GREEN WITHIN REACH

A CASE STUDY ON THE APPLICATION OF LEED FOR HOMES TO A HABITAT FOR HUMANITY PROJECT

A thesis by Kolton Barnes, April 2014
Exponential growth of human population
- Expected 7.6 billion by 2020
- Demand for more buildings
  - Increases resource requirements

Limited resources on our planet
- Current consumption requires 120% of Earth’s yearly output
- Architecture, engineering, and construction
  - Responsible for significant use of resources
Strategies can reduce a building’s impact
  - Reduce waste
    - Planning material cuts
    - Diverting material away from landfills
  - Create healthier interior environments
    - Finish and material selection
    - Construction process practices

Increase water efficiency
  - Plumbing fixtures
  - Landscaping

Increase energy efficiency
  - Appliances and electrical fixtures
  - Insulation and fenestrations
  - Sealing building envelope

The commercial sector is targeted most often because these buildings use the most energy annually.
Promote implementation of sustainable options in residential sector

What green features can be added to existing design of single-family residence?

Cost is often cited as obstacle
  - What inexpensive options earn points in LEED for Homes?
Information pertinent to study
  - Climate/geography of Norman, OK
    - Affects selection of appropriate green strategies
  - History of Habitat for Humanity
  - History of the Leadership in Energy and Environmental Design rating system
Early Oklahoman homes; sod houses
  - Made from readily available resource
  - Stacked sod strips
    - 3-4 inches thick
    - 18 inches wide
    - 24-36 inches long
  - One room
    - Roughly 225 sq ft
    - Compacted soil floor
    - 7 foot ceilings
    - Plastered walls

Modern Oklahoma Homes
  - Average home size in the South- 2393 sq ft
  - Typical construction methods/materials
Modern Oklahoma Homes

- Average home size in the southeastern US - 2393 sq ft
- Typical construction methods/materials
  - Wood frame
  - Higher ceilings than sod houses
  - Gypsum wall board for interior walls
  - Indoor plumbing
  - Electricity

- Many homes feature brick exteriors
  - Clay-rich soil lowers production cost
  - Defense against debris made airborne by tornadoes
  - Non-combustible

Sustainable Features of Brick

- Local production
- High thermal mass
- Little waste from production
- Inert material; does not leech chemicals into soil
- Very low-maintenance
- Recyclable
Household Energy Usage
- Yearly use of approximately 77 million Btu
- Average of 1,132 Kilowatt-hours of electricity per month
  - 9.51 cents/KWh, average
  - $108.00/mo electricity bill, average
    - Excluding fees and other charges

Household Water Usage
- Family of 4 can use 300+ gallons daily
- $2.00 per 1000 gallons, or 0.2 cents/gal, average
  - $18.00/mo water bill, average
    - Excluding fees and other charges
Objective 1: Identify the green building features of an existing affordable home design which might earn points in the LEED for Homes system
  - Select subject Home – HFH Compressed Earth Block Home
    - Already under construction at beginning of study
    - Construction documents, specifications, and cost estimates accessible
    - Locality provides opportunities for site visits and accurate understanding of environment
    - Part of the CEB Research Team’s study to compare sustainable features to adjacent wood-framed home built to National Green building Standards
      - Resource usage for construction
      - Post-construction energy savings
    - The building is an affordable housing project
  - Conduct full LEED for Homes scoring
    - Project Checklist
Objective 2: Identify potential LEED for Homes points which might be attainable for the selected existing home design with some additions or substitutions

- Note points not earned as-designed
- Select credits that would only require small additions/changes and would likely have little to no monetary impact
  - Innovation and Design Process
  - Water Efficiency
  - Energy and Atmosphere
  - Materials and Resources
  - Indoor Environmental Quality
  - Awareness and Education
Objective 3: Recommend the design changes necessary to earn the LEED for Homes points identified in Objective 2

- Plan actions necessary to earn points
  - Design and construction process
  - Replacement products
- Full LEED scoring with changes in place
  - Project Checklist
Objective 4: Analyze whether the extra cost associated with incorporation of the suggested design changes is no more than a 0.25% of the net initial design cost increase per point gained through changes suggested in Objective 3

- Cost comparison for net FMV increase
  - Existing features/products
  - All recommended features/products

- Cost per point
  - Net increase divided by points added

- Cost per point as percentage of initial FMV
- Repeat process with superfluous additions omitted
Subject home

- Result of collaboration between Cleveland County Habitat for Humanity and University of Oklahoma College of Architecture
- 618 Apache Street, Norman, OK
  - Existing neighborhood
- Single family residence
  - 7700 square foot lot
  - 1278 gross square foot structure with 1178 square feet of living space
- Compressed Earth Block (CEB) structure
  - Composed of soil, clay, concrete mixture, and water
  - Unbaked- compressed with powered mechanical press
  - Laid as traditional masonry
  - Resistant to tornadic debris
- Other features similar to other new-construction homes
Cost analysis procedure

- Values are retail cost
  - No discounts included
  - Directly from manufacturer if available, or from retailer suggested on manufacturers website
- $60,000 FMV for home
  - Estimation made by Cleveland County Habitat for Humanity
  - 0.25% per point = $150.00
Provide documentation to USGBC
- Team members having three qualifications below:
  - Architecture or residential building design,
  - Mechanical or energy engineering
  - Building science or performance testing
  - Green building or sustainable design
  - Civil engineering, landscape architecture, habitat restoration, or land-use planning
- All team members included in at least 3 design phases
- Hold a design charrette

ID 1.2: Integrated Project Team (1pt) and ID 1.4: Design Charrette (1pt)
- No additional cost
Plan that the home be no more than 15° off east/west axis

* ID 1.5: Building Orientation for Solar Design (1pt)
  - No additional cost
    - Assuming no interruption of site utility line access

Solar design utilizes the sun’s rays to heat a space in winter while shading windows from the heat in summer. Having a building running along the east/west axis ensures the most efficiency from incorporating of this design.
- Specify toilet that uses 1.1 gallons per flush or less
  - TOTO Drake II with SanaGloss®, model CST454CUFG
    - $605.00

- WE 3: Indoor Water Use (1pt)
  - Compared to TOTO ECO Drake®, model CST743E
    - $308.00
  - Increase of $297.00
Include ENERGYSTAR ceiling fans in other bedrooms
  • Builder Elite 5 Blade Energy Star Ceiling Fan, model 53242
    • $142.50

EA 9: Appliances (0.5pt)
  • 2 fans
  • $285.00 FMV increase
Prepare cut lists for wood framing members
  - Meets prerequisites allowing for existing features to earn points

MR 1: Material-Efficient Framing (2pts) and MR 1.4: Framing Efficiencies (3pts)
  - Reduced waste
  - Roof rafter spacing greater than 16 inches on-center
  - No added cost
    - Could reduce expense by creating less wasted lumber
**INDOOR ENVIRONMENTAL QUALITY**

- **Install Carbon Monoxide detector**
  - Kidde Carbon Monoxide Alarm with Battery Backup, model KN-COB-IC
    - $36.99
  - Meets prerequisites allowing existing design to earn points

- **EQ 2: Combustion Venting (2pts)**
  - No fireplace
  - $36.99 FMV increase

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**You can’t see, smell, or taste CO, but at certain concentrations, it can become deadly in minutes. Symptoms of CO poisoning include:**

- Headache
- Dizziness
- Nausea
- Confusion
- Rapid breathing and/or heartbeat
- Vision problems
- Seizures
Use air filters having MERV 13 rating
  - Filtrete Healthy Living 2200 Elite Allergen Reduction® filter
    - $24.22

EQ 7: Air Filtering (2pts)
  - Compared to Filtrete Clean Living 600 Dust and Pollen Reduction® filter, MERV 8
    - $8.06
  - $16.16 FMV increase
  - Recurring expense
    - Healthier living environment
Cover HVAC vent openings during construction
  - As simple as garbage bag and tape

Perform a pre-occupancy flush
  - Open all windows and run HVAC system fan for 48 hours
    - Can be non-consecutive

 EQ 8.1: Indoor Contaminant Control (2pts)
  - No FMV increase
    - Materials needed are common on construction sites
    - Expense small enough to be omitted

Covering vents during construction prevents particles, such as dust from gypsum board, from settling in ducts. These particles would otherwise be forced into the air you breathe within a space once the HVAC system is running.
Give homeowner walkthrough and operations manual for all sustainable features
  - Meets prerequisite
  - Manual includes documents submitted to USGBC

Hold open house event to increase public awareness
  - 4 hours
  - 4 weekends

Provide information about the home online and in newspaper press release

AE 1: Education of the Homeowner or Tenant (1pt)
  - No monetary impact
  - Also would bring attention to CEB Team’s research
Score in current state
  - 29 points
  - No certification level reached
    - 35 points needed after Home Size Adjustment factor of -10

Score with all recommendations
  - 45.5 points (16.5 gained)
  - LEED Certified
  - Only 4.5 points away from LEED Silver
  - $932.15 FMV increase
    - $56.49 per point gained
      - 0.09%; below goal of 0.25% increase per point
CONCLUSIONS

- Score with select recommendations
  - Ceiling fans removed
    - High cost compared to points earned
    - However, user control of thermal comfort reduced
  - Home not oriented for solar design
    - Parallel to street likely more desirable
      - Neighborhood continuity
  - 44 points (15 gained)
  - LEED Certified
  - $647.15 FMV increase
    - $43.14 per point gained
      - 0.07%; below 0.25% increase per point
End goal should not be LEED certification
- Sustainable practices incorporated in residential sector for benefits to occupants and environment
- LEED is not required, but assists in bringing public awareness

Conventionalization of green techniques
- Educating homeowners and design/construction professionals integral to standardization
Future research

- LEED for Homes analysis again once construction is complete
  - More accurate analysis of both score and cost
    - All product details available
    - Third party testing could be completed
    - Could reach certification in current state
  - Could instigate more recommendations for this or future homes
  - More precision lends itself to more influence on opinions

This influence is what is necessary to have green features present in more homes, meaning healthier living environments and lower utility bills, and making living more affordable for all.
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