORATION ESTIMATE				
First Floor - Sanctuary					
Masonry Wall Anchors (Installed from Below)					
Core Drill into Exterior Masonry Wall for 3/4" Anchor Rods	105	ea	38.50	4,043	
In-plane Masonry Wall Anchor (4' OC) - (incl. layout, epoxy rod, and HTT5)	50	ea	250.00	12,500	
Out-of-plane Masonry Wall Anchor (4' OC) (incl. layout, epoxy rod, and HTT5)	55	ea	250.00	13,750	
Supply Simpson HTT5 - Tension Ties and 3/4" threaded rod	105	ea	37.50	3,938	
Supply Simpson Joist Hangars (out-of-plane only)	220	ea	15.25	3,355	
4x6 Blocking under HTT 5 (out-of-plane only) - 2x sistered	440	lf	14.25	6,270	
Notch Existing Wood Joists for 3/4" Anchor Rod (out-of-plane only)	220	ea	28.50	6,270	
Double Sided "SureBoard" Walls					
Install New Doublesided Sureboard Walls on 4" 18ga Metal Stud Wall (135')	2000	sf	25.00	50,000	
Head of Wall Blocking Attachment to Balcony Joist	135	lf	30.00	4,050	
Balcony					
Masonry Wall Anchors (Installed from Below and Above)					
Core Drill into Exterior Masonry Wall for 3/4" Anchor Rods	98	ea	38.50	3,773	
In-plane Masonry Wall Anchor (4' OC) - (incl. layout, installation of epoxy rod and HTT5)	43	ea	250.00	10,750	
Out-of-plane Masonry Wall Anchor (4' OC) (incl. layout, installation of epoxy rod and HTT5)	55	ea	250.00	13,750	
Supply Simpson HTT5 - Tension Ties and 3/4" threaded rod	98	ea	37.50	3,675	
Supply Simpson Joist Hangars (out-of-plane only)	220	ea	15.25	3,355	
4x6 Blocking under HTT 5 (out-of-plane only) - 2x sistered	440	lf	14.25	6,270	
Notch Existing Wood Joists for 3/4" Anchor Rod (out-of-plane only)	220	ea	28.50	6,270	
Install 1/2" Plywood Sheathing -(Installed from below and above Balconies)					
Install 1/2" Plywood Sheathing @ soffit (incl. stocking)	2,240	sf	3.25	7,280	
Rolling Scaffold	2	wks	550.00	1,100	
Fasteners -10% materials	1	ls	950.00	950	
Remove/Salvage Church Pews	10	ea	650.00	6,500	
Demo Carpet, Overframing, and Flooring	1560	sf	7.50	11,700	
Install 1/2" Plywood Sheathing Top of Structure at West Balcony	1560	sf	2.75	4,290	
New Carpet installed at Balconies	1560	sf	3.50	5,460	
Reinstall Church Pews	10	ea	500.00	5,000	

SEISMIC UPGRADE

SUPERSTRUCTURE (Seismic Upgrade) - continued					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
Drag Struts Under Balcony Neck					
Supply Drag Strut (assumed angle 6"x6"x1/4")	1.8	tn	2,600.00	4,680	
Weld Drag Strut (12' sections)	12	ea	150.00	1,800	
Core Drill Exterior Masonry for Epoxy Bolts at 12" oc	180	ea	38.50	6,930	
Install Drag Strut at Neck of balcony Soffit	15	pieces	350.00	5,250	
Drag Struts to West Elevation Braced Frame					
Core 10" Hole through West Wall for Drag Strut Connections-4 locations	4	ea	1,250.00	5,000	
Supply Drag Strut (assumed 100lbs/ft) (incl. support steel)	8	tn	2,600.00	20,800	
Weld Drag Strut (12' sections)	8	ea	150.00	1,200	
Core Drill Exterior Masonry for Epoxy Bolts at 12" oc - Anchor Channel	24	ea	38.50	924	
Install Rigging and Chainfalls into structure above	4	loc	1,000.00	4,000	
Install Steel Channel on Wall	4	pieces	350.00	1,400	
Install Drag Strut into Stairwell Location below Balcony Level	4	pieces	950.00	3,800	
Lower Roof					
Masonry Wall Anchors (Installed from Below)					
Core Drill into Exterior Masonry Wall for 3/4" Anchor Rods	45	ea	38.50	1,733	
In-plane Masonry Wall Anchor (4' OC) - (incl. layout, installation of epoxy rod and HTT5)	20	ea	350.00	7,000	
Out-of-plane Masonry Wall Anchor (4' OC) (incl. layout, installation of epoxy rod and HTT5)	25	ea	350.00	8,750	
Supply Simpson HTT5 - Tension Ties and 3/4" threaded rod	45	ea	37.50	1,688	
Supply Simpson Joist Hangars (out-of-plane only)	100	ea	15.25	1,525	
4x6 Blocking under HTT 5 (out-of-plane only) - 2x sistered	200	lf	21.25	4,250	
Notch Existing Wood Joists for 3/4" Anchor Rod (out-of-plane only)	100	ea	32.50	3,250	
Upper Roof (Attic Space)					
Masonry Wall Anchors (Installed from Below)					
Core Drill into Exterior Masonry Wall for 3/4" Anchor Rods	115	ea	45.50	5,233	
In-plane Masonry Wall Anchor (4' OC) - (incl. layout, installation of epoxy rod and HTT5)	115	ea	350.00	40,250	
Supply Simpson HTT5 - Tension Ties and 3/4" threaded rod	115	ea	37.50	4,313	
Drag Struts					
Shakeout Steel and Layout	150	pieces	75.00	11,250	
Core Drill for Epoxy Anchors at Perimeter installed Drag Struts	480	ea	38.50	18,480	
Steel Drag Struts @ Exterior Walls (50 lbs/ft) - 5 sections at each wall	6	tn	2,600.00	15,600	
Full Pen Welding Sections of Ext. Wall Drag Strut.	16	ea	450.00	7,200	
Erect Drag Strut Steel @ Exterior Walls	20	pieces	1,500.00	30,000	
Steel Drag Struts Back into Core (50 lbs/ft) - 2 sections ea	6	tn	2,600.00	15,600	
Full Pen Welding Drag Strut - Bracing to Core Sections	8	ea	450.00	3,600	
Erect Drag Strut Steel Back into Core	16	pieces	875.00	14,000	
Structural Connections					
Core Drill Locations to receive Epoxy Bolts	476	ea	38.50	18,326	
Structural Angles at PL Girder and Support Steel to Masonry (20 lbs/ft)	3.2	tn	2,600.00	8,320	
Erect/Strengthen Connection of Ex. Plate Girder to Concrete Pier	16	ea	1,500.00	24,000	
Erect/Anchor Masonry to existing support steel	37	ea	675.00	24,750	
Anchor and Brace Ex. Dome Hung Ceiling (10'-0" o.c. ea way) - (100 ea) - (sheet S2.5)					
Stock Material (.5 hr per location)	50	hr	75.00	3,750	
Layout (.5 hr per location)	50	hr	75.00	3,750	
4x8 Blocking Between Joists (6 lf per location)	600	lf	24.25	14,550	
Simpson A34 (12 per location)	1200	ea	3.25	3,900	
14 GA 6x4 Angle (4 per location)	400	ea	15.25	6,100	
Bracing -Structural Metal Studs - 400S162-43 - Fastened Back to Back (26lf / Location)	2600	lf	22.50	58,500	
Fasteners (#8, #10) 5% materials	1	ls	1,850.00	1,850	
Clean-up (.5 hr per location)	50	hr	75.00	3,750	
Build Work Platforms (incl. fall anchors and safety railings)	1	ls	17,500.00	17,500	
Remobilization Premium for Remob/coordination after Mech Equip Installed	1	ls	4,500.00	4,500	
Roof					
Parapet Bracing					
Core Drill into Exterior Masonry Wall for 3/4" Anchor Rods	160	ea	38.50	6,160	
Supply Steel Angle Kicker - 6' x 80	480	lf	10.75	5,160	
Install Parapet Bracing/Kicker	80	ea	250.00	20,000	
Supply Simpson Joist Hangars at Blocking	160	ea	15.25	2,440	
4x6 Blocking between Roof Joists	280	lf	22.50	6,300	
Dome Roof					
Dome Bracing					
Steel Channel connection to Ex. Plate Girder/Truss - In Dome (25 lbs/ft)	2	tn	2,600.00	5,200	
Steel Angle Cross Bracing Between Channel	2.25	tn	2,600.00	5,850	
Steel Angle Bracing Below Roof Joists -In Dome	4	tn	2,600.00	10,400	
Erect Cross Bracing and C-Channel @ Dome	80	pieces	475.00	38,000	

SEISMIC UPGRADE

SUPERSTRUCTURE (Seismic Upgrade) - continued					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
Clip and Strap Existing Timber Roof Structure (assume 1 every 20sf)					
Supply Simpson Connector Clips and Straping	3872	ea	6.50	25,168	
Anchor 6x6 Purlins to Roof Trusses (Strap and Clip) - 26 locations ea "wedge"	416	ea	32.50	13,520	
Anchor 2x8 Roof Joists to Purlins (each side) - 54 locations ea "wedge"	3456	ea	13.25	45,792	
Anchor and Brace Ex. Dome hung ceiling (10'-0" o.c. ea way) - (50 ea) - (sheet S2.6)					
Stock Material (.5 hr per location)	25	hr	75.00	1,875	
Layout (.5 hr per location)	25	hr	75.00	1,875	
4x8 Blocking Between Joists (6 lf per location)	300	lf	24.25	7,275	
Simpson A34 (12 per location)	600	ea	3.25	1,950	
14 GA 6x4 Angle (4 per location)	200	ea	15.25	3,050	
Bracing -Structural Metal Studs - 400S162-43 - Fastened Back to Back (26lf / Location)	1300	lf	24.50	31,850	
Fasteners (#8, #10) 5% materials	1	ls	1,150.00	1,150	
Clean-up (.5 hr per location)	25	hr	75.00	1,875	
Build Work Platforms (incl. fall anchors and safety railings)	1	ls	22,500.00	22,500	
Exterior West Elevation Braced Frame (15/S3.1)					
Supply and Install Reinforcing in Grade Beam (Assume 300lbs/cy)	2	tn	1,450.00	2,900	
Supply and Install Embeds and Base Plates	3	ea	350.00	1,050	
FRP Concrete Foundation	16	cy	650.00	10,593	
Core Drill for Epoxy Anchors at all Horizontal Beams - 12" oc	176	ea	38.50	6,776	
Supply and Install WF Columns - 3 ea - 240lf @ 125 lbs/ft	15	tn	3,450.00	51,750	
Supply and Install WF Horiz. Beams - 5 ea - 105 lf @ 100 lbs/ft	5	tn	3,450.00	18,113	
Supply and Install Channel - 4 ea - 80 lf @ 50lbs/ft	2	tn	3,450.00	6,900	
Supply and Install HSS Bracing - 8 ea - 240 lf @ 50lbs/ft	6	tn	3,450.00	20,700	
Crane Rental / Rigging and Hoisting Accessories	1	ea	9,600.00	9,600	
Scaffolding Allowance at Braced Frame	1	allow	6,500.00	6,500	
Material Stocking and Safety					
Crane/BoomTruck Rental	4	mobs	5,000.00	20,000	
Hoisting/Stocking of Material to Upper Roof (includes shakeout into Attic Spaces)	1	allow	18,500.00	18,500	
Traffic Control	2.5	mos	2,500.00	6,250	
Rough Carpentry - Build Protection and Ramps at Roof for Moving Material on Roof	5500	sf	2.75	15,125	
Misc. Carpentry at Upper Roof and Interior Dome (access ladders/temp roof curbs)	1	allow	7,500.00	7,500	
Attic Space - Venting System	1	allow	18,500.00	18,500	
Fire Watch and Fire Blankets	1	allow	25,000.00	25,000	
Temporary Protection - where Stained Glass Windows Removed at Dome	32	ea	75.00	2,400	
Scaffolding for Masonry Anchors (under level 1 and high bay over stairs)	1	allow	16,500.00	16,500	
Build Work Platforms at Attic Space below Upper Roof and Interior Dome	1	allow	40,000.00	40,000	
Safety (incl. fall protection and safety planking)	1	allow	15,000.00	15,000	
Clean-up	4	mo	4,640.00	18,560	
Subtotal				**1,232,954**	34.68

EXTERIOR CLOSURE					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
Dome Roof					
Window Re-instalation					
Temp. Window Protection/In-Fills	8	ea	500.00	4,000	
Reinstall Window Glazing @ Exterior Dome	8	ea	850.00	6,800	
Remove Temp Protection and Reinstall 32 ea Stained Glass Units	32	ea	250.00	8,000	
Misc. caulking @ Dome Windows/Façade	1,250	lf	6.25	7,813	
Exterior West Elevation Braced Frame (15/S3.1)					
Patch Exterior Façade where Drag Struts tie to Structure	8	ea	1,250.00	10,000	
Paint Braced Frame at West Elevation	1	allow	15,000.00	15,000	
EXTERIOR MASONRY RESTORATION - PIONEER MASONRY PROPOSAL DATED 4/8/10					
Includes: Selective Demolition, T-Brace wall Reinforcing, shotcrete Skirt and Replace Exterior Facade					
North Elevation Structural Work	1	ls	545,000.00	545,000	
West Elevation Structural Work	1	ls	430,000.00	430,000	
East Elevation Structural Work	1	ls	290,000.00	290,000	
Credit for "minimalist" finish on unclad areas - per Mike Field revised estimate dated 4/29/10	1	ls	(60,000.00)	(60,000)	
Provide hard Trowel Finish to Shotcrete at all unclad areas	2,725	sf	5.00	13,625	
MASONRY RESTORATION SCOPE REVISION/CLARIFICATION - CPL EMAIL DATED 4/22/10 AND REV. 4/29/10					
All Elevations - Additional 1168 sf of Structural Reinforcing, per CPL Clarification (4' tall)	1	LS	295,000.00	295,000	
				1,565,238	44.03

SEISMIC UPGRADE

DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
ROOFING & SHEET METAL					
Upper Roof					
Roof Work Associated with Parapet Bracing					
Remove Roofing to Structure (Parapet Bracing Locations) 3'x3' opening	80	ea	60.00	4,800	
Replace Roof in locations after Structural Bracing is Installed - Patch	80	ea	150.00	12,000	
Temp Roofing Allowance	1	allow	6,500.00	6,500	
ROOFING & SHEET METAL (CONTINUED)					
Roofing Openings to Stock Structural Steel					
Frame Temp Roof Opening Locations (from attic) and Cut Joists	4	ea	2,600.00	10,400	
Build Roof Curbs on Roof	4	ea	550.00	2,200	
Provide Temp Roof Protection and Cut Roof Locations	4	ea	3,500.00	14,000	
Final Patch Membrane Roofing	900	ea	7.65	6,885	
Misc. Flashing Repairs	250	lf	6.25	1,563	
Supply and Install Roof Hatches	4	ea	2,750.00	11,000	
Misc. Carpentry	5,500	sf	1.00	5,500	
Subtotal				**74,848**	2.11

DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
INTERIOR CONSTRUCTION					
Basement					
Patch Ceiling at Underside of Level 1 Perimeter					
Gypsum Board Ceiling Patch Finish to Existing Plaster - High Bay	1280	sf	13.50	17,280	
Paint Gyp Ceilings - High Bay	1280	sf	1.50	1,920	
Reinstall ACT	2400	sf	4.00	9,600	
Misc. Carpentry	9360	sf	1.00	9,360	
First Floor - Sanctuary					
Finish Work Adjacent to Double Sided "SureBoard" Walls					
Reinstall Carpet	1,650	sf	3.50	5,775	
Paint "Sureboard" Shearwalls	4000	sf	1.75	7,000	
Reinstall 12" Wood Base	350	lf	6.50	2,275	
Reinstall Doors and Frame	6	ea	275.00	1,650	
Reinstal Crown Molding	35	lf	21.50	753	
Wood Paneling Wainscoting	925	sf	7.25	6,706	
Remilling, Storing and Labeling of existing wood paneling	1	ls	12,000.00	12,000	
Reinstall Stair Handrail	60	lf	35.00	2,100	
Tie in New "Sureboard" Wall to Existing Finishes	348	lf	8.75	3,045	
Reframe and Anchor Stair to New "Sureboard" Wall	4	loc	4,500.00	18,000	
Touchup Existing Millwork / Material Shortage	1	allow	30,000.00	30,000	
Patch Ceiling at Underside of Balcony					
Gypsum board (underside of balconies only - incl. level 5 finish)	3,360	sf	13.50	45,360	
Transition Detail from Face of Balcony to Soffit	158	lf	20.00	3,160	
Paint Gyp Ceilings	3,360	sf	1.50	5,040	
Misc. Carpentry	3360	sf	1.00	3,360	
Balcony					
Patch Walls and Ceiling at Stairwell					
Gypsum board (underside of balconies only - incl. level 5 finish)	480	sf	13.50	6,480	
Paint Gyp Ceilings	2,500	sf	1.25	3,125	
Ceiling of Lower Roof					
New GWB Ceiling in Corner Stairwells					
Gypsum Board Ceiling - High Bay Over Stairs	2250	sf	13.50	30,375	
Paint Gyp Ceilings - High Bay Over Stairs	2250	sf	1.50	3,375	
Misc. Carpentry	2250	sf	1.00	2,250	
Scaffolding - Allowance	1	allow	11,500.00	11,500	
Misc. Patch and Repair Allowance	1	allow	25,000.00	25,000	
Subtotal				**266,489**	7.50

DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
SPECIAL CONSTRUCTION					
				NO SCOPE	

DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
CONVEYING SYSTEMS					
				NO SCOPE	

SEISMIC UPGRADE

MECHANICAL					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
Plumbing/HVAC - Rework Ductwork and Piping to Gain Retrofit Access	35,550	sf	0.50	17,775	
Subtotal				**17,775**	0.50

ELECTRICAL					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
Temporary Power					
Construction Temp. Power and Lighting (Bsmnt, Stairwells, Sanctuary, Roof Attic)	35,550	sf	1.00	35,550	
Rework Electrical to Gain Retrofit Access - Allowance	35,550	sf	0.50	17,775	
First Floor - Sanctuary					
Fixture Removal and Re-Install from Underside of Balcony					
Remove fixtures under balcony	6	ea	150.00	900	
Remove speakers under balcony	9	ea	150.00	1,350	
Remove emergency light under balcony	2	ea	150.00	300	
Re-install fixtures under balcony	6	ea	385.00	2,310	
Re-install speakers under balcony	8	ea	250.00	2,000	
Install new emergency light under balcony	2	ea	385.00	770	
Trace and Reconnect Circuitry - Balconies	3,360	sf	0.85	2,856	
Subtotal				**63,811**	1.79

EQUIPMENT					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
				NO SCOPE	

DEMOLITION					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
Sub Basement					
Selective Demolition					
Mechanical Equipment Removal from Sub Basement	1	allow	75,000.00	75,000	
Basement					
Selective Demolition					
Soft Demolition (ACT, GWB Ceilings, Partition Walls) - High Bay	3,210	sf	3.25	10,433	
Hazardous Materials Premium (Lead Paint)	3,210	sf	1.25	4,013	
First Floor - Sanctuary					
Selective Demolition					
Soft Demolition (GWB Ceilings under Balcony)	870	sf	3.25	2,828	
Hazardous Materials Premium (Lead Paint)	870	sf	1.25	1,088	
Selective Demolition (Double Sided "SureBoard" Walls)					
Remove Carpet	1,650	sf	2.00	3,300	
Salvage 12" Wood Base	350	lf	4.00	1,400	
Salvage Door and Frame	6	ea	225.00	1,350	
Salvage Crown Molding	35	lf	8.50	298	
Salvage Wood Wainscoting	925	sf	2.75	2,544	
Salvage Interior Cased Windows	2	ea	1,650.00	3,300	
Remove and Salvage Architectural Elements on Walls	1	allow	5,000.00	5,000	
Remove and Salvage Stair Handrail	60	lf	18.00	1,080	
Salvage Framed Opening (Crown, casing, base)	2	ea	1,650.00	3,300	
Demo Sloped Overframing 4' Back of New "Sureboard" walls	432	sf	2.00	864	
Neat Cut Finishes Adjacent to New "Sureboard" Walls -24 vert. locations	348	lf	2.85	992	
Demo Interior Plaster Walls at locations of New "Sureboard" Walls	2000	sf	2.75	5,500	
Hazardous Materials Premium (Lead Paint/Asbestos)	2,000	sf	1.25	2,500	
Demo and Cut Stairs From Wall at New shearwalls	4	loc	3,500.00	14,000	
Reshore Stairs and Balconies (10 Locations)	4	loc	500.00	2,000	
Debris Dumpsters	1	lot	1,500.00	1,500	
Clean-up	80	hr	58.00	4,640	
Balcony					
Selective Demolition					
Demo wall and ceiling to install Diagonal Drag Struts in Stairwells (High Bay)	625	sf	2.75	1,719	
Hazardous Materials Premium (Lead Paint)	625	sf	1.25	781	
Selective Demolition (underside of balconies)					
"Neat Cut" at underside of balcony perimeter to remove plaster ceiling	158	lf	6.25	988	
Remove/Dispose of Plaster Ceilings	3,360	sf	2.75	9,240	
Hazardous Materials Premium (Lead Paint)	3,360	sf	1.25	4,200	
Temp Protection of Existing Finishes (includes clean-up)	5,500	sf	0.75	4,125	

DEMOLITION (CONTINUED)					
DESCRIPTION	QUANTITY	UNIT	U.P.	TOTAL	COSTS / SF
Ceiling of Lower Roof					
Selective Demolition					
Soft Demolition (GWB Ceilings under Lower Roof in Corner Stairwells)	2,250	sf	2.75	6,188	
Hazardous Materials Premium (Lead Paint)	2,250	sf	1.25	2,813	
Roof					
Selective Demolition for Structural Steel Installation/Stocking					
Salvage and Clean Stained Glass Panels at Dome	32	ea	1,200.00	38,400	
Temp Protection at Stained Glass Window Openings	32	ea	175.00	5,600	
Remove Exterior Windows for Access to Dome	8	ea	850.00	6,800	
Demo Roofing in 4 locations to stock Steel Drag Struts	4	ea	1,500.00	6,000	
Demo within Attic Space for installation of Steel Drag Struts, clips and straps ect.	1	allow	7,500.00	7,500	
Protect Existing Finishes (including roof and exterior façade)	5,540	sf	1.50	8,310	
Clean up	80	hr	58.00	4,640	
Exterior West Elevation Braced Frame (15/S3.1)					
Sawcut Alley - (location above new grade beam for braced frame)	98	lf	12.50	1,225	
Core Roof Parapet for Horiz. Beam Ties to Braced Frame	6	ea	725.00	4,350	
Demo Existing Concrete in Alley and Excavate for New Grade Beam	16	cy	150.00	2,444	
Dumpsters	4	mo	3,500.00	14,000	
General Cleanup	160	hr	58.00	9,280	
Protection of Existing Finishes (including Temp Partitions/Dust Control)	35,550	sf	0.75	26,663	
Subtotal				**312,191**	

SEISMIC UPGRADE

Appendix 9 – King Street Station: Rehabilitation Options Cost Plan

Davis Langdon

REHABILITATION OPTIONS
COST PLAN

for

King Street Station
Rehabilitation
Seattle, Washington

July 6, 2009

July 6, 2009

Tim Williams
ZGF Architects
925 Fourth Avenue
Suite 2400
Seattle, Washington 98104

King Street Station
Rehabilitation
Seattle, Washington

Dear Tim:

Please find enclosed our Rehabilitation Options Cost Plan for the project referenced above.

We would be pleased to discuss this report with you further at your convenience.

Sincerely,

Davis Langdon 270/7680

Enclosures

REHABILITATION OPTIONS COST PLAN

for

King Street Station
Rehabilitation
Seattle, Washington

ZGF Architects
925 Fourth Avenue
Suite 2400
Seattle, Washington 98104

Tel: (206) 623-9414
Fax: (206) 623-7868

July 6, 2009

Davis Langdon

719 2nd Avenue
Suite 400
Seattle
Washington 98104
Tel: 206.343.8119
Fax: 206.343.8541
www.davislangdon.com

CONTENTS

Davis Langdon

BASIS OF COST PLAN

Cost Plan Prepared From	Dated	Received
Drawings issued for		
Architectural		
A0.10-A1.12, A1.10-A1.26, A2.01-A2.03, A2.10-A2.15, A2.20-A2.24, A2.30, A2.40, A2.50, A2.60, A3.00-A3.18, A3.20-A3.25, A4.01, A5.01-A5.04, A7.01-A7.07, A8.10-A8.11, A9.11-A9.14, A9.21, A9.22	05/29/09	06/08/09
Civil		
C1.00, C2.10, C2.20, U1.10, U3.10	05/29/09	06/08/09
Structural		
S1.01, S2.11, S2.12, S2.21, S2.22, S2.30, S2.40, S3.01-S3.06, S3.61, S3.62	05/29/09	06/08/09
Mechanical		
M0.01, M0.02, M1.00, M2.11, M2.12, M2.21, M2.22, M2.31, M2.41, M6.01, M6.02	05/29/09	06/08/09
Electrical		
E001, E1.00, E2.00, E3.01-E3.03, E5.01	05/29/09	06/08/09
Lighting		
EL2.03, EL2.10-EL2.15, EL2.20-E;2.24, EL2.30, EL2.40, EL2.50, EL3.01, EL3.02	05/29/09	06/08/09
Plumbing		
P0.01, P2.11, P2.12, P2.21, P2.22, P2.31, P2.32, P2.41	05/29/09	06/08/09
Fire Protection		
F1.01-F1.04	05/29/09	06/08/09
Project Manual	05/29/09	06/08/09
Discussions with the Project Architect and Engineers		

BASIS OF COST PLAN

Conditions of Construction

The pricing is based on the following general conditions of construction

A start date of September 2009

A construction period of 18 months

The project will be procured as GC/CM

There will not be small business set aside requirements

The contractor will be required to pay prevailing wages

Construction will be phased to allow continuous use of the facility

The general contractor will have full access to the site during normal business

INCLUSIONS

The project consists of rehabilitation of the existing King Street Station in Seattle, Washington.

The design currently includes histrorical restoration, structural/seismic upgrades, replanning and reprogramming of user spaces and completely new electrical, mechanical and plumbing services.

A "Task Summary" presents the cost information contained in the report in a format which relates more to the individual components of the rehabilitation.

INCLUSIONS

BIDDING PROCESS - MARKET CONDITIONS

This document is based on the measurement and pricing of quantities wherever information is provided and/or reasonable assumptions for other work not covered in the drawings or specifications, as stated within this document. Unit rates have been obtained from historical records and/or discussion with contractors. The unit rates reflect current bid costs in the area. All unit rates relevant to subcontractor work include the subcontractors overhead and profit unless otherwise stated. The mark-ups cover the costs of field overhead, home office overhead and profit and range from 15% to 25% of the cost for a particular item of work.

Pricing reflects probable construction costs obtainable in the project locality on the date of this statement of probable costs. This estimate is a determination of fair market value for the construction of this project. It is not a prediction of low bid. Pricing assumes competitive bidding for every portion of the construction work for all subcontractors, with a minimum of 4 bidders for all items of subcontracted work. Experience indicates that a fewer number of bidders may result in higher bids, conversely an increased number of bidders may result in more competitive bids.

Since Davis Langdon has no control over the cost of labor, material, equipment, or over the contractor's method of determining prices, or over the competitive bidding or market conditions at the time of bid, the statement of probable construction cost is based on industry practice, professional experience and qualifications, and represents Davis Langdon's best judgment as professional construction consultant familiar with the construction industry. However, Davis Langdon cannot and does not guarantee that the proposals, bids, or the construction cost will not vary from opinions of probable cost prepared by them.

EXCLUSIONS

Owner supplied and installed furniture, fixtures and equipment

Loose furniture and equipment except as specifically identified

Security equipment and devices

Audio visual equipment

Hazardous material handling, disposal and abatement

Compression of schedule, premium or shift work, and restrictions on the contractor's working hours

Testing and inspection fees

Architectural, design and construction management fees

Scope change and post contract contingencies

Assessments, taxes, finance, legal and development charges

Environmental impact mitigation

Builder's risk, project wrap-up and other owner provided insurance program

Land and easement acquisition

Cost escalation beyond a construction midpoint of June 2010

Storm water detention systems

Fire sprinkler booster pumps

Emergency power

OVERALL SUMMARY

	Gross Floor Area	$ / SF	$x1,000
Building	95,564 SF	292.92	27,993
TOTAL Building Construction	95,571 SF	292.90	27,993
Sitework			5,642
TOTAL Building & Sitework Construction	***Sep-09***		***33,635***

Please refer to the Inclusions and Exclusions sections of this report

King Street Station | ***Rehabilitation Options Cost Plan***
Rehabilitation | ***July 6, 2009***
Seattle, Washington | ***027-07680.210***

Task Summary **Gross Area: 95,571 SF**

		Building	Sitework	Total	Marked Up
00099	HAZMATABATEMENT ALLOWANCE	$ -	$ 500,000	**500,000**	691,803
00100	SEISMIC/STRUCTURAL	$ -	$ -	**0**	0
00101	New Foundations incl Excavation	$ 1,609,039	$ -	**1,609,039**	2,226,275
00102	New Steel Bracing - vertical	$ 3,822,240	$ -	**3,822,240**	5,288,471
00103	New Steel Bracing - horizontal	$ 1,507,598	$ -	**1,507,598**	2,085,920
00104	Misc metals and concrete	$ 446,377	$ -	**446,377**	617,609
00105	Enabling work for vertical steel bracing	$ 590,210	$ 226,118	**816,328**	1,129,475
00106	Terracotta and Brick Repair at Tower	$ 1,000,000	$ -	**1,000,000**	1,383,605
00107	Associated Demolition and Repair	$ -	$ 327,531	**327,531**	453,174
00200	MEP UPGRADE	$ 18,780	$ -	**18,780**	25,984
00207	Plumbing	$ 329,550	$ -	**329,550**	455,967
00208	HVAC	$ 1,596,725	$ -	**1,596,725**	2,209,236
00209	Electrical	$ 1,270,189	$ -	**1,270,189**	1,757,440
00704	Site Lighting	$ -	$ 320,000	**320,000**	442,754
00703	Lighting - Historic - Rough In	$ -	$ 4,250	**4,250**	5,880
00210	Historical Lighting - Interior	$ 672,640	$ -	**672,640**	930,668
00211	MEP Demolition & Enabling Work	$ -	$ 380,804	**380,804**	526,882
00300	LIFE/SAFETY UPGRADE	$ -	$ -	**0**	0
00201	Demolition	$ -	$ 56,500	**56,500**	78,174
00202	Sprinklers	$ 194,387	$ -	**194,387**	268,954
00203	Exit Stair 1	$ 304,637	$ -	**304,637**	421,497
00204	Exit Stair 2	$ 40,000	$ -	**40,000**	55,344
00205	Elevator	$ 125,000	$ -	**125,000**	172,951
00206	Restrooms	$ 166,965	$ 7,300	**174,265**	241,113
00300	EXTERIOR ENVELOPE - RESTORATION	$ -	$ -	**0**	0
00301	Demolition - Escalator, Baggage Addition	$ -	$ 36,500	**36,500**	50,502
00302	Required Demolition	$ -	$ 444,736	**444,736**	615,339
00303	Replacement Doors, Windows	$ 952,286	$ -	**952,286**	1,317,588
00304	Brick Cleaning, Tuck Pointing, Repair	$ 442,857	$ -	**442,857**	612,739
00305	Terra Cotta Cleaning, Repair, Replacement	$ 132,840	$ -	**132,840**	183,798
00306	Lighting	$ 75,350	$ -	**75,350**	104,255
00307	Exterior Stair	$ -	$ 36,500	**36,500**	50,502
00308	Demolition - 70's Addition South End	$ -	$ 21,960	**21,960**	30,384
00802	Exterior Wall Repair & Replace	$ 122,400	$ -	**122,400**	169,353
00400	MARQUEES	$ -	$ -	**0**	0
00402	King Street Metal Panel	$ 116,980	$ 42,690	**159,670**	220,921
00405	Jackson Street Metal Panel	$ 73,790	$ 30,835	**104,625**	144,760
00500	INTERIOR RESTORATION	$ 143,412	$ -	**143,412**	198,425
00501	Main Waiting	$ 457,554	$ -	**457,554**	633,075
00502	Women's Waiting	$ 119,130	$ -	**119,130**	164,829
00503	Ticket Room	$ 120,764	$ 2,800	**123,564**	170,964
00504	Waiting Area/Baggage Claim	$ 543,089	$ -	**543,089**	751,421
00505	Second/Third Floor Public Spaces	$ 384,367	$ -	**384,367**	531,812
00506	Connecting Stair Level 2 - 3	$ 51,235	$ -	**51,235**	70,889
00507	Tenant Shell Space	$ 295,803	$ -	**295,803**	409,275
00508	Mechanical Zone	$ 272,640	$ -	**272,640**	377,225
00509	Interior Demolition	$ -	$ 655,234	**655,234**	906,586
00510	Plaster Restoration	$ 1,366,692	$ -	**1,366,692**	1,890,962
00600	KING STREET PLAZA/DROP OFF	$ -	$ -	**0**	0
00601	Area 1	$ -	$ 269,539	**269,539**	372,935
00602	Area 2	$ -	$ -	**0**	0
00801	Site Utilities	$ -	$ 204,550	**204,550**	283,016
00700	JACKSON STREET PLAZA	$ -	$ -	**0**	0
00701	Main Plaza Area	$ 834,269	$ 95,588	**929,857**	1,286,554
00702	Demolition of Existing	$ -	$ 400,770	**400,770**	554,507
00705	Site Furnishings	$ 8,500	$ 37,150	**45,650**	63,162
TOTAL DIRECT WORK		**$ 20,208,291**	**$ 4,101,354**	**24,309,646**	**33,634,951**
	Design Contingency	$ 2,020,829	$ 410,135	**2,430,965**	
01100	Bonds, Insurance, Permit, Tax, Utility	$ 222,291	$ 45,115	**267,406**	
	MACC Contingency	$ 449,028	$ 91,132	**540,160**	
01000	General Conditions From Summaries	$ 3,367,712	$ 697,161	**4,064,872**	
01800	Preconstruction Services	$ 250,000	$ -	**250,000**	
	Home Office Overhead & Fee	$ 1,060,726	$ 213,796	**1,274,522**	
TOTAL CONSTRUCTION COST (July 2009)		**$ 27,578,878**	**$ 5,558,693**	**33,137,571**	**33,634,951**
	Escalation	$ 414,000	$ 83,380	**497,380**	
TOTAL CONSTRUCTION COST (September 2009)		**$ 27,992,878**	**$ 5,642,074**	**33,634,951**	**33,634,951**

Davis Langdon

BUILDING AREAS & CONTROL QUANTITIES

Areas

	SF	SF	SF
Enclosed Areas			
Level 1	32,470		
Level 2	12,220		
Level 3	19,795		
Level 4/Attic	20,138		
SUBTOTAL, Enclosed Area		84,623	
Covered area			
Level 2 Canopy	17,980		
Level 3 Canopy - Existing	2,406		
Level 3 Canopy - New	1,495		
SUBTOTAL, Covered Area @ ½ Value		10,941	
TOTAL GROSS FLOOR AREA			95,564

Control Quantities

				Ratio to Gross Area
Number of stories (x1,000)		4	EA	0.042
Gross Area		95,564	SF	1.000
Enclosed Area		84,623	SF	0.886
Covered Area		10,941	SF	0.114
Footprint Area		32,470	SF	0.340
Gross Wall Area		53,136	SF	0.556
Retaining Wall Area		0	SF	0.000
Finished Wall Area		53,136	SF	0.556
Windows or Glazing Area	4.67%	2,484	SF	0.026
Roof Area - Flat		12,931	SF	0.135
Roof Area - Sloping		20,105	SF	0.210
Roof Area - Total		33,036	SF	0.346
Roof Glazing Area		0	SF	0.000
Finished Area		64,485	SF	0.675
Elevators (x10,000)		1	EA	0.105
Plumbing Fixtures (x1,000)		52	EA	0.544

BUILDING COMPONENT SUMMARY

		$/SF	$x1,000
	Gross Area:	**95,564 SF**	
1. Foundations		16.84	1,609
2. Vertical Structure		40.00	3,822
3. Floor & Roof Structures		27.02	2,582
4. Exterior Cladding		32.92	3,146
5. Roofing, Waterproofing & Skylights		4.65	445
Shell (1-5)		121.43	11,604
6. Interior Partitions, Doors & Glazing		10.68	1,021
7. Floor, Wall & Ceiling Finishes		31.23	2,984
Interiors (6-7)		41.91	4,005
8. Function Equipment & Specialties		0.73	70
9. Stairs & Vertical Transportation		4.08	390
Equipment & Vertical Transportation (8-9)		4.81	460
10 Plumbing Systems		3.45	330
11 Heating, Ventilating & Air Conditioning		16.71	1,597
12 Electric Lighting, Power & Communications		21.12	2,018
13 Fire Protection Systems		2.03	194
Mechanical & Electrical (10-13)		43.31	4,139
Total Building Construction (1-13)		**211.46**	**20,208**
14 Site Preparation & Demolition		0.00	0
15 Site Paving, Structures & Landscaping		0.00	0
16 Utilities on Site		0.00	0
Total Site Construction (14-16)		**0.00**	**0**
TOTAL BUILDING & SITE (1-16)		**211.46**	**20,208**
Contingency for Development of Design	10.00%	14.85	2,021
TOTAL BUILDING & SITE (1-16)		**232.61**	**22,229**
Subcontractor Bonds	1.00%	1.63	222
MACC Contingency	2.00%	3.30	449
Reimbursables / General Requirement	15.00%	24.75	3,368
MAXIMUM ALLOWABLE CONSTRUCTION COST		**193.07**	**26,268**
Preconstruction Services			250
GC/CM Fee	4.00%	7.80	1,061
Escalation to Midpoint (June 2010)	1.50%	4.33	414
RECOMMENDED BUDGET	***Sep-09***	**292.92**	**27,993**

CSI	*Item Description*	*Quantity*	*Unit*	*Rate*	*Total*
1. Foundations					
	Excavation				
00101	Excavate within building footprint and	334	CY	75.00	25,050
00101	Excavate outside building footprint and	225	CY	35.00	7,875
	Piling				
00101	Screw piles, 55' long, inside building footprint	660	LF	150.00	99,000
	Subsurface soil improvements				
00101	10' Diameter jet grout columns, 50' long	750	LF	850.00	637,500
	Reinforced concrete including excavations				
00101	Concrete mat foundation - inside building footprint	140	CY	1,307.85	183,099
00101	Concrete grade beam - inside building	89	CY	2,280.44	202,959
00101	Concrete grade beam - outside building footprint - tied to existing foundations	109	CY	2,784.92	303,556
00101	Allow for foundation retrofit at utility trench - per S3.61(3)	1	LS	150,000.00	150,000
					1,609,039
2. Vertical Structure					
	Columns and pilasters				
00102	Modify existing steel columns - Type E1	140	LF	150.00	21,000
00102	New steel columns - Type N12	7	T	6,500.00	45,500
00102	New steel columns added to existing - Grid	8,832	LB	3.25	28,704
	Shear bracing				
00102	Steel bracing/strengthening including embeds, grouting and the like	707,531	LB	3.25	2,299,476
00102	High strength non-shrink grouting for steel W8 columns embedded in existing masonry pilasters - per details of Drawing S3.62	4,115	LF	200.00	823,000
00102	FRP reinforcing attached to existing	7,012	SF	30.00	210,360
00102	Bracing for Clock Tower welded to existing diagonal bracing - per Drawings S3.06 &	2,628	LF	150.00	394,200
					3,822,240

CSI	Item Description	Quantity	Unit	Rate	Total
3. Floor and Roof Structure					
	Floor at lowest level				
00103	Replacement slab on grade inside existing building	18,061	SF	15.00	270,915
	Suspended floors				
00103	Steel beams and plate	352,000	LB	3.25	1,144,000
00103	Metal decking, 3", 20 ga	675	SF	3.50	2,363
00103	Concrete topping, 3-1/2"	7	CY	235.00	1,645
00103	Finish	675	SF	1.00	675
00103	Allow for rigging points	1	LS	25,000.00	25,000
00103	Cast in place concrete tower ring beam	18	CY	3,500.00	63,000
	Roof construction				
00701	Structural steel beams	46	T	6,500.00	299,000
00701	New steel decking and concrete topping applied to existing steel structure	13,725	SF	15.00	205,875
00701	Allow for bend plate shear connector,	11,852	LB	3.25	38,519
00701	Slot cut and install new elevated deck expansion joint	120	LF	500.00	60,000
00701	Allow for rigging points	1	LS	25,000.00	25,000
	Miscellaneous				
00104	Miscellaneous metals allowance - 1.5 lbs per	126,935	LB	3.00	380,804
00104	Concrete pads and steps	65,573	SF	1.00	65,573
					2,582,368
4. Exterior Cladding					
	Wall framing, furring and insulation				
00105	Saw cut and create cavity in existing interior masonry walls to allow for structural upgrade	4,115	LF	50.00	205,750
00105	New furring, drywall and rigid insulation to interior face of exterior walls	29,776	SF	10.00	297,760
00802	New CMU, rigid insulation, furring and drywall exterior wall	1,800	SF	35.00	63,000
00802	Brick infill to existing opening	56	SF	50.00	2,800
00802	Granite infill to existing opening	189	SF	100.00	18,900
00303	New granite sill	21	LF	250.00	5,250

CSI	Item Description	Quantity	Unit	Rate	Total
	Exterior cladding repairs				
00304	Brick and terracotta cleaning	53,136	SF	2.50	132,840
00304	Brick and terracotta tuck pointing - 30% 0f	15,941	SF	13.50	215,201
00305	Stone and terracotta replacement	53,136	SF	2.50	132,840
00303	Create new opening in existing exterior wall	134	SF	100.00	13,400
00106	Terracotta and brick repair at tower	1	LS	1,000,000	1,000,000
	Windows, glazing and louvers				
00303	Remove and replace glazing in existing window frame	48	SF	20.00	960
00303	Window replacement	1,698	SF	112.00	190,176
00303	Window rehabilitation	4,680	SF	100.00	468,000
00303	Louver allowance	1	LS	10,000.00	10,000
	Exterior doors, frames and hardware				
00303	New historical door and transome	1	EA	5,000.00	5,000
00303	New historical double panel door	3	EA	10,000.00	30,000
00303	New historical sliding wood door	1	EA	10,000.00	10,000
00303	New historical glazed double door	8	EA	15,000.00	120,000
00303	New historical double panel door - oversized	3	EA	20,000.00	60,000
00303	New historical glazed single door	1	EA	7,500.00	7,500
00303	Door automation	1	LS	25,000.00	25,000
00303	Sliding wood door, 8'-0" x 8'-0"	2	EA	3,500.00	7,000
	Fascias, bands, screens and trim				
00405	Repair existing canopy fascia	171	LF	50.00	8,550
00405	New canopy fascia	45	LF	100.00	4,500
00402	New canopy fascia	105	LF	100.00	10,500
00402	New canopy fascia	180	LF	100.00	18,000
00402	New canopy fascia	30	LF	100.00	3,000
00405	New copper fascia ornaments	74	EA	250.00	18,500
00402	New copper fascia ornaments	36	EA	250.00	9,000
00402	New copper fascia ornaments	61	EA	250.00	15,250
00402	New copper fascia ornaments	11	EA	250.00	2,750
	Balustrades, parapets and roof screens				
00802	New granite balustrade	28	LF	1,000.00	28,000
00802	Patch holes in existing granite balustrade left by railing removal	260	LF	25.00	6,500
					3,145,927

CSI	Item Description	Quantity	Unit	Rate	Total
5. Roofing, Waterproofing & Skylights					
	Waterproofing slabs				
00701	New rigid insulation and waterproofing to Jackson street plaza	13,725	SF	15.00	205,875
	Roofing				
00402	New metal panels to existing canopy structure - King Street	2,924	SF	20.00	58,480
00405	New metal panels to existing canopy structure - Jackson Street	2,112	SF	20.00	42,240
00802	New ventilation louver, 2'X2'	8	EA	400.00	3,200
	Insulation				
00507	Batt insulation to level 4	20,105	SF	2.00	40,210
	Caulking and sealants				
00304	Batt insulation to level 4	94,816	SF	1.00	94,816
					444,821
6. Interior Partitions, Doors & Glazing					
00105	New furring and drywall cladding to new steel bracing at interior walls	17,340	SF	5.00	86,700
	Concrete, block or brick walls				
00505	New brick infill	91	SF	50.00	4,550
	Partition framing and cores				
00503	Metal studs, 3 5/8"	1,978	SF	4.50	8,901
00504	Metal studs, 3 5/8"	2,089	SF	4.50	9,401
00505	Metal studs, 3 5/8"	3,514	SF	4.50	15,813
00206	Metal studs, 3 5/8"	1,239	SF	4.50	5,576
00203	Metal studs, 3 5/8"	2,504	SF	4.50	11,268
00508	Metal studs, 3 5/8"	10,210	SF	4.50	45,945
00206	Metal furring	3,727	SF	2.75	10,249
00203	Metal furring	1,662	SF	2.75	4,571
	Partition surfacing				
00503	Gypsum board, taped and sanded	3,956	SF	2.65	10,483
00504	Gypsum board, taped and sanded	4,196	SF	2.65	11,119

CSI	Item Description	Quantity	Unit	Rate	Total
00508	Gypsum board, taped and sanded	14,506	SF	2.65	38,441
00505	Gypsum board, taped and sanded	7,028	SF	2.65	18,624
00206	Gypsum board, taped and sanded	5,148	SF	2.65	13,642
00203	Gypsum board, taped and sanded	2,719	SF	2.65	7,205
00200	Gypsum board, taped and sanded	5,008	SF	2.65	13,271
00508	Gypsum board, taped and sanded	20,420	SF	4.50	91,890
00507	Fill existing door openings	4	EA	250.00	1,000
	Sound insulation				
00503	Insulation	1,978	SF	1.00	1,978
00504	Insulation	2,098	SF	1.00	2,098
00508	Insulation	10,212	SF	1.00	10,212
00507	Insulation	7,333	SF	1.00	7,333
00505	Insulation	3,514	SF	1.00	3,514
00206	Insulation	4,966	SF	1.00	4,966
00508	Insulation	10,210	SF	1.00	10,210
00203	Insulation	1,662	SF	1.00	1,662
	Balustrades and rails				
00501	New bronze guardrail, 0'-6" high	132	LF	250.00	33,000
00501	Decorative bronze grille, 4'-0" high	12	LF	300.00	3,600
00505	New brass guardrail	48	LF	500.00	24,000
00505	New brass guardrail	60	LF	500.00	30,000
00505	New brass guardrail	369	LF	500.00	184,500
00505	New marble cap to guardrails	139	LF	175.00	24,325
	Window walls and borrowed lights				
00501	Fully glazed window	143	SF	65.00	9,295
00506	New glass enclosure	371	SF	85.00	31,535
	Interior doors, frames and hardware				
00501	New wood door, double	4	EA	2,800.00	11,200
00503	New wood door, double	1	EA	2,800.00	2,800
00504	New wood door, double	1	EA	2,800.00	2,800
00503	New wood door, single	2	EA	2,000.00	4,000
00508	New wood door, single	6	EA	2,000.00	12,000
00505	New wood door, single	3	EA	2,000.00	6,000
00203	New wood door, single	2	EA	2,000.00	4,000
00206	New wood door, single	5	EA	2,000.00	10,000
00203	New roll down fire door, 12'-0" wide x 9'-0"	1	EA	10,000.00	10,000
00203	Reinstall historic door, refurbish door and hardware, double leaf	2	EA	5,000.00	10,000
00203	New fire door, 15'-0" wide	1	EA	15,000.00	15,000

CSI	*Item Description*	*Quantity*	*Unit*	*Rate*	*Total*
	Miscellaneous				
00500	Blocking and backing, allow	84,623	SF	0.50	42,312
00500	Special partitions and doors	1	LS	100,000.00	100,000
					1,020,989

7. Floor, Wall & Ceiling Finishes

CSI	*Item Description*	*Quantity*	*Unit*	*Rate*	*Total*
	Floors				
00503	Clean and make good of existing floor to receive new finishes	1,145	SF	1.85	2,118
00504	Clean and make good of existing floor to receive new finishes	2,043	SF	1.85	3,780
00505	Clean and make good of existing floor to receive new finishes	1,028	SF	1.85	1,902
00203	Clean and make good of existing floor to receive new finishes	400	SF	1.85	740
00206	Clean and make good of existing floor to receive new finishes	708	SF	1.85	1,310
00206	Liquid applied self-leveling floor underlayment to all floors receiving new floor	4,901	SF	5.00	24,505
00503	New terrazzo flooring	1,145	SF	30.00	34,350
00504	New terrazzo flooring	2,043	SF	30.00	61,290
00505	New terrazzo flooring	1,028	SF	30.00	30,840
00203	New terrazzo flooring	400	SF	30.00	12,000
00206	New terrazzo flooring	1,431	SF	30.00	42,930
00206	Tile flooring	737	SF	16.00	11,792
00501	Patch and repair existing terrazzo flooring	7,508	SF	10.00	75,080
00504	Patch and repair existing terrazzo flooring	2,783	SF	10.00	27,830
00505	Patch and repair existing terrazzo flooring	3,219	SF	10.00	32,190
00501	Patch and repair holes on terrazzo flooring	15	EA	250.00	3,750
00508	Concrete sealer	13,993	SF	1.00	13,993
	Bases or skirting, etc.				
00503	Rubber base	148	LF	2.00	296
00504	Rubber base	210	LF	2.00	420
00505	Rubber base	189	LF	2.00	378
00203	Rubber base	100	LF	2.00	200
00206	Rubber base	156	LF	2.00	312

CSI	*Item Description*	*Quantity*	*Unit*	*Rate*	*Total*
	Walls				
00501	Clean and make good of existing wall to receive new finishes	3,184	SF	1.85	5,890
00503	Clean and make good of existing wall to receive new finishes	522	SF	1.85	966
00504	Clean and make good of existing wall to receive new finishes	1,706	SF	1.85	3,156
00503	Paint to new gypsum board walls	3,956	SF	1.10	4,352
00504	Paint to new gypsum board walls	4,196	SF	1.10	4,616
00508	Paint to new gypsum board walls	14,506	SF	1.10	15,957
00505	Paint to new gypsum board walls	7,028	SF	1.10	7,731
00206	Paint to new gypsum board walls	5,148	SF	1.10	5,663
00203	Paint to new gypsum board walls	2,719	SF	1.10	2,991
00200	Paint to new gypsum board walls	5,008	SF	1.10	5,509
00508	Paint to new gypsum board walls	20,420	SF	1.10	22,462
00501	Tile wainscot	1,104	SF	16.00	17,664
00501	Marble wainscot to existing walls	1,187	SF	100.00	118,700
00502	Marble wainscot to existing walls	299	SF	100.00	29,900
00503	Marble wainscot to existing walls	22	SF	100.00	2,200
00504	Marble wainscot to existing walls	436	SF	100.00	43,600
00506	Marble wainscot to existing walls	197	SF	100.00	19,700
00507	Marble wainscot to existing walls	60	SF	100.00	6,000
00501	Glass mosaic tile to existing walls	60	SF	30.00	1,800
00502	Glass mosaic tile to existing walls	10	SF	30.00	300
00504	Glass mosaic tile to existing walls	20	SF	30.00	600
00503	Finish to new wall	1,004	SF	30.00	30,120
00504	Finish to new wall	471	SF	30.00	14,130
	Column furring and finish				
00501	Marble wainscot to existing columns	982	SF	150.00	147,300
00501	Reclaimed marble wainscot to existing	560	SF	50.00	28,000
00502	Marble wainscot to existing columns	584	SF	150.00	87,600
00504	Marble wainscot to existing columns	2,379	SF	150.00	356,850
00501	Glass mosaic tile to existing columns	65	SF	35.00	2,275
00502	Glass mosaic tile to existing columns	38	SF	35.00	1,330
00504	Glass mosaic tile to existing columns	40	SF	35.00	1,400
00508	Furring and gypsum board finish to existing columns, painted	480	SF	11.00	5,280
	Ceilings				
00507	New GWB ceiling, painted	20,105	SF	12.00	241,260

CSI	Item Description	Quantity	Unit	Rate	Total
	Plaster repairs				
00510	Plaster repair quotation	1	LS	1,256,164.0	1,256,164
00510	Repaint existing plaster - walls	12,891	SF	2.50	32,228
00510	Repaint existing plaster - ceilings	19,575	SF	4.00	78,300
					2,983,997

8. Function Equipment & Specialties

CSI	Item Description	Quantity	Unit	Rate	Total
	Prefabricated compartments and accessories				
	Toilet partitions, reinforced composite panels				
00206	Standard	12	EA	900.00	10,800
00206	ADA compliant	2	EA	1,000.00	2,000
00206	Urinal screens	3	EA	350.00	1,050
00206	Toilet room accessories - per stall	15	EA	450.00	6,750
00206	Shower compartment and accessories	2	EA	1,850.00	3,700
00206	Handsoap dispenser	10	EA	150.00	1,500
00206	Paper towel dispenser and waste receptacle	10	EA	450.00	4,500
00206	Grab bars	4	EA	350.00	1,400
00206	Mirror	288	SF	15.00	4,320
	Shelving and millwork				
00500	Janitor shelving and mop rack	2	EA	550.00	1,100
	Cabinets and countertops				
00503	Ticket counter, 3'-0" wide	28	LF	650.00	18,200
00508	Countertop, solid surface, 1'-6" deep	25	LF	250.00	6,250
	Amenities and convenience items				
00705	Bike storage rack	17	EA	500.00	8,500
					70,070

9. Stairs & Vertical Transportation

CSI	Item Description	Quantity	Unit	Rate	Total
	Staircase flights				
00203	Existing stair railing modifications	1	LS	25,000.00	25,000
	New interior stairwells - per flight				
00203	West Stair	2	EA	100,000.00	200,000
00204	East Stair - prefabricated steel	2	EA	20,000.00	40,000

CSI	Item Description	Quantity	Unit	Rate	Total
	Elevators				
00205	New passenger elevator - hydraulic	1	LS	125,000.00	125,000
					390,000

10. Plumbing Systems

CSI	Item Description	Quantity	Unit	Rate	Total
	Sanitary fixtures and connection piping				
00207	Plumbing fixtures	47	EA	1,500.00	70,500
	Sanitary waste, vent and service piping				
00207	Hose bibs with piping	6	EA	1,000.00	6,000
00207	Floor drains and sinks with piping	9	EA	1,250.00	11,250
00207	Rough-in to plumbing fixtures	47	EA	3,400.00	159,800
00207	Connections for tenant areas	1	LS	10,000.00	10,000
	Water treatment, storage and circulation				
00207	Gas fired central domestic HW, storage, and circulation equipment	1	LS	18,800.00	18,800
00207	Surface water drainage				
00207	Roof and deck drains	12	EA	850.00	10,200
00207	Drain and vent piping; insulated	700	LF	40.00	28,000
00207	Gas and fuel oil distribution				
00207	Gas piping to boiler	1	LS	15,000.00	15,000
					329,550

11. Heating, Ventilation & Air Conditioning

CSI	Item Description	Quantity	Unit	Rate	Total
	Heat generation and chilling				
00208	Geothermal wells; (36 @ 300' deep), including piping connection to building	1	LS	252,000.00	252,000
00208	Heat pumps; water to water	378	MBH	85.00	32,130
00208	Water treatment	1	LS	8,000.00	8,000
	Thermal storage and circulation pumps				
00208	Expansion tanks and air separators	1	LS	4,500.00	4,500

CSI	Item Description	Quantity	Unit	Rate	Total
00208	HHW distribution pumps	1	EA	5,750.00	5,750
00208	CW distribution pumps	2	EA	6,500.00	13,000
00208	Variable speed drives	40	HP	400.00	16,000
00208	Vibration isolation to pumps	3	EA	1,050.00	3,150
	Piping, fittings, valves and insulation				
00208	HHW piping, valves and insulation to AHU, and unit ventilators; <= 3"	3,600	LF	55.00	198,000
00208	Equipment hook-ups	13	EA	1,200.00	15,600
00208	Chilled water piping, valves and insulation;	2,400	LF	60.00	144,000
00208	Equipment hook-ups	9	EA	3,500.00	31,500
	Air handling equipment				
00208	Water to air heat pumps	7,400	CFM	6.50	48,100
00208	Heat recovery ventilator	500	CFM	6.00	3,000
00208	Unit ventilators with reheat; <= 1050 CFM	10	EA	1,150.00	11,500
00208	Sound attenuation	7,400	CFM	0.60	4,440
	Air distribution and return				
00208	Galvanized steel ductwork	56,000	LB	7.25	406,000
00208	Fire wrap/enclosure	1,350	SF	15.00	20,250
00208	Flexible duct	210	LF	14.00	2,940
00208	Duct volume dampers	42	EA	90.00	3,780
00208	Duct fire dampers	22	EA	1,400.00	30,800
00208	Duct insulation	26,200	SF	3.50	91,700
00208	Duct lining	8,800	SF	4.25	37,400
	Diffusers and return air grilles				
00208	Supply diffusers and extract grilles	42	EA	165.00	6,930
	Controls, instrumentation and balancing				
00208	Automatic control system; including CO2 monitoring and window actuators at waiting rooms.	33,577	SF	4.15	139,345
00208	Testing and balancing	200	HR	95.00	19,000
00208	Attendance on third party commissioning	100	HR	95.00	9,500
	Independent exhaust ventilation				
00208	General extract fans	7,200	CFM	0.95	6,840
00208	Relief hoods	28,700	CFM	1.10	31,570
					1,596,725

CSI	*Item Description*	*Quantity*	*Unit*	*Rate*	*Total*
12. Electrical Lighting, Power & Communication					
	Main service and distribution etc.				
00209	Main switchgear including metering, sub-metering, distribution equipment and feeders	2,500	AMP	150.00	375,000
	Machine and equipment power				
00209	Connections and switches	65,753	SF	3.00	197,259
	User convenience power				
00209	Receptacles including conduit and wire	450	EA	304.00	136,800
	Lighting				
00209	Fixtures including conduit and wire				
00209	General lighting, switching, distribution panelboards and feeders and including emergency lights	370	EA	510.00	188,700
00210	Historical interior lighting				
00210	Fixture type C1 (replicated)	18	EA	1,770.00	31,860
00210	Fixture type L1(replicated)	1	EA	58,070.00	58,070
00210	Fixture type L2 (replicated)	4	EA	10,700.00	42,800
00210	Fixture type L3 (replicated)	2	EA	11,370.00	22,740
00210	Fixture type L5 (replicated)	50	EA	4,910.00	245,500
00210	Fixture type R1(retrofit)	1	EA	3,430.00	3,430
00210	Fixture type R2 (retrofit)	24	EA	2,110.00	50,640
00210	Fixture type XL1 (replicated)	17	EA	12,800.00	217,600
	Exterior lighting (fixed to building)				
00306	Fixture type XL6	685	LF	110.00	75,350
00209	Miscellaneous/safety lighting to tenant areas	1	LS	100,000.00	100,000
	Lighting and power specialties				
00209	Grounding system	1	LS	10,000.00	10,000
00209	Lighting controls	1	LS	50,000.00	50,000
00209	Lightning protection at clock tower	1	LS	20,000.00	20,000
00209	Cable tray/ladder rack	700	LF	39.90	27,930
00209	Telephone and communications systems				
00209	MDF/IDF rough-in	1	LS	10,000.00	10,000
00209	Telephone/data outlets including conduit and wire and share of primary infrastructure	40	EA	750.00	30,000
00209	AV/sound systems rough-in	1	LS	25,000.00	25,000

CSI	Item Description	Quantity	Unit	Rate	Total
	Alarm and security systems				
00209	Fire alarm panel and annunciator	1	LS	12,500.00	12,500
00209	Fire alarm devices including conduit and	145	EA	600.00	87,000
					2,018,179

13. Fire Protection Systems

CSI	Item Description	Quantity	Unit	Rate	Total
00202	Fire sprinkler systems complete (only required to approximately 65% of GFA)	55,122	SF	3.25	179,147
00202	Premium for dry system at L4	19,050	SF	0.80	15,240
					194,387

SITEWORK COMPONENT SUMMARY

	Gross Area:	**135,722 SF**	
		$/SF	$x1,000
14 Site Preparation & Demolition		23.59	3,202
15 Site Paving, Structures & Landscaping		2.76	375
16 Utilities on Site		3.86	525
TOTAL BUILDING & SITE (1-16)		**30.22**	**4,101**
Contingency for Development of Design	10.00%		410
TOTAL BUILDING & SITE (1-16)			**4,511**
Subcontractor Bonds	1.00%		45
MACC Contingency	2.00%		91
Reimbursables / General Requirement	15.00%		697
MAXIMUM ALLOWABLE CONSTRUCTION COST			**5,345**

CSI		*Quantity*	*Unit*	*Rate*	*Total*
14. Site Preparation & Building Demolition					
	Site protection				
00601	Erosion control	12,160	SF	1.25	15,200
	Slab demolition				
00107	Slab on grade demolition and removal	17,707	SF	14.60	258,522
00107	Saw cut slab on grade	302	LF	10.00	3,020
00107	Slab cut out	1,666	SF	36.50	60,809
00107	Saw cut suspended slab	518	LF	10.00	5,180
00702	Exterior slab construction - remove asphalt and concrete and expose existing steel	13,725	SF	29.20	400,770
	Exterior wall demolition				
00105	Remove existing plaster finish on interior face of exterior walls	30,975	SF	7.30	226,118
00302	Remove existing granite clad brick wall - salvage granite	81	SF	146.00	11,826
00302	Remove existing brick walls	7,280	SF	7.50	54,600
00302	Remove existing concrete infill	1,555	SF	73.00	113,515
00302	Remove existing aluminum windows	1,774	SF	29.20	51,801
00302	Remove bars over existing windows	192	SF	29.20	5,606
00402	Canopy - strip existing metal cladding and expose existing structure	2,924	SF	14.60	42,690
00405	Canopy - strip existing metal cladding and expose existing structure	2,112	SF	14.60	30,835
	Interior partition demolition				
00509	Remove existing framed partitions including doors in line	53,666	SF	4.38	235,057
00509	Remove existing masonry partitions including doors in line	1,400	SF	10.95	15,330
00509	Remove & catalogue existing historic glazed	10	EA	2,000.00	20,000
00509	Remove & catalogue existing vault doors	3	EA	3,000.00	9,000
	Interior finishes demolition				
00509	Remove existing flooring	29,138	SF	2.19	63,812
00509	Remove existing non historic framed column covers - framed girth	2,016	SF	3.65	7,358
00509	Remove existing plaster wall finish	660	SF	15.00	9,900
00509	Salvage existing marble wall panels	3,373	SF	7.30	24,623
00509	Salvage existing Compass Room column cladding and mouldings	560	SF	15.00	8,400
00509	Salvage existing restroom flooring	1,020	SF	15.00	15,300
00509	Salvage existing wood chair rail	80	SF	10.00	800

CSI		Quantity	Unit	Rate	Total
	Fittings and fixture demolition				
00509	Remove existing guardrails adjacent to Tickets and Information	51	LF	10.00	510
00509	Demolish and remove existing Tickets and Information counter	333	LF	10.00	3,330
00509	Demolish and remove existing baggage conveyor belt system	80	LF	20.00	1,600
00509	Demolish and remove existing restroom fittings and accessories	1,020	SF	3.00	3,060
00206	Salvage existing bathroom partitions	1	LS	7,300.00	7,300
00509	Remove existing suspended ceiling	32,015	SF	2.92	93,484
	Stairwell demolition				
00201	Salvage existing stairwell for reuse	1	EA	36,500.00	36,500
00301	Remove existing escalator pair	1	LS	36,500.00	36,500
00307	Uncover existing exterior stair	1	LS	36,500.00	36,500
	Clock Tower				
00302	Create two openings in existing masonry wall for new exhaust louvers	27	SF	100.00	2,700
00302	Remove and salvage existing terracotta to be reinstall, 11th floor	128	LF	146.00	18,688
00302	Remove brick at existing ledgers, steel stripped and prepare for new paint	1,860	SF	100.00	186,000
	Miscellaneous				
00201	Protect existing stairwell to remain	1	EA	20,000.00	20,000
00705	Remove existing wrought iron fence	243	LF	50.00	12,150
00703	Salvage existing light fixture base	17	EA	250.00	4,250
00509	Gut interior space	19,156	SF	7.50	143,670
00308	Demolish existing building addition	1,464	SF	15.00	21,960
00503	Demolish existing interior arrival canopy	560	SF	5.00	2,800
00211	Coring and drilling	84,623	SF	1.50	126,935
00211	MEP demolition	84,623	SF	2.00	169,246
00211	Protection of existing to remain	84,623	SF	1.00	84,623
00099	Hazardous material abatement	1	LS	500,000	500,000
					3,201,878

15. Site Paving, Structures & Landscaping

CSI		Quantity	Unit	Rate	Total
	Jackson Street Plaza				
00701	Crushed gravel	10,227	SF	3.50	35,795
00701	Concrete	498	SF	7.50	3,735
00701	Concrete pavers	231	SF	18.00	4,158

CSI		Quantity	Unit	Rate	Total
00701	Stone pavers	1,644	SF	30.00	49,320
00701	Asphalt	645	SF	4.00	2,580
	King Street				
	New structural concrete slab on grade, 10"				
00601	Fine grade	12,160	SF	0.75	9,120
00601	Subbase, 6"	225	CY	42.00	9,450
00601	Formwork - edge	514	LF	8.00	4,112
00601	Reinforcing steel, allow 2 psf	24,320	LB	1.00	24,320
00601	Concrete, 4,000 psi	375	CY	235.00	88,125
00601	Thickened slab edge	1,028	LF	11.00	11,308
00601	Finish	12,160	SF	1.00	12,160
00601	Construction joints	699	LF	6.50	4,544
00601	Interim padestrian paving, assume concrete topping slab	12,160	SF	7.50	91,200
00705	Site furnishing	1	LS	25,000.00	25,000
					374,926

16. Utilities on Site

CSI		Quantity	Unit	Rate	Total
00801	Incoming water connection	350	LF	88.00	30,800
00801	Connections to existing	1	LS	4,000.00	4,000
00801	Valves and specialties	1	LS	10,000.00	10,000
00801	Relocate existing gas piping	250	LF	60.00	15,000
00801	Valves and specialties	1	LS	10,000.00	10,000
00801	Connections to existing	1	LS	2,500.00	2,500
00801	Underground piping	50	LF	90.00	4,500
00801	Manholes	1	EA	3,500.00	3,500
00801	Connections to existing	1	LS	2,000.00	2,000
00801	Feeder conduit and wire	200	LF	215.00	43,000
00801	Connections to existing	1	LS	5,000.00	5,000
00801	Telecommunications	200	LF	250.00	50,000
00801	Connections to existing	1	LS	7,500.00	7,500
00704	Lighting to hardscape and softscape areas	1	LS	305,000.0	305,000
00704	Remove, store and reinstall existing lighting	5	EA	3,000.00	15,000
00801	Underground piping	50	LF	95.00	4,750
00801	Manholes/catchbasins	3	EA	3,000.00	9,000

CSI		Quantity	Unit	Rate	Total
00801	Connections to existing	1	LS	3,000.00	3,000
					524,550

Appendix 10 – Material Weight Conversion Sources

Boise Cascade
Engineered Wood Products

Technical Note

Weights of Building Materials – Pounds Per Square Foot [PSF]

CEILING	
Acoustical fiber board [1]	1
Suspended steel channel system [1]	2
Suspended wood channel system	2.5
2x8 ceiling joists @ 16" o.c., R-49 insulation, 1/2" gypsum board	7
1" Plaster	8
1/2" gypsum board [1]	2.2
5/8" gypsum board [1]	2.75
ROOF	
Fiberglass shingles	3
Asphalt shingles [1]	2
Wood shingles [1]	3
Spanish clay tile [1]	19
Concrete roof tile	12
Composition Roofing:	
Three-ply ready roofing [1]	1
Four-ply felt and gravel [1]	5.5
Five-ply felt and gravel [1]	6
20 gage metal deck [1]	2.5
18 gage metal deck [1]	3
0.05" thick polyvinyl chloride polymer membrane[4]	0.35
1" fiberglass batt insulation	0.04
1" loose fiberglass insulation	0.04
1" loose cellulose insulation	0.14
1" rigid insulation [1]	1.5
Blowing wool insulation R-38 (16"deep)	0.62
3/16" slate [1]	7
1/4" slate [1]	10
Single-ply (no ballast) [1]	0.7
Single-ply (ballasted)	11
Dry gravel [1]	8.7
2x8 rafters @ 16" o.c., fiberglass shingles, 15# felt, 3/8" sheathing	8
Skylight: metal frame w/ 3/8" wire glass [1]	8
FLOOR	
1" reinforced regular weight concrete	12.5
1" plain lightweight concrete [1]	8
7/16" cementitious backerboard	3
Ceramic or quarry tile (3/4") on 1/2" mortar bed [1]	16
Ceramic or quarry tile (3/4") on 1" mortar bed [1]	23
1" mortar bed	12
1" slate [1]	15
3/8" marble tile	6
3/8" ceramic floor tile [1]	4.7
FLOOR (cont.)	
Hardwood flooring, 7/7-in [1]	4
1/4" linoleum or asphalt tile [1]	1
BCI/AJS joists @ 16" o.c., 3/4" sheathing, 1/2" gypsum board	10
3/4" Gyp-Crete® topping	6.5
Carpet & Pad	2.0
Waterproofing Membranes	
Bituminous, smooth surface [1]	1.5
Liquid applied [1]	1
SHEATHING	
11/32" or 3/8" Plywood – OSB[3]	1.0 - 1.2
15/32" or 1/2" Plywood - OSB[3]	1.4 - 1.7
19/32" or 5/8" Plywood - OSB[3]	1.8 - 2.1
23/32" or 3/4" Plywood - OSB[3]	2.2 - 2.5
7/8" Plywood - OSB[3]	2.6 - 2.9
1 1/8" Plywood - OSB[3]	3.3 - 3.6
1/2" cementitious backerboard	3
1-1/2" softwood T & G decking	4.6
FRAMING	
2x4 @ 16" o.c.	1.1
2x6 @ 16" o.c.	1.7
2x8 @ 16" o.c.	2.2
2x10 @ 16" o.c.	2.9
2x12 @ 16" o.c.	3.5
BCI® 4500s, 5000 or 5000s @ 12" o.c.	2.0 – 2.9
BCI® 4500s, 5000 or 5000s @ 16" o.c.	1.5 – 2.2
BCI® 4500s, 5000 or 5000s @ 19.2" o.c.	1.3 – 2.8
BCI® 4500s, 5000 or 5000s @ 24" o.c	1.0 – 1.5
BCI® 6000 or 6000s @ 12" o.c.	2.2 – 3.4
BCI® 6000 or 6000s @ 16" o.c.	1.7 – 2.6
BCI® 6000 or 6000s @19.2" o.c.	1.4 - 2.1
BCI® 6000 or 6000s @ 24" o.c.	1.1 - 1.7
BCI® 60, 60s, 6500 or 6500s @ 12" o.c.	2.3 – 3.8
BCI® 60, 60s, 6500 or 6500s @ 16" o.c.	1.7 – 2.9
BCI® 60, 60s, 6000 or 6500s @19.2" o.c.	1.4 – 2.4
BCI® 60, 60s, 6500 or 6500s @ 24" o.c.	1.2 – 1.9
BCI® 90 or 90s @ 12" o.c.	3.9 – 4.9
BCI® 90 or 90s @ 16" o.c.	2.9 – 3.7
BCI® 90 or 90s @ 19.2" o.c.	2.4 – 3.1
BCI® 90 or 90s @ 24" o.c.	1.9 – 2.5
AJS® 140 or 20 @ 12" o.c.	2.2 – 3.3
AJS® 140 or 20 @ 16" o.c.	1.7 – 2.5
AJS® 140 or 20 @ 19.2" o.c.	1.4 – 2.1
AJS® 140 or 20 @ 24" o.c.	1.1 – 1.7
AJS® 25 @ 12" o.c.	3.1 – 3.9
AJS® 25 @ 16" o.c.	2.3 – 2.9
AJS® 25 @ 19.2" o.c.	1.9 – 2.4
AJS® 25 @ 24" o.c.	1.6 – 2.0

Tech Note GE-1 **Page 1 of 2** r9/09

<u>WALL</u>	
5/16" x 7-1/2" fiber cement lap siding	3
4" clay brick [(1)]	39
1/4" ceramic wall tile [(1)]	3.1
1 ¾" Cultured Stone®	12
2x4 studs @ 16" o.c., 5/8" gypsum, insulation, 3/8" siding [(1)]	11
2x6 studs @ 16" o.c., 5/8" gypsum, insulation, 3/8" siding [(1)]	12
Wood or steel studs, 1/2" gypsum board each side [(1)]	8
Exterior stud walls w/ brick veneer [(1)]	48
Windows: glass, frame and sash [(1)]	8
Stucco	10
Log Wall: 10" diameter	26
Glass Block	
4" thick - standard (hollow)	20
3" thick - standard (hollow)	16
4" thick - thick face	30
3" thick - solid glass block	40
<u>MISCELLANEOUS</u>	
1" of sand	8
1" of water	5.2
Hay: baled (dry) [(2)]	15 PCF[(2)]
Straw: baled (dry) [(2)]	8 PCF[(2)]
Saturated soil (garden/landscaped roof)	135 PCF
Grand Piano	1000 LB

Include at least 1.5 psf in all dead load summations to account for incidentals such as plumbing, ducts, light fixtures, etc.

(1) *Minimum Design Loads for Buildings and Other Structures*, ASCE 7-05.
(2) *National Farm Building Code (Canada) 1995. Value in pounds per cubic foot (PCF), multiply by maximum height to obtain PSF.*
(3) *Approximate Engineering Dead Load Weight of Wood Structural Panels, APA EWS TT-019, 1998.*
(4) *Duro-Last General Specifications, Duro-Last Roofing, Inc. 2005*

Appendix

B

Weights of Building Materials

Loads given in Appendix B are typical values. Specific products may have weights which differ considerably from those shown, and manufacturer's catalogs should be consulted for actual loads.

Roof dead loads

Material	Weight, psf		
Lumber sheathing, 1 in. nominal		2.5	
Plywood, per inch of thickness		3.0	
Timber decking (MC = 15%):	2 in. nom.	3 in. nom.	4 in. nom.
DF-Larch	4.2	7.0	9.8
DF (South)	3.9	6.5	9.1
Hem-Fir	3.7	6.1	8.5
Spruce-Pine-Fir	3.7	6.1	8.5
Western Woods	3.5	5.8	8.1
Western Cedars	3.5	5.8	8.1

Roof dead loads		
Material	Weight, psf	
Aluminum (including laps):	Flat	Corrugated (1½ and 2½ in.)
12 American or B&S gage	1.2	...
14	0.9	1.1
16	0.7	0.9
18	0.6	0.7
20	0.5	0.6
22	...	0.4
Galvanized steel (including laps):	Flat	Corrugated (2½ and 3 in.)
12 U.S. std. gage	4.5	4.9
14	3.3	3.6
16	2.7	2.9
18	2.2	2.4
20	1.7	1.8
22	1.4	1.5
24	1.2	1.3
26	0.9	1.0
Other types of decking (per inch of thickness):		
Concrete plank	6.5	
Insulrock	2.7	
Petrical	2.7	
Porex	2.7	
Poured gypsum	6.5	
Tectum	2.0	
Vermiculite concrete	2.6	
Corrugated asbestos (¼ in.)	3.0	
Felt:		
3-ply	1.5	
3-ply with gravel	5.5	
5-ply	2.5	
5-ply with gravel	6.5	
Insulation (per inch of thickness):		
Expanded polystyrene	0.2	
Fiber glass, rigid	1.5	
Loose	0.5	
Roll roofing	1.0	

Shingles:
Asphalt
Book til
Book til
Cement
Clay til
Ludowi
Roman
Slate (
Spanisl

Acoustica
Channel-
For gypsu
see *Wal*

Hardwooc
Plywood (
Asphalt n
Cement fi
Ceramic
Concrete
Lightw
Reinfor
Stone
Cork tile
Flexicore
Linoleum
Terrazo fi
Vinyl tile

Wood par
Wood stu
12 in. c
16 in. c
24 in. c
Glass blo
Glass (¼
Glazed ti
Marble o

…t, psf

Corrugated (1½ and 2½ in.)
...
1.1
0.9
0.7
0.6
0.4

Corrugated (2½ and 3 in.)
4.9
3.6
2.9
2.4
1.8
1.5
1.3
1.0

Roof dead loads

Material	Weight, psf
Shingles:	
Asphalt (¼ in. approx.)	2.0
Book tile (2 in.)	12.0
Book tile (3 in.)	20.0
Cement asbestos (⅜ in. approx.)	4.0
Clay tile (for mortar add 10 psf)	9.0 to 14.0
Ludowici	10.0
Roman	12.0
Slate (¼ in.)	10.0
Spanish	19.0

Ceiling dead loads

Material	Weight, psf
Acoustical fiber tile	1.0
Channel-suspended system	1.0
For gypsum wallboard and plaster, see *Wall and partition dead loads*	

Floor dead loads

Material	Weight, psf
Hardwood (1 in. nominal)	4.0
Plywood (per inch of thickness)	3.0
Asphalt mastic (per inch of thickness)	12.0
Cement finish (per inch of thickness)	12.0
Ceramic and quarry tile (¾ in.)	10.0
Concrete (per inch of thickness)	
Lightweight	6.0 to 10.0
Reinforced (normal weight)	12.5
Stone	12.0
Cork tile (1/16 in.)	0.5
Flexicore (6-in. slab)	46.0
Linoleum (¼ in.)	1.0
Terrazo finish (1½ in.)	19.0
Vinyl tile (⅛ in.)	1.4

Wall and partition dead loads

Material	Weight, psf
Wood paneling (1 in.)	2.5
Wood studs (2 × 4 @ 15% mc DF-Larch):	
12 in. o.c.	1.2
16 in. o.c.	0.9
24 in. o.c.	0.6
Glass block (4 in.)	18.0
Glass (¼-in. plate)	3.3
Glazed tile	18.0
Marble or marble wainscoting	15.0

Wall and partition dead loads

Material	Weight, psf
Masonry (per 4 in. of thickness):	
Brick	38.0
Concrete block	30.0
Cinder concrete block	20.0
Hollow clay tile, load bearing	23.0
Hollow clay tile, non-load-bearing	18.0
Hollow gypsum block	13.0
Limestone	55.0
Terra-cotta tile	25.0
Stone	55.0
(The average weights of completed reinforced and grouted concrete block and brick walls can be found in Ref. 12.)	
Plaster (1 in.)	8.0
Plaster (1 in.) on wood lath	10.0
Plaster (1 in.) on metal lath	8.5
Gypsum wallboard (1 in.)	5.0
Porcelain-enameled steel	3.0
Stucco (⅞ in.)	10.0
Windows (glass, frame, and sash)	8.0

SOURCE: Weights from *Western Woods Use Book,* Western Wood Products Association, 4th ed., 1996.

Weights Of Building Materials, Agricultural Commodities, and Floor Loads For Buildings

The loads considered for a building are divided into two major categories; dead loads and live loads. Dead loads are associated with the building and do not change magnitude or location. It includes the weight of the building components, structural parts, and also any fixed equipment such as plumbing, electric, heating, ventilating, refrigeration, and sprinkler systems. Live loads change with time and include loads caused by people, animals, grain, potatoes, equipment, manure, etc.

Table 1 and 2 list estimated weights of selected materials. Known values should be used when available.

Table 1. Weights of common building materials.

Building material		Unit weight
Aluminum[1]		171 pounds per cubic foot
Cast Iron[1]		450 pounds per cubic foot
Cement[2]		94 pounds per cubic foot
Concrete[2]		150 pounds per cubic foot
Crushed Stone[2]		2,500 pounds per cubic yard
Gravel[2]		2,700 pounds per cubic yard
Gypsum or plaster board[3]		
	3/8 inch	1.56 pounds per square foot
	1/2 inch	2.08 pounds per square foot
	5/8 inch	2.60 pounds per square foot
Insulation[3]		
	Mineral fiber (fiberglass)	2 pounds per cubic foot
	Extruded polystyrene	1.8 pounds per cubic foot
	Expanded polystyrene	1.5 pounds per cubic foot
	Polyurethane	1.5 pounds per cubic foot
	Vermiculite	40 pounds per cubic foot
Limestone		171 pounds per cubic foot
Lumber (@ 35 pounds per cubic foot, Douglas Fir)[4]		
	2X4	1.28 pounds per foot
	2X6	2.00 pounds per foot
	2X8	2.64 pounds per foot
	2X10	3.37 pounds per foot
	2X12	4.10 pounds per foot
	4X4	2.98 pounds per foot
	6X6	7.35 pounds per foot
	6X8	10.03 pounds per foot

Masonry Walls[5]		
	4 inch brick	42 pounds per square foot
	8 inch concrete block	55 pounds per square foot
	12 inch concrete block	80 pounds per square foot
Plywood[3]		
	1/4 inch	0.71 pounds per square foot
	3/8 inch	1.06 pounds per square foot
	1/2 inch	1.42 pounds per square foot
	5/8 inch	1.77 pounds per square foot
	3/4 inch	2.13 pounds per square foot
Roofing[5]		
	Asphalt shingles	3 pounds per square foot
	1/4 in. slate	10 pounds per square foot
	Aluminum (26 gauge)	0.3 pounds per square foot
	Steel (29 gauge)	0.8 pounds per square foot
	Built-up 3 ply & gravel	5.5 pounds per square foot
Sand[2]		
	Bank sand	2,500 pounds per cubic yard
	Torpedo Sand	2,700 pounds per cubic yard
Steel[1]		490 pounds per cubic foot

Table 2. Bulk density of selected products[6]

Product	Unit density
Baled hay or straw	8-14 pounds per cubic foot
Shelled corn	45 pounds per cubic foot
Ear corn	28 pounds per cubic foot
Feed Grains & supplement	32 pounds per cubic foot
High protein supplement	50 pounds per cubic foot
Potatoes	43 pounds per cubic foot
Fruits and vegetables	30-40 pounds per cubic foot
Soil	2,500 pounds per cubic yard
Manure	60 pounds per cubic foot
Water	62.4 pounds per cubic foot

Tables 3 and 4 list distributed floor live loads from the BOCA code and a standard from ASAE. Live loads for design are usually estimated based on code requirements or standards of practice. By code definition, the design live load is the greatest load by the intended use or occupancy but not less than the minimum uniformly distributed load outlined in the codes.

Table 3. Minimum Uniformly Distributed Live Loads (BOCA, Building Officials and Code Administrators)[7]

Occupancy or Use	Live Load (psf)
Garages	
Passenger Cars	50
Trucks and Buses	50
Manufacturing	
Light	100
Heavy	150
Office Buildings	
Offices	50
Lobbies	100
Residential	
Attics	20
Dwelling units	40
Sleeping rooms	30
Sidewalks	250
Storage Areas	
Light	125
Heavy	250
Yards and terraces, pedestrians	100

Table 4. Design Floor Live Load (American Society of Agricultural Engineers EP378.3)[8]

Occupancy or Use	Live Load, Solid Floor(psf)
Beef Cattle	
Calves to 300 lb.	50
Feeders, breeders	100
Dairy Cattle	
Calves to 300 lb.	50
Mature cows	100
Stall area	60
maternity or hospital pen	50
Swine	
to 50 lb.	35
200 lb.	50
400 lb.	65
500 lb.	70
Sheep	
Feeders	40
Ewes, rams	50
Horses	100
Turkeys	30
Chickens (floor houses)	20
Greenhouses	50

The above loadings are for uniformly distributed loads. Loads that are considered concentrated at one point should be handled differently than distributed loads. For example, the thickness of a concrete slab should be greater when a load such as a jack base is considered. Table 5 lists some minimum concentrated loads from the BOCA code. Unless otherwise specified the load is assumed to occupy an area of 2.5 feet square and located to produce the maximum stress in the structural members.

Table 5. Minimum concentrated loads (BOCA)[7]

Location	Pounds
Garages	
Passenger cars (20 square inches)	2,000
Trucks or buses (20 square inches)	Maximum axle load
Greenhouse roof bars, purlins, rafters	100
Manufacturing and storage	2,000
Office	2,000
Sidewalks or driveways	8,000

Tractors and other equipment can be treated similar to trucks or buses. The maximum axle load of the equipment should be taken as the concentrated load.

EXAMPLE 1.
What is the distributed floor load under baled hay 16 feet high?
From table 2. baled hay weighs 8 to 14 pounds per cubic foot.
For each square foot of floor area the maximum loading for 16 feet of baled hay is:
16 feet X 14 pounds per cubic foot = 224 pounds per square foot.

EXAMPLE 2.
How much does a wall of 8 inch concrete block weigh that is 10 feet high and 40 feet long?
From Table 1, a 8 inch concrete block wall weighs 55 pounds per square foot.
For each running foot, the wall would weigh,
10 feet X 55 pounds per square foot = 550 pounds per foot.and
550 pounds per foot X 40 feet = 22,000 pounds

EXAMPLE 3.
According to the specifications for a tractor, the front axle load is 5,000 pounds and the rear axle load is 7,000 pounds. For loading considerations the minimum concentrated load is 7,000 pounds over 20 square inches or 350 pounds per square inch.

PSU/89
"This fact sheet was developed by Jon Carson and originally published in 1989. It was reviewed in 1995 by Robert Graves and found suitable for continued use."

---

1 Mazria, Edward. 1979. The Passive Solar Energy Book. Rodale Press, Emmaus, PA.
2 1986. The Building Estimator's Reference Book. Frank R. Walker Company. Chicago, IL.
3 1985. Fundamentals, ASHRAE Handbook. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. Atlanta, GA.
4 1977. National Design Specification for Wood Construction. National Forest Products Association. Washington, D.C.
5 Muller, Edward J. 1967. Architectural Drawing and Light Construction. Prentice-Hall, Inc. Englewood Cliffs, NJ.
6 Hall, Carl W. 1980. Drying and Storage of Agricultural Crops. AVI Publishing Company, Inc. Westport, CN.
7 1987. The BOCA National Building Code. Building Officials and Code Administrators, Inc. Country Club Hills, IL.
8 ASAE Standards 1988. American Society of Agricultural Engineers. St. Joseph MI.

Appendix 11 – Environmental Protection Agency – Waste Reduction Model Tool

Environmental Protection Agency (EPA) Waste Reduction Model (WARM)				
WARM Material	WARM Data Source Definition	Source	Year	Title/Notes
Aluminum Cans	Aluminum cans represent cans produced out of sheet rolled aluminum ingot.	Franklin Associates	2002	Energy and Greenhouse Gas Factors for Personal Computers: Final Report
Steel Cans	Steel cans represent three-piece welded cans produced from sheet steel which is made in a blast furnace and basic oxygen furnace (for virgin cans) or electric arc furnace (for recycled cans).	Franklin Associates	1998	Background Document A: A Life Cycle Inventory of Process and Transportation Energy for Eight Different Materials
Copper Wire	Copper wire is used in various applications including power transmission and generation lines, building wiring, telecommunication, and electrical and electronic products.	Franklin Associates	2002	Energy and Greenhouse Gas Factors for Personal Computers: Final Report
Glass	Glass represents glass containers (e.g., soft drink bottles and wine bottles)	EPA	2008	MSW Facts and Figures, which is where our generation data come from.
HDPE	HDPE (high-density polyethylene) is usually labeled plastic code #2 on the bottom of the container, and refers to a plastic often used to make bottles for milk, juice, water and laundry products. It is also used to make plastic grocery bags.	American Chemistry Council Glossary	n.d.	http://www.americanchemistry.com/s_plastics/sec_content.asp?CID=1185&DID=4422
LDPE	LDPE (Low-density polyethylene), usually labeled plastic code #4, is often used to manufacture plastic dry cleaning bags. LDPE is also used to manufacture some flexible lids and bottles.	American Chemistry Council Glossary	n.d.	http://www.americanchemistry.com/s_plastics/sec_content.asp?CID=1185&DID=4422
PET	PET (Polyethylene terephthalate) is typically labeled plastic code #1 on the bottom of the container. PET is often used for soft drink and disposable water bottles, but can also include other containers or packaging.	American Chemistry Council Glossary	n.d.	http://www.americanchemistry.com/s_plastics/sec_content.asp?CID=1185&DID=4422
Corrugated Containers	Corrugated cardboard boxes made from containerboard (liner and corrugating medium) used in packaging applications.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Magazines/Third-class Mail	Third Class Mail is now called Standard Mail by the U.S. Postal Service and includes catalogs and other direct bulk mailings such as magazines, which are made of coated, shiny paper. This category represents coated paper produced from mechanical pulp.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Newspaper	Newspaper represents uncoated paper made from 70% mechanical pulp and 30% chemical pulp. For the carbon sequestration portion of the factor, it was assumed that the paper was all mechanical pulp.	Franklin Associates	1998	Background Document A: A Life Cycle Inventory of Process and Transportation Energy for Eight Different Materials
Office Paper	Office paper represents paper made from uncoated bleached chemical pulp.	Franklin Associates	1998	Background Document A, Attachment 1 : Partial LCI for Boxboard and Paper Towels
Phonebooks	Phonebooks represent telephone books that are made from paper produced from mechanical pulp.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Textbooks	Textbooks represent books made from paper produced from chemical pulp.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Dimensional Lumber	Lumber includes wood used for containers, packaging, and building and includes crates, pallets, furniture and dimensional lumber like two by fours.	EPA	2008	MSW Facts and Figures, which is where our generation data come from.
Medium-density Fiberboard	Fiberboard is a panel product that consists of wood chips pressed and bonded with a resin. Fiberboard is used primarily to make furniture.	EPA	1995	AP 42, Volume I, Fifth Edition (US EPA)
Food Scraps	Food consists of uneaten food and wasted, prepared food from residences, commercial establishments such as grocery stores and restaurants, institutional sources such as school cafeterias, and industrial sources such as factory lunchrooms.	EPA	2008	MSW Facts and Figures, which is where our generation data come from.
Yard Trimmings	Yard trimmings are assumed to be 30% grass, 40% leaves, and 30% tree and brush trimmings from residential, institutional, and commercial sources.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Mixed Paper: Broad Definition	Mixed paper is assumed to be 24% newspaper, 48% corrugated cardboard, 8% magazines, and 20% office paper.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Mixed Paper: Residential Definition	Residential mixed paper is assumed to be 23% newspaper, 53% corrugated cardboard, 10% magazines, and 14% office paper.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Mixed Paper: Office Paper Definition	Office mixed paper is assumed to be 21% newspaper, 5% corrugated cardboard, 36% magazines, and 38% office paper.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Carpet	Carpet represents nylon broadloom residential carpet containing face fiber, primary and secondary backing, and latex used for attaching the backings.	EPA	2003	Background Document for Life-Cycle Greenhouse Gas Emission Factors for Carpet and Personal Computers
Personal Computers	PCs are made up of a central processing unit (CPU) and a cathode ray tube (CRT) monitor. The components of the CPU and monitor include steel housing, internal electric components, the CRT, plastic casing, and circuit boards. In addition to these valuable components, PCs contain lead, brominated flame retardants and other potentially hazardous chemicals.	Franklin Associates	2002	Energy and Greenhouse Gas Factors for Personal Computers: Final Report
Clay Bricks	Bricks are produced by firing materials such as clay, kaolin, fire clay, bentonite, or common clay and shale. The majority of the bricks produced in the US are clay. In WARM, clay brick source reduction is considered to be the reuse of full bricks rather than the grinding and reusing of broken or damaged brick.	EPA	2003	Background Document for Life-Cycle Greenhouse Gas Emission Factors for Clay Brick Reuse and Concrete Recycling
Concrete	Concrete is a high-volume building material produced by mixing cement, water, and coarse and fine aggregates. In WARM, concrete is assumed to be recycled into aggregate, so the GHG benefits are associated with the avoided emissions associated with mining and processing aggregate.	EPA	2003	Background Document for Life-Cycle Greenhouse Gas Emission Factors for Clay Brick Reuse and Concrete Recycling
Fly Ash	Fly ash is a byproduct of coal combustion that is used as a cement replacement in concrete.	EPA	2003	Background Document for Life-Cycle Greenhouse Gas Emission Factors for Fly Ash Used as a Cement Replacement in Concrete
Tires	Tires represent scrap tires that have been disposed of by consumers and have several end uses in the U.S. market including as a fuel, in civil engineering, and in various ground rubber applications such as running tracks and molded products.	Atech Group	2001	A National Approach to Waste Tyres
		EIA	2009	2006 Manufacturing Energy Consumption Survey, Table 3.2: Fuel Consumption, 2006 for Synthetic Rubber
		Corti, A. and Lombardi, L.	2004	End life tyres: Alternative final disposal processes compared by LCA
		Athena Institute	2000	Life Cycle Analysis of Residential Roofing Products
Mixed Metals	Mixed metals are made up of 38% aluminum cans and 62% steel cans.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Mixed Plastics	Mixed plastics are made up of 45% HDPE, 33% LDPE, and 22% PET plastic.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Mixed Recyclables	Mixed Recyclables are made up of approximately 1% aluminum cans, 3% steel cans, 6% glass, 1% HDPE, 1% LDPE, 1% PET, 46% corrugated cardboard, 7% magazines/third-class mail, 22% newspaper, 8% office papers, <1% phonebooks, 1% textbooks, and 3% dimensional lumber. See those definitions for details.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Mixed Organics	Mixed organics are made up of 48% food scraps and 52% yard trimmings. See those definitions for details.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Mixed MSW	Mixed MSW (municipal solid waste) comprises the waste materials typically discarded by households and collected by curbside collection vehicles; it does not include white goods (e.g., refrigerators, toasters) or industrial waste.	EPA	2006	Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks
Asphalt Concrete	Asphalt concrete is composed primarily of aggregate, which consists of hard, graduated fragments of sand, gravel, crushed stone, slag, rock dust, or powder.	Census Bureau	2001	Fuels and Electric Energy Report. U.S. Economic Census
		Census Bureau	1997	Mining-Subject Series, Product Summary, U.S. Economic Census
		Athena Sustainable Materials Institute	2001	Life Cycle Inventory for Road and Roofing Asphalt
		National Renewable Energy Laboratory (NREL)	2009	U.S. Life-Cycle Inventory Database
		Natural Resources Canada	2005	Canadian Industry Program for Energy Conservation c/o Natural Resources Canada
		Levis, J.W.	2008	A Life-Cycle Analysis of Alternatives for the Management of Waste Hot-Mix Asphalt, Commercial Food Waste, and Construction and Demolition Waste
Asphalt Shingles	Asphalt shingles are typically made of a felt mat saturated with asphalt. Fiberglass shingles are composed of asphalt cement (36 percent by weight), a mineral stabilizer like limestone or dolomite (40 percent), sand-sized mineral granules (38 percent), in addition to the organic or fiberglass felt backing (15 percent).	Athena Sustainable Materials Institute	2000	Life Cycle Analysis of Residential Roofing Products
		Cochran, K.	2006	Construction and Demolition Debris Recycling: Methods, Markets, and Policy
		Construction Materials Recycling Association (CMRA)	2007	Recycling Tear-Off Asphalt Shingles: Best Practices Guide
Drywall	Drywall, also known as wallboard, gypsum board, or plaster board, is manufactured from gypsum plaster and a paper covering.	Venta, G.	1997	Life Cycle Analysis of Gypsum Board and Associated Finishing Products
Fiberglass Insulation	Fiberglass insulation is produced from a blend of sand, limestone, soda ash, and recycled glass cullet, which accounts for about 40 percent of the raw material inputs.	Lippiatt, B.	2007	Building for Environmental and Economic Sustainability (BEES)
		Enviros Consulting	2003	Glass Recycling — Life Cycle Carbon Dioxide Emissions
Vinyl Flooring	All vinyl flooring is comprised of polyvinyl chloride (PVC) resin along with additives such as plasticizers, stabilizers, pigments, and fillers.	Lippiatt, B.	2007	Building for Environmental and Economic Sustainability (BEES)
		European Council of Plasticisers and Intermediates (ECPI)	2001	Eco-profile of high volume commodity phthalate esters (DEHP/DINP/DIDP)
		Franklin Associates	2007	Revised Final Report: Cradle to Gate Life Cycle Inventory of Nine Plastics Resins Polyurethane Precursors
		ecoinvent Centre	2008	ecoinvent Database v2.1. Swiss Centre for Life Cycle Inventories
Wood Flooring	Virgin hardwood flooring is produced from lumber. Coatings and sealants can be applied to wood flooring in “pre-finishing” that occurs at the manufacturing facility, or on-site.	Bergman, R. and Bowe, S.A.	2008	Environmental impact of producing hardwood lumber using life-cycle inventory
		Hubbard, S.S. and Bowe, S.A.	2008	Life-Cycle Inventory of Solid Strip Hardwood Flooring in the Eastern United States
		Bergman, R.	2010	Personal communication between Richard Bergman, USDA Forest Service and Robert Renz and Christopher Evans, ICF International

Appendix 12 – Athena EcoCalculator Embodied Energy Analysis Tool

Athena Institute

ATHENA® Impact Estimator for Buildings

In North America, the ATHENA® *Impact Estimator for Buildings* is the only software tool that is designed to evaluate whole buildings and assemblies based on internationally recognized life cycle assessment (LCA) methodology.

Using the *Impact Estimator*, architects, engineers and others can easily assess and compare the environmental implications of industrial, institutional, commercial and residential designs – both for new buildings and major renovations. Where relevant, the software also distinguishes between owner-occupied and rental facilities.

The *Impact Estimator* puts the environment on equal footing with other more traditional design criteria at the conceptual stage of a project. It is capable of modeling 95% of the building stock in North America, using the best available data.

The *Impact Estimator* takes into account the environmental impacts of:

- Material manufacturing, including resource extraction and recycled content
- Related transportation
- On-site construction
- Regional variation in energy use, transportation and other factors
- Building type and lifespan
- Maintenance and replacement effects
- Demolition and disposal

Although the *Impact Estimator* doesn't include an operating energy simulation capability, it does allow users to enter the results of a simulation in order to compute the fuel cycle burdens, including pre-combustion effects, and factors them into the overall results.

Complex Results in a User-friendly Format

Although LCA is a complex process, the *Impact Estimator* has been designed for ease of use.

The first step is to enter required information such as geographic location (the user selects the most representative North American city), building life and occupancy/type, and, if desired, annual operating energy values by energy form.

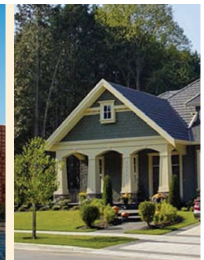
Pre-set dialogue boxes prompt users to describe the different assemblies – by requesting the width, span and live load of a floor assembly, for example – that together form a conceptual building design. The *Impact Estimator* then instantly provides cradle-to-grave implications in terms of:

- Primary Energy Consumption
- Acidification Potential
- Global Warming Potential
- Human Health Respiratory Effects Potential
- Ozone Depletion Potential
- Photochemical Smog Potential
- Eutrophication Potential
- Weighted Raw Resource Use

Life cycle assessment (LCA) is widely accepted as one of the best ways to compare the environmental impacts of materials, components and services. In the case of buildings, material manufacturing is the most important contributor of emissions to water and land, including toxic releases. For example, one study conducted in the US found that the construction industry produces more carbon dioxide emissions through the manufacture, transport and use of materials than any other sector. LCA is a way to document, understand and reduce critical environmental effects.

DESIGN BETTER BUILDINGS WITH ATHENA





Simplified Tracking

As design data is entered for each assembly, the software builds a "tree" of information so that each individual assembly can be identified and viewed easily. The tree can also display, as a value or percentage, the impact of each assembly in terms of a selected measure such as global warming potential. This allows users to track the effects of each assembly as it's added, or to quickly pinpoint what is causing a particular environmental effect.

Detailed LCA Results

Results from an individual design can be seen in summary tables and graphs by assembly group and life cycle stage. Detailed tables and graphs show individual energy use by type or form of energy, and emissions by individual substance.

Flexible Comparison of Alternate Building Designs

Accommodating multiple comparisons at once, the *Impact Estimator* allows users to change the design, substitute materials, and make side-by-side comparisons for any one or all of the environmental impact indicators. It also lets users compare similar projects with different floor areas on a unit floor area basis.

System Requirements

The *Impact Estimator* is a Visual C# (C-Sharp) application. It is PC-compatible but can also be run on a Mac system with appropriate Windows capability.

'Inner Workings' of the Software

Provided on our website in the interests of transparency, the Inner Workings document presents an overview of the *Impact Estimator*, illustrating what it does and how it does it. The software's embedded databases are also explained, highlighting their use within the tool. View or download the document at http://www.athenasmi.org/tools/impactEstimator/innerWorkings.html.

Free Trial Version

Morrison Hershfield has collaborated with the Athena Institute in the development of Version 4 of the *Impact Estimator for Buildings*, and is also the software distributor. To download a free trial copy of the *Impact Estimator* or to order the full version, please visit the following url: http://www.morrisonhershfield.com/sustainability/OurPartnerAthena.

Note: The Impact Estimator is not an engineering design tool. It is a tool that allows users to express a design in simple terms in order to assess the environmental implications of their choices.

ATHENA®
Impact Estimator
for buildings

The Athena Institute is a non-profit organization dedicated to sustainability of the built environment – a goal that can only be achieved by meeting the building community's need for better information and tools. Through offices in Canada and the United States, the Institute furthers the use and science of LCA through groundbreaking software, worldclass databases and customized consulting services, and by working collaboratively with the international research community.

Athena Sustainable Materials Institute
629 St. Lawrence St., Box 189, Merrickville, ON
Canada K0G 1N0
Tel: (613) 269-3795 Fax: (613) 269-3796

Athena Institute International
183 W. Main St., Kutztown, PA
19530 United States
Tel: (610) 683-9066 Fax: (610) 683-5733

www.athenaSMI.org

Appendix 13 – Embodied Energy Values (Inventory of Carbon and Energy [ICE])

	ICE EE value						
	embodied energy (MJ/kg)				embodied carbon (Kg CO2e/kg)		
	UK Typical - EU 59% Recycled	World Typical - World 39% Recycled	Primary (100% hypothetical virgin)		UK Typical - EU 59% Recycled	World Typical - World 39% Recycled	Primary (100% hypothetical virgin)
General Steel	20.1	25.3	35.4		1.46	1.95	2.89
Bar & Rod	17.4	22.3	21.6		1.4	1.86	2.77
Coil (Sheet)	18.8	23.5	32.8		1.38	1.85	2.74
Coil (Sheet) - Galvanized	22.6	28.5	40		1.54	2.03	3.01
Pipe	19.8	24.9	34.7		1.45	1.94	2.87
Plate	25.1	32	45.4		1.66	2.21	3.27
Section	21.5	27.1	38		1.53	2.03	3.03
Wire		36				3.02	
Stainless		56.7				6.15	

	embodied energy (MJ/kg)	embodied carbon (Kg CO2e/kg)
General Concrete	0.75	0.107
16/20 MPa	0.7	0.1
20/25 MPa	0.74	0.107
25/30 MPa	0.78	0.113
28/35 MPa	0.82	0.12
32/40 MPa	0.88	0.132
40/50 MPa	1	0.151

	embodied energy (MJ/kg)				embodied carbon (Kg CO2e/kg)		
% Cement Replacement - Fly Ash	0% (using CEM I)	15%	30%		0% (using CEM I)	15%	30%
GEN 0 (6/8 MPa)	0.55	0.52	0.47		0.076	0.069	0.061
GEN 1 (8/10 MPa)	0.7	0.65	0.59		0.104	0.094	0.082
GEN 2 (12/15 MPa)	0.76	0.71	0.64		0.114	0.105	0.093
GEN 3 (16/20 MPa)	0.81	0.75	0.68		0.123	0.112	0.1
RC 20/25 (20/25 MPa)	0.86	0.81	0.73		0.132	0.122	0.108
RC 25/30 (25/30 MPa)	0.91	0.85	0.77		0.14	0.13	0.115
RC 28/35 (28/35 MPa)	0.95	0.9	0.82		0.148	0.138	0.124
RC 32/40 (32/40 MPa)	1.03	0.97	0.89		0.163	0.152	0.136
RC 40/50 (40/50 MPa)	1.17	1.1	0.99		0.188	0.174	0.155
PAV 1	0.95	0.89	0.81		0.148	0.138	0.123
PAV 2	1.03	0.97	0.89		0.163	0.152	0.137

Appendix 14 – Embodied Energy Values (Building for Environmental and Economic Sustainability [BEES]

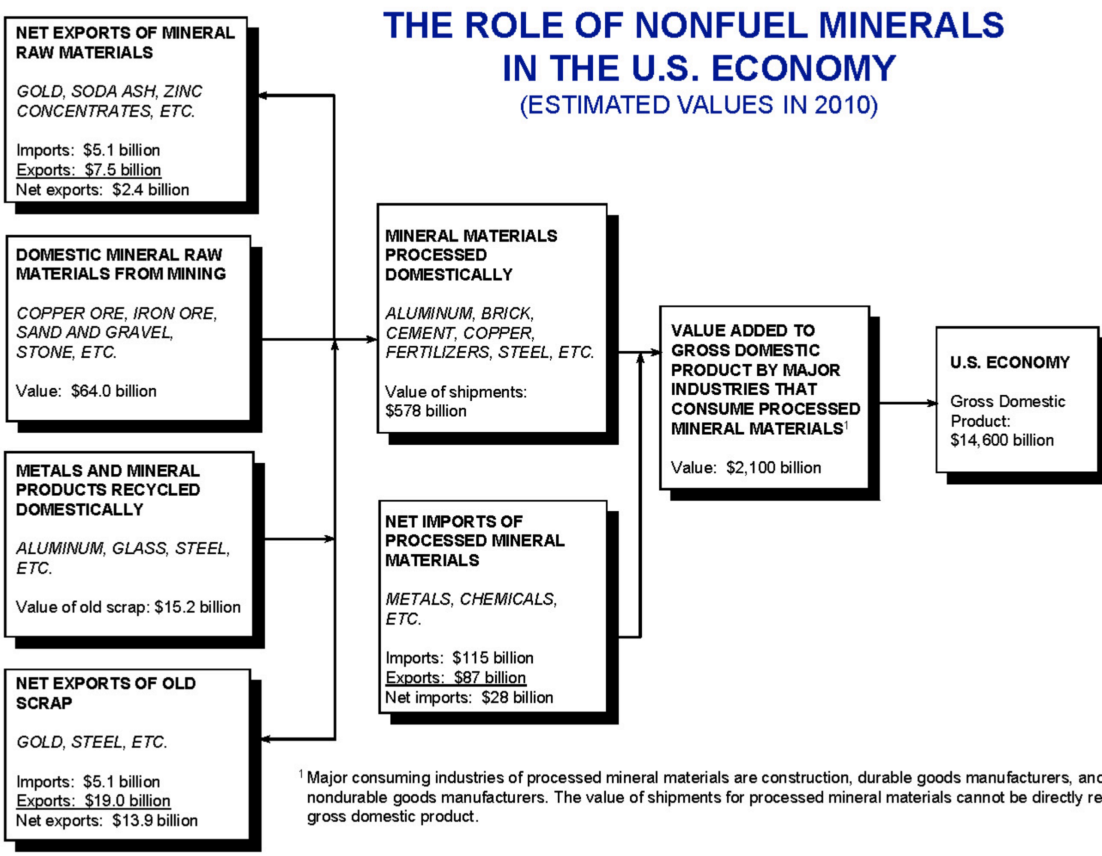
	BEES EE value		
	BEES product choice	MJ/unit	units
masonry	Generic Brick and Mortar	79.6	square feet (3.6" x 2.7" x 8")
terrazzo floor	Generic terrazzo flooring (grout, epoxy, sealant)	21.4	square feet
carpet	Generic nylon carpet (broadloom, standard glue)	75.9	square feet
gypsum board	Generic gypsum board	29.4	square feet
ceramic tile	Generic Ceramic Tile with Recycled Glass	23.6	square feet (6" x 6"x 0.5")
structural steel	Generic steel framing	8.9	square feet
steel	Generic steel framing	8.9	square feet
metal deck	Generic steel framing	8.9	square feet
metal roofing	Generic steel framing	8.9	square feet
misc. metals	Generic steel framing	8.9	square feet
glass and glazing	Curtinwall viewable glazing (double pane, low-e, argon filled)	134.72	square feet
concrete	Lafarge NewCem Slag Cement 5KSI (35%)	160	tons
misc. concrete	Generic 100% Portland Cement	39.5	tons
nominal wood	Generic wood framing - treated	4	square feet
plywood sheathing	Generic plywood sheathing	5.03	square feet
3/4" fire rated plywood	Generic plywood sheathing	5.03	square feet
FRP panels	Generic plywood sheathing	5.03	square feet
medium density fiberboard	Generic plywood sheathing	5.03	square feet
paint	Generic virgin latex paint	2.27	gallons
striping	Generic virgin latex paint	2.27	gallons
grading	Generic 20% fly ash cement	91.4	square feet
subbase	Generic 20% fly ash cement	91.4	square feet
asphalt paving	Generic asphalt, traditional maintenance	59.1	square feet
rigid insulation	Centria Formawall	255.23	square feet
waterproofing membrane	Anonymous masonry waterproofing product	561	square feet

Appendix 15 – Embodied Energy Values (Canadian Architect)

	Canada EE value	
	MJ/unit	MJ/m3
Aggregate	0.1	150
Straw Bale	0.24	31
Soil-Cement	0.42	819
Stone (local)	0.79	2030
Concrete Block	0.94	2350
Concrete (30 Mpa)	1.3	3180
Concrete Precast	2	2780
Lumber	2.5	1380
Brick	2.5	5170
Cellulose Insulation	3.3	112
Gypsum Wallboard	6.1	5890
Particle Board	8	4400
Aluminum (recycled)	8.1	21870
Steel (recycled)	8.9	37210
Shingles (asphalt)	9	4930
Plywood	10.4	5720
Mineral Wool Insulation	14.6	139
Glass	15.9	37550
Fiberglass Insulation	30.3	970
Steel	32	251200
Zinc	51	371280
Brass	62	519560
PVC	70	93620
Copper	70.6	631164
Paint	93.3	117500
Linoleum	116	150930
Polystyrene Insulation	117	3770
Carpet (synthetic)	148	84900
Aluminum	227	515700

Appendix 16 – U.S. Department of the Interior U.S. Geological Survey (USGS):

Mineral Commodity Summary 2011 – The Role of Nonfuel Minerals in the U.S.



[1] Major consuming industries of processed mineral materials are construction, durable goods manufacturers, and some nondurable goods manufacturers. The value of shipments for processed mineral materials cannot be directly related to gross domestic product.

Sources: U.S. Geological Survey and U.S. Department of Commerce.

5

Appendix 17 – U.S. Department of the Interior U.S. Geological Survey (USGS): Mineral Commodity Summary 2011 – The Value of Nonfuel Minerals in the U.S.

mineral materials valued at $1.30 billion remained in the stockpile.

In August 2008, DLA had announced plans to suspend competitive commercial offerings of six mineral commodities and reduce the sale quantities of nine additional mineral commodities for the remainder of fiscal year 2008. During fiscal year 2010, sales of iridium, niobium metal ingot, platinum, tantalum carbide powder, tin, and zinc remained suspended.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2010[p, 1]

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$1,010,000	21	1.58	Stone (crushed), cement (portland), lime, salt, sand and gravel (construction).
Alaska	3,240,000	5	5.07	Zinc, gold, lead, silver, sand and gravel (construction).
Arizona	6,700,000	2	10.46	Copper, molybdenum concentrates, sand and gravel (construction), cement (portland), stone (crushed).
Arkansas	630,000	31	0.98	Bromine, stone (crushed), sand and gravel (construction), cement (portland), lime.
California	2,710,000	6	4.23	Sand and gravel (construction), boron minerals, cement (portland), stone (crushed), gold.
Colorado	1,930,000	11	3.01	Molybdenum concentrates, gold, sand and gravel (construction), cement (portland), stone (crushed).
Connecticut[2]	141,000	*43	0.22	Stone (crushed), sand and gravel (construction), clays (common), stone (dimension), gemstones (natural).
Delaware[2]	12,700	50	0.02	Magnesium compounds, sand and gravel (construction), stone (crushed), gemstones (natural).
Florida	2,080,000	9	3.25	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction), zirconium concentrates.
Georgia	1,500,000	14	2.35	Clays (kaolin), stone (crushed), clays (fuller's earth), sand and gravel (construction), cement (portland).
Hawaii	112,000	46	0.17	Stone (crushed), sand and gravel (construction), gemstones (natural).
Idaho	1,200,000	16	1.88	Molybdenum concentrates, phosphate rock, silver, sand and gravel (construction), lead.
Illinois	910,000	23	1.42	Stone (crushed), sand and gravel (construction), cement (portland), sand and gravel (industrial), tripoli.
Indiana	837,000	25	1.31	Stone (crushed), cement (portland), sand and gravel (construction), lime, stone (dimension).
Iowa	542,000	32	0.85	Stone (crushed), cement (portland), sand and gravel (construction), lime, gypsum (crude).
Kansas	1,040,000	19	1.63	Helium (Grade–A), salt, cement (portland), stone (crushed), helium (crude).
Kentucky	742,000	27	1.16	Stone (crushed), lime, cement (portland), sand and gravel (construction), clays (common).
Louisiana	492,000	33	0.77	Salt, sand and gravel (construction), stone (crushed), sand and gravel (industrial), clays (common).
Maine	114,000	45	0.18	Sand and gravel (construction), stone (crushed), cement (portland), stone (dimension), peat.
Maryland	438,000	*35	0.68	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), stone (dimension).
Massachusetts[2]	194,000	40	0.30	Stone (crushed), sand and gravel (construction), lime, stone (dimension), clays (common).
Michigan	1,960,000	10	3.07	Iron ore (usable shipped), cement (portland), sand and gravel (construction), salt, stone (crushed).
Minnesota[2]	3,860,000	4	6.03	Iron ore (usable shipped), sand and gravel (construction), stone (crushed), sand and gravel (industrial), lime.
Mississippi	183,000	**41	0.29	Sand and gravel (construction), stone (crushed), clays (fuller's earth), clays (ball), clays (bentonite).
Missouri	2,140,000	8	3.35	Cement (portland), stone (crushed), lead, lime, sand and gravel (construction).
Montana	1,120,000	17	1.74	Copper, molybdenum concentrates, palladium metal, platinum metal, sand and gravel (construction).

See footnotes at end of table.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2010[p, 1]—Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Nebraska[2]	$181,000	*42	0.28	Sand and gravel (construction), cement (portland), stone (crushed), sand and gravel (industrial), lime.
Nevada	7,550,000	1	11.79	Gold, copper, sand and gravel (construction), lime, silver.
New Hampshire	100,000	47	0.16	Sand and gravel (construction), stone (crushed), stone (dimension), gemstones (natural).
New Jersey[2]	232,000	38	0.36	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), greensand marl, peat.
New Mexico	1,010,000	20	1.57	Copper, potash, sand and gravel (construction), stone (crushed), cement (portland).
New York	1,290,000	15	2.01	Salt, stone (crushed), sand and gravel (construction), cement (portland), clays (common).
North Carolina	908,000	24	1.42	Stone (crushed), phosphate rock, sand and gravel (construction), sand and gravel (industrial), stone (dimension).
North Dakota[2]	88,000	48	0.14	Sand and gravel (construction), lime, stone (crushed), clays (common), sand and gravel (industrial).
Ohio	1,080,000	18	1.69	Stone (crushed), salt, sand and gravel (construction), lime, cement (portland).
Oklahoma	646,000	30	1.01	Stone (crushed), cement (portland), sand and gravel (construction), iodine, helium (Grade-A).
Oregon	292,000	*37	0.46	Stone (crushed), sand and gravel (construction), cement (portland), diatomite, perlite (crude).
Pennsylvania[2]	1,530,000	13	2.39	Stone (crushed), cement (portland), lime, sand and gravel (construction), cement (masonry).
Rhode Island[2]	34,400	49	0.05	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), gemstones (natural).
South Carolina[2]	440,000	34	0.69	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), sand and gravel (industrial).
South Dakota	298,000	*36	0.46	Gold, sand and gravel (construction), cement (portland), stone (crushed), stone (dimension).
Tennessee	814,000	26	1.27	Stone (crushed), zinc, cement (portland), sand and gravel (industrial), sand and gravel (construction).
Texas	2,560,000	7	4.00	Stone (crushed), cement (portland), sand and gravel (construction), salt, lime.
Utah	4,420,000	3	6.90	Copper, molybdenum concentrates, gold, magnesium metal, potash.
Vermont[2]	119,000	44	0.19	Stone (crushed), sand and gravel (construction), stone (dimension), talc (crude), gemstones (natural).
Virginia	952,000	22	1.49	Stone (crushed), cement (portland), sand and gravel (construction), lime, zirconium concentrates.
Washington	665,000	28	1.04	Gold, sand and gravel (construction), stone (crushed), cement (portland), lime.
West Virginia	230,000	39	0.36	Stone (crushed), cement (portland), lime, sand and gravel (industrial), cement (masonry).
Wisconsin	651,000	29	1.02	Sand and gravel (construction), stone (crushed), sand and gravel (industrial), lime, stone (dimension).
Wyoming	1,860,000	12	2.90	Soda ash, helium (Grade–A), clays (bentonite), sand and gravel (construction), stone (crushed).
Undistributed	237,000	XX	0.37	
Total	64,000,000	XX	100.00	

[p]Preliminary. XX Not applicable.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Partial total; excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with "Undistributed."

*Correction posted on March 7, 2011.

**Correction posted on March 15, 2011.

MAJOR METAL-PRODUCING AREAS

MAJOR INDUSTRIAL MINERAL-PRODUCING AREAS—PART I

MAJOR INDUSTRIAL MINERAL-PRODUCING AREAS—PART II

Appendix 18 – County of Hawai‘i – Energy

ENERGY

INTRODUCTION AND ANALYSIS

[Nationally, for the remainder of the 20th Century, most of the energy demand will be met with fossil fuels and nuclear fission. In turn, fossil fuels are fast becoming a scarce world commodity due to the increasing demand.] **For the foreseeable future, Hawaii will continue to be dependent on petroleum to meet its energy demands. Fortunately,** Hawaii is [currently most vulnerable to dislocation in the global oil market, but is also] endowed with a variety of natural energy [resource alternatives which] **resources that** are renewable [or inexhaustible and potentially] **for** low polluting sources of electricity. Hawaii's [near total] dependence on imported petroleum provides the incentive for the promotion of energy [conservation] **efficiency** and the development of [technology] **technologies** to harness [local] natural [(solar, hydrologic, and geothermal)] energy resources[,] **(solar, hydrologic, wind, and geothermal)** and to convert solid waste into [an alternate] **a** fuel resource.

Petroleum provides [approximately 60-65%] **up to 75 per cent** of the Island's energy needs. [One hundred percent] **All** of the petroleum [products] **used in the State** must be imported [into the State] in one of several forms. Most of the petroleum consumed in the State is imported as crude oil, which is then processed [in the] **at** two local refineries, Chevron and [Hawaiian Independent Refinery, Inc.] **Tesoro,** both located at Barber's Point, Oahu in the Campbell Industrial Park. Both refineries receive crude oil from Indonesia, Alaska, Africa, Malaysia, and the Persian Gulf. Petroleum products, primarily jet fuel, fuel oil, and [liquid petroleum gas,] **propane,** are also imported from California, the Caribbean, Singapore, and other areas to meet the demand not met by the refineries. [Synthetic natural gas] **Propane,** which is widely used on the Island of Hawaii**,** is also manufactured from petroleum on Oahu. Petroleum products are received [on the Big Island] at the Kawaihae and Hilo Harbors.

Under normal circumstances**,** an estimated 30-day aggregate supply of most petroleum products is stored at the oil terminals and tank farms. A major interruption of petroleum supply due to a lengthy maritime strike, a disaster at the source of crude oil supply, the sinking of a petroleum tanker or barge, **or** an aviation disaster at Campbell Industrial Park [, etc.] could seriously affect the County of Hawaii's petroleum supply. The island's economy is also vulnerable to interruptions in the supply of oil from the Middle East.

The County of Hawaii must decrease economic vulnerability and energy costs. To do so, the County must combine the efforts of energy [conservation] **efficiency** and the development of natural **renewable** energy alternatives that reduce the dependence on imported fossil fuels and increase energy self-sufficiency.

ELECTRICITY

Electricity is a major form of energy utilized on the island of Hawaii. The Hawaii Electric Light Company, Inc.**, (HELCO)** which is regulated by the State, owns [6] **and operates a number of** power generation plants in the County. Most of these plants operate on steam [energy] **or combustion gases** and burn imported fuel. Two [of the Hilo] plants **in Hilo** generate power through hydroelectric means[.] **and a South Kohala location produces wind energy.** A few [sugar plantations generate their own power by burning bagasse, wood chips, coal and fuel oil, selling their excess to the utility company and often buying power when their demand exceeds supply.] **Independent Power Producers (IPPs) generate power using various fuels and resources, and sell energy to HELCO. The methods of power production include geothermal, hydropower, wind, coal, and oil plants. Most recently, the construction of a 60 megawatt (MW) co-generation power plant in the Hamakua district will provide a firm power source and the excess heat generated by the power plant will be used to further develop agriculture and product manufacturing in the district.**

[Electricity sold in the County increased 125% between 1960 and 1969, despite a population increase of 3.5%. The average annual residential power used in 1960 was 3,084 kilowatt hours. By 1969 the average amount of power consumed per household was 4,845 kilowatt hours. The population increased from 61,332 in 1960 to 106,403 in 1984 and correspondingly the average annual residential consumption increased to 5,827-kilowatt hours.]

The average annual residential power used in 1990 was 6,794-kilowatt hours (kWh). In 1999, the average residential usage decreased to 6,563-kilowatt hours.

Electric Utility for the County of Hawaii 1999			
Customers	**Number of Customers & Percent of Total Number**	**Power Sold (1,000 kWh) & Percent of Total Sold**	**Ratio of Power Sold (1000 kWh) to Customer**
Residential	**52,277 = (84%)**	**343,085 = (37%)**	**6.563 to 1**
General Loads	**9,654 = (15%)**	**308,493 = (34%)**	**31.955 to 1**
Commercial Cooking and Heating	**396 = (Less than 1%)**	**25,964 = (3%)**	**65.566 to 1**
Large Power Service	**65 = (Less than 1%)**	**234,889 = (26%)**	**3,613.677 to 1**
Street Lighting	**86 = (less than 1%)**	**3,879 = (Less than 1%)**	**45.105 to 1**
Total	**62,478 = (100%)**	**916,310 (100%)**	**14.666 to 1**

Hawaiian Electric Company, 1999

Estimate - Planning Department

Residential refers to single-metered residential customers and may include condominiums for visitor use but excludes master-metered apartment and condominium buildings used by residents classified as commercial customers. General Loads refer to general light and/or power loads supplied through a single meter. Commercial Cooking and Heating applies only to commercial heating (heat pump water heaters), air conditioning, and refrigeration service. Large Power service is applicable to large light and/or power service supplied and metered at a single voltage and delivery point.

The table presented on the previous page clearly indicates that of the 62,478 customers of electrical power, approximately 84 per cent are residential customers. However, of the 916,310 total kilowatt hours used, residential customers accounted for approximately 37 per cent. This yields a ratio of about 6,563 kilowatt hours per customer as opposed to Large Power Service customers that account for less than 1 per cent of the customer base but use 26 per cent of the total kilowatt hours. These customers yield a ratio of 3,613,677 kilowatt hours per customer.

Power rates on this island are among the highest in the nation. One factor [which] **that** contributes to the [is situation] **high cost of power** is the present method of power generation. Most of the electricity is obtained through the burning of imported oil. The cost of fuel**,** coupled with transportation costs**,** cause higher rates. [The two hydroelectric plants in Hilo cannot generate enough power to service the city's needs.] **Additionally, the size of the service area and length of transmission and distribution lines necessary to transfer the power to the load centers are significant factors. A good example is the fast growing loads in West Hawaii. The major generating plants are located in East Hawaii. This requires generating more in East Hawaii to compensate for losses in lines going over to West Hawaii.** Other factors creating higher costs are the small market and the sparseness of population in a relatively large service area.

[Power generating plants will be faced with increasingly stringent air and water pollution standards. Heated water discharge into the ocean, for instance, may be affecting the environment. The effects, however, are not fully understood at the present time. More stringent pollution controls for a better environment could possibly result in higher costs of power.]

Except in a few instances, most of the power lines in the County are overhead [ones.] **lines.** Although underground wiring has an aesthetic desirability, there are several problems in establishing such a standard. Underground power lines will probably last longer but cost more to install, especially in rocky areas. There is a problem of common sharing of trenches with other utilities. Another problem [concerns the repair of breaks,] **is repair and maintenance,** for while broken lines will probably occur infrequently, they will be more difficult to locate. There has been, however, considerable progress in solving the technological problems concerning underground power lines.

[Consumption of power will continue to accelerate faster than population growth as people become more affluent. Utility companies will probably design new plants which are more efficient and less polluting.] **As affluence of the population increases, the consumption of power tends to accelerate faster than population growth.** Studies of sources of energy other than the burning of fuel are being conducted. **On September 1, 1998, HELCO submitted its second Integrated Resource Plan (IRP) to the Public Utilities Commission with input from a public advisory group.**

Electrical Energy Self-Sufficiency for the Big Island

The County of Hawaii must strive to attain energy self-sufficiency in order to minimize [the] **its** dependence on imported fossil fuels. A commitment by both the government and the public must continue [for] **in** research, planning, and development to attain the goal of energy self-sufficiency for the County of Hawaii.

As a result of the 1974 and 1978 oil crisis, there has been concern over Hawaii's dependence on imported petroleum. In 1974 and 1976, the State Legislature enacted several significant bills [which were] designed to promote the research and development of natural energy resources, and the conservation of energy in order to foster a greater independence from imported fossil fuels.

The State Legislature adopted Act 237 (Chapter 196, H.R.S.) in 1974, which [among other things,] created the position of a State Energy Resources Coordinator to review and formulate existing and proposed energy resource programs.

Also in 1974, the State Legislature established the Hawaii Natural Energy Institute (HNEI, Act 235) to foster development of local natural energy research at the University of Hawaii. The HNEI maintains cooperation and coordination between all levels of government and private organizations involved with energy related projects with potential for Federal funding, and serves as the central source of information on natural energy policies and programs.

Act 236, adopted by the State Legislature in 1974, established the Natural Energy Laboratory of Hawaii (NELH) at Keahole (North Kona, Hawaii) to provide essential support facilities for future electrical energy research programs. The legislature selected Keahole Point through the criteria for development of three of the proposed natural energy programs (OTEC, Biomass conversion, and direct solar energy utilization systems).

In 1976, the State Legislature adopted Act 189 which complemented the development half for energy self-sufficiency by the creation of tax incentives for the installation and use of "solar energy devices" and "alternate energy improvements" to promote energy conservation. These devices and improvements increase the level of efficiency, and decrease the utilization of electrical power [which] **that** accounts for 42[%] **per cent** of the total energy demand in the County of Hawaii.

In January of 1980**,** a final report prepared for the County of Hawaii entitled "Energy Self-sufficiency for the Big Island of Hawaii" was released. The report recommended that the County government provide a favorable climate for energy savings and new energy production. It also recommended establishing an Office of Energy Coordinator. The Energy Coordinator [is to]:

- [Coordinate] **Coordinates** and [provide] **provides** information regarding conservation and energy production;
- [Organize] **Organizes** ride sharing and travel reduction programs;
- [Assist] **Assists** business in obtaining information and financial support for energy-related development;
- [Fund] **Funds** necessary information gathering programs;
- [Monitor] **Monitors** the progress of energy departments;

- [Recommend] **Recommends** changes in the county's energy program;
- [Analyze] **Analyzes** the impact of proposed developments on the energy balance of the Island.

In addition, the development of naturally occurring energy resources will become an increasingly important factor in determining future industrial activity on the Island of Hawaii.

Gas

Propane gas is widely available and is a major source of energy for the Island of Hawaii. The two primary methods used in delivering gas are via an underground pipeline or tank/cylinder refill. The Public Utilities Commission regulates the underground gas delivery system in Hilo and along Alii Drive in Kailua-Kona. Gas is delivered by tanks or cylinders for the remainder of the island.

The use of propane gas diversifies the island's energy supply and creates less pollution. Compared to electricity generation and diesel emissions, propane offers a cleaner, less polluting fuel. Alternatives like propane gas offer opportunities to lessen the island's dependence on electricity and minimize land use conflicts created by the siting of large-scale electric generation, transmission and distribution facilities.

Propane can be used for self-generation (e.g. cogeneration, micro turbines) for large customers, thereby delaying the need to site and construct large, centralized electric generation facilities.

[1.] Geothermal Energy

Geothermal Energy is natural heat energy from the earth that can be harnessed for direct thermal use and for electrical power generation. [There are] **The** four basic ways [in which] **that** this type of natural heat energy may be found[: 1)] **are** steam[; 2)]**,** hot water[; 3)]**,** magma[; 4)]**, and** hot[,] dry rock. [The construction of electrical power plants using hot water, brines, or steam separated from hot water or brine deposits is the most probable development of geothermal energy resources.]

Geothermal drilling on the Big Island started in the early 1960's. Initial wells were either found to be unsuccessful or once drilled**,** were not further developed.

In 1972, the Hawaii Geothermal Project (HGP) was organized to investigate the development of geothermal energy in Hawaii, [and is] **as a** cooperative project involving Federal, State, County, and private funds. In April 1976, a successful well was completed near Kapoho in the Puna District, and HGP [has since] installed a power plant to demonstrate that geothermal energy is an economically viable natural energy alternative for the Big Island. The plant [has been in operation for several years.] **commenced operations in 1982 and ceased in 1989.**

In 1983 and with subsequent amendments**,** the Legislature amended the State Land Use Law, Chapter 205, Hawaii Revised Statutes, by authorizing the State's Board of Land and Natural Resources to conduct a county by county assessment of areas with geothermal potential for the purpose of designating geothermal resources subzones. Geothermal resource subzones may be designated within the urban, rural, agricultural and conservation land use districts. Only those areas designated as geothermal resource subzones may be utilized for the exploration, development or production of electrical energy from geothermal resources. Other amendments to the State Land Use law provide authority to regulate the direct use applications of geothermal resources.

In addition, the 1983 Legislature set criteria for [legislatively] designating geothermal resource subzones. Three geothermal resource subzones were established by this legislative method. The Board of Land and Natural Resources has subsequently designated the Kapoho, Kamaili, Kahaualea, and Kilauea Middle East Rift Geothermal Resource Subzones. **The geothermal resource subzones are shown on the Land Use Pattern Allocation Guide (LUPAG) map.**

In April 1993, Puna Geothermal Venture (PGV) completed its geothermal power plant on the Kapoho Subzone on the East Rift Zone. The geothermal power

plant uses steam and steam separated from hot water or brine resources at depths of around 5,000 feet below the surface. The closed loop system injects the spent fluids into injection wells at depths of 7,000 feet to be recycled. Although PGV currently produces 30 megawatts of power to the HELCO grid, PGV has been permitted under Geothermal Resource Permit No. 2 to provide up to 60 megawatts of geothermal power. PGV has been supplying approximately 25 per cent of the electricity for the County of Hawaii. Geothermal power generation has displaced nearly 110 million gallons of fuel oil that would have been used for electricity production. The reduction in fuel oil use has resulted in a reduction in carbon dioxide and other emissions common to fossil fuel plants and contributed to a cleaner environment in Hawaii.

[2.] Hydroelectric Power

Hydroelectric power is one of the oldest generators of electrical energy. On the Big Island, hydroelectric power fulfills [only a very small portion] **about 5 per cent** of the County's electrical energy demand[.] **at any given time.**

On the Big Island, the percent of total demand supplied by hydroelectricity will probably [remain insignificant] **not increase** due to the reliance on normal stream flows and the lack of impoundment required to store enough water for continuous or increased energy output. However, small-scale hydroelectric units have been [installed] **constructed** at Hawi**, Onomea, Wailuku River in Hilo,** and Waimea [and others have been proposed for the Wailuku and Honolii Rivers]. **The Wailuku River Hydroelectric facility has the capacity to supply 11 megawatts of power to the electric power grid.**

[3.] Solar Energy

Solar energy is the basis of many natural energy alternatives in Hawaii. Solar energy generates the global winds; stores energy in biomass through photosynthetic activity; warms the oceans, [can produce] **produces** electrical power directly via photovoltaic cells; and can be used directly for heating through solar heat collection devices.

[Solar Devices/Improvements:] There are two direct forms of solar energy applicable to households; solar heat collection and solar light energy to electrical power via photovoltaic cells.

Solar heat collection is adaptable to domestic water heating**,** which accounts for [a major portion] **approximately 30-35 per cent** of the electrical power demand [per] **for an all-electric** household.

[Advances in the use of photovoltaic cells to generate electrical power is also applicable on a public utility scale as well as on a domestic basis.] **Photovoltaic technology uses solar cells that convert sunlight into electricity. Industrial, commercial, and residential applications of photovoltaic technology are still being researched. However, advances in photovoltaic technology are resulting in improved efficiencies, lower costs, and integration into building products and designs. In May of 1998, the Mauna Lani Bay Resort installed a 100-kilowatt photovoltaic system on the rooftop, covering 10,000 square feet. The energy production is expected at approximately 423 kilowatts per day and the measured roof temperature reduction has exceeded 60 degrees. This project is expected to save operation costs for the hotel by providing electricity to 20 per cent of the 350 hotel rooms and reducing air conditioning costs. The resultant success of the project led to the installation of photovoltaic systems for the resort's golf facilities. The photovoltaic system will also be used to recharge Mauna Lani's golf carts.**

These solar energy devices and improvements can be considered energy conservation technologies since their domestic use will possibly decrease the total energy demand in Hawaii County.

[4.] Wind Energy

[The University of Hawaii, Department of Meteorology, initiated a five-year program in 1977 for Solar Energy Meteorological Research for the purpose of continuing wind surveys to establish the relationship between weather conditions and wind strengths, speeds, and distribution.] **The process of generating energy from wind simply uses the force and speed of wind to rotate the blades on windmills. This wind** [Wind] energy can be used [directly] to generate electricity through windmill electrical generators or by pumping water into storage for use in hydroelectric power systems. [Wind energy technology has been advancing, but as yet is not competitive enough to be a serious natural energy alternative. Once the technology is developed, Hawaii will be in an advantageous position due to favorable wind regimes in many areas of the island.] **Wind energy is a relatively clean form of energy, in that it produces no emissions or chemical waste. Unfortunately, wind energy is inconsistent and electrical grids cannot rely solely on wind and must provide a back up supply from another source. Such is the case with the wind energy generation farms at Kahua Ranch, Lalamilo Wind Farm, and Kamaoa Wind Farm.**

[5.] Biomass Conversion

Biomass is defined as "the total mass or amount of living organisms in a particular area or volume." Solar energy is converted into plant biomass through photosynthesis. [Biomass] **Plant biomass** can be used by [direct combustion] **power plants** to produce thermal energy, then steam to generate electrical power.

[On the Big Island, biomass conversion generates about 34% of the County's electrical energy. Locally, bagasse, the fibrous waste of sugar cane processing, is one source of biomass in use. Other sources of biomass that have been used for alternate energy include forest products from planted as well as natural stands of native and exotic species.]

Historically, biomass has been the Big Island's largest renewable energy resource. As recently as 1994, almost 13 per cent of the Big Island's electricity production were still being provided by two sugar processing companies that burned a mixture of biomass, coal, and fuel oil. With the closure of sugar operations, the companies have ceased burning biomass completely. However, one company continues the production of electricity using coal and fuel oil. Other uses of biomass are currently being reviewed by both the public and private sectors.

Biomass conversion is one of the **proposed** projects of the NELH program at Keahole point, and involves the cultivation and harvest of plant and animal life forms as a natural energy alternative.

Biomass can also be considered solid waste, since it is the basis for most of mankind's organic refuse, and can be processed into ethyl alcohol. Alcohol fuel is adaptable for use in hydrocarbon combustion systems [which] **that** account for about 58[%] **per cent** of the total energy demand of Hawaii County. Through combustion, alcohol can generate electrical power (via heat and steam) which represents the remaining 42[%] **per cent** of the County's total energy demand.

[6.] **Ocean Thermal Energy Conversion**

[Ocean Thermal Energy Conversion (OTEC) is a form of solar energy where the ocean acts as a solar heat collector. This process uses the thermal differences between the warm surface waters and the cold deep waters to power a tu`rbine/generator for electrical power generation. The NELH program at Keahole point has installed an OTEC project plant to research the potential of this natural energy alternative.]

The oceans are the earth's largest solar energy collector and storage system, covering approximately 70 per cent of the earth's surface. Ocean Thermal Energy Conversion or OTEC is a power production method by which energy is derived from the difference in temperatures between the warm surface and cold deep ocean waters. In 1974, the Natural Energy Laboratory of Hawaii (NELH) was founded. In establishing the NELH, the Hawaii State Legislature set aside 321 acres of land for research and development of alternative energy resources, primarily OTEC.

In 1984, The State Legislature set aside an additional 547 acres of land adjacent to NELH for the commercial expansion of successful NELH research projects. This area was called the Hawaii Ocean Science and Technology (HOST) Park. However, in 1990 the legislature combined NELH and HOST Park into the Natural Energy Laboratory of Hawaii Authority (NELHA). There are now 26 tenant companies that operate at NELHA.

OTEC research began in earnest in 1982 following the construction of the laboratory and administration buildings and deployment of the first 30 centimeter diameter, 600 meter intake deep sea water pipeline. Currently, NELHA continues

to conduct experiments and is working with other organizations to plan the construction of a 1 megawatt OTEC experimental facility and additional ocean pipelines for sufficient water supply.

GOALS

- Strive towards energy self-sufficiency [for Hawaii County].

- Establish the Big Island as a demonstration community for the development and use of natural energy resources.

POLICIES

- [The County shall encourage] **Encourage** the development of alternate energy resources.

- **Encourage the development and use of agricultural products and by-products as sources of alternate fuel.**

- [The County shall encourage] **Encourage** the expansion of energy research industry.

- [The County shall strive] **Strive** to educate the public on new energy technologies and foster attitudes and activities conducive to energy conservation.

- [The County shall ensure] **Ensure** a proper balance between the development of alternative energy resources and the preservation of environmental fitness and ecologically significant areas.

- [The County shall strive] **Strive** to assure a sufficient supply of energy to support present and future demands.

- [The County shall provide] **Provide** incentives [which] **that** will encourage the use of new energy sources and promote energy conservation.

- [The County shall seek] **Seek** funding from both government and private sources for research and development of alternative energy resources.

- [The County shall coordinate] **Coordinate** energy research and development efforts of both the government and private sectors.

- [The County shall encourage] **Encourage** the continuation of studies concerning the development of power [which] **that** can be distributed at lower costs to consumers.

- **Strive to diversify the energy supply and minimize the environmental impacts associated with energy usage.**

[• The County shall encourage the study of the effects of discharging heated water directly into the ocean.]

- [The County shall] **Continue to** encourage the development of geothermal resources to meet the energy needs of the County of Hawaii.

- **Encourage the use of solar water heating through the continuation of state tax credit programs, through the Building Code, and in County construction.**

- **Encourage energy-saving design in the construction of buildings.**

- **Support net-metering and other incentives for independent power producers.**

[STANDARD] **STANDARDS**

- New power plants shall incorporate devices [which] **that** minimize pollution.

- **Applicable standards and regulations of Title 11, Chapter 46, "Community Noise Control" of the Hawaii Administrative Rules.**

- **Applicable standards and regulations of Title 11, Chapter 59, "Ambient Air Quality Standards" of the Hawaii Administrative Rules.**

- **Applicable standards and regulations of Title 11, Chapter 60.1, "Air Pollution" of the Hawaii Administrative Rules.**