Sustainable Design

How to manage the design process differently to achieve sustainable buildings.

Why?

Sustainability is responsible stewardship of our natural, human, financial resources through a practical and balanced approach.

What?

Sustainability requires changes to the design process to ensure the "best fit" of the built environment to the natural environment. The design process must be "front loaded," investing more time to understand the building as a system and to optimize the interrelationships of the various components of that system to best meet the needs of the end users.

How?

Strategies for getting it done

Planning –

Goals: Integrate sustainability into project goals as early as possible. The end user should participate in setting these goals. Sustainable goals will infuse the project with a longer time framework.

Players: More involvement of the design team up front; interdisciplinary teamwork critical for maximum success. The end user should be represented on the design team.

Process: The more comprehensive the planning, the more likely opportunities will not be missed, and unnecessary costs will not be generated.

Evaluation Options available:

- Product & Equipment Selection Software
- Computer Modeling, Simulation, and Optimization
- Cost Analysis (Simple Payback, Life-Cycle Cost Analysis, Value Engineering) www.value-eng.org

Budget: Although you can achieve "green" without cost premiums, you will experience cost shifting. More upfront design time will pay off

Implementation

Predesign Phase:

- Have a goal-setting meeting.
- Ensure sustainability is integrated with overall project goals.
- Identify performance standards or guidelines (i.e. LEED, Built Green™)

Schematic Design Phase:

- Selecting team – include green element in any RFQ's released for the project
- Arrange an Eco-charette (a strategic

Eco Charette Tips

- **Bring all the players** - Documents and key players will provide information about organizational goals, and specific objectives that relate to sustainable building project.
- **Provide pictures** of techniques that may be proposed as part of charrette.
- **Capture results** - Ensure there is some mechanism for documenting the results of the eco-charrette.
- **Get everyone on the same page** - Provide a concise introduction (20-30 minutes) to sustainable building strategies.
- **Be the Guide** - Provide a structure or framework for considering strategies. If the owners are considering LEED or a local rating system, then organizing the discussion around LEED or the rating systems' categories is recommended.
- **Never say die** - Ensure charrette participants come up with solutions when barriers are raised.
- **Keep people connected** - Breakout into smaller groups when there are more than 20 participants.
- **Turn off the editors** - Use basic facilitation rules for brainstorming (allow "dreaming")

brainstorming session) for the team to generate a list of green options for the project. If the project is going for LEED™, the LEED™ Rating system can provide a framework for this session.

Design Development:

- Determining applicability and cost-effectiveness of green strategies from charette;
- Match strategies with client priorities, project's potential for LEED or other certification.
- Begin "Focused Design Reviews" to pick up inconsistencies between design elements and design intent. (This is the first step in "Commissioning.")

Construction Design:

Incorporate "green" products and practices into specifications. Basic tips for writing green specifications include:

- Stick with CSI Format – do NOT add a Part 4 section to the spec.
- Write the specification for the contractor: Say it once and in the right place, eliminate ambiguous terminology and use correct grammar and punctuation – be clear and precise!
- Ensure all areas depicted in the drawings are addressed in the specifications.
- Use the imperative; use words such as "provide" and "apply" rather than "shall" or "should be."

Select products carefully:

Court decisions have found design professionals liable when they failed to properly research products that later proved unsuitable for their intended purpose.

- Research the manufacturer's reputation for on-time delivery and reputation for honoring warranties.
- Reference a standard when you can – e.g. CRI (Carpet & Rug Institute; ASTM, ANSI, AWI, FSC, etc.)
- Assume responsibility for specifying green products
- Research availability, lead times, and cost.
- List at least three manufacturers for each product (for public jobs, usually required.)
- Include telephone numbers and contact persons if possible
- Do not use term "or equal"; use "or approved"
- Define terms unique to green products – e.g. recycled content, low-VOC, non-toxic.
- When in doubt, leave it out!

Construction: With green building, conventional construction practices will frequently need to be modified.

- Plan for on-site training and oversight.
- Integrate education into weekly safety meetings
- Provide clear site signage on green practices and requirements.

Commissioning

The bulk of Cx takes place during this phase, with the contractor very much involved in the process of ensuring that the building is constructed in accordance with design intent. Generally an independent Cx agent or someone not on the design team itself is used to conduct the Cx process.

Occupancy:

Many green building features require the "cooperation" of occupants either in operation or maintenance to be really effective over the long term,. For that reason, training, handbooks, and signage are frequently part of the picture. In addition, final CX and post occupancy evaluations are an important aspect of sustainable construction.

When?	Planning, Design and Construction
Cost	The sustainable design process typically places more of the budget emphasis in the design phase. This does not lead to higher costs, however. Thorough, stakeholder-based planning, focused design reviews and clear, effective spec writing will generally eliminate or avoid far more cost in the construction phase, than they incur during design. The end result will be a building with significant social, environmental and economic benefits.
Resources	CSI Manual of Practice, Construction Specifications Institute. Construction Specifications Institute, www.csinet.org Several tools to assist in selecting green strategies and materials: Life Cycle Assessment primer - http://www.cityofseattle.net/sustainablebuilding/leeds/docs/LCA_Primer.pdf Life Cycle Cost Analysis - http://www.greenbuildingsbc.com/new_buildings/resources_guide/10.0_epr.html BEES 3.0 Materials selection software - http://www.bfrl.nist.gov/oae/software/bees.html Athena Decision support software - http://www.eere.energy.gov/buildings/tools_directory/software/athena.htm

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Transportation

Siting projects to optimize transportation choices.

Why?

Siting projects close to transit and services can reduce on-site parking needs and save associated construction costs, stormwater management, etc.

Convenient location can reduce residents' need to own a car – eliminating the costs of vehicle ownership (estimated at $5,000 per year).

What?

The most effective transit-oriented locations include a range of transportation options; pedestrian and bike friendly, access to regular bus, rail and other services when needed.

How?

Strategies for getting it done

Bike friendly features –

- secure long-term bicycle storage, sized appropriately for the number of units
- a bicycle repair work area.

Reduce parking availability and offer incentives for transit or bicycle use:

- "No car" covenant on lease – negotiate reduced parking allocation with permitting agency based on percentage of tenants signing the "no car" covenant.
- Bicycle commuter pledge – provide rent relief or other incentive for bicycle commuters

Use overlay maps to identify sites within ¼ mile of mass transit and ½ mile of stores and employment centers.

Locate in new mixed-use developments, or evaluate the viability of incorporating commercial, retail and other community services into the development.

Provide safe, convenient pedestrian and bicycle access routes to services to help residents reduce vehicle use for daily trips.

Locate a "Flexcar" station or equivalent near site if possible.

When?

Planning and design

Cost

Long-term reduced demand for parking can facilitate negotiating reduced parking space allocations in urban and suburban locations, allowing more buildable space, reduced stormwater management costs and other benefits.

Resources

Transportation Choices Coalition – www.transportationchoices.org

Transit Oriented Development website - http://www.metrokc.gov/kcdot/alts/tod/index.htm

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Site Protection and Erosion Control

Minimizing on-site and off-site impacts of construction.

Why?

The process of site development and construction has a dramatic impact on the natural systems at work on and around a site.

Potential impacts on soil and water during build-out include: Erosion, Surface flow, Pollution, Top soil loss, and Habitat loss

What?

Careful planning and construction management can minimize impacts, avoiding possible non-compliance costs, protecting soil and water quality and improving the post-construction condition and performance of the site.

Standards and Guidelines

The EPA document "Storm Water Management for Construction Activities" provides the baseline for good practice, unless superceded by local standards and codes. For Washington, see also Department of Ecology Stormwater Manuals for Eastern and Western Washington (See Resources).

LEED. Built Green and SeaGreen all offer credits for use of best management practices.

How?

Strategies for getting it done

Erosion and Sedimentation Control Plan - Good erosion control requires having a plan in place. Many jurisdictions now require some form of erosion control plan be posted or available on site and communicated to all subcontractors. Key elements are:

- The standard being used on the project (local code, LEED, etc.)
- Site conditions, i.e. where water will flow and where site will be disturbed
- The BMPs to be used, when and in what order (see examples below)
- Communication plan – making all site personnel and subs aware of the plan and their responsibilities for implementing it.
- Monitoring plan – ensuring that BMPs are monitored to ensure performance, particularly after 0.5" rainfall in 24 hrs. Also protocols for volume and turbidity sampling at outlets.

The basic approach to reducing impacts on soil and water during construction follows the following priorities:

1. Prevent erosion and water pollution from occurring
2. Control erosion where it does occur
3. Clean polluted waters

Best Management Practices

Stormwater Management Manuals (See Resources) detail many different best management practices for preventing and controlling erosion. Here are the basic steps in order of priority:

- **Limit site disturbance** – Preserve existing vegetation; Establish vegetated buffers around sensitive areas and mark protected areas clearly with fences or other methods.
- **Establish controlled construction access** – Construct quarry spall or crushed rock construction entrance, develop and post protocols for vehicles on site, provide tire washes.
- **Stabilize exposed soils** – Mulch exposed soil with compost, nets or blankets, plastic sheeting for temporary protection.
- **Control water flows** – Protect storm drain inlets with interceptor dikes or swales, channel flow through grass- or riprap-lined channels,
- **Filter or settle sediments** – use gravel or compost filter berms or filter fences, rock check dams, sediment ponds or water tanks.
- **Minimize water pollutants** – pesticides, engine or fuel oil, toxic concrete form releases. Perform

	regular clean-up of site. **Use of Compost -** One significant development in this field in recent years is the use of compost for stormwater management – as an erosion control mulch cover for exposed soil slopes, and as a filter berm material. Connecticut, Iowa, Washington, and Texas Departments of Transportation (DOT) among others, have documented "extraordinary successes" with the use of compost to control erosion on highway projects. An increasing number of authorities are increasing compost use as supplies allow. Benefits include:- Improved water quality and flow buffering, quicker results, less failure under heavy rainfall conditions, and improved aesthetics, as well as easier disposal on project completion.
When?	Planning and Construction
Cost	The use of compost as a tool for managing construction site storm water management also appears to offer cost benefits over many "conventional" alternatives. Compost is comparable in cost to alternatives, and in some cases cheaper. It generally requires less maintenance during operation, and can be tilled in on project completion, avoiding disposal costs of plastic mulches and filter fences.
Resources	The Municipal Research and Services Center of Washington lists several resources on Erosion and Sediment control at www.mrsc.org/Subjects/Environment/water/SW-erosion.aspx. Stormwater Management Manual for Western Washington, Volume II: Construction Stormwater Pollution Prevention – http://www.ecy.wa.gov/biblio/9912.html Stormwater Management Manual for Eastern Washington (DRAFT) - http://www.ecy.wa.gov/programs/wq/stormwater/eastern_manual/workshops.html#draft_documents Land Development Today article on use of Compost for Filter Berms and other BMPs - http://www.landdevelopmenttoday.com/2002/12/landscape/land_1.htm EPA Construction Site Storm Water Runoff Control Menu of BMPs - http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm

Low Impact Development

Decentralized stormwater control and treatment.

Why?

Proliferation of impervious surface, and heavily compacted soils, in developed areas leads to decreases in base flow and evapotranspiration and increases in peak run-off velocities. This results in erosion of surface soils and stream banks, and degradation of water quality; temperature, clarity and purity.

What?

Use planning and design practices to preserve the pre-development hydrological performance of a site.

Standards and Guidelines

For Washington, Department of Ecology Stormwater Management Manuals for Eastern and Western Washington detail Best Management Practices for Low Impact Development (See Resources).

How?

Strategies for getting it done

Low Impact Development (LID) uses various land planning and design practices and technologies to conserve and protect natural resource systems and reduce infrastructure costs. By incorporating both economic and environmental considerations, LID allows land to be developed, but in a cost-effective manner that helps mitigate potential environmental impacts.

Best suited for new, suburban development, LID can offer developers both infrastructure savings and a way to respond to increasingly stringent environmental regulations. For municipalities, LID can help contain burgeoning street and storm water management costs. For community residents, LID encourages local environmental stewardship. In terms of the environment, the benefits speak for themselves.

Project Planning & Design – Evidence indicates one of the keys to a successful LID project is to invest additional time and money in the initial planning stages of development. While this idea may appear unpopular at first glance due to increased up-front costs, these expenditures are often recouped in the form of rapid home sales, enhanced community marketability, and higher lot yields.

Storm Water Management - Low impact development storm water management systems can reduce development costs through the reduction or elimination of conventional storm water conveyance and collection systems. LID systems can reduce the need for paving, curb and gutter, piping, inlet structures, and storm water ponds by treating water at its source, rather than at the end of the pipe. Municipalities also benefit from LID in the long run as a result of reduced maintenance costs.

Wastewater Management - Cost considerations or health and environmental concerns sometimes make linking a proposed development's wastewater system to existing municipal sewer connections unfeasible. Using the LID approach, however, developers can choose from a variety of on-site wastewater treatment system options, either as alternatives or enhancements to conventional septic systems. Some on-site treatment alternatives to conventional systems, such as recirculating sand filters and evapotranspiration systems, are "add-ons" to a traditional septic tank system. The additional treatment unit is connected in-line with the septic tank, and provides an extra level of treatment.

Circulation & Design - Municipalities have begun to reexamine the connection between circulation design and storm water management practices. Using the LID approach, new designs for streets, sidewalks, and driveways can maintain the functions of circulation while helping to reduce expanses of impervious surfaces that can alter local hydrology and degrade water quality. In turn, new street designs can influence the layout of lots, and help increase the volume of open space in new residential developments.

LID practices include:

- **Porous Pavements** (Permeable Surfaces) improves infiltration and allows for stormwater detention and treatment in pavement sub-base.
- **Soil Amendments** (Compost Amended Soils) enhance soil structure, improving infiltration rates.
- **Green Roofs** detain and transpire roof-top rainwater, reducing and buffering stormwater flows.
- **Bioretention** (Rain Gardens) retain and treat stormwater on-site
- **Rainwater Collection** and Water Reuses reduce stormwater flows and conserve water resources
- **"Disconnect" & Reduce Impervious surfaces** reduce runoff velocities and aid infiltration

Details of these BMPs are beyond the scope of this fact sheet. Please see the Resource section for good sources of LID guidance.

LID strategies are most applicable in suburban situations where it protects water quality, preserves open space and decreases infrastructure costs. However, even in high density, urban environments, on-site stormwater management BMPs can be used effectively. Any reduction and/or buffering of offsite flow will reduce pressure on existing stormwater facilities and have a positive impact on downstream water quality. Depending on the locality, incentives and ordinances may be in place to promote LID practice.

In rural developments, LID practices that protect surface and groundwater quality may be helpful in gaining community support for affordable housing developments. Use of existing "green" infrastructure, such as ponds and wetlands can significantly reduce the cost of site development.

When?

Planning, Construction and Post-occupancy

Cost

LID offers the following financial benefits to developers:

- Reduced land clearing and grading costs
- Reduced infrastructure costs (streets, curbs, gutters, sidewalk)
- Reduced storm water management costs
- Increased lot yields and reduces impact fees
- Increased lot and community marketability

A selection of LID case studies are included in this Resource Kit. See: Duke Street Square, Kensington Estates, Somerset Community, Bellingham City Hall, SEAStreets Seattle.

Resources

Stormwater Management Manual for Western Washington - http://www.ecy.wa.gov/programs/wq/stormwater/manual.html

Western Washington; Puget Sound Action Team - http://www.psat.wa.gov/Programs/LID.htm

Stormwater Management Manual for Eastern Washington (DRAFT) - http://www.ecy.wa.gov/programs/wq/stormwater/eastern_manual/workshops.html#draft_documents

HUD – The Practice of Low Impact Development - http://www.huduser.org/Publications/PDF/practLowImpctDevel.pdf

Outdoor Water Conservation

Minimizing landscape water use for environmental and economic benefit.

Why?

Population growth is increasing demand for limited water resources. Landscape irrigation increases water use during the summer, typically the dry season. On hottest summer days it can increases water use by over 100%. Whether treated potable water or well water is used, irrigation has a significant impact on water resources and water quality.

Water demand, water quality and habitat protection issues will make new water supplies more expensive and difficult to find. Reduced outdoor water use is both an environmental and an economic benefit.

What?

Evidence suggests that improved irrigation system design and better equipment does not have a significant impact on water conservation. In addition, effective operation and maintenance is required; education of end users is critical to reducing irrigation water consumption.

How?

Strategies for getting it done

Sample Strategies

Landscape design –

- Retain existing plants and soil to the greatest extent possible;
- Specify proper soil preparation – perform soil test, balance pH if necessary, and amend with at least 2" to 4" of Grade A mature compost tilled into the top 8" to 12"of soil.
- Use native, drought-tolerant plants grouped by water needs to facilitate effective irrigation during establishment;
- Limit use of turf grasses and irrigate only in high wear areas, if at all; dormant turf will revive with Fall rain;

Irrigation design – If you must install irrigation for plant establishment phase:

- Use and Irrigation Association-certified designer in partnership with your landscape designer;
- Develop a Water Budget – accounting for all the water moving into and out of the effective root zone as the basis for calculating irrigation requirements;
- Use drip or soaker type irrigation wherever possible;
- Use evapotranspiration (ET) linked controllers, rainfall shut-offs, check valves and flow sensors;
- Control system must be easily accessible for operation, monitoring and maintenance;

Landscape implementation –

- Verify adherence to design specifications
- Verify soil testing, and appropriate amendment – compost, mulching, etc.;
- Ensure the right plants go in the right hydrozones;
- Make landscape contractor responsible for success of installation throughout establishment phase (two to three years);

Irrigation Implementation –

Enhancing soil life with compost creates:

- Soil structure
- Fertility/nutrient cycling = lower fertilizer needs
- Plant disease protection = lower fungicide needs
- Plant vigor = fewer weed and bug problems
  = less herbicide & insecticide needs, costs
- Stormwater detention/infiltration into groundwater
- Improved drainage/aeration = healthier plants
- Improved moisture retention = water conservation

- Verify installation as specified – no substitutions
- Set up to avoid runoff and overspray onto pavement, etc.
- Audit after set-up and use audit flow rate to set controller run times
- Train O&M managers and staff in all aspects of operation
- Schedule annual audit and refresher training operators;

Landscape Operation and Maintenance –

- Amend soil when replanting
- Mulch annually with compost or other appropriate organic mulch
- Replace problem plants with varieties better adapted to a location
- If needed, use slow-release organic fertilizers
- Use Integrated Pest Management practices
- Use mulching mowers on turf, mow at correct height, top dress and overseed as necessary

Irrigation Operation and Maintenance –

- Perform annual irrigation system audit and repair, replace or upgrade parts as needed
- Replacement parts to original specifications
- Complete check on annual or seasonal start up
- Monthly visual check of all zones
- Let turf go dormant in dry season, unless high use or other priority

Water Efficiency - outdoor water conservation strategies can be integrated with alternative "waste water" strategies to further enhance water efficiency:

- Waste water, particularly greywater (from sinks, showers, laundry, etc.) and rainwater (rooftop runoff), should be reused wherever possible;
- Designs should focus on simplicity, gravity flow, and elimination of chemicals such as chlorine;
- Rainwater catchment for irrigation, and greywater irrigation are code compliant practices in most parts of the State and can be cost effective in areas where water and sewer rates are high.

When?	Design, Operations and Maintenance
Cost	Effective water conservation programs can yield significant savings, depending on the cost of water supply. Some water utilities offer rebates for upgrades of existing and newly installed sprinkler systems –For more information, visit: http://www.savingwater.org/sprinklers.htm
Resources	Irrigation Association BMP 2003 Draft – http://www.irrigation.org/PDF/IA_BMP_SEPT_2003_DRAFT.pdf Irrigation Association – http://www.irrigation.org/ Center for Irrigation Technology – http://cati.csufresno.edu/cit/ American Society of Landscape Architects – http://www.asla.org/ The Virtual Irrigation Library – http://www.wiz.uni-kassel.de/kww/projekte/irrig/irrig_i.html Saving Water Partnership – www.savingwater.org Austin GreenBuilder; Sustainable Building Sourcebook: Rainharvesting - http://www.greenbuilder.com/sourcebook/Rainwater.html#contents

Indoor Water Conservation

Water conserving fixtures and appliances.

Why?

Indoor water consumption is a significant cost of operation for affordable housing providers. Residents are generally unaware of the cost of water and sewage service, since it is typically included in their rent, and for the same reason there is little incentive for them to use water economically.

What?

Installation of water conserving plumbing fixtures and water efficient appliances is an "invisible" means of minimizing indoor water consumption.

Standards and Guidelines

LEED. Built Green and SeaGreen all offer credits for use of the most conserving fixtures and Energy Star appliances.

How?

Strategies for getting it done

Showers and Faucet Specification - Specify flow rate, not just "low-flow" which can refer to shower flow rates up to 3.5 gpm:

- Showerheads:- 2.0 gallons per minute (gpm) pressure compensating model with built in shut-off;
- Faucet Aerators:- 1.0 gpm pressure-compensating design

(Available through Seattle Public Utilities in their service area: See Resources)

These fixtures can save up to $100 per year in combined water and energy savings in an average family unit.

Toilets – 1.6 gallons per flush (gpf) performance varies considerably. While many 1.6 gpf toilets meet or exceed user expectations, quite a few do not, and some do not deliver the required 1.6gpf flush in actual use.

Toilets that do not flush effectively on the first flush will typically be reflushed - becoming a 3.2 gpf toilet. Also, blockages may result in overflow damage, additional maintenance calls and costs.

Seattle Public Utilities have tested a range of models for less than $100 each. See Resources.

Dual-flush Toilets – Dual flush toilets offer a short, "liquids only" flush, which is generally 50% of the full flush volume, i.e. 0.8 gallon short flush/1.6 gallon full flush.

A December, 2000 Seattle study compared average flush volumes and flushes per capita per day before and after installation of 1.6gpf and Dual Flush toilets in 37 homes in the city, with the following results.

Average flush volume:

Before: Inefficient fixtures 3.61-gpf
After: Conventional 1.6-gpf fixtures 1.54-gpf
Dual flush fixtures - 1.6/0.8-gpf 1.25-gpf

20% reduction in average flush volume vs 1.6gpf

Flushes per capita per day:

Before: Inefficient fixtures 5.17-fpcd
After: Conventional 1.6-gpf fixtures 5.50-fpcd
Dual-flush fixtures - 1.6/0.8-gpf 5.40-fpcd

2% increase in flushes per day vs 1.6gpf

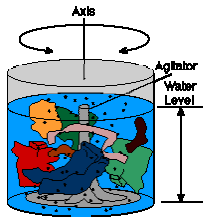
The total water savings resulting from the dual-flush fixture installation (vs the inefficient fixture) amounted to 10,600 gallons per year per home, while replacement with a conventional 1.6-gpf fixture amounted to 9,000 gallons per year. The very small increase in average flushing frequency was not enough to diminish the water savings accomplished through the installation of the efficient fixtures.

Toilet Durability – Standard toilet flappers are susceptible to corrosion by chlorine in water and in-tank toilet bowl cleaners which result in continuous leaks that can go undetected and result in significant water loss:

- Specify Chlorine Resistant Flapper when ordering

Fill valves are also prone to wear, resulting in continuous leaks that can go undetected:

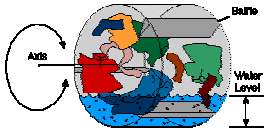
- Specify Fluidmaster 700A fill valve, or approved equivalent



Appliances

Clothes Washers - There is a trend towards providing in-unit washing machines (or hook ups) in multi-family developments, rather than common area laundry facilities with coin operated machines. While it may have market appeal, studies indicate that this results in significantly higher water (and energy) use due to more frequent washing with partial loads.

A secondary impact of this approach is decreased resource intensity – more materials going to make more washing machines that, individually, get used less of the time. Residential machines also generally have a shorter service life than commercial machines.



Coin-operated commercial grade machines are more costly to purchase but will result in lower energy and water consumption. Coin charges will offset common area water and energy consumption.

Horizontal axis (front loading) washing machines that are Energy Star® compliant represent the best water and energy efficient performance. See Energy Star® Residential and Commercial machine listings - http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

Dishwashers

The most efficient dishwashers use as little as 3.9 gallons of water per cycle at the economy setting. This may be significantly less water than is used to hand wash and rinse dishes in a sink. Although not explicit in the criteria, Energy Star® dishwashers will generally be more water efficient.

Local energy and water utility rebates or other incentives may make it cost effective to install dishwashers to reduce water and energy consumption. Check with your local utility for incentive programs.

Other Strategies

Emphasize leak reporting and repair – residents will often leave leaky faucets, toilets and other fixtures unreported if they are not causing actual damage or inconvenience. Using resident manual, newsletters and other communications vehicles to remind residents to report leaks. Require O&M staff to respond promptly and acknowledge the importance of reporting the leak.

When?

Design Specification, Operations and Maintenance/Resident Education

Cost

If specified during design, efficient fixtures have little or no additional cost, but significant savings in operation and maintenance. Common-area laundries may not cost more to set up, simplify unit plumbing and electrical supply and significantly reduce water consumption costs.

Resources

Toilets under $100 Report -http://www.savingwater.org/docs/toilets_under_100.pdf

California Urban Water Conservation Council: Toilet test reports - http://www.cuwcc.org/products_tech.lasso. In particular, the Maximum Performance (MaP) Testing - http://www.cuwcc.org/Uploads/product/MaP_Anaheim.pdf

Tankless Water Heaters - Fact sheet by the US Department of Energy, Energy Efficiency and Renewable Energy Network (EREN) at - http://www.eren.doe.gov/consumerinfo/refbriefs/bc1.html.

How to Buy a Water-Saving Faucet, available online at www.eren.doe.gov/femp/procurement/pdfs/faucet.pdf

How to Buy a Water-Saving Showerhead, available online at www.eren.doe.gov/femp/procurement/pdfs/toilet.pdf.
Seattle Public Utilities Incentive Programs - http://www.savingwater.org/incentives.htm

Energy Efficient Construction – Climate Responsive Design

Why?

The energy to operate a building over its lifetime is by far the most critical piece of an environmentally friendly project. And the cost of paying for energy use occurs year after year after year. So it makes sense to design a building appropriate for its climate from the start and to keep energy use and utility bills low – both for facility owners and for individual tenants.

Designing energy efficient affordable housing is especially critical. Lower income families spend a disproportionate percentage of their income on energy costs. In 1997, the average household energy expenditure for households with income over $50,000 was $1,696. For those earning less than $10,000 it was $997.[i]

How?

Strategies for getting it done

HEATING

Insulation

The easiest way to keep heat in a building is to do just what we ourselves do when trying to stay warm – put on a thick coat. A well-insulated building keeps the heat generated within a building from escaping. In turn, less heating energy is required and energy bills are reduced. Some specific methods for improving the building envelope include:

- Increase wall, roof, and perimeter insulation. This might include increasing wall and roof framing thickness; adding a layer of rigid insulation on the outside of framing; and increasing the depth and thickness of perimeter insulation.
- If using steel studs in an exterior wall, realize that there is increased thermal bridging across the metal thereby reducing the effectiveness of the insulation. A layer of rigid insulation should be used as an integral component of the wall system.
- Use high-density batt insulation. For 5 ½" fiberglass batts this increases the R-Value from 19 to 21.
- Use cellulose insulation in lieu of batt insulation. While the R-Values themselves are comparable, cellulose insulation fills voids in the stud cavities and around obstructions thereby reducing air infiltration.
- Build with advanced framing techniques which increase the spacing between structural members and allow for a greater percentage of insulation in the wall and roof systems.
- Build to reduce infiltration. Tight construction practices reduce the amount of cold exterior air entering a space.
- Consider alternative wall systems such as Structural Insulated Panels.
- Use landscaping to protect a building from colder, northern winds and to provide a protective airspace around the building.

Windows

Windows are the primary source of heat loss in a building. A standard 2x6 wood framed wall with fiberglass batt insulation has an R-Value of around 18, whereas even the best energy-efficient low-E, double-glazed, argon filled window will only have an R-Value of around 3.5.[ii] While windows are critical for light, air and views they do need to be used judiciously.

And they need to be energy-efficient. In a 1996 study, the effect of various window types on energy performance was evaluated for a 1,540 sf prototypical single-family house in a number of climates. In Seattle substituting low-E, argon filled windows (.33 U-Value) for a more standard double glazed product (.49 U-Value) reduced the annual heating load by 13% and the annual cooling load by 3.3%.[iii] In more extreme climates,

the results are even more significant. In multi-family construction, where surface area to floor area ratios are higher, the percentage impact per square foot of floor area will be smaller but the overall monetary savings for the entire building will be greater.

Passive Heating

Make use of the solar heat from sun to provide passive heatin. Passive solar heating tends to be more appropriate to single family homes that have more flexibility in terms of location, orientation and material. A full-scale passive solar heating approach requires extensive south glazing, the use of thermal mass to store and re-radiate heat, and the means to transfer this heat throughout the interior spaces. Sun-tempering – using the heat of the sun to heat air directly – can be used in a greater variety of applications and would be more achievable for most affordable housing projects. Regardless of the extent of passive solar heating desired, a few basic principles can be kept in mind:

- Orientation: Locate buildings on the site to maximize their access to the sun and create a building forms that maximize southern exposure.
- Programming: Locate those spaces that would benefit most from solar access – living room, dining room – towards the south and the less used rooms – bedrooms, baths, storage – towards the north.

Window placement: Put more windows towards the south and fewer on the north, east and west, while still providing adequate natural light to all spaces. Keep in mind that the direct rays of the sun can cause glare.

COOLING

Insulation / Thermal Mass

Just as a well-insulated building can keep heat from escaping in the winter, it can also keep heat from entering interior spaces in the summer. Another approach, in climates with large diurnal temperature swings, is to incorporate thermal mass to absorb heat during the day and utilize that heat to warm spaces when temperatures have dropped.

Shade / Reflective Surfaces

Keeping the direct rays of the sun from entering the building is key to keeping the interior spaces from overheating. The sun's rays can be blocked in a couple of key ways:

- Provide shade for the building. Large trees will block the sun before it reaches the building exterior.
- Use reflective surface on the building exterior. Light colored walls and roofs that reflect solar waves will minimize the heat entering the building interior. ENERGY STAR rated products are a good choice for roofs and walls and roofs can benefit from reflective surfaces within the wall and roof construction.

Windows/Shading

Windows can provide a great source of solar heat gain when heating is desired, but where summers are hot they need to be adequately protected to eliminate excessive solar gain. Windows can be protected from direct sun and still provide natural light. The heat from the sun can be intersected in a number of ways.

- Vegetation: Trees or vegetated trellises can block the sun's rays and keep solar gain from entering through windows. Vegetation is a great choice for shading because deciduous plants, those adapted to the local climate, will work in concert with weather patterns to provide shade when it's warm

but to allow direct sun during colder months.

- Overhangs and fins: Shading devices can be constructed as part of building itself – either as horizontal overhangs to block the sun from above, or as vertical fins to block sun angles from the side. Shading should be correctly sized to block direct sun only when required, and to allow the sun to enter in the colder months when it would be desired. Note that due to the low angles of the sun in the morning and afternoon, east and west windows are especially hard to shade with simple horizontal overhangs.
- Window technology: Reflective window surfaces and selective coatings can be used to block unwanted wavelengths of the sun's rays. While each situation is distinct, in general to reduce heat gain but maintain daylighting potential it makes sense to look for low Solar Heat Gain Coefficients [the percentage of solar heat that is transmitted through glazing] and high Visible Transmittance [the percentage of visible light that enters the interior].

Passive Cooling

In addition to keeping heat out to the greatest extent possible, keeping a space cool requires that the heat that does collect inside be dissipated. Cooling through natural ventilation allows the outside air to help keep the interior cool. At its most basic, natural ventilation only requires operable windows. For cooling to be most effective, the direction of the prevailing breeze needs to be considered, window openings need to be adequately sized, and openings should be on opposite walls.

In very hot climates, where the exterior air would actually make the interior warmer, passive cooling with natural ventilation won't be effective. In these locations, keeping a building closed during the day and providing ventilation at night makes more sense. The addition of thermal mass can help to absorb excess heat during the day, which is then allowed to dissipate to the exterior at night.

When?	Planning & Design
Cost	While some climate responsive design features may require a little more design and implementation budget than conventional design and construction, they may allow for downsizing or even elimination of heating and/or cooling systems. They will also result in lower energy consumption and reduced operation and maintenance costs. This "cost shifting" is best achieved through a fully integrated design process.

iEnergy Information Administration. *A Look at Residential Energy Consumption in 1997*. Office of Energy Markets and End Use, U.S. Department of Energy, 1999.

[ii] *Windows are rated by their U-Value, which represents the amount of heat being lost over time [Btu/h-ft2-F°]. Insulation and wall systems, on the other hand, are typically identified by their R-Value which is the reciprocal of the U-Value. R-Value identifies the time it takes for heat to be transferred through a material or a wall system [h-ft2- F°/Btu]. Hence, to create an envelope better able to keep heat in – we want lower U-Values for windows & doors and higher R-Value for walls, floors and roofs.*

[iii] Carmody, John et. al. *Residential Windows: A Guide to New Technologies and Energy Performance*. New York: W.W. Norton, 1996.

CASE STUDY: TRAUGOTT TERRACE

50 units of affordable housing in downtown Seattle

Architect: Environmental Works; Energy Modeling: Sider & Byers

Photos by Greg Krogstad

Energy Efficient Construction Practices

- The building form optimizes southern exposure in a dense urban environment and ensures access to natural light and ventilation regardless of future developments

- Envelope construction goes beyond code to provide R-21 walls; R-49 roof; and durable and efficient windows with a .30 U-Value. Combined, these features are projected to save $4,000/year in energy costs, beyond a building constructed to ASHRAE 90.1 standards.

- Windows minimize heat gain with a low Solar Heat Gain Coefficient (37%), while still maintaining a high Visible Transmittance (69%).

- Natural ventilation is provided with large areas of operable windows for each unit.

Alternate Wall Systems

Enhancing envelope performance.

Why?

Conventional construction methods do not offer the best combination of energy, resource and economic efficiency.

What?

While the majority of single and multi-family residential buildings are wood frame construction, a number of alternative construction types exist that may provide environmental and economic advantages. Alternative wall systems might be used to: improve the energy-efficiency of a building; utilize environmentally preferable materials; and/or reduce construction time.

How?

Advanced Faming

Advanced Framing, or Optimum Value Engineering, entails designing a framing layout that minimizes wood use and maximizes the percentage of insulation in the wall system. Advanced framing does require some changes to typical construction practices but adds no additional material costs. In fact, the reduction in wood can save money on lumber costs. A number of framing techniques can be incorporated either in combination or individually:

- Stud spacing @ 24" on center, in lieu of the typical 16" on center.
- Design to 2' modules to correspond to the 24" spacing and to standard sheet goods sizes.
- Corners framed with 2 studs, instead of 3, to allow for insulation.
- Insulated headers.
- Raised heel trusses, to allow insulation at the wall/roof connection.
- Align trusses with wall framing members. By point loading the trusses above the studs, a single top plate can be used.

Burke Gilman Gardens Mutual Housing and Childcare Center in Seattle provides housing and on-site childcare for low to middle income and disabled residents. The project was built with advanced framing techniques – 2x6 studs 24" on center, insulated corners, insulated headers and raised heel trusses.

Owner: Burke Gilman Gardens Limited Housing Partnership - Architect: Environmental Works

Building Cost: $63/sq.ft. 1998

Structural Insulated Panels

Structural Insulated Panels (SIPs) consist of a rigid foam core sandwiched between two layers of Oriented Strand Board (OSB) or Plywood. The resulting panel is both structural and highly insulative. The foam core eliminates the thermal bridging inherent in wood, or steel, frame construction creating a higher R-Value wall assembly. Infiltration is also reduced because the gaps common between insulation and adjacent studs is eliminated. Panels are delivered to a jobsite precut, including openings for doors and windows, and are assembled by the contractor SIP's reduce both job site waste and construction time. There is an upcharge in material costs for SIPs but their ease of installation reduces labor time, and costs.

SHARE Bunkhouse provides a shelter for 50 men and women and transitional housing for 8 SHARE staff. R-25

Structural Insulated Panels were utilized for all exterior walls to create a tighter, better insulated envelope.

Owner: Washington Housing Equity Alliance - Architect: Environmental Works

Development: Beacon Development Group

Building Cost: $85/sq.ft. 1999

Insulated Concrete Forms

Photo courtesy of ECO-Block

Insulated Concrete Forms (ICFs) are insulating foam blocks, planks or panels used to create permanent concrete formwork. The foam acts as the formwork for poured concrete foundations or above grade walls and eliminates the need for the contactor to install, and then remove, wood or steel formwork. The resulting wall has the strength and durability of concrete, is airtight and is well insulted. The type and thickness of the two foam layers will determine the final insulative value; typical values are in the R-20 range. Be sure to determine whether the reported R-Value includes the effect of thermal mass, because the insulation either side of the concrete will actually render the thermal mass much less effective. Interior wall surfaces will need to be finished with a fire resistant finish, such as drywall; exterior finishes can be any material but may require additional furring strips. A related product, cement wood fiber blocks, are similar to ICF blocks except that they are made from a wood fiber bound together with cement.

While the cost of ICF foundation walls is comparable to block or poured walls, the cost of building above grade with ICF's is generally higher than for wood frame construction. According to a study by the NAHB, building a single-family home with ICF will add 1-8% to the construction cost. The benefits of ICF come in energy use reductions due to a higher insulative value and lower infiltration rates. The same NAHB study found yearly energy savings for ICF houses ranging from 17 to 25%.i

The Millenium House, a prototypical affordable home in Tulsa, Okalahoma used reinforced Insulated Concrete Form construction for energy-efficiency, cost and storm resistance. The 1,200 sq. ft. home, developed by the non-profit organization Neighbor for Neighbor, was completed in summer of 2003 and was expected to sell for $50,000 - $55,000.

Strawbale

Straw is the stalk that remains after the edible portions of grain, such as wheat, have been harvested. A waste material, it is baled to be used for animal bedding, or as is often the case, burned in the fields. Strawbale construction utilizes this waste product as a building block to create thick, highly insulative walls. Bales of straw, typically 24"x48"x16", are stacked and pinned together as either load-bearing or infill walls. The characteristics of the material and the thickness of the walls make for R-Values of 35 or more.

Building with strawbales makes the most sense for projects close to agricultural sources. Construction with strawbales doesn't require skilled labor, just training in the proper method, and therefore lends itself to self-help or communal building projects. The cost of the strawbales themselves is relatively inexpensive, however the interior plaster and exterior stucco finishes can add significant labor costs.

Factory Built

Factory built means that a building is constructed within a factory, in discrete modules, and then shipped to the site where the modules are installed and attached. Factory built construction can be used for single-family and duplex housing, as well as for larger multi-family projects. Factory built can be either modular construction, which are built to local code requirements, or manufactured homes, which adhere to the HUD code, and can also be distinguished by a steel frame supporting the floor.

The cost of factory built construction will not necessarily be any less expensive than traditional stick frame construction and can, in fact, cost more. Financial savings and benefits come with a shorter on-site timeframe required to erect the buildings, reduced building permit fees as these are handled through the manufacturer, and minimal construction document requirements.

The Opal Community Land Trust provides homeownership on Orcas Island to households earning less than 80% of the median income. Oberon Woods, a development of five 1,200 sf single family homes, was built using modular construction. Modules were factory built in Idaho and then transported to the job site on Orcas.

Owner/Developer: Opal Community Land Trust

Building Cost: $76/sq.ft. 2002

When?	Planning and Design
Cost	The cost implications of different wall systems are complex. Material costs may be higher, but labor costs lower. Choosing a superinsulating system may allow for significantly downsized heating and cooling systems. The price per square foot examples shown above indicate that all these systems can be used to build affordable housing

As cited in "Insulating Concrete Forms," PATH Technology Inventory @ www.toolbase.org

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Mechanical Systems

Selecting mechanical systems to optimize building performance and comfort.

Why?

The mechanical systems in a building are generally the largest consumers of energy, and a significant contributor to the overall comfort and usability of the building. Inefficient systems waste energy, cause discomfort and potentially other, more serious health impacts.

What?

Decisions about a building's energy system can be broken down into four parts: Envelope, HVAC, Lighting and Plug loads, and Domestic Hot Water. This fact sheet addresses issues that influence the choice of HVAC system. The other areas are covered separately. However, it is important to remember that HVAC is a part of the larger energy system and cannot be considered in isolation. Thorough sustainable design approaches will integrate all aspects of this system during the early stages of design. (See Sustainable Design Fact Sheet)

How?

Strategies for getting it done

Approach

Phase 1: **Consider the needs of your resident population** – the heating, cooling and ventilation requirements of family housing are very different from those of senior housing; their physiological needs are different, and so are their schedules of occupancy and activity. Concern for the needs of resident population significantly influence HVAC decisions.

Will resident population profile remain constant? An inflexible system, tailored to one population, may make a building highly inefficient under different usage. Other factors to consider include acoustic comfort, thermal comfort, and respiratory health.

Phase 2: **Consider the local climate** – what are the heating and cooling loads for the building location? How does orientation and layout of the building affect passive solar heating and natural ventilation; diurnally and seasonally? How efficient is the envelope? How well matched is the building to the local climate? The heating and cooling needs of a building in Yakima, are different from those of a similar building in Seattle.

Phase 3: **Assess local renewable energy resources** –

- **Solar energy** – can provide direct heat and/or electrical energy.
  Solar heat gain can have significant influence on HVAC specification depending on location, orientation and design of a building. Integrated at the design phase, there should be little cost premium to ensure that passive solar building design works to minimize HVAC system requirements;
  Photovoltaic systems are continuing to come down in price, but in the relatively low cost energy market of the Pacific Northwest, it is unlikely that solar electricity generation would be the most sustainable use of limited budget for an affordable housing project.
- **Wind energy** – for natural ventilation and energy generation.
  Natural ventilation can significantly increase the comfort level of a building during hot weather, while reducing the cooling demands placed on HVAC. Indoor air quality is also positively impacted. Integrated at the design phase, there should be little cost premium to ensure that building design uses natural ventilation to minimize HVAC system requirements;
  Small scale wind turbines are becoming more cost effective, but have significant associated operations and maintenance costs.
- **Other sources** include geothermal (typically using ground source heat pumps), biomass (digestion or combustion type) and small scale hydro generation.

Affordable housing projects interested in use of renewable energy should also consider renewable energy purchase programs offered by utilities in the region.

Phase 4: Assess other fuel base issues – First cost issues often drive the decision to use electrical resistance heating, although energy cost and maintenance issues over the lifecycle of the equipment generally make this an expensive choice. However, regional utility incentives (Seattle City Light, for example) can significantly lower the installed cost of efficient electrical equipment. Natural gas can be an efficient and cost effective choice in some areas.

Phase 5: Design the Energy System – The general philosophy of the design of sustainable building energy systems is to: (1) understand occupant needs, (2) meet as many needs as possible through renewable energy resources, (3) satisfy remaining loads with passive solar design elements, and (4) use integrated design strategies and high-efficiency technologies to provide the balance of energy services.

On this basis, HVAC is considered the balancing source of heating, cooling and ventilation, rather than the primary source. Taking this approach can result in significant downsizing of HVAC systems with resultant savings in first cost, operations and maintenance.

System Selection

When choosing a mechanical system, consider what will work best for the building based on its orientation, population, types of units, and number of occupants, as well as other design criteria such as conventional or renewable fuel base. Using life cycle cost analysis, aim to choose the system that best achieves the lowest total cost for a 20 year service life.

Make sure equipment is sized appropriately for the building and local climate, particularly if there are substantial energy upgrades to the envelope, passive solar orientation or other design features that influence heating and cooling loads. Oversized mechanical systems are costly, run inefficiently and may cause indoor air quality problems.

Some recommended heating and domestic hot water systems include:

Electric	Natural Gas
Zonal (Room by Room) • Baseboard & electric H_2O • Fan coil & electric H_2O • Electric resistance radiant & electric H_2O • Package thermal heat pumps & electric H_2O	Zonal (Room by Room) • Hydronic fan forced & gas H_2O
Unit System • Forced air furnace & electric H_2O • Central heat pump & electric H_2O	Unit System • Forced air furnace & gas H_2O • Hydronic baseboard & gas H_2O • Hydronic radiant & gas H_2O
Whole Building • Central heat pump & (central or unit) electric H_2O	Whole Building • Central gas (forced air or hydronic radiant) & central gas H_2O

Controls

Specify accurate, programmable thermostats wherever applicable, that proved control of heating system to plus or minus 2 degrees F and have night and weekend settings. Inexpensive thermostats can be quite inaccurate and tend to allow wide temperature swings. This causes discomfort and wasted energy as residents constantly adjust the system in pursuit of a steady temperature.

When? Design

Energy Efficient Appliances

Why?

The choice of appliances for an affordable housing project will have a long-term impact on the utility bills the owner or tenant will need to pay every year. According to 1997 data from the Department of Energy, appliances are responsible for 56.7% of all electricity consumed in homes.i This number leaves out water use, and the energy to heat that water, for clothes and dish washers.

What?

The appliance category includes everything from refrigerators to televisions. While many of the smaller appliances will be supplied by the occupants, the larger items typically installed by the owner need to be considered not just on first cost, but on how their use will impact the occupant over time.

Standards and Guidelines

Appliances that are ENERGY STAR rated (USEPA) meet specific energy-efficient criteria that exceed minimum standards. For instance, refrigerators need to be at least 10% more efficient than the current minimum federal standard. These products will be labeled with an ENERGY STAR logo and product listings can be found at the ENERGY STAR website @ www.energystar.gov . In addition to its' product listings, the website has useful 'Savings Calculators' for each appliance that allow you to compare product choices for yearly operating cost, lifetime operating cost and payback time period. You can input the total number of, say refrigerators, and get calculations for a development project as a whole.

While there are minimum efficiency standards for clothes dryers, ovens and ranges, the products don't vary as much in energy use from model to model and are therefore are not included in the EnergyGuide labeling requirements nor are they ENERGY STAR rated.

Built Green and SeaGreen all offer credits for use of Energy Star appliances.

How?

Strategies for getting it done

Refrigerators

Refrigerators are always on so it shouldn't be surprising that they are the most energy-consuming appliance in a home. In fact, they use 12.9% of all electricity consumed in U.S. housing units.ii When specifying refrigerators keep in mind:

- Models with the freezer on top are the most efficient type. A top freezer model will consume 10-25% less electricity than a similarly sized side by side model. And, they're less expensive.
- Ice-makers and dispensers not only add cost, they increase electric use for a refrigerator by 14-20%.
- Refrigerators work by running a basic refrigeration cycle, similar to that of an air-conditioner. Heat is extracted from the interior of the refrigerator, and exhausted into the kitchen. A more efficient refrigerator will have the added benefit of reducing cooling needs in a housing unit.

Clothes Washers

Clothes washers should be evaluated both on their electric consumption and on their water usage. Reduced water consumption has the additional benefit of reducing energy needed to heat the water going into the washing machine.

At Traugott Terrace, a 50 unit low-income housing project in Seattle, efficient front-loading washing machines are projected to reduce overall water consumption in the building by 18%. The efficient washing machines, combined with low-flow fixtures, has in turn generated a 26% reduction in the energy required for water heating.

The energy consumption on the EnergyGuide label is currently based on an Energy Factor that takes into account both the energy required to operate the washer and the energy required to heat the water used.

Beginning in January 2004, the federal standards will require that the EnergyGuide label be based on a Modified Energy Factor, which also takes into account how much moisture is left in the clothing and the drying energy then required to remove that moisture. This more encompassing standard is currently used to evaluate ENERGY STAR rated washers.

ENERGY STAR also requires that manufacturers report the Water Factor, which is based on the per cycle water consumption as compared to the machine capacity.

Horizontal axis, or front loading, washing machines will be the most efficient choice for both energy and water consumption and are worth the added up front cost in long term savings. If the only option is a top loading machine, be sure to specify an ENERGY STAR rated model.

Dryers

Clothes dryers are the second most energy consuming appliance in the home, @ 5.9% of total electric consumption.iii No EnergyGuide or ENERGY STAR labels exist to guide the choice of model, but there are features that will reduce the energy required to operated these appliances.

- Provide clothes lines. The easiest way to save energy is to simply not use it. If residents have the option of hanging clothes out to dry then the dryer will get more limited use.
- Specify models that incorporate a moisture sensor for automatic shut off when clothes are dry. These can reduce the energy use of the dryer by 15%.iv
- Compare the Energy Factor for different models of clothes dryers. Here the Energy Factor refers to the pounds of clothing that are dried per Kwh, so choose a model with a higher Energy Factor.

When? Planning and Construction

Cost Energy Star compliant appliances have a small cost premium over non-rated products of comparable quality and features.

Resources

Energy Star – www.energystar.gov

American Council for an Enrgy Efficient Economy - http://www.aceee.org/consumerguide/mostenef.htm

Consumer Federation of America - http://www.buyenergyefficient.org/

Office of Energy Efficiency and Renewable Energy - http://www.eere.energy.gov/consumerinfo/refbriefs/ve8.html

i Energy Information Administration. *A Look at Residential Energy Consumption in 1997*. Office of Energy Markets and End Use, U.S. Department of Energy, 1999.
ii Ibid.
iii Ibid.
iv Rocky Mountain Institute. *Home Energy Brief #6: Washers, Dryers and Misc. Appliances*. 1995.

Materials

Selecting and specifying healthy, resource efficient materials.

Why?

Many materials used in construction may release gases and compounds into the air for a period of time after construction is complete. These emissions, such volatile organic compounds (VOCs) from solvents may cause respiratory irritation or other health impacts to both construction workers and building occupants.

Resource efficient materials reduce consumption of virgin raw materials, are generally easy to maintain, reducing costs and the use of cleaning chemicals, and rarely need replacement, decreasing waste.

What?

Make cost effective decisions in the design phase to select materials that minimize the risk of health impacts while offering the longest service life. Also, increase overall resource efficiency by using salvaged or recycled materials, and selecting recyclable products where possible.

How?

Strategies for getting it done

Consider Life-Cycle Impacts

The life cycle of a material consists of four phases: raw materials extraction and processing; manufacturing; use; and disposal or reuse. Studies suggest that most of a building's environmental impact occurs during the use phase through its effects on energy and water consumption and on indoor air quality. It is therefore important to pay particular attention to impacts of use.

Products produced through low-intensity manufacturing processes contain less "embodied energy" than products produced through energy intensive processes. While life-cycle assessment (LCA) is a complex issue, in many instances a thoughtful, informed choice results in a better final project. For example, the use of locally-grown, sustainably-harvested wood may be a better choice than material with high-recycled content that is manufactured in another state. Using local products supports the local economy, reduces transportation-related energy expenditures, and brings local context into the design.

Financial cost is often, but certainly not always, a good proxy for environmental cost. Resource scarcity, energy intensive manufacturing, and large transportation impacts often show up in the cost of a product. However, so does efficiency, reliability and durability (better quality products generally cost more).

Life Cycle Costing is a process that captures the total financial cost of a product:

Purchase Cost + (Annual Operating Cost x Service life in years) + Disposal Cost

To compare the cost of products of unequal service life, divide each Lifecycle Cost by the Service Life in years, to get an Annualized Lifecycle Cost.

Source reduction

Build Less – one very effective way to reduce the material consumption of a building, and reduce cost is to make it smaller. Reducing the footprint and making more efficient use of space has a substantial effect, not only on materials consumption, but on impacts such as energy consumption, furnishings and finishes.

Build with Less – For any given size of building it is still possible to reduce the materials used for construction. Advanced Framing (also known as Optimum Value Engineering – OVE) reduces the need for framing lumber by spacing studs at 24" on center, using two stud corners, insulated headers, and aligning vertical load members to allow single top plates.

Make it last longer (See Lifecycle Impacts) - When selecting materials, both durability and initial cost should be considered. Materials, such as linoleum, wood flooring, tile, and concrete typically last longer than carpet,

vinyl flooring, or other synthetic materials. In the long-term, an investment in higher quality materials both saves money and reduces environmental impacts.

Resource Conservation

Specifying salvaged or recycled materials is an excellent way to reduce resource consumption.

- **Salvaged lumber** and materials from demolitions is increasingly available. Remember that lumber will have to be regraded if it is used for structural purposes.
- **Recycled building materials** are used for interior finishes. Other common uses include insulation (fiberglass or cellulose), drywall (specify recycled content), carpet, roof tiles, siding, decking, landscaping, and pavement. In many instances recycled-content products are competitive in both cost and performance.
- **Flyash** is another "recycled" material; a waste product of burning coal for energy generation. It is an inexpensive substitute for up to 40% of the Portland Cement used in concrete. Flyash increases the strength and durability of the concrete. By reducing the amount of cement needed, it also decreases the overall environmental impacts of cement production (mining, energy consumption and greenhouse gas emissions).
- **Engineered Wood** for Headers, Joists, and Sheathing – Large dimension, solid sawn lumber typically comes from old growth forests. Engineered lumber generally comes from small-diameter, fast growing plantation trees. This reduces pressure on old growth forest resources. Floor and ceiling joists and other large size lumber can be replaced with engineered products like microlam, paralam, and gluelam in most applications. Wood I-Joists are an alternative to 2X6s or 2X8s used for floor and roof joists. Engineered lumber uses wood fiber more efficiently, is more stable and less prone to warps and cracks and creaks.

Enhance Indoor Air Quality

Material choices significantly impact indoor air quality and hence the wellbeing of residents. Most paints, carpets, insulation, glues, and fire retardants emit potentially harmful volatile organic compounds (VOCs). Particle board and fiberboard contains formaldehyde, which may cause headaches and respiratory ailments. Take care to select materials and finishes that do not release potentially toxic or irritant compounds. Many major manufacturers offer low-toxic and no- or low-VOC products at competitive prices.

- **Low- or no-VOC Paints, Finishes and Adhesives** – "No-VOC" products do not emit volatile organic compounds (VOCs). Organic chemicals are common ingredients in household products like paint, adhesives, cleaning supplies, etc. No-VOC paint is used exactly like conventional paint. Current no-VOC paints are most suitable for indoor use. The EPA uses the following standards to define Low VOC paint for their Environmentally Preferable Purchasing Program (See next page):

Type of Paint	VOCs (grams/liter)	VOCs (pounds/gallon)
Interior Architectural		
Flat	50	0.42
Nonflat	150	1.25

Most adhesives have some level of VOCs, but there is no definition for "Low VOC" for adhesives. The

California South Coast Air Quality Management District (SCAQMD) rules are currently an accepted industry standard:

Recommended Limits for VOCs in Adhesives
(in grams per liter, less water and example compounds)
(Source: *State of California, South Coast Air Quality Management District Rule #1168*)

Application	VOC Limits
Non-vinyl backed indoor carpet installation Carpet pad installation Wood flooring installation VCT and asphalt tile installation	150
Ceramic tile installation	130
Subfloor installation	200
All other	250

- **Formaldehyde Free Fiberglass insulation** – if you choose fiberglass insulation, select a product which is certified as Formaldehyde –free. Johns Manville has a line of Formaldehyde Free products. Certainteed and Owens Corning has products certified by GreenGuard (www.greenguard.org)
- **Plywood and composites of exterior grade** for interior use, or purchase formaldehyde free products. Particleboard, interior grade medium density fiberboard (MDF), and other interior use, glue-containing products use urea-formaldehyde glue as a binder. Urea-formaldehyde continues to off-gas formaldehyde for a long time after application. Exterior grade products use phenoformaldehyde glue, which off-gases quickly. Most formaldehyde is gone before the product reaches the jobsite. Exterior grade products include most plywood and OSB currently available. Instead, use materials containing no formaldehyde, such as Medex grade MDF, whenever possible.
- **Minimize the use of carpet**. Synthetic carpet off-gases when it is new. In addition, carpeting acts as a highly effective reservoir for allergens such as dirt, pollen, mold spores, dust mites, and other microbes. Moreover, as carpet wears out, the surface yarn breaks down and becomes house dust. Instead use hard surface floors, such as linoleum, salvaged wood, cork, bamboo or ceramic tile.
- **Where you do use carpet,** look for products with take-back/recycling guarantees or leasing arrangements.

Resource Efficient Materials

Exterior

- **Siding with long service life and reclaimed or recycled content** – Aluminum siding generally contains high levels of recycled content. Vinyl siding also has some pre-consumer scrap included. However, vinyl is not recommended before difficulties in recycling it after use and concerns about environmental impacts of manufacture.

  Fiber cement siding contains reclaimed wood fiber and is a very cost effective, durable and low maintenance choice.
- **Use salvaged masonry brick or block** for exterior finishes, or use dyed stucco with recycled content, which is durable and needs no painting.

- **Wood composite windows** - Wood/plastic composites consist primarily of waste sawdust and scrap PVC generated in the production of wood and vinyl windows, or with PVC, from post-consumer bottle waste. Wood content ranges from 40% to 70%, depending on the manufacturer. According to recent tests, the frames have roughly the same energy performance as solid wood, but perform slightly better than vinyl window frames. They are also more stable than wood or plastic frames.

Roofing

- Use **recycled or reclaimed content roofing** - Several new composite options are available that provide lower maintenance along with durability. Many of these options include recycled-content or reclaimed materials: fiber-cement composites (there have been durability problems with some brands), asphalt shingles, plastic shakes, ridged sheet material made with fiber and asphalt, and metal shingles.
- **50 year roofing products** - Some brands of aluminum or steel shingles have a 50-year limited warranty and in addition, come with a coating approved by HUD, which allows the roof to be used for collecting rainwater. Fiberboard shakes, a durable product that can be nailed and sawn similar to wood shakes, generally come with a 30 to 50 year warranty.
- **Reclaimed materials for landscape walls and features**
- **Recycled-content plastic or wood polymer lumber for decks and porches**

When?

Design

Cost

Many low- or No-VOC finishes and products are available at little or no additional cost. The benefits of resource efficient materials should be weighed by looking at the total cost of purchase, installation, maintenance and replacement, rather than simple first cost.

Resources

Resource Conservation Research House Information Guide (also Resource Conservation House Plans and Resource Conservation House Video), NAHB Research Center, Upper Marlboro, MD. 800-638-8556 or www.nahbrc.org.

GreenSpec – The Environmental Building News Product Directory and Guidelines Specifications, E Build, Inc., Brattleboro, VT, 1999. 802-257-7300 or www.buildinggreen.com. *GreenSpec* is organized in standard CSI divisions. *Environmental Building News* (EBN) also offers product reviews, information, and also lists some articles at the following website: www.buildinggreen.com/products/productslist.html.

Environmental Resource Guide (AIA/John Wiley) www.wiley.com

The ERG gives architects and others in the building industry a basis for comparing the environmental impact of building materials, products and systems. The document and loose-leaf supplements are available at http://www.wiley.com/WileyCDA/WileyTitle/productCd-0471140430.html

Guide to Resource-Efficient Building Elements, Center for Resourceful Building Technology, Missoula MT. 406-549-7678 or crbt@montana.com.

Green Building Resource Guide, The Architectural Machine, Redwood City, CA. www.greenguide.com. Lists over 600 green building materials and products, available as CD-ROM database or reference manual.

Oikos Product Directory, formally the REDI Guide (Resources for Environmental Design Index), free extensive online directory containing product descriptions for green products; a good resource for energy-efficient products. Available from Iris Communications, Eugene, OR, online at oikos.com.

Operations and Maintenance

Ensure sustainable performance post-occupation.

Why?

Design and construction make up only a part of the lifecycle impacts of a building project. Post-occupancy practices significantly influence how well the intended environmental and economic benefits of the project are achieved.

Operation and maintenance practices impact the building owner's costs and residents' health, comfort and safety.

What?

The key to successful, sustainable building performance is convenient, cost –effective design, good information and education for occupants and operators.

How?

Strategies for getting it done

O&M Manual - A thorough O&M manual covering all key aspects of the building is essential. Special needs of sustainable features should be integrated with "conventional" O&M issues as part of standard practice or standard operating procedure. Conventional practices that conflict with sustainability goals should be modified.

Ideally, the maintenance staff should be included in the development of the manual. They know a great deal about what works and what doesn't. An annual review of the manual, including an update of approved maintenance products should be standard practice.

The manual should include:

- **Annual maintenance schedule** for all aspects of building, including:
    - Envelope
    - Roof
    - Vents
    - Filters
    - Plumbing
    - Combustion Equipment
- **Operating Tips** to reduce resource consumption, minimize waste, etc.
- **Summary of policies** and requirements relevant during occupancy
- **List of sustainable products/features** installed in the project, with preferred maintenance and replacement procedures for those products;
- If the project is an existing building, **address any "problem" substances** – such as encapsulated asbestos – that remain in the building, and include a hazardous materials management plan for those materials;
- Hand over of the manual should include an **orientation and training for maintenance staff and facility management**. Equipment manufacturers will often provide orientation for their products.

A sustainable landscape O&M plan should also be included, either in the manual, or as a separate document. The plan should include:

- A statement of the importance of using environmentally preferable methods of landscaping.
- Explanation of desired landscaping practices, such as integrated pest management (may also apply to aspects of building), mulching, use of mulching mowers for grassed areas, etc.
- Specific guidance on preferred soil preparation and amendment techniques, use of irrigation system (e.g. during plant establishment only), etc.

Waste Reduction and Recycling –

- Include recycling requirements in resident manual and move-in orientation;
- Recycling programs work best if there is some incentive for residents – this generally requires the support and buy-in of a group of residents to be effective;
- Provide adequate and convenient exterior location for resident recycling, with at least one bin provided for recyclables in each unit;
- Garbage should also be conveniently located and clearly marked to reduce risk of inadvertent cross-contamination;
- Liaise with local recycling contractors on bin sizes, location and access for trucks;
- Provide and maintain clear signage to reduce contamination;
- Include recycling and disposal procedure in the staff O&M manual; nothing stalls a recycling program faster than when residents see staff tipping the recycling in the garbage!

Maintenance supply storage (a code requirement)–

- Provide a secure, properly ventilated storage area for maintenance supplies, paints, and other materials.
- Ensure it is properly sealed and isolated from living spaces.
- Ventilation exhaust must be well clear of other air intakes and windows.

Resident Manual – provide guidance on living in a residence that incorporates sustainable features. The manual should be available in languages appropriate to your population, and should include:

- Recommendations for non-toxic cleaning supplies
- The importance of notifying property managers about leaks (mold prevention, structural integrity)
- Information on getting the best out of appliances or features of their residence that they may not be familiar with – programmable thermostats, zoned heating, fan timers in bathrooms;
- Recycling and garbage disposal procedures
- Low impact gardening practices
- Care and treatment of any sensitive areas on the site, e.g. wetlands, streams, buffers, etc.

Staff Training – The familiarity of O&M staff with the features of the building can be critical to achieving the designed environmental and economic performance of the project.

- Schedule regular training for retained and new staff, either on-site or at local service providers;

When?	Occupancy
Cost	Effective Operations and Maintenance will reduce the cost of operation, repair and replacement.
Resources	EPA Cleaning Products Pilot Project - www.epa.gov/opptintr/epp/cleaners/select/ Greenseal: Environmental product rating system – www.greenseal.org Home Ecology: Information on non-toxic cleaning supplies – www.homeecology.org Seattle Public Utilities: Apartment Recycling Program (Seattle area only, but some useful information, check your solid waste utility for similar program) – www.ci.seattle.wa.us/util/services/apartment/default.htm Training: City of Seattle Office of Housing – www.seattle.gov/housing/10-propertymanagers

Sustainable Design

How to manage the design process differently to achieve sustainable buildings.

Why?

Sustainability is responsible stewardship of our natural, human, financial resources through a practical and balanced approach.

What?

Sustainability requires changes to the design process to ensure the "best fit" of the built environment to the natural environment. The design process must be "front loaded," investing more time to understand the building as a system and to optimize the interrelationships of the various components of that system to best meet the needs of the end users.

How?

Strategies for getting it done

Planning –

Goals: Integrate sustainability into project goals as early as possible. The end user should participate in setting these goals. Sustainable goals will infuse the project with a longer time framework.

Players: More involvement of the design team up front; interdisciplinary teamwork critical for maximum success. The end user should be represented on the design team.

Process: The more comprehensive the planning, the more likely opportunities will not be missed, and unnecessary costs will not be generated.

Evaluation Options available:

- Product & Equipment Selection Software
- Computer Modeling, Simulation, and Optimization
- Cost Analysis (Simple Payback, Life-Cycle Cost Analysis, Value Engineering) www.value-eng.org

Budget: Although you can achieve "green" without cost premiums, you will experience cost shifting. More upfront design time will pay off

Implementation

Predesign Phase:

- Have a goal-setting meeting.
- Ensure sustainability is integrated with overall project goals.
- Identify performance standards or guidelines (i.e. LEED, Built Green™)

Schematic Design Phase:

- Selecting team – include green element in any RFQ's released for the project
- Arrange an Eco-charette (a strategic brainstorming session) for the team to generate a list of green options for the project. If the

Eco Charette Tips

- **Bring all the players** - Documents and key players will provide information about organizational goals, and specific objectives that relate to sustainable building project.
- **Provide pictures** of techniques that may be proposed as part of charrette.
- **Capture results** - Ensure there is some mechanism for documenting the results of the eco-charrette.
- **Get everyone on the same page** - Provide a concise introduction (20-30 minutes) to sustainable building strategies.
- **Be the Guide** - Provide a structure or framework for considering strategies. If the owners are considering LEED or a local rating system, then organizing the discussion around LEED or the rating systems' categories is recommended.
- **Never say die** - Ensure charrette participants come up with solutions when barriers are raised.
- **Keep people connected** - Breakout into smaller groups when there are more than 20 participants.
- **Turn off the editors** - Use basic facilitation rules for brainstorming (allow "dreaming")

project is going for LEED™, the LEED™ Rating system can provide a framework for this session.

Design Development:

- Determining applicability and cost-effectiveness of green strategies from charette;
- Match strategies with client priorities, project's potential for LEED or other certification.
- Begin "Focused Design Reviews" to pick up inconsistencies between design elements and design intent. (This is the first step in "Commissioning.")

Construction Design:

Incorporate "green" products and practices into specifications. Basic tips for writing green specifications include:

- Stick with CSI Format – do NOT add a Part 4 section to the spec.
- Write the specification for the contractor: Say it once and in the right place, eliminate ambiguous terminology and use correct grammar and punctuation – be clear and precise!
- Ensure all areas depicted in the drawings are addressed in the specifications.
- Use the imperative; use words such as "provide" and "apply" rather than "shall" or "should be."

Select products carefully:

Court decisions have found design professionals liable when they failed to properly research products that later proved unsuitable for their intended purpose.

- Research the manufacturer's reputation for on-time delivery and reputation for honoring warranties.
- Reference a standard when you can – e.g. CRI (Carpet & Rug Institute; ASTM, ANSI, AWI, FSC, etc.)
- Assume responsibility for specifying green products
- Research availability, lead times, and cost.
- List at least three manufacturers for each product (for public jobs, usually required.)
- Include telephone numbers and contact persons if possible
- Do not use term "or equal"; use "or approved"
- Define terms unique to green products – e.g. recycled content, low-VOC, non-toxic.
- When in doubt, leave it out!

Construction: With green building, conventional construction practices will frequently need to be modified.

- Plan for on-site training and oversight.
- Integrate education into weekly safety meetings
- Provide clear site signage on green practices and requirements.

Commissioning

The bulk of Cx takes place during this phase, with the contractor very much involved in the process of ensuring that the building is constructed in accordance with design intent. Generally an independent Cx agent or someone not on the design team itself is used to conduct the Cx process.

Occupancy:

Many green building features require the "cooperation" of occupants either in operation or maintenance to be really effective over the long term,. For that reason, training, handbooks, and signage are frequently part of the picture. In addition, final CX and post occupancy evaluations are an important aspect of sustainable construction.

When?	Planning, Design and Construction
Cost	The sustainable design process typically places more of the budget emphasis in the design phase. This does not lead to higher costs, however. Thorough, stakeholder-based planning, focused design reviews and clear, effective spec writing will generally eliminate or avoid far more cost in the construction phase, than they incur during design. The end result will be a building with significant social, environmental and economic benefits.
Resources	CSI Manual of Practice, Construction Specifications Institute. Construction Specifications Institute, www.csinet.org Several tools to assist in selecting green strategies and materials: Life Cycle Assessment primer - http://www.cityofseattle.net/sustainablebuilding/leeds/docs/LCA_Primer.pdf Life Cycle Cost Analysis - http://www.greenbuildingsbc.com/new_buildings/resources_guide/10.0_epr.html BEES 3.0 Materials selection software - http://www.bfrl.nist.gov/oae/software/bees.html Athena Decision support software - http://www.eere.energy.gov/buildings/tools_directory/software/athena.htm

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Global Green Top Twenty

COST-EFFECTIVE WAYS TO GREEN AN AFFORDABLE HOUSING PROJECT.

1. Design Water Efficient Landscapes	**Description**: Low-water landscape designs, such as xeriscape, reduce water use by emphasizing native and/or drought tolerant plants, elimination of turf areas, and minimizing maintenance. Efficient irrigation systems, such as drip and micro irrigation, place the correct amount of water directly at the base of each plant, thus reducing water use and waste from overwatering. **Benefits**: Water efficient landscape and irrigation systems help plant growth and overall health by eliminating overwatering or excessive drying. They also lower water bills and reduce impacts on water supply infrastructure.
2. Install Water Efficient Toilets and Fixtures	**Description**: New toilets use 1.6 gallons per flush compared with old toilets that require 5-7 gallons per flush. Flow reducers fit into the aerator at the tip of the faucet and reduce the rate of water flow through the faucet. Low-flow showerheads replace standard showerheads. **Benefits**: It is estimated that low-flow toilets can save up to 22,000 gallons of water per year for a family of four. Flow reducers can cut water usage of faucets and showers by as much as 40% with little noticeable effect.
3. Use 15% or Greater Flyash in Concrete	**Description**: Flyash is a byproduct of coal burning power plants and can be an inexpensive substitute for 15% - 40% of the Portland cement used in concrete. **Benefits**: Flyash increases the strength and durability of the concrete. Using flyash also reduces the amount of cement needed, thereby decreasing the overall environmental impacts of cement production (mining and energy consumption).
4. Use low- or no-VOC Paint	**Description**: No-VOC paint does not emit odors related to volatile organic compounds (VOCs). Organic chemicals are widely used as ingredients in household products like paint, adhesives, cleaning supplies, etc. No-VOC paint is used exactly like conventional paint. Current no-VOC paints are most suitable for indoor use. **Benefits**: VOCs can cause eye, nose, and throat irritation, loss of coordination, and potentially damage the liver and central nervous system. Outside, VOCs can bond with other pollutants and create ground-level ozone.
5. Seal All Exposed Particleboard or MDF	**Description**: Particleboard typically includes formaldehyde. Sealing with a flat, latex-based primer or other suitable material can prevent the off-gassing of formaldehyde. **Benefits**: EPA ranks formaldehyde as a probable human carcinogen. Exposure to formaldehyde can cause eye, nose and throat irritation, skin rashes, headaches, nosebleeds and nausea.
6. Install Carbon Monoxide Detector	**Description**: Carbon monoxide detectors monitor the level of this gas in individual dwelling units. **Benefits**: Carbon monoxide is a common indoor air pollutant created by the combustion of natural gas from stoves and heaters and is harmful to human health.
7. Vent Rangehood to the Outside	**Description**: Steam, gases, smoke and other combustion by-products (such as unburned hydrocarbons) can result from cooking. Stovetop range hoods expel these by-products to the outside. **Benefits**: Range hoods improve indoor air quality, prevent overheating and excess moisture build-up.

8. Maximize Natural Daylighting	**Description**: Natural daylighting is usually available to the east, south, and west facades. **Benefits**: Maximizing natural daylighting reduces the need for artificial light, thus reducing energy consumption and utility bills. Dwellings that have good natural daylighting are usually considered to be more pleasant for the residents.
9. Provide Overhangs or Screens on South-Facing Windows	**Description**: Overhangs or screens on south-facing windows are one component of a natural cooling system. **Benefits**: Shading south-facing windows can make homes more comfortable without airconditioning by screening the hot summer sun.
10. Incorporate Natural Cooling/Ventilation	**Description**: Natural cooling/ventilation systems incorporate shading from deciduous trees (for east and west-facing glass) and window overhangs and awnings. **Benefits**: Natural cooling/ventilation reduces the need for air conditioning, saves money on energy bills, and can make homes without air conditioning more comfortable.
11. Select Light Colored Roofing	**Description**: Dark roofing materials absorb heat, making the house warmer in summer months, whereas light colored roofing reflects heat away from the building. **Benefits**: Light colored roofing reduces heat buildup through the roof, thus increasing occupancy comfort, and decreasing air conditioning bills. Light colored roofing can also last longer because it does not thermally expand and contract as much as darker colors.
12. Use Recycled Fiberglass or Cellulose Insulation in Walls and Ceilings	**Description**: Both fiberglass and blown cellulose insulation have recycled content. Fiberglass products are used identically to standard products. Blown cellulose (made of recycled newsprint) requires a special installer. **Benefits**: Cellulose insulation provides a tighter enclosure than fiberglass. Recycled-content products support state solid waste diversion goals.
13. Install High R-Value Insulation	**Description**: High-density insulation, rigid foam insulation and products such as Structural Insulated Panels and Insulated Concrete Forms offer very high R-value envelopes. **Benefits**: "Super insulation" increases energy efficiency and comfort of a home, and may lead to downsizing of heating and cooling systems.
14. Install Fluorescent Lights w/ Electronic Ballasts 15. Install Compact Fluorescent Light Bulbs 16. Install Lighting Controls (occupant sensors, timers)	**Description**: Interior fluorescent bulbs and (where practical and appropriate) fixtures produce light quantity and quality that is comparable to incandescents, while expending less energy. Electronic ballasts also improve efficiency and reduce flickering. Lighting controls use sensors and timers to turn lights off in unused areas or during times when lighting is not needed. **Benefits**: Energy efficient lighting reduces energy consumption and lowers utility bills. One compact florescent bulb will pay itself back over ten times over the course of its life through reduced energy use. Lighting controls reduce energy use by having the lights on for shorter periods of time.

17. Install Energy Star Refrigerator and Other Appliances	**Description**: Refrigerators and freezers are among the largest users of electricity in most homes. They can account for up to 25% of household energy use. Energy Star appliances are in the 15% of efficiency for their type. **Benefits**: Energy Star refrigerators can save over 10% of the total annual electrical bill in a home. Check with the local utility company for rebate programs.
18. Use Engineered Wood for Headers, Joists, and Sheathing	**Description**: Solid sawn lumber in sizes of 2X10 or greater typically comes from old growth forests. Engineered lumber products, however, come from small-diameter and fast growing plantation trees. 2X10 and larger dimensional lumber is typically used for floor and ceiling joists and some seismic applications. Large size lumber can be replaced with engineered lumber (microlam, paralam, gluelam) in most applications unless required by seismic codes. Solid sawn 4X6s are often used for headers when smaller dimension lumber would suffice, such as double 2X6s, unless solid 4X6s are required by seismic codes. Wood I-Joists are an alternative to 2X6s or 2X8s used for floor and roof joists. **Benefits**: Reducing demand for large dimensional lumber decreases pressure to cut down old growth forests. Engineered lumber uses wood fiber more efficiently that conventional lumber, resulting in stronger and higher quality homes.
19. Install Ceiling Fans	**Description**: Ceiling fans improve interior comfort by circulating cold and warm air. They can be adjusted to either draw warm air upward during summer months or push it downward during the winter. **Benefits**: Ceiling fans can reduce the need for air conditioning and heating by circulating air effectively.
20. Select Double-Paned, Spectrally Selective (low-e) Windows	**Description**: "Low E" windows generally reduce the amount of heat that comes through windows without significantly reducing the amount of visible light. **Benefits**: Minimizing heat gain through glass during hot periods can reduce cooling loads and utility bills.