Green Buildings Workbook

A guide for IDB practitioners

This workbook explains the advantage of green versus standard buildings for both new and existing buildings. Topics included are: motivators for building green, climate change impacts on buildings, pay back calculator of energy savings, options for building design as well as operation and maintenance, influence of building codes on labels and building design, green building certification schemes, etc.

IDB

This workbook is a product of several internal
workshops under IDB's effort to mainstream energy
efficiency in its' operations. It was developed in INE/
ECC by Milena Breisinger, Manela Diez and Christoph
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This workbook explains the advantage of green versus standard buildings for both new and existing buildings. Topics included are: motivators for green building, climate change and building impacts, importance of building design as well as operation and maintenance, influence of building codes and building design, green building certification schemes, etc.

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Workbook Introduction

IDB has assembled this workbook as a resource to assist Bank employees to make informed decisions about how to best incorporate sustainable design into development projects. Included in this workbook are answers to frequently asked questions about influencing developments to use energy saving technologies and including sustainable features into building design. Knowing the basic principles of green buildings will give building blocks necessary to support sustainable projects.

In order to support your understanding of the subject, this workbook includes:

• Green building terms and definitions to familiarize Bank employees with the necessary foundation to support sustainable development projects;

• A short description of the most important design and building features;

• A sample pay-back calculator that can be used to determine the financial viability of a particular technology;

• A list of additional resources to continue further individual research and knowledge sharing on green buildings are listed in the Annex; Some things you need to know about using this workbook

• This manual is specifically focused on Latin American and the Caribbean (LAC) projects to further assist Bank employees and their clients as they begin to undertake the development, design, and, construction of green buildings.

- Due to the lack of available statistics of green certification programs, the authors rely on USGBC LEED studies, as do many of the Green Building Councils in Latin America and the Caribbean to highlight cost savings, return on investments, and emission reductions.

Chapter One: Basic Principles of Green Building

1. Why Build Green?

1.1. General

The growing world energy use has raised concerns over supply difficulties, exhaustion of energy resources and heavy environmental impacts (ozone layer depletion, global warming, climate change, etc.). The global contribution from buildings towards energy consumption, both residential and commercial, has steadily increased reaching figures between 20% and 40% in developed countries, and has exceeded the other major sectors: industrial and transportation[1].

Most of this energy is used for the provision of lighting, heating, cooling, and air conditioning.

Growth in population, increasing demand for building services and comfort levels, increasing awareness of the environmental impact of Greenhouse Gas (GHG) emissions together with the rise in time spent inside buildings, assures the upward trend in energy demand will continue in the future. For this reason, energy efficiency in buildings is today a prime objective for energy policy at regional, national and international levels.

Energy efficiency and conservation are usually not considered a "source" of energy, of course. But from a cost standpoint, they most certainly are. Between 1990 and 2005, a group of 16 industrialized countries met around half of their increased energy demand through improved efficiency. In 2005 these countries saved at least US$180 billion in fuel and electricity costs.[2]

1.2. Regional

The region's appetite for energy continues to grow and Latin America will need 75% more energy by 2030 than it needed in 2004, if current growth trends continue. Electricity production will have to expand by an estimated 50% within the next 10 years. Latin America and the Caribbean (LAC) has enjoyed many decades of growth with relatively clean power compared to the world's average, given the dominant use of hydroelectricity in the region and, consequently, the low use of fossil-fuel-fired power plants. With the most recent economic crisis in 2008/2009 there has been a shift away from hydroelectricity toward electricity generated from burning natural gas and coal, which will definitely increase the carbon intensity of the region's power sector. This shift has been driven by concerns over the past few years about

1 Luis Pérez Lombard et al. 2009. "A review on buildings energy consumption information". Energy and Buildings, Elsevier. 40 (3): 394-398.
2 International Energy Agency (IEA). 2009. "World Energy Outlook 2009". Paris, France: International Energy Agency.

the need to increase the region's diversity of energy options as a means to improve its energy security. Reductions in water availability due to changing hydrologic conditions resulting from climate change have destabilized the supplies of hydroelectric power upon which the region has traditionally depended.
Pessimism about the goal of achieving energy security has become pervasive in LAC. A 2007 poll by Latinobarómetro asked citizens across the region whether they thought they would have to endure energy rationing in the near future. An astonishing 80% of respondents said they were "very worried" or "somewhat worried" that this would be the case.
Though some countries— notably Mexico and Brazil—are already reaping substantial savings from energy efficiency programs begun in the 1980s and 1990s, most of their neighbors have yet to look seriously at conservation. The opportunities are everywhere, because LACs energy productivity is uniformly low. The region is still overwhelmingly reliant on incandescent light bulbs, for example, even though these consume 70% more power than newer "compact fluorescent" alternatives. The region's factories and water systems use millions of old, energy-wasting electric motors and pumps. Commercial and residential buildings are full of outdated air conditioning systems, refrigerators, washing machines and water heaters.

1.3. Why Green Buildings are important for the IDB

LAC as a whole could reduce energy consumption by 10% over the next decade by investing in widely available technology and equipment. It would cost approximately US$16 billion to reach that target, which would reduce total energy consumption by some 143,000GWh in 2018. And contrary to popular perception, such efficiency measures would not compromise people's comfort or compromise the region's economic competitiveness. And what if the region does not improve its energy efficiency? In that case, LAC will need to spend around US$53 billion to build the equivalent of 328 gas-powered open cycle generators (250MW each) necessary to produce the same 143,000GWh of power.[3]
At the 2010 annual meeting of the IDB in Cancun, President Moreno announced the preparation of a Sustainable Cities Initiative to promote environmental sustainability and improve the quality of life in LAC cities. This initiative will articulate actions of various sectors of the Bank with a vision of integrated and sustainable development in cities, pursuing three inter-related objectives: environmental sustainability and climate change, integrated urban development and fiscal sustainability and governance.
City governments throughout LAC have begun to consider the effects of climate change on urban development with an increasing number of cities putting in place mitigation and adaptation actions or engaged in the design and implementation of these actions.

2. What is a green building?

Green buildings incorporate sustainable features in their design and construction. The four main goals of green development are to create buildings that use less energy, cost less to operate and maintain, limit the impact on precious natural resources, and create places for people to work and live that promote health and productivity. Buildings can be considered green if they incorporate sustainable elements that satisfy the four main goals of green, or sustainable, real estate development. Project owners can design and construct healthy, efficient buildings, without having to compromise functionality. These built environments are designed to conserve water and energy; use space, materials, and resources efficiently; minimize construction waste; create a healthful indoor environment, and incorporate improvements and technologies that provide real cost-savings and swift pay-back schedules.
Design, construction, and occupancy all play a vital role in creating and maintaining green buildings and each one should incorporate sustainable practices. Buildings can be described using a Sustainability Profile which can include information about the various sustainable features that contributed to the development. The profile can be updated as the project moves from design to construction and finally to occupancy and used to communicate the various sustainability features to the project stakeholders. Projects may choose to use the sustainability profile for case studies, information materials, and/or tenant guidelines.
As for building type basically, all buildings can have sustainable and efficient features which have to be looked into in detail for each project.

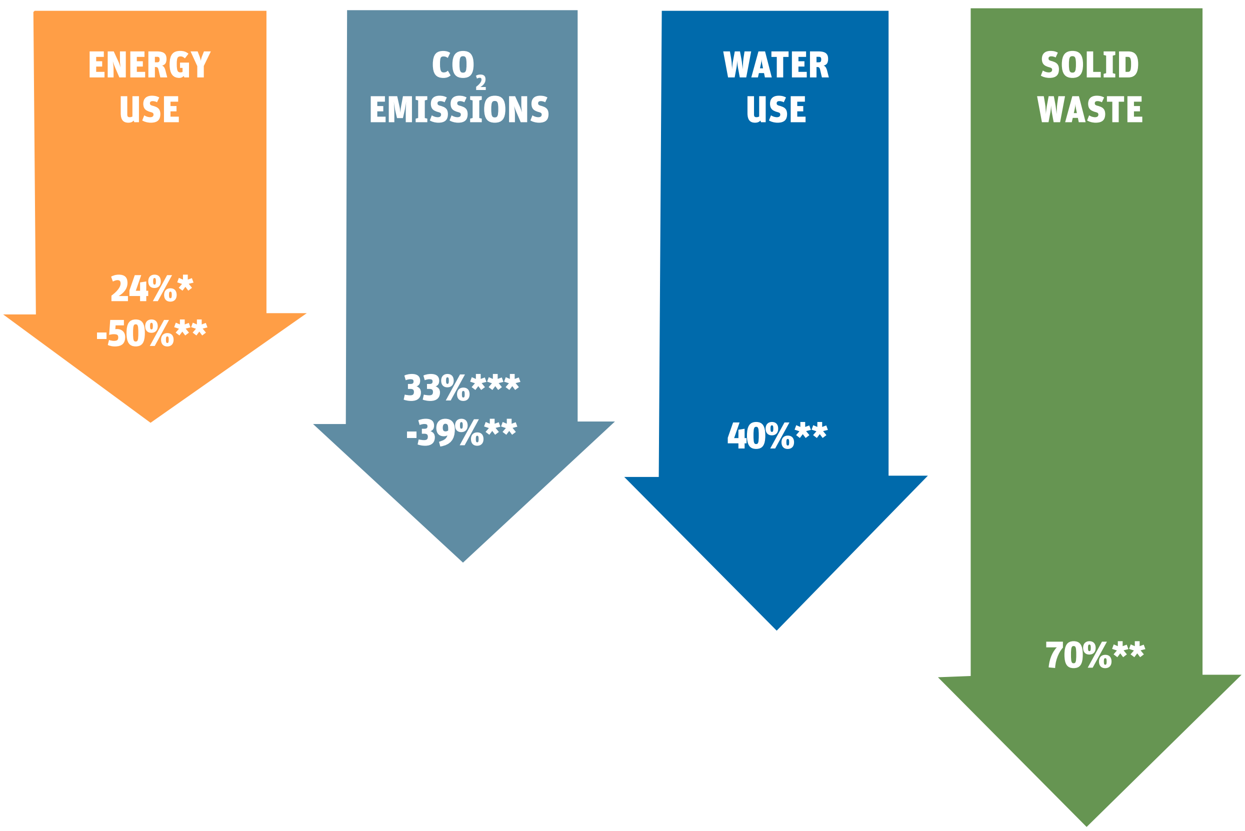
3 Inter-American Development Bank (IDB). 2008. "How to save US$36 billion worth of electricity". Washington DC, United States: Inter-American Development Bank

3. Arguments for green building vs. standard buildings

Green development is becoming more business-savvy. This is based on a framework of several rewards and benefits but the two most obvious benefits are long-term financial savings and returns on investments (ROI). Nevertheless, some people need to be convinced. A couple of arguments have been listed below. Keep in mind that benefits and rewards for constructing green buildings vary by type of ownership, type of use, owner's and project teams level of investment and the team's drive to build a sustainable building.

Conducting a building life cycle cost analysis in the design stage of a project can help show the financial benefits of a green building versus a conventional structure. It is especially useful when project alternatives that fulfill the same performance requirements, but differ with respect to initial costs and operating costs, have to be compared in order to select the one that maximizes net savings. It takes into account all costs of acquiring, owning, and disposing of a building or building system. Lowest life-cycle cost is the most straightforward and easy-to-interpret measure of economic evaluation.

Figure 1: Green Building Benefits



* Turner C. & Frankel M, 2008 "Energy performance of LEED for New Construction Buildings: Final report". Paper prepared for: U.S. Green Building Council. Washington DC, United States: U.S. Green Building Council.
** Kats G. 2003. "The Costs and Financial Benefits of Green Building: A Report to California´s Sustainable Building Task Force". California, United States.
*** Kim M. Fowler and Emily M. Rauch. 2008. "Assessing green building performance: A post occupancy evaluation of 12 GSA buildings". Prepared for the U.S. General Services Administration (GSA) Public Buildings Service. Washington, United States.

Source: United States Green Building Council (USGBC), www.usgbc.org

3.1. Economic

3.1.1. Significantly lower operating and maintenance costs for the owner/occupant through important savings on energy, water and maintenance in general making green buildings the more cost effective choice. Please review the annex for pay back calculator and parameters to help you calculate savings. Please note: Green buildings are commonly perceived to be more expensive but additional costs are reported to have an average cost premium of around 2% or US$3-5/ft2 (Kats, 2009) when comparing green buildings to ones following minimum codes. The majority of this premium is related to higher architectural and engineering costs as well as modeling activities necessary for building improvements. Generally, the earlier green building features are incorporated into the design process, the lower the cost.
3.1.2. Higher building value: studies show that sustainable buildings reach higher asset values as well as achieve higher lease rates.

3.2. Environmental/Social

3.2.1. Reduced local air pollution: Location of buildings highly impacts local transport needs, especially distances traveled. By locating buildings close to public transport individual transport needs can be reduced, decreasing local air pollution.

3.2.2. Less waste diverted to landfills through building materials recycling, better construction practices and waste management programs for building operation.

3.2.3. Reduced global environmental footprint: Green buildings are designed to reduce demand of resources like energy, water and materials and therefore cause less related GHG emission.

3.2.4. Better indoor environments: Due to mainly better lighting conditions and thermal comfort, green buildings can improve occupants' productivity in office buildings, learning results in schools and employee or occupant motivation as well as reduce sick days in general.

3.2.5. Improved corporate sustainability: Investing in green buildings aligns with the Banks' commitment to corporate sustainability to the global community.

3.3. Community

3.3.1. Less stress on public energy and water grids and therefore reduced investment needs for public infrastructure through reduced resource demand and less water discharged to the sewer system (recycling of water and storm water management). This is of special importance for LAC since in 2030 its energy demand is expected to be 75% higher than today requiring high investment in energy and water infrastructure. Green buildings can help reduce this investment needs.

3.3.2. Supports local innovation and technology transfer through application and showcasing of new technologies

3.4. IDB internal

3.4.1. Including sustainable building components in the project documentation for related IDB loans can be reflected positively in the Development Effectiveness Matrix (DEM) and help in providing indicators for its completion. Please refer to the annex for resources that can help develop indicators for DEM; Figure 11 represents the energy prices per kWh in the various countries depending on end use, such as industrial energy usage, commercial or residential.

3.5. Marketing / Publicity

3.5.1. Transforming the work environment into a sustainable one can be used as marketing promoter, reflecting onto the product that will be sold.

Related to point 3.1.1
Regardless of variations projects that include green buildings features normally can garner an internal rate of return of 20% or more. This is achieved by increased annual energy savings (think of rising oil and natural gas prices for the foreseeable future). Green buildings are specified to use 30 to 50% less water and energy use than current codes.
For instance, compare a 100,000 square foot green building that saves US$1.50 per square foot in energy costs to a similar building built to code – resulting in savings of US$150,000 per year. In order to get US$1.50 in energy savings, the building owner had to invest US$400,000 on green related items; in other words, put down a US$4.00 per square foot premium. As a result, it would take a little over 2.5 years to receive your investment back[5].

Related to point 3.1.2
In the world of commercial real estate, commercial properties are normally valued as a multiple of "net operating income", which is determined by dividing the income by the capitalization rate of roughly 6%. Capitalization rate is expressed as a percentage – similar to corporate bonds. If the building reduced annual energy and water costs by US$150,000, the capitalized rate of 6% would result in an incremental increase of property value by US$150,000 divided by 6% = US$2.5 million.
The result of investing US$400,000 in annual savings of US$150,000 would be to yield a return on investment of 625% – more than a "six-bagger" in the investing world!
Another way of looking at it, would be to give the 100,000 square

foot building costs of US$275 per square foot (industry average is between US$150 to US$300 per square foot). Multiply US$275 per square foot by 100,000 square feet and you end up with US$27.5 million in overall construction costs. The savings of US$150,000 may appear diminutive compared to the cost of US$27.5 million to build the project – but it's a savings nevertheless.

As previously stated, with the going rate of roughly 6% annual capitalization rate, the green investments made by the owner and project team would add US$2.5 million to the value of the building (US$150,000 savings divided by 6% rate) – an increase of US$25.00 per square foot compared to an investment of US$4.00 per square foot. That's a net increase value of US$21.00 per square foot. The value of the project when completed would increase from US$27.5 million to US$30 million.

In the end, when the building owner or developer arrive at the decision to sell their building on the market, it is the norm for green buildings to command 30% premium price over similar standard buildings due to the economic benefits they offer.[6]

4 Katz G. 2003. "Green Building Costs and Financial Benefits". Published for Massachusetts Technology Collaborative. Massachusetts, United States.

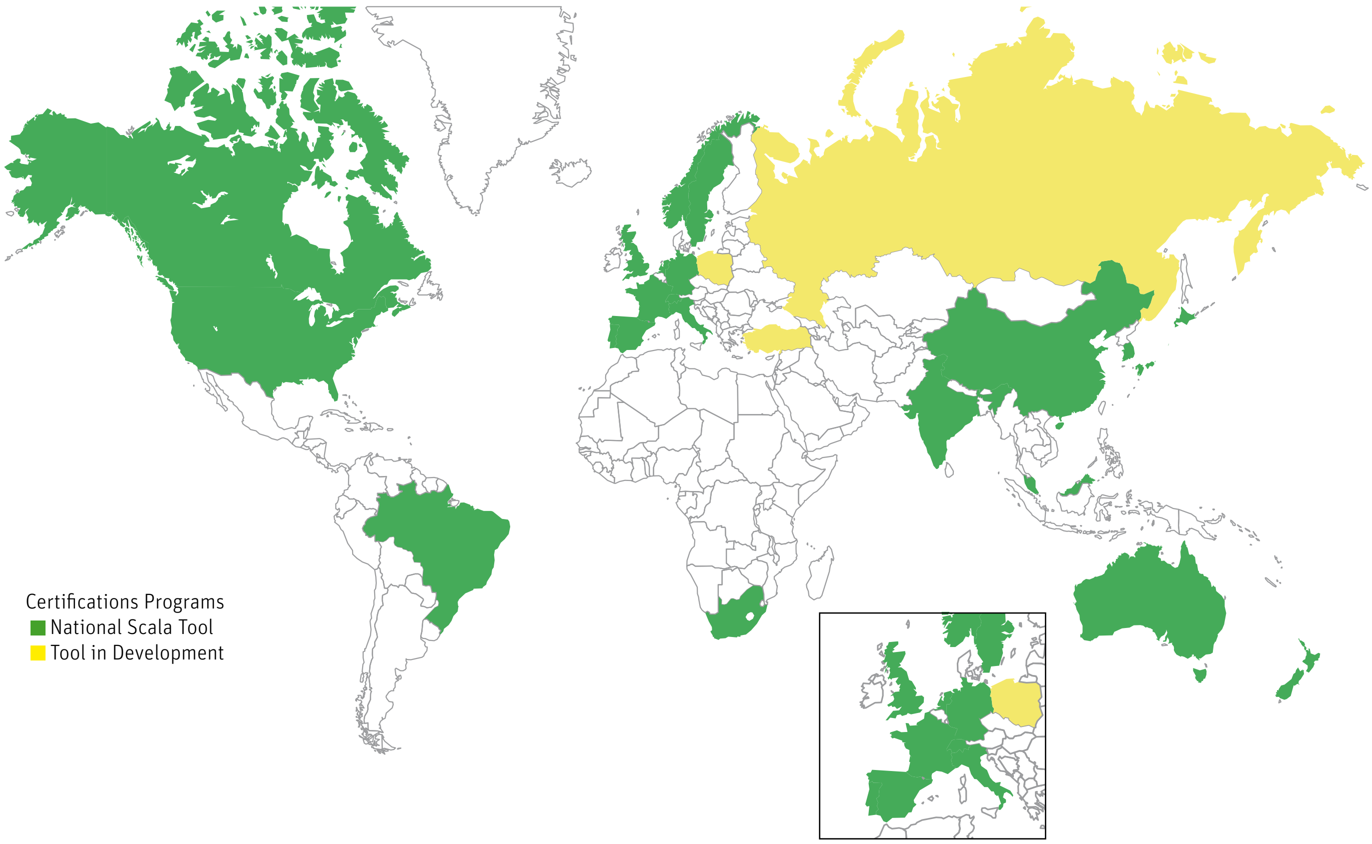
5 U.S. Green Building Council (USGBC). 2002. "Making the Business Case for High-Performance Green Buildings". Washington DC, United States: U.S. Green Building Council.

6 Jerry Yudelson. 2009. Green Building through Integrated Design". United States: Green Source/McGraw-Hill Construction.

4. Green Building Standards

One of the unique qualities about green buildings is that no matter the budget, it is possible to incorporate some aspect of sustainability into every project. Different rating systems exist that evaluate the level of sustainability of a project. The more sustainable features included in a project, the higher the level of certification that could be awarded. There are numerous rating systems worldwide that certify green building projects and more come online frequently.
Some of the most prevalent are LEED, Green Globes, and BREEAM (BRE Environmental Assessment Method) and while each is unique they all share the same goal and general structure. Using a standard such as these can be helpful, especially when defining goals and strategies for design, construction, and management. The World Green Building Council (WorldGBC) supports the adoption and ongoing development of these standards and does not promote any particular system or methodology. Within LAC a regional network is currently under development (www.worldgbc.org) with members from the entire region.

Figure 2: Green Building Certifications Worldwide



Source: http://www.pikeresearch.com/wordpress/wp-content/uploads/2010/05/GBCP-10-Executive-Summary.pdf

Figure 2 demonstrates the prevalence of these types of certifications – the yellow countries are in the process of developing certification programs. This demonstrates that the demand for green buildings is growing and that certification programs are fast becoming the norm and not the exception within the building construction industry.

4.1. LEED

LEED (Leadership in Energy and Environmental Design) is a certification program through the U.S. Green Building Council (USGBC), a non-profit organization. The USGBC is committed to transforming the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life.[7]

LEED is a third-party certification program and the nationally accepted benchmark for the design, construction and operation of high-performance green buildings. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health:

- sustainable site development
- water savings
- energy efficiency
- materials selection
- indoor environmental quality.

Certification can be achieved in the levels: Certified, Silver, and Gold and Platinum.

LEED 2009 for New Construction and Major Renovation

Project Checklist

Project Name

Date

Y	N	?			
			Sustainable Sites	**Possible Points:**	**26**
Y			Prereq 1	Construction Activity Pollution Prevention	
			Credit 1	Site Selection	1
			Credit 2	Development Density and Community Connectivity	5
			Credit 3	Brownfield Redevelopment	1
			Credit 4.1	Alternative Transportation—Public Transportation Access	6
			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
			Credit 4.4	Alternative Transportation—Parking Capacity	2
			Credit 5.1	Site Development—Protect or Restore Habitat	1
			Credit 5.2	Site Development—Maximize Open Space	1
			Credit 6.1	Stormwater Design—Quantity Control	1
			Credit 6.2	Stormwater Design—Quality Control	1
			Credit 7.1	Heat Island Effect—Non-roof	1
			Credit 7.2	Heat Island Effect—Roof	1
			Credit 8	Light Pollution Reduction	1
			Water Efficiency	**Possible Points:**	**10**
Y			Prereq 1	Water Use Reduction—20% Reduction	
			Credit 1	Water Efficient Landscaping	2 to 4
			Credit 2	Innovative Wastewater Technologies	2
			Credit 3	Water Use Reduction	2 to 4
			Energy and Atmosphere	**Possible Points:**	**35**
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
			Credit 1	Optimize Energy Performance	1 to 19
			Credit 2	On-Site Renewable Energy	1 to 7
			Credit 3	Enhanced Commissioning	2
			Credit 4	Enhanced Refrigerant Management	2
			Credit 5	Measurement and Verification	3
			Credit 6	Green Power	2
			Materials and Resources	**Possible Points:**	**14**
Y			Prereq 1	Storage and Collection of Recyclables	
			Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
			Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
			Credit 2	Construction Waste Management	1 to 2
			Credit 3	Materials Reuse	1 to 2
			Materials and Resources, Continued		
			Credit 4	Recycled Content	1 to 2
			Credit 5	Regional Materials	1 to 2
			Credit 6	Rapidly Renewable Materials	1
			Credit 7	Certified Wood	1
			Indoor Environmental Quality	**Possible Points:**	**15**
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
			Credit 1	Outdoor Air Delivery Monitoring	1
			Credit 2	Increased Ventilation	1
			Credit 3.1	Construction IAQ Management Plan—During Construction	1
			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
			Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
			Credit 5	Indoor Chemical and Pollutant Source Control	1
			Credit 6.1	Controllability of Systems—Lighting	1
			Credit 6.2	Controllability of Systems—Thermal Comfort	1
			Credit 7.1	Thermal Comfort—Design	1
			Credit 7.2	Thermal Comfort—Verification	1
			Credit 8.1	Daylight and Views—Daylight	1
			Credit 8.2	Daylight and Views—Views	1
			Innovation and Design Process	**Possible Points:**	**6**
			Credit 1.1	Innovation in Design: Specific Title	1
			Credit 1.2	Innovation in Design: Specific Title	1
			Credit 1.3	Innovation in Design: Specific Title	1
			Credit 1.4	Innovation in Design: Specific Title	1
			Credit 1.5	Innovation in Design: Specific Title	1
			Credit 2	LEED Accredited Professional	1
			Regional Priority Credits	**Possible Points:**	**4**
			Credit 1.1	Regional Priority: Specific Credit	1
			Credit 1.2	Regional Priority: Specific Credit	1
			Credit 1.3	Regional Priority: Specific Credit	1
			Credit 1.4	Regional Priority: Specific Credit	1
			Total	**Possible Points:**	**110**

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

Source: United States Green Building Council (USGBC), www.usgbc.org

7 More information about LEED at: www.usgbc.org/DisplayPage.aspx?CMSPageID=124

4.2. BREEAM

BREEAM (Buildings Research Establishment (BRE) Environmental Assessment Method) is a voluntary environmental assessment method for buildings established in the UK by BRE. It can be used to assess the environmental performance of any type of building (new and existing). Standard versions exist for common building types and less common building types can be assessed against tailored criteria under the Bespoke BREEAM version. Buildings outside the UK can also be assessed using BREEAM International. The standard looks at environmental impacts in the areas:

- Management
- Health and Wellbeing
- Energy, Transport
- Water
- Material and Waste
- Land use and Ecology
- Pollution.

Credits are awarded in each of the above areas according to performance. A set of environmental weightings then enables the credits to be added together to produce a single overall score. Certifications can be achieved in the levels: Pass, good, very good, excellent and outstanding[8] .

4.3. Green Star

Green Star is a voluntary environmental rating system for buildings in Australia. It was launched in 2003 by the Green Building Council of Australia.
The system considers a broad range of practices for reducing the environmental impact of buildings and to showcase innovation in sustainable building practices, while also considering occupant health and productivity and cost savings.
Nine categories are assessed with the Green Star tools:

- Management
- Indoor environment quality
- Energy
- Transport
- Water
- Materials
- Land Use & Ecology
- Emissions
- Innovation

Certifications can be achieved in the levels of 1-6 stars, 6 being the highest. [9]

8 More information about BREEAM at:www.breeam.org
9 More information about Green Star at: www.gbca.org.au/green-star

5. What are the main categories of green buildings?

In order to further define green buildings, categories for achievement are recognized by the green building community. While they are not universal, they structure the different technologies and help to understand the broader concept. These categories are:

5.1. Site Selection

This area includes elements such as the type of infrastructure available, the proximity to public transportation, storm water management options, and roofing.

5.2. Water Efficiency

Water efficiency limit the use of water inside and outside the building by considering water demand reduction like low-flow restroom fixtures and high-efficiency irrigation systems and supply like use of storm water or grey-water (water used from showers, wash basins, and laundry) recycling. .

5.3. Energy Efficiency

Energy Efficiency focuses on ways to reduce demand by incorporating energy efficiency features such as passive design like natural shading and lighting, high efficiency lighting, building controls, effective HVAC management and also includes supplying renewable energy by using technologies like solar photovoltaic panels, solar hot water heaters among others.

5.4. Materials and Resources

Material and resources include reduction of waste in construction and operation, the way the construction materials are disposed of and what materials are included in the building finishes with the objective to reduce waste to be disposed at landfills.

5.5. Indoor Environmental Quality

Indoor Environmental quality is focused on keeping the building healthy for the building occupants, by regulating thermal comfort, increasing natural lighting, improving indoor air quality, and minimizing noise levels, therefore reducing absenteeism and increasing occupant productivity.

These five categories can help designers and builders select which sustainable features to include in a building project. Often these categories are interrelated, e.g. improved natural lighting provides better indoor environmental quality and at the same time reduces electricity demand and cost for artificial lighting. The investment officer can then help/suggest priority areas where to invest funding based on the payback calculations, which can be found in the annex of this workbook. If the goal is to save money on energy, then the best place to focus the project is on energy efficiency measures. When the cost-benefit analysis is completed, the owners and builders can determine which features to include in the final project.

6. Green Buildings & Project Planning

The Operations section of the Project Cycle represents the regulations and procedures to be followed in the processing (i.e. before approval) of operations financed by the Bank. This section intends to discuss the IDB project cycle and its correlation with the steps of creating a viable green building development project.

Early planning is important and can help the project build a viable budget so that green features can be accurately priced and properly incorporated into the design and construction. Seeking advice from IDB technical experts will help to ensure good communication and understanding on how to best integrate project ideas as it moves through design and completes construction in the early planning stage.

As project ideas are proposed, the IDB project team determines whether the project idea is aligned with the policy and strategy identified and agreed upon with the borrower. In this phase, creating a business case will highlight the business rewards associated with developing a green building project. This will help you make a strong case about the benefits of going green to the project stakeholders/ client. Based on the type of project, the highlights of this case could be vastly different, but the overall goal is the same – demonstrate how incorporating sustainability can reduce utility costs (mainly energy, water, and gas), provide a higher monthly payback capacity, improve marketability, and to boost the project's public image.

At the analysis stage of a proposed loan or sector program, the objectives and components are placed in a medium-term framework, concrete actions are specified, and an assessment is made of the feasibility of these actions from a technical, financial, environmental, legal, and institutional standpoint. Part of this is completed through the Development Effectiveness Matrix (DEM). Here, project leaders must provide indicators on criteria in order to proceed with the project cycle process. This workbook has information on payback calculations and can provide some guidance for indicators; please refer to the annex of this manual for more information.

If clients propose an advanced project that does not incorporate any sustainability considerations, the investment officer still has the opportunity to include sustainability components in the project
proposal with the client, based on the arguments in paragraph Arguments for green building vs. standard buildings paragraph 3 of this manual.

Project budgets and financial plans are important and have to be calculated thoroughly to estimate costs and payback schedules with respect to sustainability components. To support your financial calculations, please review the annexes and the payback calculator.

Although, the investment officer, will not be making design decisions on sustainable features installed at the execution level, it is still wise to encourage and promote a whole-building approach to the borrower. Team coordination is integral to the success of the project and should be continually supported and managed throughout the design, construction, and occupancy of the project. Therefore, promoting collaboration and discourse among the architects, engineers, contractors, and building mangers could improve design, lower your upfront costs and increase the payback of the loan.

Figure 4: DEM Criteria examples include:

Impact of the program
Desired Outcome
Desired Output
IDB Environmental & Social Policy Assessment
Impact on Climate Change
Improvement of Environmental Impact/ Corporate Responsibility as a result of IDB Participation.
Improved Living Standards
Environmental Management

7. Payback Calculator

7.1. Calculating Payback

While it is interesting to know how much energy it takes to run an item, energy efficiency is about savings. As energy efficient products tend to cost more than conventional energy technologies, how quickly will the savings cover the product's purchase price? Calculation of simple payback can determine at what point this will occur through the realized electricity savings. Although simple payback does not take into account compounded savings, discount rates, inflation rates, or replacement costs, it is a very easy, commonly used, and useful tool.

Projects with paybacks less than 3 to 5 years should be implemented.

Projects with paybacks greater than 10 years are generally not cost effective.

Cost calculators for appliances and lighting technologies may be found at:

http://www.eren.doe.gov/femp/procurement/energy_cost_calculators.html

7.2. Step by step

When assessing which green technologies to incorporate into a building, it is helpful to understand how to determine the simple payback associated with various efficiency options.

Here are the steps to estimating payback.

1. Determine the cost of installing the standard option (the non-green option) (A)

2. Determine the usage associated with the standard option (B).

3. Determine the cost of the efficient option (green option) (C).

4. Determine the usage associated with the green option (D).

5. Use a viable cost for the resource used, determine the annual cost for the normal option and then perform the same calculation for the green option (N=utility cost per unit).

6. Subtract the green option utility cost from the normal option utility costs to determine the annual savings associated with the green option.

7. Subtract the normal option installation costs from the green option installation costs to determine the additional cost associated with green.

8. The final payback can now be determined – divide the additional cost by the annual savings – this number represents how many months it will take to fully recover the upfront green costs. Now that you have the payback determined, you can calculate the long term savings to the project. Once the payback months are realized, each month that the technology is being used in the building, it contributes to reduced operating costs.

Payback calculation equation:

$$R \text{ (annual payback)} = \frac{(C - A)}{(B - D) * N}$$

9 U.S. Department of the Interior, www.doi.gov/greening/energy/Calculating_Payback.doc

New Fixture Assessment Example
1.0 gallon/flush urinal vs. 0.25 gallon/flush urinal

REQUIRED INFORMATION

0.25 gallon/flush Urinal	US$320.00/unit
1.0 gallon/flush Urinal	US$250.00/unit
Water Cost (Equation Variable N)	US$0.0034/gallon
Number of Male Building Occupants	2500 persons
Total Number of Urinals to Replace	110

DETERMINING WATER SAVINGS

Green Option – 0.25 gal/flush:
0.25gpf urinal X 2 daily uses X 250 days X 2500occupants = 312,500 gallons/year

Regular Option – 1.0 gal/flush:
1.0gpf X 2 daily uses X 250 days X 2500 occupants = 1,250,000 gallons/year (B)

Projected Savings with 0.25 gallon/flush urinal
937,500 gallons/year saved

DETERMINING COST SAVINGS

(Equation Variable B): 1.0 gal/flush = US$4,250 annual costs
(Equation Variable D): 0.25 gal/flush = US$1,062 annual costs

Project Savings with 0.25 gallon/flush urinal
US$3,188 annually saved

DETERMINING PAYBACK – ECONOMICALLY FEASABLE? (Y/N)

Green Option – 0.25 gal/flush urinal Installation Cost:
(Equation Variable C): US$320.00 X 110 units = US$35,200

Regular Option – 1.0 gal/flush urinal Installation Cost:
(Equation Variable A): US$250.000 X 110 units = US$27,500

Upfront Cost for 0.025 gal/flush = US$7,700

Payback (in years) = 2.4 years =(US$7,700/US$3188)
Yes – Economically Feasible

Chapter Two: Green Technologies and Decision-Making

In today's market, green technologies, (or technologies that improve building performance and limit the negative impact on the environment), are more prevalent than ever before. For the purposes of this workbook, technologies are broadly defined and include everything from natural shading (tree or shrub walls) to efficient HVAC systems.

The technologies listed are organized by sustainable category mentioned in chapter 1. Typically some technologies can be assigned to several categories, i.e. natural lighting can reap benefits for energy efficiency and indoor environmental quality. These are a sample of green technologies being used in project development right now; of course it is not a complete list as new technological solutions are always arriving on the market.

Selecting the right technologies to incorporate into a particular project should take into account the climate, design goals, occupancy type and availability of resources. Projects should also try to respond to the particular environmental needs of the local area.

Figure 5, highlights a sample of real technologies incorporated in green buildings.

Figure 5: Technology/Features and Sustainable Categories

Technology/Feature	Description	Sustainable Category
Sustainable Site Location/ Alternative Transportation Access	Project site is within 1/2 mile of Metro Station, Bus Stop This also includes the use of Bike Racks and Showers, as well as preferred parking for Hybrid/Electric Cars. This provides incentives for alternative transportation methods.	Site Selection
Site Orientation	The way the building uses its positioning to incorporate natural and sustainable practices.	Site Selection
Low Topographical Impact	Buildings that do not affect the natural grade and soil.	Site Selection
Municipal rehabilitation	The use of sustainable construction to rehabilitate an economically depressed area	
Grey Water Recycling Tanks	Greywater is wastewater generated from domestic activities such as laundry, dishwashing, and bathing which can be recycled on-site for uses such as landscape irrigation and constructed wetlands. The recycling tanks help to redistribute the water for useful purposes.	Water Efficiency
Rainwater Collection	Accumulating and storing of rainwater. Used to provide water for sanitary needs, livestock irrigation to refill aquifers in a process called groundwater recharge.	Water Efficiency
Water Saving Plumbing Fixtures	Sanitary fixtures and fittings with lower water consumptions like l flow shower heads and toilets, dual flush toilets, waterless urinals, faucets aerator	Water Efficiency
Building insulation	Techniques such as Double Skin Roof and insulation on Walls that hold heat and air ultimately reducing energy costs for heating and cooling	Energy Efficiency
Green Roof	A roof of a building partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems. This helps reduce heat island effect.	Energy Efficiency/Water Efficiency
Green Façade	A wall, either free-standing or part of a building partially or completely covered with vegetation and, in some cases, soil or an inorganic growing medium. The vegetation for a green façade is always attached on outside walls; with living walls this is also usually the case, although some living walls can also be green walls for interior use. For living walls there are many methods including attaching to the air return of the building to help with air filtration. They are also referred to as living walls, biowalls, or vertical gardens. This helps improve building insulation and head reduce island effect.	Energy Efficiency

Energy Efficient Windows	Windows which provide less heat gain in summer and less heat loss in the winter. This can be reached through better glazing materials, multiple glazing, window frame materials with higher heat flow resistance and better designs, interior and exterior shading, thermally improved edge spacers, low emissivity (low-E) coatings and window orientation	Energy Efficiency
Geothermal Heat Pumps	A central heating and/or cooling system that pumps heat to or from the ground. It uses air, earth or a lake as a heat source (in the winter) or a heat sink (in the summer) and takes advantage of the moderate temperatures in the ground to boost efficiency and reduce the operational costs of heating and cooling systems, and may be combined with solar heating to form a geosolar system with even greater efficiency	Energy Efficiency
Efficient Lighting Products	Use of technologies to reduce electricity consumption for lighting by using fluorescent lighting, reflectors, LEDs and daylight- and occupancy sensors	Energy Efficiency
Natural Lighting	Designing a building in a way that natural light penetration is a maximum, making use of glass structures/fronts and tubular skylights	Energy Efficiency/Indoor Environmental Quality
Combined heat and power On-Site Energy Generation (Micro-Turbines)	Technologies that produce electricity and at useful heat for usually internal use from the input fuel. Used in commercial, industrial or big residential buildings	Energy Efficiency
Shading (passive techniques)	Using shade to lower temperature in building spaces and thereby reduce energy costs for cooling.	Energy Efficiency
Solar Heating	Using solar energy to heat water and/or building spaces	Energy Efficiency
Solar Panels	Solar panel (photovoltaic module or photovoltaic panel) is a packaged interconnected assembly of solar cells, also known as photovoltaic cells. The solar panel is used as a component in a larger photovoltaic system to offer electricity for commercial and residential applications.	Energy Efficiency
Water for Natural Cooling Canal	Using water to natural cool the building environment	Energy Efficiency
Low-Emitting materials	Materials like paintings and coatings, composite wood, desks with lower emission of toxic chemicals called volatile organic compounds (VOC). They can have negative effects on human health. Low emitting materials can significantly reduce VOC concentrations in buildings because they control one of the most active sources. In addition to being low-emitting, it is beneficial to use materials with the following characteristics: low odor, least toxic, moisture resistant.	Indoor Environmental Quality
Operable Windows	Windows that mechanically open and close, allowing for controlled natural ventilation	Energy Efficiency/Indoor Environmental Quality

8. Climate Zones in Latin America and the Caribbean

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) define 8 international climate zones with 3 subcategories A, B, and C. However, the climate zones in LAC only reflect 6 zones, since zone 7 and 8 are very cold or arctic temperatures. Figure 6 represents the 6 color coded climate zones and their sub categories in LAC. Climate Zones are as Follows:

Zone 1 – 1A Hot/Humid
Zone 2 – 2A Warm/Humid
Zone 3 – 3A Semiarid
Zone 3 – 3B Warm Marine
Zone 4 – 4A Humid Sub-Tropic
Zone 4 – 4B Arid
Zone 5 – 5C Marine
Zone 6 – 6B Highlands

The definitions for A, B, C are:
(A) Moist – Locations that are not marine and not dry.
(B) Dry – Locations meeting the following criteria:
Not marine and
$P < 0.44 \times (T - 19.5)$ [I-P units]
$P < 2.0 \times (T + 7)$ [SI units]
Where:
P = annual precipitation in inches (cm) and
T = annual mean temperature in °F (°C).
(C) Marine – Locations meeting all four of the following criteria:
a) Mean temperature of coldest month between 27°F (-3°C) and 65°F (18°C)
b) Warmest month mean < 72°F (22°C)
c) At least four months with mean temperatures over 50°F (10°C)
d) Dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year. The cold season is October through March in the Northern Hemisphere and April through September in the Southern Hemisphere.

10 ANSI/ASHRAE/IESNA Standard 90.1-2007 Normative Appendix B

Figure 6: Climate Zones for Latin America

Depending on the climate zone, sustainable technologies and features can be adapted to correspond with the surrounding environment.

Sustainable features for Green Buildings –in detail

This section of this workbook discusses particular sustainable features that can be implemented into your building sites. Site selection, energy and water efficient systems as the most relevant for LAC will be the highlighted categories and each category includes several sustainable features. The categories will follow the structure described below:
Description: of the feature.
Strategies to achieve: these suggested alternatives.
Benefits: to both the building the environment and the community.
Barriers: that may occur for implementing these components.
Building Type: in which this feature is most common.
Description: of the feature.
Strategies to achieve: these suggested alternatives.
Benefits: to both the building the environment and the community.
Barriers: that may occur for implementing these components.
Building Type: in which this feature is most common.

Please note that some of the features described in the following chapters are applicable to several categories, e.g. reduce heat island effect is applies to site selection and energy efficiency.

9. Site Selection

The location of a building can have a large impact on the way the building is designed. Some of the issues related to Site Selection which are most important once, relevant for the LAC region, and/or have tangible results are:

- Access to public transportation
- Access to infrastructure (utility lines, sewer systems, etc)
- Heat-Island Effects

9.1. Access to Public Transportation

9.1.1. Description

Public transportation access for a building can be a bus or metro line that is within walking distance to the building. Buildings can also include bike racks and shower rooms that make biking or walking to work more attractive for occupants.

9.1.2. Strategy to Achieve

Locate the building close to a metro or bus stop so people can use public transportation to get to and from the building site. Install showers and secure bike racks for people to use.

9.1.3. Benefits to the Building

Access to public transportation allows the building to house less parking, which can lower design and construction costs. This can be particularly valuable when a project is planning to build below grade parking.

9.1.4. Additional Benefits

When a project site is close to public transportation, it reduces the amount of commuters via automobile, therefore reducing emissions and traffic. If occupants chose to bike or walk to work, it will also increase the health of building occupants. Depending on the design, shape, and color of bike racks it could attract the eye of the viewer and work as a marketing tool.

9.1.5. Barriers

Building owners may not be able to choose a site location that is suitable to meet this sustainable design component. Not all cities have bus, or metro systems. In most areas, installing bike racks and showers are not costly, however, the propensity of the future occupants to bike or walk to the building site should be taken into account so that money is not spent frivolously.

9.1.6. Building Types

The opportunity for new buildings to take advantage of locations near public transport access is greater than for existing buildings. Additionally, new projects can easily design facilities that are commuter-friendly. In comparison, existing buildings cannot relocate in order to utilize public transportation; however commuter facilities may be installed if space and budget allow.

9.2. Access to Infrastructure

9.2.1. Description

Construction of a new building in a developed area gives the project access to infrastructure like energy, water, telecommunication and other community benefits that may not be available in non-developed area.

9.2.2. Strategy to Achieve

Select a building site that is in an already developed area and which can be easily connected to existing infrastructure.

9.2.3. Benefits to the Building

There is no need to spend money building infrastructure to serve the project. The new building will be able to take advantage of what has already been developed.

9.2.4. Additional Benefits

Building in population centers reduces urban sprawl, and can also provide services to building occupants and can help to foster community connectivity.

9.2.5. Barriers

The type of building and the various project requirements can limit the ability of the project owners to select a site that takes advantage of infrastructure.

9.2.6. Building Types

All building types can take advantage of access to infrastructure.

9.3. Reduce Heat-Island Effect

9.3.1. Description

In areas where there is already a lot of development, there is something called a Heat Island Effect: areas that are densely populated are often covered in concrete which traps and holds heat close to the surface. The heat-island effect makes cooling a building very difficult and costly.

9.3.2. Strategies to Achieve

There are three ways that building design can reduce this effect. a) Install a white or light colored roof, b) Install a green, or vegetated roof or c) Reduce outdoor surfaces covered with concrete or asphalt. One possibility is to locate parking below grade.
a) White surfaces reflect sunlight and trap less heat than darker ones. White roofs cost between US$10 and US$20 per square foot and will require regular cleaning.
b) The cost associated with installing a green roof is approximately US$15 - US$25 per square foot. Green roofs may require maintenance for the first two years but long-term, green roofs require the same or less regular maintenance than traditional roofing systems. While the costs for green roofs may be higher in some cases, they shown to reduce energy usage by 20%. Additionally, green roofs are designed to last 40% longer than standard roofs. Buenos Aires is conceived as an example at the scale of an entire city. Authorities in the Argentine capital are using tax breaks to encourage people to establish gardens on the terraces and roofs of buildings with the goal of improving the urban environment and saving energy, as is already being done in Tokyo and in Berlin, among other cities.

c) Reduce concrete or asphalt surfaces
Locating parking below grade is more expensive but it may be the only option available in some areas. Space not needed for parking can be covered by green space (flowers, grass) having less capacity to trap heat. If surface parking is the only option available, then consider shading it so that it won't contribute to heat island effect.

9.3.3. Benefits to the Building

Reducing the heat-island effect can help save energy and money. This is possible because the building absorbs less heat and therefore it's easier to control interior building temperatures.

9.3.4. Additional Benefits

In the case of a green roof it can provide space for building occupants to enjoy. Green roofs can also contribute to air quality, storm water management and reduce stress on public sewer systems. (See Water Efficiency Section in chapter 10)

9.3.5. Barriers

The largest barrier to reducing the heat island effect is that to see a significant change, buildings in the same area all need to participate. The building itself may save energy by installing a green or white roof but the heat island effect may still be present. The financials may not allow for below grade parking. The most difficult part for green roofs is to find the proper plant, because it has to be ideal for the climate, withstand all types of weather and adjusted to (very little or lot) watering.

9.3.6. Building Types

Buildings can install roofing systems during initial design and construction or after the building is complete. For green roofs building statics have to be considered. The parking plan should be considering during new construction.

10. Water Management

Water management is one of the most important components to consider during building design, because reduction from water can be up to 40%. The most common water management practices include water supply, demand and treatment. The primary issues related to water management are:
• Plumbing Fixtures
• Water Usage Sub-meters
• Stormwater Management
• Irrigation

During the initial phase of design, project stakeholders should identify the various water management measures that best fit the building type (office, school, housing, etc.) and location.

10.1. Plumbing Fixtures
10.1.1. Description

Plumbing fixtures, or restroom plumbing fixtures, significantly contribute to water demand management. Building occupants will interact with plumbing fixtures more than any other water management feature. Incorporating flush and flow controls can control water demand. Throughout the course of a day, each building occupant will flush a toilet 3 times and use a hand-washing sink 3 times for approximately 15 seconds – for a building with 300 occupants that translates into over 3 million liter annually.

10.1.2. Strategies to Achieve

There are several different products that can be installed to reduce water usage. a) Low-flow commodes, b) Low-Flow Urinals, c) Low-flow Showers, and d) Low-flow Sinks, or adjusting the flow from existing toilets manually.

a) Low-flow Commodes

Low-flow commodes limit the water used per flush by at least 55% over traditional commodes (13.25 liter/flush). There are several different options for flush rates that the project could select for installation. Determining which flow rate commode is right for the project depends on the cost of water and the availability of the fixture, using a simple cost-benefit analysis can help stakeholders make the right choice.
The low-flow commode flush rate options are:
• 6 liter /flush
• 4.8 liter/flush
• 4-6 liter/flush (dual flush model)
• 3,78 liter/flush (pressure assist)
• 0.2 liter/flush (foam flush)
• 0.0 liter/flush (waterless or composting toilet)

b) Low-flow Urinals

Like low-flow commodes, low-flow urinals have drastically reduced water usage by limiting water usage by over 40% over the traditional design (5.6 liter /flush). There are four flush rate options available in the marketplace. Project stakeholders can decide which option is the best choice for installation based on building type and location.
The low-flow urinal flush rate options are:
• 3.78 liter/flush
• 1.9 liter/flush
• 0.47 liter/flush
• 0.0 liter/flush (waterless)

c) Low-flow Sinks

Project stakeholders can consider selecting sinks that have a lower flow rate per minute and limit water usage. Depending on the selection, the project could save as much as 90% on sink-related water usage over traditional designs (9.5 liter/minute).
The low-flow sink rate options are:
• 3.78 liter/minute
• 1.9 liter/minute
• 0.94 liter /minute

d) Low-Flow Showers

Shower flow rates can vary greatly and which type to install depends on the user. For example, the needs of a hotel will be very different than an office building or a school.
The low-flow shower rate options are:
• 9.5 liter/minute
• 6.8 liter/minute

10.1.3. Benefits to the Building

Installing low-flow plumbing fixtures limits water demand for the building and lowers operating and maintenance costs and saves money on utility bill.

10.1.4. Additional Benefits

It also reduces the strain on municipal water sewer and treatment systems. In many places, sewer systems are too small for the demands of modern life and are being overwhelmed by current usage. Overwhelmed systems are more likely to break and often require additional maintenance which can mean higher costs to the consumer and potential disruptions in service. In areas where water is scarce and municipal systems are suffering, reducing demand is vital to the overall health of the public water supply.

10.1.5. Barriers

The largest barrier to installing low-flow plumbing fixtures is the availability of certain fixture types. Before a design team selects a particular fixture, the team should gather information about what is available on the local market. In some cases, maintenance issues have been reported with waterless fixtures, but with proper

guidance, this is only a temporary issue and can be remedied with training.

10.1.6. Building Types

Low-flow plumbing fixtures can be installed in new and existing buildings. If a building is being retro-fitted with low-flow fixture options, building designers need to make sure that any original plumbing will work properly with the new fixtures. In some cases, it may be possible to limit the replacement to a flush valve or aerator, which is a cheaper because it doesn't require replacing the entire fixture.

10.2. Water Usage Submeters

10.2.1. Description

Water submeters measure water usage associated with a particular water system. In most cases, building owned submeters are used to track the demand side water usage. It is assumed that up to 5% of water used in buildings is being lost due to leakages. Submeters give building owners detailed information on water usage and can contribute to high quality water use management. Submeters can be tied into building management systems and alarmed so that leaks can be detected in real time. Municipal water meters typically only track water usage for billing purposes and do not have the capacity to send an alarm. Submeters can be used for irrigation systems, cooling towers, domestic hot water, and restroom fixtures.

10.2.2. Strategies to Achieve

Install submeters on one or more water system in a building in order to track usage and prevent leaks from going unnoticed. Regular meter readings should be set up and can be done manually by a building staff employee or tied into the building management system. If it's possible, alarm the meters for a particular usage setting; if the meter reads a number that is above a defined threshold the building staff is alerted to the issue and can resolve the problem in real time.

10.2.3. Benefits to the Building

Submeters can identify leaks in real time and therefore can drastically shorten the duration of a leak which saves water and money. Savings can be achieved two ways, 1. on the actual water usage, and 2. by preventing damage to the building. Water damage can be very costly and time consuming to fix so prevention is one of the best ways to avoid high-cost maintenance fees. Submeters can also help to verify municipal charges and confirm that the building is being charged for the right usage. Finally, submetered data allows building owners and operators to review usage and make recommendations for further savings. It is difficult to assign a cost savings per submeter because of the variety of systems and meters available, but generally, they can contribute to at least 5% overall savings on water costs.

10.2.4. Additional Benefits

Submetering helps to reduce water waste by keeping users informed about particular usages. Saving water reduces stress to municipal water systems and helps to maintain a healthy water supply for the community.

10.2.5. Barriers

During the building design it is important to make sure that there is enough space allotted to install and read the submeters. Usually submeters are small but this issue should be taken into consideration.

10.2.6. Building Types

Water system submeters can be installed in new or existing buildings. Space should be allocated for the submeters; in some existing buildings the submeters may only be installed if space allows.

10.3. Stormwater Management

10.3.1. Description

In practically all climate zones, storm water is an issue for building owners. Stormwater runoff can flood sewer systems, exacerbate erosion and sedimentation problems, and have adverse effects on natural habitat conditions. As pervious surfaces are replaced by impervious surfaces, storm water management has become a large issue for building owners and municipal managers. A large rainfall can flood a water system and cause serious and costly problems. High quality storm water management can help limit negative impacts of storm water.

10.3.2. Strategies to Achieve

There are three options to consider for storm water management. a) Limit the amount of impervious area on the site, b) Harvest and/or capture storm water, and c) Install a green roof (see Green Roof chapter 9.3.2. b).

a) Limit the Amount of Impervious Area

During the initial stages of design, consider specifying pervious surfaces for surface parking. This will drastically cut down on the amount of storm water the site has to manage. Landscape designers should also consider using plant species that are natural to the area to help reduce the negative impact of erosion and are accustomed to typical annual rainfall. In some cases, create a natural wetland may be an option which is a natural way of managing storm water. The more area on a given site that are pervious, the less time and money required to manage excess storm water runoff.

b) Stormwater Harvesting and Capture

Storm water collection has become more common as building owners look for ways to manage rainfall runoff and save money. There are two separate approaches to storm water management: 1. A detention system that manages the storm water runoff from a building site, and 2. A retention system that utilizes the storm water for other purposes, such as irrigation, toilet flushing, and cooling tower makeup.

A detention basin acts as a temporary storage area, allowing runoff to be released at a slower, predetermined rate to reduce the impact on the downstream drainage system. Detention systems can be located as part of the exterior design or located inside the building in large tanks and may be the only option in urban areas. Detention systems can be part of the landscape feature and may look like a pond to occupants and visitors.

The amount of water that a detention system can manage is based on total capacity of the system. Sizing a detention system properly is very important; too small and it will become overwhelmed and not perform properly; too big and it is a waste of space and money. An interior storm water detention tank can be transformed into an interior storm water retention system by utilizing the captured storm water for use in the building. Irrigation systems, toilet flushing and cooling tower makeup are the most common.

10.3.3. Benefits to the Building

Making storm water management part of the initial design, projects can be proactive about a strategy which will likely produce cost savings for the site. If a building manages 60% of the storm water associated with the site naturally, then only 40% of the runoff will have to be removed from the site. The energy used to pump excess water away from the site can be drastically reduced if storm water management is incorporated.

Capturing storm water and using it in building operations can save money on water bills and drastically reduce the use of excess potable water. Depending on the water needs of a building and the annual rainfall of a particular area, buildings may be able to capture a great deal of their water required for irrigation and other major water end-uses.

10.3.4. Additional Benefits

Limiting the negative impact of storm water runoff on the public water supply is a significant benefit of implementing comprehensive storm water management. Water systems will be less strained by large amounts of rainfall which will benefit the surrounding community and protect the public water supply from flooding and contamination. If storm water retention is used it can reduce the amount of potable water demand which is particularly important in areas that have limited drinking water availability.

Also green roofs (see Heat Island Effect in chapter 9.3) contribute to storm water management by increasing the pervious area on the site and managing one of the largest contributors to storm water runoff – roof drainage. The size of the green roof will determine how much storm water it can manage on a given site but this is another factor that should be considered when selecting a roofing material.

10.3.5. Barriers

The location of the building is the largest barrier to storm water management strategies and can dictate the potential of implementing a high quality strategy. The amount of annual rainfall for a particular area will also have an impact on what is possible for a particular project.

10.3.6. Building Types

Storm water management strategies such as detention ponds, green roofs, and landscaping features are typically easier to implement in new construction projects. Existing buildings may be able to implement some, or partial management programs but typically the cost of installation may be prohibitive. The least expensive strategy for existing buildings is to incorporate a storm water capture system and reuse the water for building operations.

10.4. Irrigation System

10.4.1. Description

Buildings that include an exterior landscape component almost always have a mechanical irrigation. Irrigation systems are typically scheduled to reflect the needs of the plants associated with the landscape design. Exterior landscape needs to be properly irrigated to maintain the health of the plants, the ascetics of the property, and the viability of the space. Irrigation control is necessary to limit the use of potable water and save energy.

10.4.2. Strategies to Achieve

There are several ways to achieve high quality irrigation and limit potable water use. a) Moisture control and Drip irrigation systems, b) Use non-potable water, and c) Select drought resistant species.

a) Moisture Control Systems

Select an irrigation system that uses moisture sensors which save water by only allowing watering when necessary for plant health. Drip irrigation applies water directly to the roots very slowly and can save up to 50% over traditional sprinkler systems. The percent savings with moisture controls is difficult to calculate without knowing the specific climate and plant requirements. Working with a landscape architect will help a project determine actual savings.

b) Use Non-Potable Water
Rain/Stormwater harvesting and capture systems can drastically reduce, and in some cases eliminate, the need for non-potable water use for irrigation (see Stormwater Management in chapter 10.3). Rainwater can be collected from many different surfaces (roofs, paved areas, etc) and then filtered in preparation for use. The best surfaces to harvest rainwater from are metal, clay, or concrete. Asphalt and lead-containing materials will contaminate the water and may damage the landscaping. Collected grey-water can also be used for irrigation and further reduce the use of potable water.

c) Select Drought Resistant Plants
During the landscape design, select climate tolerant plants that can survive and thrive under natural conditions. Plants species that are accustomed to the normal rainfall of a particular area will help to reduce the amount of irrigation needed. It may be possible to seriously reduce the size of the on-site irrigation system or eliminate the need entirely.

10.4.3. Benefits to the Building

The largest benefit to the project, regardless of which strategy is in place, is the reduction in water costs. By reducing water usage associated with irrigation, by 50% or more, projects can save a significant amount on water. Recycling on-site grey water can save additional money if the building is charged for discharge sewer water as the water would not be re-entering the municipal system.

10.4.4. Additional Benefits

As with all systems that reduce excess water usage, the primary benefit is that it reduces stress on the public water supply and the public sewer system.

10.4.5. Barriers

If the project requires a certain look to the outside, then it may be difficult to change the plant type or relax the irrigation requirements to reduce water. Some projects are located in urban areas that have very little space of landscaping in which case focusing on irrigation savings does not make sense.

10.4.6. Building Types

Efficient irrigation systems can be installed during new construction or to an existing facility. Buildings that have significant green space will realize the most savings from an efficient irrigation program.

11. Energy Management

Controlling the amount of energy used in a building is the best way to save money and reduce the negative impact on natural resources. The operation of buildings is accountable for almost 40% of total energy use. There are many ways to reduce the amount of energy needed to run a building, but none can be a magic solution. The best way to save energy is to make sure the building is designed and operated properly. The energy issues covered in this text are as follows:

- Building Design
- Envelope
- HVAC
- Solar Power
- Building Management System

11.1. Building Design

11.1.1. Description

Building design is a general term, but in the context of saving energy, it is limited to the way that buildings can help reduce energy usage. A building design can help or hurt energy usage. The demands for improved comfort, energy efficiency and further issues in the area of sustainability are adding new challenges to it. Therefore, when designing a green building, it is ideal to use the building design techniques to limit energy consumption. The building industry offers a huge number of new solutions and products.

11.1.2. Strategies to Achieve

These should focus on passive design features which try to achieve thermal and visual comfort by using natural energy sources and sink e.g. outside air, solar radiation, vegetation, wet surfaces. Three main strategies can be considered in order to limit energy consumption: a) Natural Ventilation, b) Building Orientation and, c)Day lighting.

a) Natural ventilation

There are two types of natural ventilation; slack driven and wind driven. Depending on the area and the climate, building designers can select which type is best for the project. Night cooling, or free cooling, is one way to drastically reduce costs. In climates where evening temperatures drop significantly, the building can be opened up at night and allowed to cool naturally. In most systems, the primary ventilation will be natural and there will be a mechanical back-up for when natural ventilation cannot meet occupant comfort requirements. Energy and money can be saved by eliminating, or vastly reducing, the need for mechanical ventilation and air conditioning.

b) Building Orientation, solar heat gains/avoidance

The basic considerations for optimizing the solar heating potential of a sunspace include the directional orientation and the angle of the glazing (glass or windows). In general, a south-facing (northern hemisphere) or north facing (southern hemisphere) orientation within 30º east or west of true south and north respectively will provide around 90% of the maximum static solar collection potential. The optimum directional orientation depends on site specific factors and on local landscape features such as trees, hills or other buildings that may shade the sunspace during certain times of the day. Rectangular buildings should be oriented with the long axis running east-west, so the east and west walls receive less direct sun in the summer. In the winter, passive solar heat gain occurs on the south side of the building.

c) Day lighting

Windows are one of the most common design elements that help make day lighting possible. The prudent placement of each window to allow daylight into the space in both the mornings and the afternoons helps to minimize the amount of energy to provide lighting for work spaces such as a desk area, cubicle, or even a kitchen counter. In terms of cost, windows are probable one of the most affordable of all day lighting resources.

Building orientation, which is defined during the design process, provides opportunities for passive solar heating when needed, solar heat gain avoidance during cooling time, natural ventilation and use of daylight throughout the year.

11.1.3. Benefits to the Building

Thoughtful building design can help save energy required to run the building which will save the owner money on operating expenses. Using one, or more of these strategies, can have a large impact on energy usage. These strategies together can save approximately 20% on energy costs annually.

11.1.4. Additional Benefits

Proper building design can help save energy and therefore reduce the negative impact on natural resources. The other benefits of thoughtful building design are the value to the future building occupants. The combination of fresh air and daylight make workers, students, and guests more productive and happier which is a benefit no matter the building type.

11.1.5. Barriers

The largest barrier is the location of the building. It may be impossible to incorporate natural ventilation or building orientation in some areas and climates. Daylighting is an option almost everywhere. Another barrier to natural ventilation is that building occupants need to understand that it's a natural system so perfect control of occupant comfort is not always possible.

11.1.6. Building Types

The design of a building is limited to new construction projects. In some cases, existing buildings can be renovated to include natural ventilation

and daylighting. Buildings that require strict temperature control also may be unable to take advantage of natural ventilation and daylighting.

11.2. Envelope

11.2.1. Description

The materials that make up the outside of a building, or the envelope, have a great deal to do with how the building controls internal temperature. Proper insulation is crucial and can have a significant effect on the amount of heating and cooling required and reduces the need for additional energy.

11.2.2. Strategies to Achieve

There are three main components of the building envelope and strategies to achieve energy savings: a) Windows, b) Skin, c) Doors.
a) Windows and frames
In climates with a significant heating season, windows have represented a major source of unwanted heat loss, discomfort and condensation problems. In recent decades, windows have undergone a technological revolution. It is now possible to have lower heat losses, less air leakage, and warmer window surfaces that improve comfort and minimize condensation. The graphs in the link below illustrate the simulated savings in heating season costs associated with energy efficient windows for a typical U.S house in a heating dominated climate. The savings shown do not include possible savings from reduced air leakage. Depending on the condition of the old windows in an existing home, the savings can be higher if window replacement leads to long-term air leakage reduction.

In climates that mainly require cooling, windows have represented a major source of unwanted heat gain. In recent years, low-E coatings that reject solar heat without darkening the glass have undergone a technological revolution too. It is now possible to significantly reduce solar heat gain and improve comfort while providing clear views and daylight. The graph below illustrates the simulated savings in cooling season costs associated with improved windows for a house in a cooling-dominated climate. The savings shown do not include possible

Figure 7: Annual heating energy cost for new and existing construction

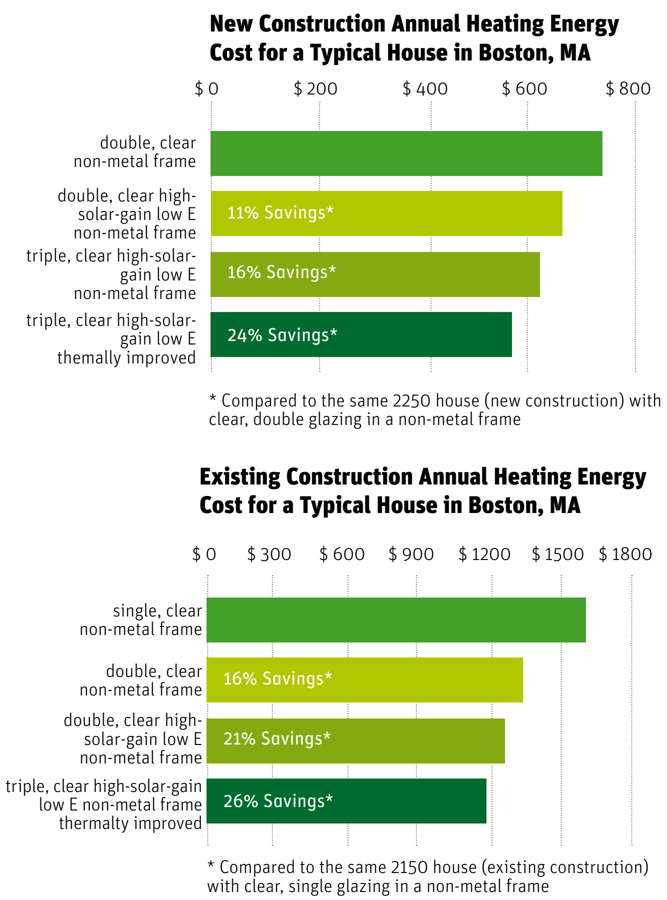
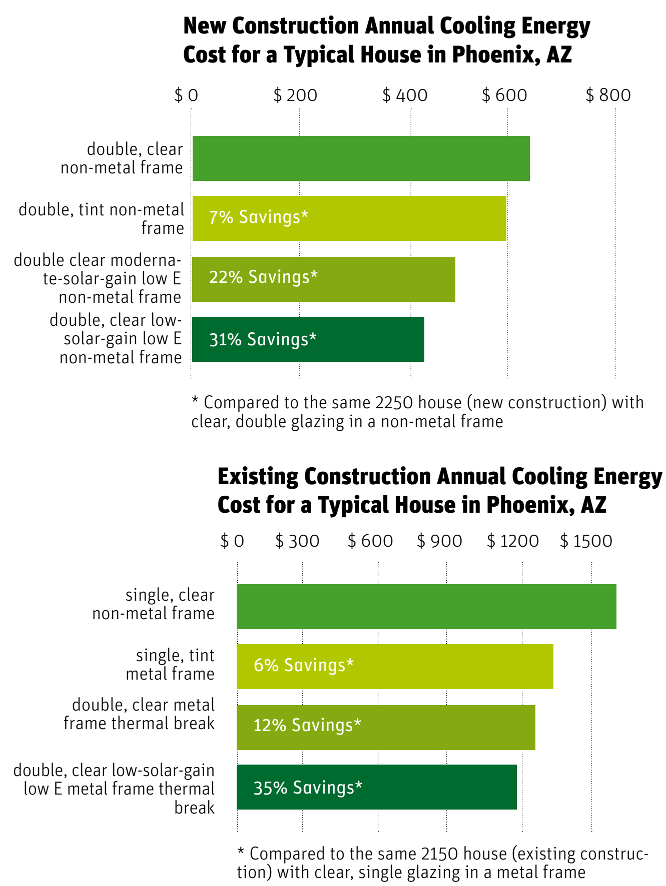


Figure 8: Annual cooling energy cost for new and existing construction



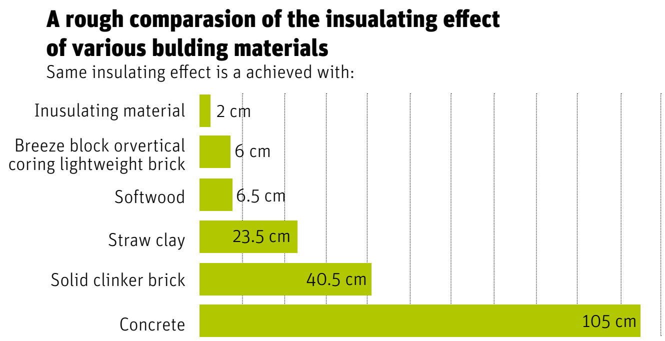
Source: www.efficientwindows.org/energycosts.cfm

savings from reduced air leakage. Depending on the condition of the old windows in an existing home, the savings can be higher if window replacement leads to long-term air leakage reduction.

"Windows and glazed areas are required to bring in daylight but at the same time have to reduce solar heat gains (for warm climates) and heat losses (for cold climates). Hence passive design features like proper location, sizing and detailing of the windows as well as aspects of shading must be considered."

b) Skin (walls and roof)
Building insulation materials are thermal insulation used in the construction or retrofit of buildings. The materials are used to reduce heat transfer by conduction, radiation or convection and are employed in varying combinations to achieve the desired outcome (usually thermal comfort with reduced energy consumption). Insulation may be categorized by its composition (material), by its form (structural or non-structural), or by its functional mode (conductive, radiative, convective). Nonstructural forms include batts, blankets, loose-fill, spray foam, and panels. Structural forms include insulating concrete forms, structured panels, and straw bales. Sometimes a thermally reflective surface called a radiant barrier is added to a material to reduce the transfer of heat through radiation as well as conduction. The type of insulation used as well as the climate and needs of the building will provide a percent savings.

Figure 9: Insulation effect of building materials



Source: Federal ministry of economics and technology. 2008. "Energy efficiency made in Germany". Berlin, Germany: Federal ministry of economics and technology.

c) Doors
There are two primary door types used today, swinging and non-swinging. Doors have a U factor[10] which refers to their heat transmission. The lower the U number, the better the door is at insulating. The number of entrances and the use of the building should be taken into account. In some climates, it is a good idea to have a vestibule or some sort of area that separates the external door from the internal door to reduce the amount of heating or cooling that escapes a building during passing times. To learn more about energy savings and guidance on building specifications, please refer to section 3 in the annex.

11.2.3. Benefits to the Building

Depending on the material, the size, and the location of the building, using these strategies saves money on energy costs. Buildings that have tight envelopes and are focused on energy savings can also have greater control over the building systems and can find additional savings when a building is fully operational.

11.2.4. Additional Benefits

The primary reason to focus on building envelope is that it will create a very controllable environment for occupants and can provide a great deal of thermal comfort. This can help with productivity and overall occupant happiness.

11.2.5. Barriers

No matter what, a new building is required to include these features so there is less of a cost impact on the project. The biggest challenge is selecting the right set of materials that blend correctly to produce the energy savings desired for the final project. There can be some additional upfront cost but the overall savings on energy can be recouped with energy price and climate zone highly influencing payback.

11.2.6. Building Types

Windows, skin, and doors are typically features that are incorporated during new construction. Also large renovations may be able to change these elements usually involving higher costs.
The location of the building will significantly influence the materials selected for the envelope. Working with local designers and understanding the realities of the area can be a huge advantage. For example, in extreme climates, door vestibules can make a big difference in heating and cooling needs.

11.3. Heating Ventilation Air Conditioning (HVAC)

11.3.1. Description

In most cases, this is one of the largest costs to a project and can be an influencing factor on the energy consumption for years following construction. Savings associated with HVAC can have large impacts on energy usage and cost savings.

10. A measure of the rate of non-solar heat loss or gain through a material or assembly. U-values gauge how well a material allows heat to pass through. The lower the U-value, the greater a product's resistance to heat flow and the better its insulating value. The inverse of (one divided by) the U-value is the R-value

11.3.2. Strategies to Achieve

There are two main systems that have been selected to save energy and save money during building operations. a) Compression Heat Pumps and b) Absorption Heat Pumps

a) Compression Heat Pumps

Refrigerators and air conditioners absorb energy (source) in a cooler medium, raise its temperature and release it in a warmer medium (sink), which is the basic principal of heat pumps and can be done in either direction, i.e. the source and sink can be switched to provide heating in winter and cooling in summer with the same heat pump. The source where heat is drawn for heating purposes can be air, ground and water which for cooling would be the sinks. Air source heat pumps are relatively easy and inexpensive to install, however they suffer limitations due to their use of the outside air as a heat source or sink. Air source heat pumps are only really applicable for heating purposes in temperate climates. Ground source (Geothermal) and water source heat pumps, typically have higher efficiencies (higher COPs) and lower operating costs than air-source heat pumps. This is because they draw heat from the ground or groundwater which is at a relatively constant temperature all year round below a depth of about eight feet (2.5 m). The trade off for this improved performance is that ground-source heat pumps are more expensive to install due to the need for the digging of wells or trenches in which to place the pipes that carry the heat exchange fluid. When compared versus each other, groundwater heat pumps are generally more efficient than heat pumps using heat from the soil. Geothermal and Water-Source Heat Pump systems are the most energy, cost, and space efficient of any system in the industry.

b) Absorption Heat Pumps - Solar Cooling

Absorption heat pumps are heat pumps driven not by electricity, but mainly by an additional heat source such as solar-heated water, geothermal-heated water or natural gas. They use an absorption cycle with working medium (e.g. ammonia-water) to provide heating or cooling. The main difference to compression heat pumps is that only a low power pump is needed which consumes less energy than a compressor used for compression heat pumps. Absorption heat pumps are mainly used in industrial, commercial and large residential homes and require and external heat source, which can be solar energy.
The cost of electricity and high availability of solar energy could pose an argument for solar cooling especially in the Caribbean.

11.3.3. Benefits to the Building

Compression heat pumps used for heating purposes can offer important energy savings compared to conventional heat systems. In case of cooling, absorption heat pumps (solar cooling) can provide energy savings compared to widely used AC technology based on compression heat pumps.

11.3.4. Additional Benefits

As with all energy savings technologies, it reduces the need for energy use which in case of solar cooling also reduces peak electricity demand and takes off pressure from the public grid.

11.3.5. Barriers

There are ways of heating, cooling and ventilating buildings which require less upfront investment, so cost can be a discouraging factor – especially if long-term ownership is not part of the project development.

11.3.6. Building Types

HVAC design is typically part of the new construction process and not a strategy for energy savings in renovations. HVAC renovations can take advantage of newer and more efficient systems, but because HVAC systems tend to last 20+ years, the need to renovate these systems is somewhat rare. In buildings that are going to have mechanical heating, cooling, and ventilation, some sort of HVAC system will be needed. The size of the building will dictate the size of the HVAC requirements.
The better the building design and envelope, the less investment is needed for the HVAC system. The location of the building will also have a great deal of influence on the system specifications. The needs of the building and the type of climate stress it will endure, should be well understood before an HVAC system is selected.

11.4. Solar Power

11.4.1. Description

Solar power is energy that is derived from the sun and converted into heat or electricity. It is a versatile source of renewable energy that can be used in an amazing number of applications, providing power for everything from cars and boats to houses and spacecraft. Solar power is also clean and pollution-free.

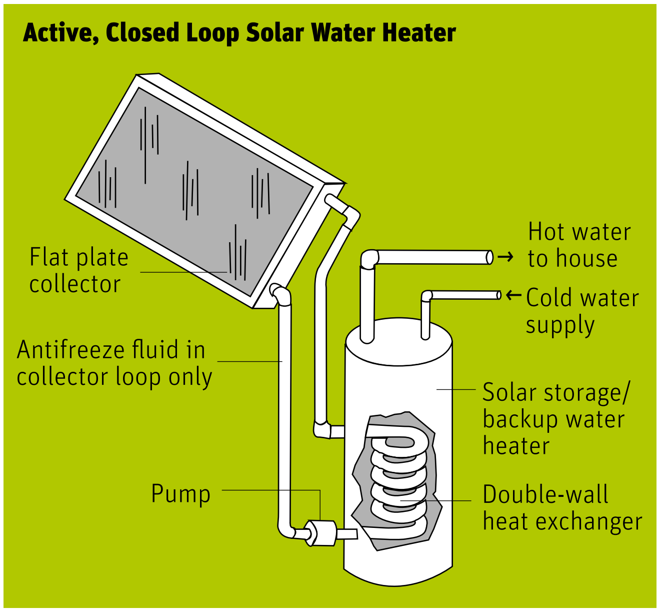
11.4.2. Strategies to Achieve

Using solar power has become more popular world-wide as the dependence on fossil fuels has become less desirable. There are two ways that active solar energy can be used in buildings. a) Solar Photovoltaic (PV) Panels and b) Solar Powered Water Heaters.

a) 1. Solar PV Panels

Solar panels are designed to convert light into electricity. The process of extracting electricity from light is called Photovoltaic (PV) and the PV process converts solar energy directly into electricity. It simplicity provides stability because it has no moving parts and does not require refueling. The solar panels are made of multiple interconnected solar cells. They should face the sun at all times to maximize the benefit of the light available. There are solar

Figure 10: Solar Water Closed Loop System



Source: http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12850

panels that can move with the sun in order to take full advantage. Photovoltaic cells are considered low maintenance and well suited to remote applications. They use semiconductors like silicon to convert energy from the sun into electricity.

b) 2. Solar Water Heater (SWH)
SWH systems are designed to deliver the optimum amount of hot water for most of the year. However, in winter there sometimes may not be sufficient solar heat gain to deliver sufficient hot water. In this case a gas, electric or biomass booster is normally used to heat the water. In some cases, SWH can save 85% of the energy associated with domestic hot water.
In a "close-coupled" SWH system the storage tank is horizontally mounted immediately above the solar collectors on the roof. No pumping is required as the hot water naturally rises into the tank through thermosiphon flow.
In a "pump-circulated-closed loop" system the storage tank is ground or floor mounted and is below the level of the collectors; a circulating pump moves water or heat transfer fluid between the tank and the collectors.

11.4.3. Benefits to the Building

Producing energy on-site can save a lot of energy costs. These systems also have low maintenance which will save money on replacements and operations.

11.4.4. Additional Benefits

Producing clean energy on-site reduces the need for energy carrying infrastructure and reduces the dependency on grid-electric power. This makes the public power supply last longer and saves energy.

11.4.5. Barriers

There is some upfront cost associated with the using solar energy but the largest is access to the sun. In most areas, this isn't a large barrier but it should be taken into account during design in order to ensure that the system can provide for the needs of the building.

11.4.6. Building Types

One of the best features about solar power is that it is available for large and small buildings of almost any types and can be installed during new construction and during renovations.

11.5. Building Management System

11.5.1. Description

The objective of an energy management/building automation system (also known as an energy management and control system [EMCS]) is to achieve an optimal level of control of occupant comfort while minimizing energy use. These control systems are the integrating component to fans, pumps, heating/cooling equipment, dampers, mixing boxes, and thermostats. Monitoring and optimizing temperature, pressure, humidity, and flow rates are key functions of modern building control systems.

11.5.2. Strategies to Achieve

The only way to achieve this level of control is to install and use a building automation system.

11.5.3. Building Automation System

a) Types of Building Automation Systems
At the crudest level of energy management and control is the manual operation of energy using devices—the toggling on and off of basic comfort and lighting systems based on need. The earliest forms of energy management involved simple time clock and thermostat-based systems. Indeed, many of these systems are still being used. Typically, these systems are wired directly to the end-use equipment and mostly function autonomously from other system components. Progressing with technology and the increasing economic availability of microprocessor-based systems, energy management has quickly moved to its current state of computer based, digitally controlled systems.

b) Direct Digital Control
Direct digital control (DDC) systems function by measuring par-

ticular system variables (temperature, for instance), processing those variables (comparing a measured temperature to a desired set-point), and then signaling a terminal device (air damper/mixing box) to respond. With the advent of DDC systems, terminal devices are now able to respond quicker and with more accuracy to a given input. This increased response is a function of the DDC system capability to control devices in a nonlinear fashion. Control that once relied on linear "hunting" to arrive at the desired set-point now is accomplished through sophisticated algorithms making use of proportional and integral (PI) control strategies to arrive at the set-point quicker and with more accuracy.

11.5.4. Benefits to the Building

Estimates suggest lighting energy savings of 30 to 50 percent from an EMS in an office building. There are additional savings to be considered but the possibility of saving 50% on lighting alone may make these systems worthwhile. There is also savings associated with maintenance, systems can let operators know when a problem arises which can reduce the costs of fixing the issue or allowing problems to continue unchecked.

11.5.5. Additional Benefits

Saving energy is a clear benefit but the larger benefit to occupants is that it will allow the building to be run better and more efficiently. Broken equipment will not result in delays and will allow occupants to keep working.

Active, Closed Loop Solar Water Heater
Flat plate
collector
Antifreeze fluid in
collector loop only
Pump Double-wall
heat exchanger
Solar storage/
backup water
heater
Cold water
supply
Hot water
to house

11.5.6. Barriers

There is an associated cost for installing and alarming the building but the largest barrier is associated with the operator understanding the system and using it properly. Investing in education is key to getting all the benefits of a building system and achieving the maximum system performance.

11.5.7. Building Types

All building can use building automation systems but installing them and having them properly set-up is easier during new construction.

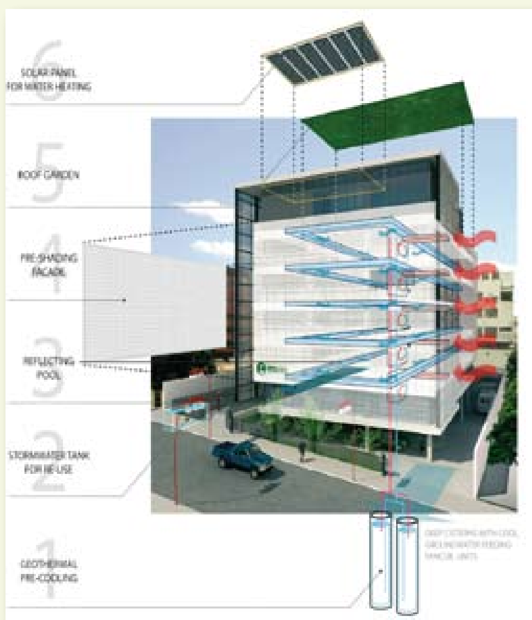
Chapter Three: Case Studies

12. Case Studies from LAC, US and EUROPE

Overview:	**Library** **Medellin, Colombia** **Climate Zone: 6 – 6B Highlands**
Environmental Aspects:	Given the program, orientation and sustainable design premises, the configuration becomes evident; the building gives way to a finger type arrangement resulting from a rigorous solar chart analyses allowing passively controlled solar access, permitting morning sun and shading in the afternoon and maximizing its relation with the environment and the natural forces that surround between them. Common spaces such as circulations, halls and lounge areas are opened as courtyards, verandas or shading canopies to receive maximum air flow. Well-illuminated shelter utilizing cross ventilation for cooling is provided to the coffee area, administrative offices, library and reading rooms. Spaces that require darkness such as the lecture theatre take advantage of stable underground thermal mass and use stack effect ventilation cooling. The layout arrangement begins (access) in the east where the best morning sun is received, then distributing uniformly different spaces towards the west, obtaining a homogeneous wind flow in each space of the building. Amenities and services are located in western end providing a buffer zone from the peak afternoon sun radiation. A double roof protects the horizontal planes where most of the solar radiation is received. The proposed use of indigenous materials is a commendable measure for considerably lowering implementation costs and for stimulating the local economy.
Project Photos:	

Overview:	**Renovation** **Goethe Institute São Paulo, Brazil** **Climate Zone: 5 – 5C Marine**
Environmental Aspects:	The task was to open more space to the public, eliminating the damage of the building and improve the environment of the institute. The project proposes a convincing and innovative renovation of an existing structure to increase its overall environmental, functional and aesthetic performance. A solution is explored to increase energy efficiency by the clever combination of a green roof, green external walls, and an advanced window design. Additional technologies that are to be commended in this work include a chimney that provides natural ventilation while barring noise from the surroundings, solar panels, water tanks that recycle grey water, as well as those measures taken to increase soil permeability. The work is also ethically sensible, incorporating directly the input of effected stakeholders. An economically viable model is advanced in that the overall costs for refurbishment and subsequent maintenance are greatly reduced. Through careful exploration of the potential yield of sustainable construction, the project makes a positive impact on the community by offering a contextual catalyst to the neighborhood. Sustainable reform of the Goethe Institute initially only discussed changes needed in the conventional execution. The task was to move to restructure the areas and installing new accommodation. It's scientifically proven that plants offer unique benefits for the micro-climates (absorption of noise, heat, radiation, water, pollution). These benefits are essential to improve mega-cities with the majority of surfaces being concrete.
Project Photos:	

Overview:	**Hotel Hanga Roa** **Easter Island, Chile** **Climate Zone: 3 – 3B Warm Marine**
Environmental Aspects:	The hotel was planned with the aim to minimize its environmental impact on the island. The 75 rooms have a base of organic architecture and green roofs, which seeks to rescue the type of construction of Easter Island and be based on the stunning scenery of the island. According to Jeannette Schiess, (executive director of the hotel), it has an ecological system of air conditioning: "We have incorporated all sorts of technologies to minimize the impact of our facilities on the island, to save energy and water as well as the practice of recycling waste and waters. At the same time, we generate our own electricity through a system of micro-turbines that generate electricity, heat and cold. That is, we have a new tri-generation system." All rooms have an Anti-Electrosmog protection against low-frequency waves that alter the natural immune system of humans. So, we decided not to install Wi-Fi because of its permanent radiation damage to humans. Regarding building materials, they decided to use only a minimum of concrete, because of its high emission levels."
Project Photos:	

Overview:	**Medical and Social Center** **São Paulo, Brazil** **Climate Zone: 5 – 5C Marine**
Environmental Aspects:	Many passive measures were integrated into the design such as an optimal building orientation and shading elements on the façades without affecting high daylight penetration. Geothermal pre-cooling is an entirely new strategy for the sub-tropical region of Brazil. An integrated system was developed that brings available groundwater as cooling fluid to standard fan-coil units of conventional air conditioning systems. The adaptation of readily available equipment is proving highly economical and will utilize the excess of ground water that otherwise would have to be continuously pumped out of the site. The building pre-shading is an important strategy adopted in order to decrease thermal loads and at the same time to optimize natural daylight conditions avoiding glare. The increased level of energy efficiency compared to conventional buildings is estimated to be around 80%. Natural resources such as rainwater and groundwater will be used nearly 100%, improving storm water management.
Project Photos:	

Overview:	**Mall** **Santiago, Chile** **Climate Zone: 3 – 3B Warm Marine**
Environmental Aspects:	This building is described as: Bright, efficient and “recyclable.” One of the most important aspects to comply with is recycled materials. The construction steel used here is 100% recycled. It also has a green roof of 30,000m2 on the seventh floor, which is a good thermal insulator so that the surrounding buildings will be free from heat. In theory, it does not generate thermal radiation. “Regarding air conditioning, the waters of the canal San Carlos, will act as current chiller. The used water will be recycled and returned to the canal. For this project, the team constantly monitored and quantified emissions of dust and gases. Construction waste management was also performed, which shortened travel to rubbish dumps. Other responsible practices incorporated during construction are dust and gas emissions control and noise pollution monitoring, apart from energy saving systems. Chile’s Green Building Council named it recently the greenest building project in the country, and it will also feature the tallest tower (70 floors, 300 meters high). Costanera Center, a major architecture developing in Santiago de Chile which will host a shopping mall, offices, homes and a hotel, is aiming for a Gold LEED certification.
Project Photos:	

Overview:	**School** **Rio De Janeiro, Brazil** **Climate Zone: 1 – 1A Hot/Humid**
Environmental Aspects:	The work inventively implements a comprehensive series of environmentally sensitive features in a public school facility. Deserving attention are such features as natural ventilation, natural lighting with protection provided from direct solar radiation and an accessible roof garden. Although such measures are widely deployed, this project is distinguished as an innovative contribution to the region. Instead of manifesting a foreign element in the environment, great care is taken to effectively integrate the ensemble of indoor and outdoor spaces into the natural surroundings, suggesting an expanded conception of ecosystems. In addition to these concerns, every attempt has been made to maximize performance of both the architectural and natural systems while assuring their mutual resonance and compatibility. Also deserving merit is the intensive analysis of the building's adaptability to changing light conditions throughout the year. Overall, the work presents a very legible spatial order that is aesthetically cultivated and attuned to the needs of diverse local interests.
Project Photos:	

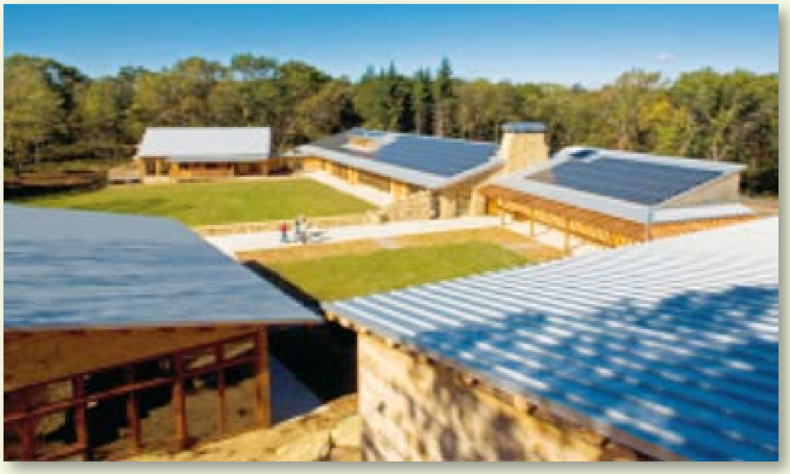
Overview:	**Research Center** **Bocas del Toro, Panama** **Climate Zone: 1 – 1A Hot/Humid** **New construction** **7,530 ft² (700 m²)** **Project scope: a single building** **Rural setting** **Completed October 2003**
The Process:	Pre-design: environmental goals for the project Design: using a design-build process created some problemsConstruction: difficult due to remote area, not all designed components were completed properlyOccupancy: monitoring the energy savings to see payback
Financing:	Grant: Private (foundation) Procurement process: Design-build Total project cost (land excluded): US$1,300,000
Environmental Aspects:	Building design takes cues from the local vernacular in its raised wood frame, siding, and large overhanging roofs. Its combination of high-tech and low-tech solutions suits its location as a remote research station with sophisticated scientific equipment form of the roof directs rainfall into centrally located tanks on the lower level, where it will be stored in 4,000-gallon storage containers, filtered, and treated with ultraviolet light before being used as the building's water supply. The unreliability of local grid was a major impetus behind the design. There is daylight in every room, and the main photovoltaic system has been configured so that after it turns off for a few seconds, when the main power goes off, it quickly turns on again when the on-site generator comes on. A secondary PV-UPS subsystem dedicates 6 kW PV to a 16-kWh battery bank serving one or two outlets in each lab for sensitive electronic equipment. Low-VOC paints were used throughout, and wood that did not need to be treated was chosen.
Lessons Learned:	An innovative, cutting-edge project is very difficult to achieve through a design-build process, especially in a remote location. The project was initially on an extremely fast-track schedule where construction began before drawings were complete. When full pricing came in, some features were cut or delayed until phase 2, even though it would have been more efficient to do them in phase 1. Nevertheless, most of the project's goals were fulfilled, and some aspects, such as the first-of-its-kind roof, were technical and economical successes

Overview:	**Housing** **Medellín, Colombia** **Climate Zone: 4 – 4B Arid**
Environmental Aspects:	The project is given distinction for its socially ambitious vision to provide affordable housing in areas where temporary shelters prevail. The authors demonstrate keen awareness of the fact that due to political and financial limitations in the region, almost all provisional shelters become permanent houses, yielding as a result very unsustainable conditions for human settlement. To counter this tendency, the project convincingly demonstrates the potential of introducing sustainable construction techniques, proposing to utilize industrialized modular wooden volumes that are upgradeable to a permanent house through the addition of new modules. Consequently, a new human settlement can be generated from a former emergency shelter area. High ethical standards are evidenced by the foreseeable integration of the inhabitants in the construction process. Ecologically, the project is also manifests a very responsible disposition by promoting the use of recycled wood and effective treatment of water and solid wastes. Socially, the work promotes collective interaction among community members while also providing zones necessary for individual privacy. The simplicity of the structures presents an economically feasible solution to low cost housing that is also applicable to other regions.
Project Photos:	

Overview:	**Elementary School** **Kirkland, Washington, USA** **Climate Zone: 3 – 3A Semiarid** **Building type: Education** **New construction** **56,800 ft² (5,280 m²)** **Project scope: 2-story building** **Suburban setting** **Completed August 2005** **Typically occupied by 483 people, 38 hours per person per week; and 200 visitors per week, 20 hours per visitor per week** **Total project cost (land excluded): US$9,857,000**
The Process:	The Ben Franklin Elementary School serves 450 students in kindergarten through grade six. The students are distributed within small learning communities, each including a cluster of four naturally ventilated and daylit classrooms around a multipurpose activity area. Stacked within two-story wings that extend toward the woods, these communities are integrally linked with views and access to nature beyond.
Financing:	The building was designed not to exceed the budget of a conventional building. Investing in the structure, building form, and architecture allowed the design team to reduce the size and amount of mechanical equipment. Because the design and construction process was funded by the State, the design team was required to perform a detailed comparative analysis of several building system options in the form of an energy life-cycle cost analysis. This process involved a review of mechanical options with varying system components to evaluate the cheapest option over a 30-year life span. The capital costs of the four systems varied within a range of approximately US$300,000, with the selected system at the mid-range of first costs, lower than the mechanically cooled systems in terms of replacement costs within the 30-year time frame, lower or equivalent for maintenance costs, and significantly lower in energy costs. After tradeoffs between mechanical and envelope systems were taken into account, the selected design was demonstrated to be the most cost-effective option.
Environmental Aspects:	The new school expands learning beyond the classroom by connecting the district's educational pedagogy with environmental sustainability at every level. The school was designed to preserve and harness the environment as a learning opportunity. The large wooded area along the north end of school's site is valued as a community asset. Creating connections to this rich natural environment became a primary goal in the design process. Two-story classroom wings reach like fingers toward the woods and visually connect students with nature. Between, courtyards landscaped with native plants and enhanced by integrated artwork, serve as outdoor classrooms and feature an intermittent stream fed by roof runoff. Gathering areas for outdoor classes are located within the landscaping. Because daylight and indoor air quality profoundly impact student performance, the school was designed to maximize performance in these areas. The classroom areas of the school are entirely naturally ventilated and daylit. This design also led to exemplary energy performance: the school is anticipated to use only 16,405 Btu per ft2 per year.

Lessons Learned:	Because school districts are charged with spending their constituents' resources wisely, a balance must be struck between what the districts knows is the responsible action and the public perception. Progressive thought is often tempered by the status quo. Recognizing that each building, client, and site has particular requirements was the first step to achieving the right balance of high-performance features. Schools in particular have many needs that are unique to the building type. High-performance strategies were established and agreed to by all individuals involved in the design and future maintenance and operations of the building. Ultimately this integrated process resulted in systems that work together and are fundamental to the building performance. In addition, support from other public entities was essential to the success of the project. Local and state agencies were receptive to the new approaches and rewarded the progressive goals of the district. The School district is committed post-occupancy evaluations to understand the effects of high-performance buildings on student test results, staff retention, student absenteeism, energy savings, and true total cost of ownership.
Project Photos:	

Overview:	**Office Center** **Baraboo, Wisconsin, USA** **Climate Zone: 2 – 2A Warm/Humid** **Building type(s): Interpretive Center, Commercial office** **New construction** **11,900 ft^2 (1,100 m^2)** **Project scope: 3 1-story buildings** **Rural setting** **Completed April 2007** **Rating: U.S. Green Building Council LEED-NC, v.2/v.2.1--Level: Platinum (61 points)** **Rating: Zero Energy Building**
The Process:	The goal for this project was to demonstrate how human activity, the built environment and the natural world are intertwined in a larger cycle of energy and life. Perhaps the most lasting achievement of the Legacy Center will be its strict adherence to a holistic design process consistent with Leopold's understanding of ecological systems, a process that offers the promise of shared benefit for both human inhabitants and the land.
Financing:	The Aldo Leopold Legacy Center was funded largely through the multiyear, US$6.9 million "Land Ethic Campaign" capital fundraising effort. In addition to providing construction funds, the Land Ethic Campaign proceeds will help restore and protect the historic Leopold Shack, preserve and maintain the Leopold archives, and establish an endowment fund. The Kresge Foundation provided a US$300,000 challenge grant and a US$50,000 green building planning grant. The architectural team provided conceptual fundraising materials and gave presentations at donor events. The site-harvested lumber had a market value conservatively estimated at US$250,000, more than 70% of the value of all lumber used in the project.
Environmental Aspects:	The Foundation located the project on a previously disturbed site, which it is restoring to native ecosystems. The project team used crushed gravel in place of blacktop or concrete paving, increasing rainwater infiltration and blending the developed areas into the surrounding landscape. The native landscaping requires no irrigation. Waterless urinals, dual-flush toilets, and efficient faucets reduce water consumption by 65%. An on-site well provides potable water, and an existing septic system treats wastewater. Thinning the Leopold forests improved forest health while providing 90,000 board feet of wood for use in the project. More than 75% of all wood used in the project was certified to Forest Stewardship Council standards, and 60% of all materials were manufactured within 500 miles of the project site. The Legacy Center was designed to use 70% less energy than a comparable conventional building. A 39.6-kW rooftop photovoltaic array produces more than 110% of the project's annual electricity needs. This excess renewable energy, along with on-site carbon sequestration, offsets the greenhouse gas emissions resulting from the project's operations. Daylighting eliminates the need for electric lighting during most of the day. Ground-source heat pumps connected to a radiant slab provide heating and cooling, and an earth-tube system provides tempered fresh air.

Lessons Learned:	Although the availability of Leopold wood presented an extraordinary opportunity unlikely to be repeated in other projects, the process through which the project team engaged in the design of this facility is replicable and holds lessons for the construction of other buildings. The Legacy Center's precedent-setting aspects include the rigorous analysis of its energy use and carbon footprint, its innovative approach to natural ventilation, its extensive use of locally harvested and recycled-content materials, and its small overall ecological footprint. The process of creating the Leopold Legacy Center was ultimately about finding real solutions to large-scale problems, about finding hope and a larger sense of community, and about demonstrating what it means to live on a piece of land without spoiling it.
Project Photos:	

Overview:	**University** **Gainesville, Florida, USA** **Climate Zone: 2 – 2A Warm/Humid** **Building type(s): Higher education** **New construction** **47,300 ft² (4,390 m²)** **Project scope: 3-story building** **Urban setting** **Completed March 2003** **Rating: U.S. Green Building Council LEED-NC, v.2/v.2.1--Level: Gold (39 points)**
The Process:	An interactive and open design process characterized the design of Rinker Hall from its start. Two three-day design workshops on site with faculty and students from the School of Architecture and School of Building Construction, University personnel, the construction manager, and the design team forged open communication from day one. These sessions helped clarify program elements, establish goals, test assumptions, and estimate costs. They also ensured a highly integrated, interactive process with a strong focus on environmental goals. Importantly, these workshops included input from University personnel charged with maintaining the building, mechanical systems, and site.
Financing:	It is important to note that the total budget was limited by previous State of Florida authorization limits, and neither design fees nor construction costs varied significantly from the norms for the University. Despite these budget challenges, the design team delivered this building for a construction cost of US$6.5 million, or US$137.50 per ft2. Cost data in U.S. dollars as of date of completion: Total project cost (land excluded): US$6,500,000 The cost of the green strategies employed in Rinker Hall was US$182,000. Using DOE 2.2 methodology and the Building Life-Cycle Cost method from the National Institute of Standards and Technology (NIST), the team estimates an annual utility savings of US$21,900, yielding an 8.3-year simple payback. The team considers this conservative, given reasonable energy-cost projections over the next 25 years. The client expressed ready acceptance of the 8.3-year payback, knowing that this calculation includes only energy savings and does not capture any of the benefits in productivity, health, or well-being.
Environmental Aspects:	Rinker Hall incorporates a range of green building features and, in 2004, achieved a LEED Gold rating. Rinker Hall is oriented on a pure north-south axis, demonstrating the ability to utilize low-angle light for daylighting. Egress paths from all classrooms at all levels are daylit, allowing for emergency exit during a daytime power failure. Materials were reviewed for proximity in manufacturing, recycled content, renewable-resource content, sustainable harvesting, longevity, low maintenance requirements, low toxicity, and ability to be recycled or reused at the end of a useful life. Large-scale, open, linear accessibility was “mapped” through all major classroom spaces in such a manner as to provide nondisruptive servicing and maximum flexibility for future retrofit. The building was also designed through material selection, assembly, and detailing to facilitate disassembly. Two major programmatic areas, the assembly room on the north and the construction shop on the east, were fully or partially incorporated in the design as indoor/outdoor spaces. They take advantage of measurable thermal shading and sheltering attributes at the “edge condition” of the building.

Lessons Learned:	A first-order objective was to demonstrate that a high-performance design (LEED Gold) could be completed within the constraints of the State of Florida budget scale (US$137.50 per ft2). We realized that with 74°F groundwater in an area defined by ASHRAE as a humid climate belt, we were going to get major benefits from energy innovation compared to conventional practice. In this unique setting, large performance gains were achieved and were assisted by savings through materials minimization and simplification (for example, sealed concrete floors in classrooms). When creating high accessibility and flexibility for future growth and change, carefully consider the environmental positives of each material removed. For example, we had to return to acoustically "tune" hard-slab conditions above several mechanical system vents.
Project Photos:	

Overview:	**Care Center-Augustijnslei** **Antwerp, Belgium** **Climate Zone: 3 – 3B Warm Marine** **Refurbishment (2003-2010)** **Size:7,314m²**
The Process:	The Rotonde is a Belgium non-profit organization taking care of mentally handicapped adults.
Environmental Aspects:	Energy Management is a core element of the general policy of the organization and is recognized in Belgium as a pioneer in energy management in its sector. Heating System: condensation boiler with improved control space temperature in the separate buildings. 12 cm insulation on the roof High performance double glazing windows Energy saving light bulbs 11.2 kW photovoltaic panels Professional energy monitoring system High performance pumps for central heating system. Primary energy demand: 3,316,000 kWh/a (consumption) Electricity demand: 372,000 kWh/a (consumption) Primary Energy savings: 1,500,400 kWh/a (45%) 18% electricity savings and 56% natural gas savings CO_2 savings 309 t/a

Overview:	**Library-Split** **Split, Croatia** **Climate Zone: 6 – 6B Highlands** **New Construction (2008)** **Size: 13,700m^2**
The Process:	University of Split was founded in 1974 and consists of 9 faculties, an Academy of Arts and several institutes and scientific facilities. Scientific works is in the field of natural, historic, social, economic, and other disciplines characteristic of Croatian, Adriatic and Mediterranean area.
Environmental Aspects:	The University library in Split uses alternative energy sources and high efficient systems with heat recovery. The building is completely ventilated and air conditioned for specific purposes and as a result has better indoor air quality. There are three main areas: lower building with 6 underground levels and upper building with 7 levels. Double skin glass façade with inner space 80cm width in which natural air is circulating providing buffer zone both in winter and summer. Ventilation system with heat recovery of 80-92%. Cooling Energy is supplied by adiabatic process and mechanical cooling integrated in air conditioning system and compact cooling device. Primary energy demand of 806,400 kWh for heating and cooling which is 51 kWh/m2a Total Energy Savings estimated at 35% CO2 savings 149t/a
Project Photos:	

Overview:	**Industrial Warehouse-Banco Sabadell** **Barcelona,Spain** **Climate Zone: 3 – 3B Warm Marine** **New Construction (2005)** **Size: 12,046m²**
The Process:	Banco Sabadell is a financial company which planned a new warehouse for documentation and utilities. The new warehouse was developed in collaboration with Coperfil (endorser of the GreenBuilding program). The goal was to achieve a consumption of energy.
Environmental Aspects:	The building's main characteristics to achieve energy efficiency are: Increase of sky domes and windows in façade Low level lighting, daylight use at the working place Lighting regulation with the human presence 12 kWp Photovoltaic roof system and solar thermal water heating system. Complemented with other measures the energy demand was reduced by 56.7 %. The Building has a good level of insulation and it maintains a comfortable temperature, without heating or air-conditioning in the warehouse, only in the office areas. Primary energy demand: 1,377,358 kWh/a compared reference building Electricity demand: 468,000 kWh/a compared to reference building Total Energy Savings: 265,633 kWh/a CO2 savings 121 t/a
Project Photos:	

Annex

Financial schemes for Green Buildings
Developing Indicators for DEM
High Efficient Building Specification Guidance as of ASHRAE - Technology Matrix
Articles & Reports
Additional Resources

1. Financial schemes for Green Buildings

The following section will briefly outline three major financing schemes to scale-up local investments into the green housing and building sectors. Pilot projects financed by the IADB in different member countries could lead to a transformation in the local construction and building sector if they have the potential to be replicated in a bigger scale.

1.1. Green building lending through local financial institutions

1.1.1. Commercial Banks

Design of major operations might begin with partnering with the financial intermediaries. With this approach, project development begins with identification of local financial intermediaries interested in green building lending, followed by design of green building lending programs that conform to the specific business interests of those financial intermediaries. Once local financial intermediaries have successfully finance one major green building operation, they could offer the same financing product to other clients interested in green building construction.

1.1.2. Loan Guarantee Programs

Partial-risk loan guarantee programs supported by international financial institutions have shown some success in recent years in jump-starting energy efficiency financing programs such as lending programs for energy efficient building through local financial institutions. These guarantee instruments are designed to defray part of the risks of loan repayment for energy efficiency loans, and are particularly useful where local financial institutions attach additional risks to business concepts of energy efficiency because they are unfamiliar with the concepts or with specialized means to mitigate those risks. The instrument also may provide a useful platform for delivery of a broad package of assistance to financial intermediaries, including technical support for development of energy efficient building loan products or for development of institutional arrangements for meeting technical assessment requirements.

1.2. Energy service companies (ESCOs)

ESCOs can be an important institutional mechanism involved in delivery of energy efficient building investment. The term ESCO may mean different things to different people. At times, the term is used simply to describe companies involved in completing technical assessment work, especially energy audits. In this context, ESCOs are defined to include any company using energy performance contracting as part of energy efficiency investment transactions. An energy performance contract (EPC) in the ESCO business may be broadly defined as a contract between the ESCO and its client, involving an energy efficiency investment in the client's facilities, the performance of which is somehow guaranteed by the ESCO, with financial consequences for the ESCO. Technical assessment work is a key part of the work of all ESCOs. Although there are many variations in the business models used, a key distinction between ESCO business models involves whether or not the ESCO provides any financing for the investment projects it develops. A business model is called "full service" ESCO model, if the ESCO identifies, designs, finances, and oversees installation and commissioning of projects in the facilities of the client, and receives compensation in the form of a share of the energy savings achieved over a defined period, according to a "shared savings" EPC. ESCOs that do not provide financing to clients may best be categorized as technical assessment and engineering services entities, although their guarantee of the energy savings from investments may be a critical element for closing the related financing contract between a financier and the client. The ESCO model offers an appealing, market-based approach to energy efficiency project development. Especially where ESCOs finance projects, they offer an attractive proposition to clients: the ESCO will do the project design and management, shoulder the specific project technical risks, provide off-balance-sheet financing, and seek payment only from the cash flow of energy savings.
In Brazil for instance, there are dozens of engineering firms providing some energy efficiency services, of which fewer than 25 have sufficient project flow to permit more diversified professional capacity and can potentially enter into EPCs. Investments of these companies are estimated to be on the order of US$40 million per year.

1.3. Energy utility demand – side management (DSM)

A strong advantage of utility DSM is the use of what are usually well-developed and financially strong utility institutions that have direct relations with energy users for program delivery. In some cases, as in the case of the Colombian utility company CONDESA and EPM, utilities may even be able to use electricity bills as the contractual mechanism to ensure repayment from customers for energy efficiency investments. A strong disadvantage of this mechanism is that most utilities do not have natural incentives to promote true energy conservation (as distinguished from load management), which results in a loss of sales of their core product. Although temporary energy shortages may spark utility interest in promoting energy efficiency for a time, especially when subject to high-profile publicity and political pressure, the fundamental economics of the utility's position as an energy supplier still tends to undermine utility interest in DSM/energy efficiency programs over time. In countries such as the United States, therefore, DSM programs were only successful on a large scale when governments and regulators made the programs mandatory and they allowed utilities to receive special compensation from electricity consumers for lost revenues. To use the DSM mechanism effectively, the utility incentive issue must be properly addressed.

2. Developing Indicators for DEM

2.1. Energy prices per kWh in LAC

Figure 11: 2006 Energy prices per kWh in the countries

PRICES			
Electricity Industry US$/kWh Domestic WITH TAX	industry	commercial	residential
COUNTRY		2006	
DOMINICAN REPUBLIC	0.005	0.003	0.006
TRINIDAD AND TOBAGO	0.028	0.039	0.036
ARGENTINA	0.078	0.086	0.039
VENEZUELA	0.032	0.040	0.045
PARAGUAY	0.044	0.071	0.066
BOLIVIA	0.047	0.102	0.067
COSTA RICA	0.063	0.094	0.074
HAITI	0.107	0.112	0.076
HONDURAS	0.107	0.132	0.079
MEXICO	0.116	0.223	0.101
COLOMBIA	0.095	0.124	0.103
GUATEMALA	0.115	0.118	0.120
PERU	0.067	0.092	0.121
PANAMA	0.104	0.125	0.128
CHILE	0.102	0.162	0.152
EL SALVADOR	0.153	0.149	0.161
URUGUAY	0.066	0.106	0.162
NICARAGUA	0.174	0.222	0.173
SURINAME	0.132	0.186	0.184
BRAZIL	0.125	0.168	0.193
CUBA	0.087	0.110	0.212
BARBADOS	0.226	0.229	0.216
GUYANA	0.237	0.255	0.220
GRENADA	0.188	0.234	0.221
JAMAICA	0.183	0.231	0.248
ECUADOR	-	-	-

3. High Efficient Building Specification Guidance as of ASHRAE - Technology Matrix

ASHRAE Standard 90.1 is a code that has been adopted as state or local energy code in many jurisdictions. Alternatively, a jurisdiction may choose to adopt the International Energy Conservation Code (IECC), which allows ASHRAE 90.1 as a compliance path. Standard 90.1 is updated by addenda that are compiled every 18 months, and is published in full every three years due to changes in technologies. ASHARE is focused on keeping the code aggressive so updates are vital.
Application of the recommendations in the matrix should result in 30% energy savings when compared to those buildings designed to the minimum requirements of ANSI/ASHRAE/IESNA Standard 90.1-1999. This Guide represents a way, but is not exclusive to build energy-efficient buildings that use significantly less energy than those built to minimum code requirements. A matrix is provided for small office-, small retail buildings, schools and hospitals. The recommendations in this Guide provide benefits for the owner while maintaining quality and functionality of the space.
Legend:

• **R-value:** indicates an insulation resistance to heat flow. The higher the R-value, the greater the insulating effectiveness.
• U-factor or coefficient of heat transmission: a measure of the rate of non-solar heat loss or gain through a material or assembly. U-values gauge how well a material allows heat to pass through. The lower the U-value, the greater a product's resistance to heat flow and the better its insulating value. The inverse of (one divided by) the U-value is the R-value.

• **(SHGC):** measures how well a window blocks heat from sunlight. The SHGC is the fraction of the heat from the sun that enters through a window. SHGC is expressed as a number between 0 and 1. The lower a window's SHGC, the less solar heat it transmits.

• **Projection factor:** enables you to characterize the shading impact of horizontal overhangs or canopies that project outward from the plane of the window. The projection factor is the ratio of the distance the overhang projects from the window surface to its height above the sill of the window it shades.

o Window-to-Wall Ratio (WWR): ratio of transparency (e.g windows) to solidity (e/g walls) and is part of determining the requirements for day lighting. Seasonal Energy Efficiency Ratio (SEER):) cooling output in Btu (British thermal unit) during a typical cooling-season divided by the total electric energy input in watt-hours during the same period. The higher the SEER rating the more energy efficient the air conditioner.

• **Energy Efficiency Ratio (EER)** the ratio of output cooling (in Btu/hr) to input electrical power (in Watts) at a given operating point (indoor and outdoor temperature and humidity conditions). The Seasonal Energy Efficiency Ratio (SEER) has the same units of Btu/W•hr, but instead of being evaluated at a single operating condition, it represents the expected overall performance for a typical year's weather in a given location. The EER is related to the coefficient of performance (COP), with the primary difference being that the COP of a cooling device is unit-less: the cooling load and the electrical power needed to run the device are both measured using the same units, e.g. watts. Therefore a COP is universal and can be used in any system of units. However, the COP is an instantaneous measure (i.e. a measure of power divided by power), whereas both EER and SEER are averaged over a duration of time (i.e. they are measures of energy divided by energy). The time duration considered is several hours of constant conditions for EER, and a full year of typical meteorological and indoor conditions for SEER. Integrated part-load value (IPLV) similar to EER but weighs performance at different (peak and off-peak) conditions during the cooling season.

• **Annual Fuel Utilization Efficiency (AFUE)** It measures the amount of heat actually delivered to your house compared to the amount of fuel that you must supply to the furnace. Thus, a furnace that has an 80% AFUE rating converts 80% of the fuel that you supply to heat -- the other 20% is lost out of the chimney.
Explanation how to use the matrix
This matrix can help building owners make good choices about particular areas of building design. First, select the climate zone that the project is located in, next select a feature or features that the project would like to focus on for energy efficiency. These specification can be used together to meet 30% efficiency or separately although the best way to ensure maximum savings is to incorporate as many specifications as possible. The specifics of each project will also dictate what is possible and engineers should be consulted prior to finalizing any program plan. To see the different climate zones please refer to item: 8 Climate Zones in Latin America and the Caribbean
The following table is applicable for small office buildings only. Specific information on hospitals and schools can be found at: http://www.ashrae.org/technology/page/938

Figure 12: Building specification guideline for small office buildings

ZONE	PROJECT HIGHLIGHTS - REAL WORL EXAMPLES per ZONE	ROOF	DOORS	VERTICAL GLAZING	SKYLIGHTS
1	• Using a geothermal system air conditioning system that pumps cool groundwater through a heat exchanger to cool the building; small scale solar panels are also used on the roof to convert sunlight into electricity • The envelop is made from precast panels of lightweight autoclaved aerated concrete which allows for better insulation; the insulation rating is more than double what is considered “standard” • Rainwater from the roof is channeled into a 28,000 gallon (annual rainfall of 54 inches) underground cistern; water is filtered for debris and used to flush toilets and irrigate landscaping • Taking advantage of daylighting using daylight sensors that call for artificial light only when needed • No windows on the east and west sides of the building; windows to the south are shaded with roof overhang, insulated, double-pane, impact-resistant windows on the north side allow for natural light	Insulation = R-15 c.i.	Swinging = U-0.70	Window to Wall Ratio = 20%-40%	Maximum Percent of Roof Cover = 3%
		Metal Building = R-19	Non-Swinging = U-1.45	Max Thermal Transmittance = U-0.56	Thermal Transmittance = U-1.36
		Attic and Other = R-30		Solar Heat Gain Coefficient = N,S,E,W, -0.35 (N only -0.49)	Solar Heat Gain Coefficient (SHGC) = 0.19
		Single Rafter = R-30		Window Orientation = Ax-Window are for orientation	
		Surface Reflectance/ Emittance = 0.65 initial/0.86		Exterior Sun Control (S,E, W only) = Projection Factor 0.5	
2	• Some of the energy-saving strategies include the use of occupancy sensor lighting, harmonic transformers, low-E insulated glazing, an east-west orientation, appropriate glazing locations, and an efficient HVAC system. • Vegetated swales and bioretention basins were designed to reduce the rate of stormwater runoff and remove water contaminants. • Water-saving fixtures include motion sensor lavatory faucets, waterless urinals, and low-flow kitchen faucets and shower heads • The roof system and paving surfaces with a high reflectance help minimize heat absorbed on the site. • Windows are located throughout the building to provide daylight and views for more than 75 percent of all the occupied spaces	Insulation = R-15 c.i.	Swinging = U-0.70	Window to Wall Ratio = 20%-40%	Maximum Percent of Roof Cover = 3%
		Metal Building = R-19	Non-Swinging = U-1.45	Max Thermal Transmittance = U-0.45	Thermal Transmittance = U-1.36
		Attic and Other = R-38		Solar Heat Gain Coefficient = N,S,E,W, -0.31 (N only -0.44)	Solar Heat Gain Coefficient (SHGC) = 0.19
		Single Rafter = R-38		Window Orientation = Ax-Window are for orientation	
		Surface Reflectance/ Emittance = 0.65 initial/0.86		Exterior Sun Control (S,E, W only) = Projection Factor 0.5	

	INTERIOR LIGHTING	HVAC	VENTILATION	DUCTS	SERVICE WATER HEATER
	Lighting Power Density (LPD) = 0.9 W/sf	Air Conditioner (0-65KBtuh) = 13.0 SEER	Outside Air Damper = Motorized Control	Friction Rate = 0.08 in. w.c./100 ft	Gas Storage = 90% Et
	Light Source (liner flourescent) = 90 mean lumen/watt	AC (>65-135KBtuh) = 11.3 EER/11.5 IPLV	Demand Control = CO2 Sensors	Sealing = Seal Class B	Gas Instantaneous = 0.81 EF or 81%Et
	Ballast = Electronic Ballasts	AC (>135-240KBtuh) = 11.- EER/11.5 IPLV		Location = Interior Only	Electrical Storage 12kW = EF>0.99-0.0012xVolume
	Dimming Controls for Daylight Harvesting for WWR 25% or higher = Dim Fixtures within 12 ft of N/S Window wall or within 8 ft of skylight edge	AC (>240KBtuh) = 10.6 EER/11.2 IPLV		Insulation Level = R-6	Pipe Insulation (d<1.5in./d≥1.5in) = 1in./1.5in
	Occupancy Controls = Auto-off all unoccupied rooms	Gas Furnace (0-225KBtuh-SP) = 80% AFUE			
	Interior Room Surface reflectances = 80%+ on ceilings, 70%+ on walls and vertical partitions	Gas Furnace (0-225KBtuh - Split) = 80% AFUE			
		Gas Furnance (0-225KButh) = 80% Ec			
		Heat Pump (0-65KBtuh) = 13.0 SEER/7.7 HSPF			
		Heat Pump (>65-135KBtuh) = 10.6 EER/11.0 IPLV/3.2 COP			
		Heat Pump (>135KBtuh) 10.1 EER/11.5 IPLV/3.1 COP			

	Lighting Power Density (LPD) = 0.9 W/sf	Air Conditioner (0-65KBtuh) = 13.0 SEER	Outside Air Damper = Motorized Control	Friction Rate = 0.08 in. w.c./100 ft	Gas Storage = 90% Et
	Light Source (liner flourescent) = 90 mean lumen/watt	AC (>65-135KBtuh) = 11.3 EER/11.5 IPLV	Demand Control = CO2 Sensors	Sealing = Seal Class B	Gas Instantaneous = 0.81 EF or 81%Et
	Ballast = Electronic Ballasts	AC (>135-240KBtuh) = 11.- EER/11.5 IPLV		Location = Interior Only	Electrical Storage 12kW = EF>0.99-0.0012xVolume
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	Occupancy Controls = Auto-off all unoccupied rooms	Gas Furnace (0-225KBtuh-SP) = 80% AFUE			
	Interior Room Surface reflectances = 80%+ on ceilings, 70%+ on walls and vertical partitions	Gas Furnace (0-225KBtuh - Split) = 80% AFUE			
		Gas Furnance (0-225KButh) = 80% Ec			
		Heat Pump (0-65KBtuh) = 13.0 SEER/7.7 HSPF			
		Heat Pump (>65-135KBtuh) = 10.6 EER/11.0 IPLV/3.2 COP			
		Heat Pump (>135KBtuh) 10.1 EER/11.5 IPLV/3.1 COP			

ZONE	PROJECT HIGHLIGHTS - REAL WORL EXAMPLES per ZONE	ROOF	DOORS	VERTICAL GLAZING	SKYLIGHTS
3	• The buildings feature operable windows and natural ventilation. The buildings' geometry further encourages natural ventilation because of the shallow floor plates that place occupants close to a window. • To avoid a harsh glare, fluorescent uplighting was selected because of its soft, shadow-free low-glare quality of light, particularly good where there is high computer use. Skylights provide natural lighting. To increase interior daylighting, evergreen trees were removed (and replaced with deciduous trees) on the buildings' south side. Primarily unoccupied spaces are away from daylight sources. Lighting controls are ordinary light switches combined with occupancy sensors in many areas, especially areas with intermittent use. • Low-flow plumbing fixtures were installed because they conserve water as well as reduce distribution pumping energy and lower domestic hot water heating energy. Other water-conserving strategies include the use of drought-tolerant plants in the landscaping, use of low-flow irrigation systems, and the capture of rainwater for supplemental irrigation	Insulation = R-20 c.i.	Swinging = U-0.70	Window to Wall Ratio = 20%-40%	Maximum Percent of Roof Cover = 3%
		Metal Building = R-13 + R-13	Non-Swinging = U-1.45	Max Thermal Transmittance = U-0.42	Thermal Transmittance = U-0.69
		Attic and Other = R-38		Solar Heat Gain Coefficient = N,S,E,W, -0.31 (N only -0.46)	Solar Heat Gain Coefficient (SHGC) = 0.19
		Single Rafter = R-38		Window Orientation = Ax-Window are for orientation	
		Surface Reflectance/ Emittance = 0.65 initial/0.86		Exterior Sun Control (S,E, W only) = Projection Factor 0.5	
4	• Site location and building orientation were taken advantage of to allow south-facing windows and skylights for solar gain. • The windows are all occupant-controlled and provide 100 percent of ventilation needs. • No air conditioning is used with the building; instead, a night-flushing ventilation system is used to pre-cool the building with the region's cool nighttime air. The system incorporates a high-level exhaust vent that uses gravity to vent hot air from the building, maintaining interior air temperatures at comfortable levels. • Siltation blockage of permeable paving was a concern, which led to two separate demonstration techniques. The first is a prefab plastic infiltration vault system under the drive-through paving. In the second system, water from the roof is discharged through a scupper into a landscaping pond for storage and settling before the water is reabsorbed into sandfill below. • Building envelope efficiency was achieved with R-21 walls, R-38 floors and roof, U.30 windows and U.38 skylights. As a result, the building provides an aggregate of twice the code standards for energy efficiency. • Inside the building, all cabinetry and partitions, except the teller steel, were built locally, from local materials. Eighty-five percent of the county the building is in is part of the world's most productive timber-growing area. Wherever possible, minimally processed, nontoxic, and recycled-content materials were used, including driftwood posts and door handles, natural linoleum and slate flooring, low-toxicity paints and wood finishes, and recycled desks and carpet pads. The resulting product is a building that honors its natural community and its resources.	Insulation = R-20 c.i.	Swinging = U-0.70	Window to Wall Ratio = 20%-40%	Maximum Percent of Roof Cover = 3%
		Metal Building = R-13 + R-19	Non-Swinging = U-0.50	Max Thermal Transmittance = U-0.56	Thermal Transmittance = U-0.69
		Attic and Other = R-38		Solar Heat Gain Coefficient = N,S,E,W, -0.46 (N only -0.46)	Solar Heat Gain Coefficient (SHGC) = 0.34
		Single Rafter = R-38		Window Orientation = Ax-Window are for orientation	
		Surface Reflectance/ Emittance = No Recommendation		Exterior Sun Control (S,E, W only) = Projection Factor 0.5	

	INTERIOR LIGHTING	HVAC	VENTILATION	DUCTS	SERVICE WATER HEATER
	Lighting Power Density (LPD) = 0.9 W/sf	Air Conditioner (0-65KBtuh) = 13.0 SEER	Outside Air Damper = Motorized Control	Friction Rate = 0.08 in. w.c./100 ft	Gas Storage = 90% Et
	Light Source (liner flourescent) = 90 mean lumen/watt	AC (>65-135KBtuh) = 11.0 EER/11.4 IPLV	Demand Control = CO2 Sensors	Sealing = Seal Class B	Gas Instantaneous = 0.81 EF or 81%Et
	Ballast = Electronic Ballasts	AC (>135-240KBtuh) = 10.8- EER/11.2 IPLV		Location = Interior Only	Electrical Storage 12kW = EF>0.99-0.0012xVolume
	Dimming Controls for Daylight Harvesting for WWR 25% or higher = Dim Fixtures within 12 ft of N/S Window wall or within 8 ft of skylight edge	AC (>240KBtuh) = 10.0 EER/10.4 IPLV		Insulation Level = R-6	Pipe Insulation (d<1.5in./d≥1.5in) = 1in./1.5in
	Occupancy Controls = Auto-off all unoccupied rooms	Gas Furnace (0-225KBtuh-SP) = 80% AFUE			
	Interior Room Surface reflectances = 80%+ on ceilings, 70%+ on walls and vertical partitions	Gas Furnace (0-225KBtuh - Split) = 80% AFUE			
		Gas Furnance (0-225KButh) = 80% Ec			
		Heat Pump (0-65KBtuh) = 13.0 SEER/7.7 HSPF			
		Heat Pump (>65-135KBtuh) = 10.6 EER/11.0 IPLV/3.2 COP			
		Heat Pump (>135KBtuh) 10.1 EER/11.0 IPLV/3.1 COP			

	Lighting Power Density (LPD) = 0.9 W/sf	Air Conditioner (0-65KBtuh) = 13.0 SEER	Outside Air Damper = Motorized Control	Friction Rate = 0.08 in. w.c./100 ft	Gas Storage = 90% Et
	Light Source (liner flourescent) = 90 mean lumen/watt	AC (>65-135KBtuh) = 11.0 EER/11.4 IPLV	Demand Control = CO2 Sensors	Sealing = Seal Class B	Gas Instantaneous = 0.81 EF or 81%Et
	Ballast = Electronic Ballasts	AC (>135-240KBtuh) = 10.8- EER/11.2 IPLV		Location = Interior Only	Electrical Storage 12kW = EF>0.99-0.0012xVolume
	Dimming Controls for Daylight Harvesting for WWR 25% or higher = Dim Fixtures within 12 ft of N/S Window wall or within 8 ft of skylight edge	AC (>240KBtuh) = 10.0 EER/10.4 IPLV		Insulation Level = R-6	Pipe Insulation (d<1.5in./d≥1.5in) = 1in./1.5in
	Occupancy Controls = Auto-off all unoccupied rooms	Gas Furnace (0-225KBtuh-SP) = 80% AFUE			
	Interior Room Surface reflectances = 80%+ on ceilings, 70%+ on walls and vertical partitions	Gas Furnace (0-225KBtuh - Split) = 80% AFUE			
		Gas Furnance (0-225KButh) = 80% Ec			
		Heat Pump (0-65KBtuh) = 13.0 SEER/7.7 HSPF			
		Heat Pump (>65-135KBtuh) = 10.6 EER/11.0 IPLV/3.2 COP			
		Heat Pump (>135KBtuh) 10.1 EER/11.0 IPLV/3.1 COP			

ZONE	PROJECT HIGHLIGHTS - REAL WORL EXAMPLES per ZONE	ROOF	DOORS	VERTICAL GLAZING	SKYLIGHTS
5	• Thus, the all-electric building relies on renewable energy sources, including an on-site photovoltaic array that powers the building's closed-loop ground-source heat pump system. Careful detailing of the envelope optimizes use of these resources—the building is well-insulated, with an extremely secure envelope. • Through careful sitting, the building's design and location take advantage of natural features to achieve thermal comfort. The 19,200-square-foot office building is elongated along an east-west axis to gain optimal solar energy. Skylights and full-height windows provide abundant daylight and access to views, while ventilation systems and operable windows supply fresh air. A temperature and humidity monitoring system further enhances indoor environmental quality.	Insulation = R-20 c.i.	Swinging = U-0.70	Window to Wall Ratio = 20%-40%	Maximum Percent of Roof Cover = 3%
		Metal Building = R-13 + R-19	Non-Swinging = U-0.50	Max Thermal Transmittance = U-0.43	Thermal Transmittance = U-0.69
		Attic and Other = R-38		Solar Heat Gain Coefficient = N,S,E,W, -0.46 (N only -0.46)	Solar Heat Gain Coefficient (SHGC) = 0.39
		Single Rafter = R-38 +R-5 c.i.		Window Orientation = Ax-Window are for orientation	
		Surface Reflectance/ Emittance = no recommendation		Exterior Sun Control (S,E, W only) = Projection Factor 0.5	
6	• A 1998 renovation of the headquarters included installation of a photovoltaic array and wood-chip boiler. Placing the wood-chip boiler in a separate building eliminates all combustion from the building. • A south-facing clerestory, which runs the length of the wing, and four moderate-sized north-facing skylights illuminate a two-story atrium. Each office is lit with lighting from two outside windows. To give occupants even lighting throughout their offices, the windows are placed close to the sidewalls. • High-efficiency, occupancy-sensor-controlled single-lamp fluorescent fixtures and task lighting are used in the offices. Occupancy sensors are used in the kitchen, bathrooms, copier room, and conference rooms. Airtight construction, in combination with R-25 walls and R-42 roof, are key to achieving the wing's low heating requirement. • The integration of daylighting, efficient artificial lighting, and building envelope allow the building to achieve energy usage 60 percent below the ASHRAE 90.1 baseline. • Water conservation is addressed by use of composting toilets and recycled graywater pumped to planters surrounding the atrium at the second floor and then to a wild-flower garden. No septic system is required. The result of the water-saving technologies is a 90 percent water reduction of the baseline building modeled using the Energy Policy Act of 1992. • Electricity is used in place of gas for the kitchen range and summertime water heating. A central heat-recovery ventilator is in the building's basement and provides ducted fresh air to all the offices. • The building is cooled by a whole-building fan that is turned on at night and off in the morning. Only the copier room has mechanical air conditioning.	Insulation = Insulation = R-20 c.i.	Swinging = U-0.70	Window to Wall Ratio = 20%-40%	Maximum Percent of Roof Cover = 3%
		Metal Building = R-13 + R-19	Non-Swinging = U-0.50	Max Thermal Transmittance = U-0.42	Thermal Transmittance = U-0.69
		Attic and Other = R-38		Solar Heat Gain Coefficient = N,S,E,W, -0.46 (N only -0.46)	Solar Heat Gain Coefficient (SHGC) = 0.49
		Single Rafter = R-38 + R-5 c.i.		Window Orientation = Ax-Window are for orientation	
		Surface Reflectance/ Emittance = no recommendation		Exterior Sun Control (S,E, W only) = no recommendation	

	INTERIOR LIGHTING	HVAC	VENTILATION	DUCTS	SERVICE WATER HEATER
	Lighting Power Density (LPD) = 0.9 W/sf	Air Conditioner (0-65KBtuh) = 13.0 SEER	Outside Air Damper = Motorized Control	Friction Rate = 0.08 in. w.c./100 ft	Gas Storage = 90% Et
	Light Source (liner flourescent) = 90 mean lumen/watt	AC (>65-135KBtuh) = 11.0 EER/11.4 IPLV		Sealing = Seal Class B	Gas Instantaneous = 0.81 EF or 81%Et
	Ballast = Electronic Ballasts	AC (>135-240KBtuh) = 10.8- EER/11.2 IPLV		Location = Interior Only	Electrical Storage 12kW = EF>0.99-0.0012xVolume
	Dimming Controls for Daylight Harvesting for WWR 25% or higher = Dim Fixtures within 12 ft of N/S Window wall or within 8 ft of skylight edge	AC (>240KBtuh) = 10.0 EER/10.4 IPLV			
	Occupancy Controls = Auto-off all unoccupied rooms	Gas Furnace (0-225KBtuh-SP) = 80% AFUE	Demand Control = CO2 Sensors		
	Interior Room Surface reflectances = 80%+ on ceilings, 70%+ on walls and vertical partitions	Gas Furnace (0-225KBtuh - Split) = 90% AFUE		Insulation Level = R-6	Pipe Insulation (d<1.5in./d≥1.5in) = 1in./1.5in
		Gas Furnace (0-225KButh) = 80% Ec			
		Heat Pump (0-65KBtuh) = 13.0 SEER/7.7 HSPF			
		Heat Pump (>65-135KBtuh) = 10.6 EER/11.0 IPLV/3.2 COP			
		Heat Pump (>135KBtuh) 10.1 EER/11.0 IPLV/3.1 COP			

	Lighting Power Density (LPD) = 0.9 W/sf	Air Conditioner (0-65KBtuh) = 13.0 SEER	Outside Air Damper = Motorized Control	Friction Rate = 0.08 in. w.c./100 ft	Gas Storage = 90% Et
	Light Source (liner flourescent) = 90 mean lumen/watt	AC (>65-135KBtuh) = no recommendation		Sealing = Seal Class B	Gas Instantaneous = 0.81 EF or 81%Et
	Ballast = Electronic Ballasts	AC (>135-240KBtuh) = no recommendation		Location = Interior Only	Electrical Storage 12kW = EF>0.99-0.0012xVolume
	Dimming Controls for Daylight Harvesting for WWR 25% or higher = Dim Fixtures within 12 ft of N/S Window wall or within 8 ft of skylight edge	AC (>240KBtuh) = no recommendation			
	Occupancy Controls = Auto-off all unoccupied rooms	Gas Furnace (0-225KBtuh-SP) = 80% AFUE			
		Gas Furnace (0-225KBtuh - Split) = 90% AFUE	Demand Control = CO2 Sensors		
		AFUE Gas Furnance (0-225KButh) = 80% Ec			
		Heat Pump (0-65KBtuh) = 13.0 SEER/7.7 HSPF		Insulation Level = R-6	Pipe Insulation (d<1.5in./d≥1.5in) = 1in./1.5in
	Interior Room Surface reflectances = 80%+ on ceilings, 70%+ on walls and vertical partitions	Heat Pump (>65-135KBtuh) = no recommendation			
		Heat Pump (>135KBtuh) = no recommendation			

ZONE	PROJECT HIGHLIGHTS - REAL WORL EXAMPLES per ZONE	ROOF	DOORS	VERTICAL GLAZING	SKYLIGHTS
7	• The building was built on a south-facing slope to provide the building with exposure to sunlight. This access to sunlight enables the center to have passive solar features, natural lighting, ground-source heat pumps, and solar walls. There are solar panels mounted on the roof, capable of producing 11.8 kilowatts of electrical power. • The building has insulated concrete forms, heat recovery ventilation, and energy system sensors that track energy use as well as energy produced by the solar panels. • The nature center also used sustainable and environmentally preferable building materials, such as 100 percent recycled content roof shingles, recycled content ceiling tiles, Forest Steward Council certified wood, recycled content carpet tiles, natural-based wood glaze, and non-PVC materials. • The center also constructed a pervious paving system on the walkways to minimize stormwater runoff.	Insulation = R-20 c.i.	Swinging = U-0.70	Window to Wall Ratio = 20%-40%	Maximum Percent of Roof Cover = 3%
		Metal Building = R-13 + R-19	Non-Swinging = U-0.05	Max Thermal Transmittance = U-0.33	Thermal Transmittance = U-0.69
		Attic and Other = R-60		Solar Heat Gain Coefficient = N,S,E,W, no recommendation	Solar Heat Gain Coefficient (SHGC) = 0.64
		Single Rafter = R-39 + R-10 c.i.		Window Orientation = no recommendation	
		Surface Reflectance/ Emittance = no recommendation		Exterior Sun Control (S,E, W only) =no recommendation	
8	• Zone 8 receives an average of more than 50 inches of snow each year and is characterized by high winds and temperatures as low as –40° F in the winter. Thus, the Community Health Services Building is heated by fuel-oil-fired boilers. Diesel-electric generators provide all power needs for the community. • The building's placement on the site considers the prevailing wind direction. The placement protects the entry from blowing snow and accommodates "wind scour" that keeps snow from building up at entrances and under the building. The building is set on steel piling driven deep into the permanently frozen soil (permafrost). To prevent thawing of the permafrost and subsequent foundation failure, the building is completely isolated from the soil by an open air space of four feet or more. Although this feature compounds envelope heat loss by adding another surface to the envelope, the building is, however, energy efficient with R-values ranging from R-30 for the walls and under-floor to R-50 for the roof. • The exterior vestibule (arctic entry) was designed to create a temperature buffer between the indoors and outdoors. The separation creates an air chamber that reduces heat loss when the doors are open. • Motion-sensor lighting controls and high-efficiency lighting fixtures contribute to energy savings. To reduce power consumption, lighter hues of color were used to make each lumen "go farther" and interior materials and finishes were chosen for high light reflectance properties. Triple-glazed, low-E vinyl-framed windows were placed in strategic locations to provide views and daylighting where possible.	Insulation = R-30 c.i.	Swinging = U-0.70	Window to Wall Ratio = 20%-40%	Maximum Percent of Roof Cover = 3%
		Metal Building = R-19 = R-19	Non-Swinging = U-0.05	Max Thermal Transmittance = U-0.33	Thermal Transmittance = U-0.58
		Attic and Other = R-60		Solar Heat Gain Coefficient = N,S,E,W, no recommendation	Solar Heat Gain Coefficient (SHGC) = no recommendation
		Single Rafter = R-38 + R-10 c.i.		Window Orientation = no recommendation	
		Surface Reflectance/ Emittance = no recommendation		Exterior Sun Control (S,E, W only) = no recommendation	

	INTERIOR LIGHTING	HVAC	VENTILATION	DUCTS	SERVICE WATER HEATER
	Lighting Power Density (LPD) = 0.9 W/sf	Air Conditioner (0-65KBtuh) = 13.0 SEER	Outside Air Damper = Motorized Control	Friction Rate = 0.08 in. w.c./100 ft	Gas Storage = 90% Et
	Light Source (liner flourescent) = 90 mean lumen/watt	AC (>65-135KBtuh) = no recommendation	Demand Control = CO_2 Sensors	Sealing = Seal Class B	Gas Instantaneous = 0.81 EF or 81%Et
	Ballast = Electronic Ballasts	AC (>135-240KBtuh) = no recommendation		Location = Interior Only	Electrical Storage 12kW = EF>0.99-0.0012xVolume
	Dimming Controls for Daylight Harvesting for WWR 25% or higher = Dim Fixtures within 12 ft of N/S Window wall or within 8 ft of skylight edge	AC (>240KBtuh) = no recommendation		Insulation Level = R-6	Pipe Insulation (d<1.5in./d≥1.5in) = 1in./1.5in
	Occupancy Controls = Auto-off all unoccupied rooms	Gas Furnace (0-225KBtuh-SP) = 80% AFUE			
	Interior Room Surface reflectances = 80%+ on ceilings, 70%+ on walls and vertical partitions	Gas Furnace (0-225KBtuh - Split) = 90% AFUE			
		Gas Furnance (0-225KButh) = 80% Ec			
		Heat Pump (0-65KBtuh) = 13.0 SEER/7.7 HSPF			
		Heat Pump (>65-135KBtuh) = no recommendation			
		Heat Pump (>135KBtuh) = no recommendation			

	Lighting Power Density (LPD) = 0.9 W/sf	Air Conditioner (0-65KBtuh) = 13.0 SEER	Outside Air Damper = Motorized Control	Friction Rate = 0.08 in. w.c./100 ft	Gas Storage = 90% Et
	Light Source (liner flourescent) = 90 mean lumen/watt	AC (>65-135KBtuh) = no recommendation	Demand Control = CO_2 Sensors	Sealing = Seal Class B	Gas Instantaneous = 0.81 EF or 81%Et
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		Gas Furnance (0-225KButh) = 80% Ec			
		Heat Pump (0-65KBtuh) = 13.0 SEER/7.7 HSPF			
		Heat Pump (>65-135KBtuh) = no recommendation			
		Heat Pump (>135KBtuh) = no recommendation			

1. Articles and Reports on Green Building Design

"Breaking Down the Barriers": Challenges and Solutions to Code Approval of Green Building," (247 KB), by David Eisenberg, Robert Done, and Loretta Ishida. Development Center for Appropriate Technology, Tucson, AZ, 2002

"Building Green: Onus or Bonus," (7.34 MB) Zoning News, April 2005 - Chart of jurisdictions listing green building requirements and programs

"A Cautionary Tale, Amid our green-building boom, why neglecting the old in favor of the new just might cost us dearly," by Wayne Curtis, Preservation Magazine, Jan./Feb. 2008

"The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force," (3.13 MB) October 2003

"County Program Standardizes Green Building Practices," 1 MB) by Elizabeth Perry, NACo County News, May 18, 2009 (about King County Green Tools program)

"How Green is Your Neighborhood,' by Bryan Walsh, Time, Wednesday, Dec. 19, 2007

"It's Way Too Easy Being Green, The decidedly dupable system for rating a building's greenness,"
By Daniel Brook, Slate, Posted Wednesday, Dec. 26, 2007

"Major U.S. Cities Put High Value on Sustainability Goals: Report," by GreenBiz Staff, GreenBiz, published May 7, 2009.
Community Quality of Life and Smart Growth
Community Quality of Life, Smart Growth Issue Area, Smart Growth Online - Includes list of topics and access to community quality-related materials by type.

Design and Smart Growth
Smart Growth, National Trust for Historic Preservation
Communities by Design, American Institute of Architects
Design Review, MRSC Web page

Design, Smart Growth Issue Area, Smart Growth Online - Includes list of topics and access to design-related materials by type
Governors' Institute on Community Design - An initiative of the National Endowment for the Arts and the Environmental Protection Agency to support governors' leadership in good community design and innovative planning.

Green Communities and Building Design, MRSC Web page
Green Development, Smart Communities Network
Community Design and Public Spaces, Smart Growth Solutions, N.J. Smart Growth Gateway
Place Matters - Database for communities to improve community design and decision making.
Economics and Smart Growth
Economic Development, MRSC Web page
Economics, Smart Growth Issue Area, Smart Growth Online
Includes list of topics and access to economics-related materials by type

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Building the Case for Energy Smart Growth, by Carol Werner, Environmental and Energy Study Institute, July 2005
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Massachusetts Smart Growth/Smart Energy Toolkit.

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Environmental Characteristics of Smart Growth Neighborhoods, Natural Resources Defense Council, Case Studies in Sacramento and Nashville, 2000 and 2003

Coastal and Waterfront Smart Growth, NOAA
EcoEarth Info - Environmental Sustainability Portal
Protecting Water Resources with Smart Growth, U.S. EPA, 2001
Using Smart Growth Techniques as Stormwater Best Management

Practices, EPA, December 2005
Growing Toward More Efficient Water Use: Linking Development, Infrastructure, and Drinking Water Policies, EPA, Jan. 2006

Climate Change, MRSC Web page
Environment & Natural Resources, MRSC Web page
Water and Smart Growth, The Funders' Network for Smart Growth and Livable Communities, 2004.

Housing and Smart Growth
"Affordable Housing and Smart Growth: Making the Connection," Smart Growth Network and the National Neighborhood Coalition, (2002) identifies a range of policies and approaches that help achieve both smart growth and affordable housing objectives. It includes case studies of towns, cities, and states that have benefited from linking these two interrelated goals.
Smart Growth and Affordable Housing, U.S. EPA

Best Practices in the Production of Affordable Housing, Urban Land Institute, 2005

Environmentally Sustainable Affordable Housing, ULI Community Catalyst Report No. 7, prepared by Deborah L. Myerson, Urban Land Institute, 2008 - Based on an October 2007 Forum on Community Issues

Green Buildings - Affordable Housing, Smart Communities Network - Emphasis on energy efficient affordable housing, success stories, and related articles

Growth Management, Smart Growth and Affordable Housing, **Anthony Downs, Brookings Institution**, May 2003 speech
Housing, Smart Growth America - Addresses issues such as range of choice in housing and affordability

Housing, Smart Growth Issue Area, Smart Growth Online - Includes list of topics, access to housing-related materials by type, and useful collection of links.

Smart Growth Policy, National Association of Home Builders
Housing, MRSC Web page - includes links to Affordable Housing Ordinances.

Land Use and Smart Growth/Sustainability
Land Preservation: An Essential Ingredient in Smart Growth, by Tom Daniels and Mark Lapping, Journal of Planning Literature, Vol. 19, No. 3, pp. 316-329. February 2005 (provided by Private Land Network)

Principles of Smart Growth, Mix Land Uses, Smart Growth Online
Smart Communities Network, Land Use Planning
Smart Growth Land Use Policies, American Council for an Energy-Efficient Economy

Smart Growth: Land Use, Zoning, and Growth Management, National Association of Realtors
Smart Land Use, Victoria Transport Policy Institute.

Natural Resources and Smart Growth
Agricultural Sustainability and Smart Growth: Saving Urban Influenced Farmland, The Funders' Network for Smart Growth and Livable Communities, April 2001

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Transportation and Smart Growth

Smart Growth and Transportation: Issues and Lessons Learned, Report of a Conference held in 2002, Transportation Research Board, 2005

"Smart Growth and the Transportation-Land Use Connection: What Does the Research Tell Us?" Susan Handy, International Regional Science Review, Vol. 28, No. 2, 146-167 (2005)
Smartgrowthplanning.org - The transportation perspective
Driving Urban Environments: Smart Growth Parking Best Practices, Maryland Governor's Office of Smart Growth. Overview of parking strategies that meet the challenges faced by projects in the context of smart growth.

Parking Spaces/Community Places: Finding the Balance Through Smart Growth Solutions, U.S. EPA, Jan. 2006

Land Use, American Association of State Highway and Transportation Officials (AASHTO) Center for Environmental Excellence
Coordinating Land Use and Transportation, Federal Highway Administration

I-405 Corridor Program: Implementing Smart Growth, Washington State Department of Transportation
Congestion Management, MRSC Web page

TDM Encyclopedia, Victoria Transport Policy Institute - Transportation demand management; comprehensive source of information about innovative management solutions to transportation problems

Transportation, Smart Growth America
Transportation, Smart Growth Online
Smart Growth and Transportation in Small Communities ( ), by Joseph Blakeman, University of Wisconsin, 2003
Smart Transportation Guidebook: Planning and Designing Highways and Streets that Support Sustainable and Livable Communities, by Daniel A. Kueper, ITE Journal, September 2008 Via BNet FindArticles
Sustainability, Center for Environmental Excellence by AASHTO -

Transportation focus
Transportation, Smart Growth Issue Area, Smart Growth Online - Includes list of topics and access to health-related materials by

type
Transportation Demand Management, MRSC Web page
Transportation Efficient Land Use, MRSC Web page.

Healthy Communities

Health, Smart Growth Issue Area, Smart Growth Online - Includes list of topics and access to health-related materials by type
Linking Smart Growth and Active Living and Health, Smart Growth

Resource Library, Smart Growth Resource Network

Health and Smart Growth, The Funders' Network for Smart Growth and Livable Communities, Feb. 2003
Building Healthy Communities, MRSC Web page.

Schools and Smart Growth

Children & Schools, Smart Growth America
Smart Growth and Schools, National Clearinghouse for Educational Facilities

Behavioral Sustainability

Electricity, an innovative, award-winning social network that helps users track and reduce their electricity consumption at home. Electricity is based on principles of behavioral economics – it incorporates behavioral nudges to motivate people to reduce their consumption. www.welectricity.com

ADDITIONAL RESOURCES:al Energy Agency (IEA) is an intergovernmental organisation which acts as energy policy advisor to 28 member countries in their effort to ensure reliable, affordable and clean energy for their citizens.
http://www.iea.org/about/index.asp

Energy Cost Calculators for Energy-Efficient Products

The calculators below allow Federal agencies to enter their own input values (e.g., utility rates, hours of use, etc.) to estimate energy cost savings from buying more efficient products. Some are Web-based tools; others are Excel spreadsheets provided by ENERGY STAR® for download.
http://www1.eere.energy.gov/femp/technologies/eep_eccalculators.html

Payback Calculator for Energy Efficiency

U.S. Department of the Interior
Greening the Interior Program
Energy Facility Management
www.doi.gov/greening/energy/Calculating_Payback.doc
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
ASHRAE is an international organization which fulfills its mission of advancing heating, ventilation, air conditioning and refrigeration to serve humanity and promote a sustainable world through research, standards writing, publishing and continuing education.
http://www.ashrae.org/technology/
U.S Green Building Council
The U.S. Green Building Council is committed to a prosperous and sustainable future for the United States through cost-efficient and energy-saving green buildings.
www.usgbc.org

Resources on Roofs

This article discusses the environmental, social and cost benefits for installing and maintaining a green roof on your building.
http://hubpages.com/hub/Green_Roofs_Energy_Savings

Great Lakes Water institute goes through construction, installation and plant type for green roofs.
http://www.glwi.uwm.edu/research/genomics/ecoli/greenroof/roofinstall.php
This free roofing price calculator is designed to help home/ building owners estimate roof replacement costs for Flat and Metal Roofing systems, and provides you with instant roofing cost estimate.
Price calculations are based on your building dimensions, roof difficulty and number of roof penetrations.
http://www.coolflatroof.com/roofing-calculator.php
Windows
The U.S. Department of Energy provides basic information on windows and energy saving tips.
http://www1.eere.energy.gov/consumer/tips/printable_versions/windows.html

HVAC

ClimateMaster provide information on HVAV system comparisons and their maintenance and operating expenses along with annual costs.
http://www.climatemaster.com/index/comm_watersource_savings

Storm water capture

This article reviews creative and innovative ways to capture and detain stormwater, and provide information on flow rates for detention schemes.
http://www.buildings.com/Magazine/ArticleDetails/tabid/3413/ArticleID/10155/Default.aspx

Daylighting

The Whole Building Design Guide provide information on natural lighting within in building structure.
http://www.wbdg.org/resources/daylighting.php

Building Automation Systems

FacilitiesNet provides information on energy management systems.
http://www.facilitiesnet.com/buildingautomation/article/Is-Your-EMS-on-Target-For-Energy-Savings--1499
The U.S Department of Energy provides information on building automation types, tools, and case studies to help the general public.
https://www1.eere.energy.gov/femp/operations_maintenance/om_bas.html
Solar Panels
Siemens gives basic information on solar panels and types.
http://www.siemenssolar.com/types-solar-cells.html