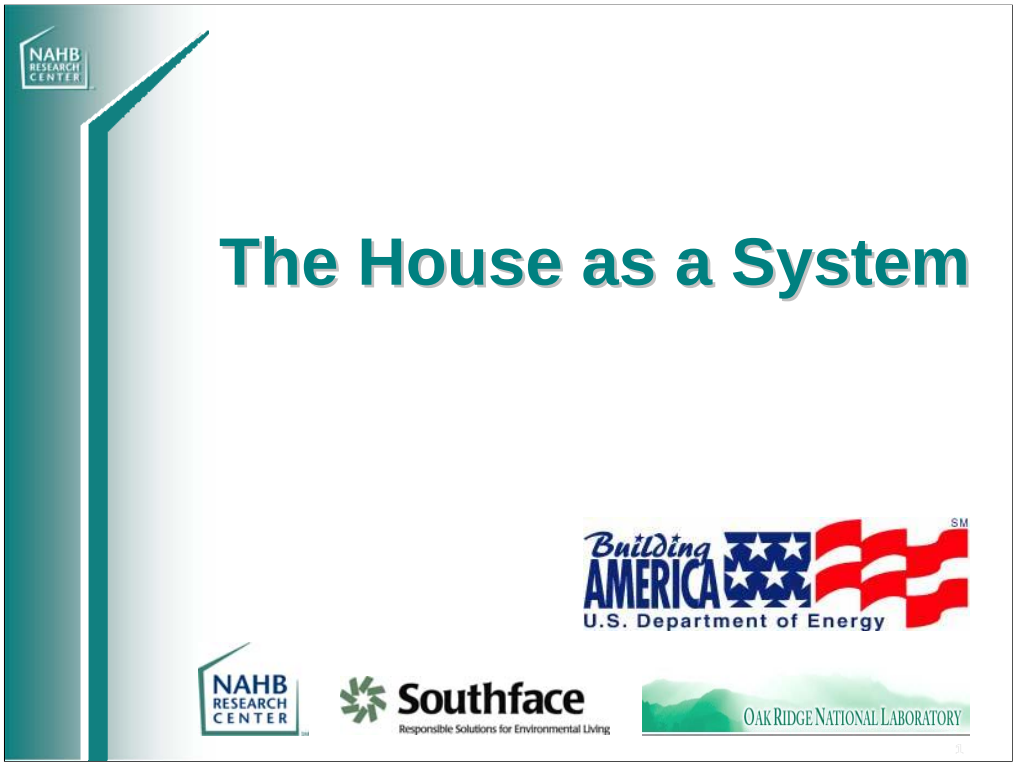
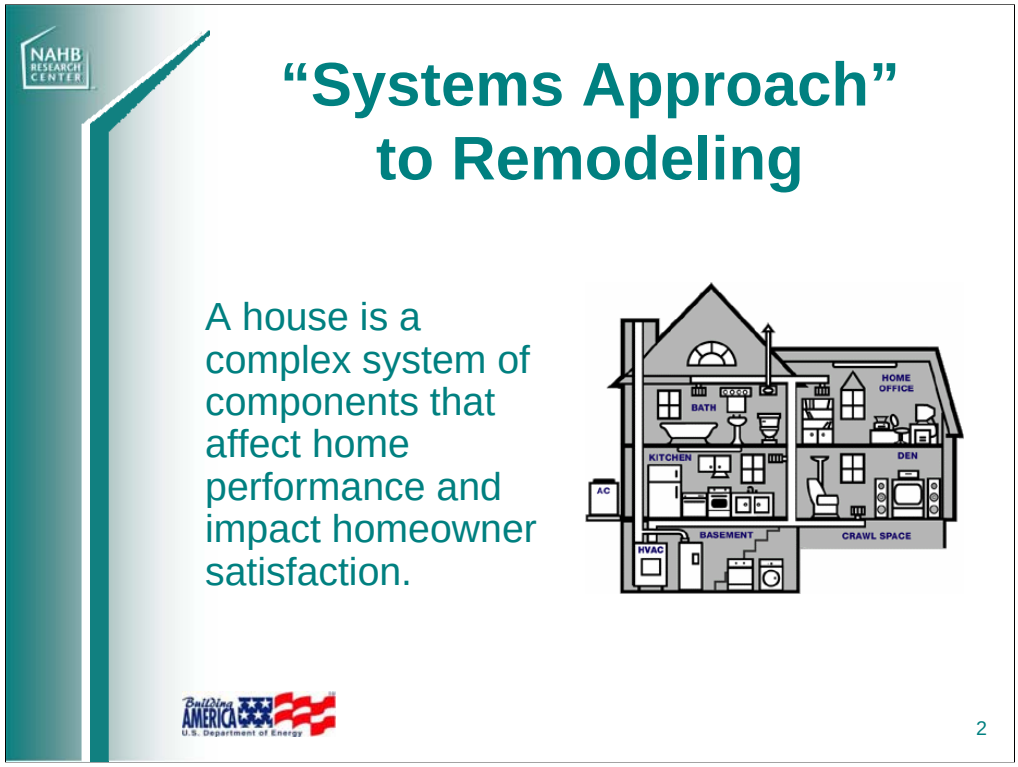


Key Concepts
Module overview

Explanation
This module is part of a larger course on energy efficiency in remodeling. Although a remodeling project may involve only one room in a house, the project will affect other parts of the house because a house works as a system of its parts. For example, if replacing the siding on a home, check to see if the walls are insulated. Also, inspect the age and condition of the windows. It is usually always a cost effective practice to install an air barrier with seams properly lapped and taped. Consider whether an additional layer of rigid foam insulation might be a cost effective energy improvement, but be sure the material you use will not be a vapor retarder that could trap moisture**.** Attention to interactions is needed to ensure that the final product performs well and that the customer is happy. The objective of this module is to increase your understanding of a systems approach to remodeling and to demonstrate how a systems approach can improve the final product. Examples will be presented.

Action Items

Resources
Systems Engineering Research - http://www.eere.energy.gov/buildings/building_america/se_research.html
Information Resources - http://pix.nrel.gov:8020/BASIS/nich/www/bapublic/SF

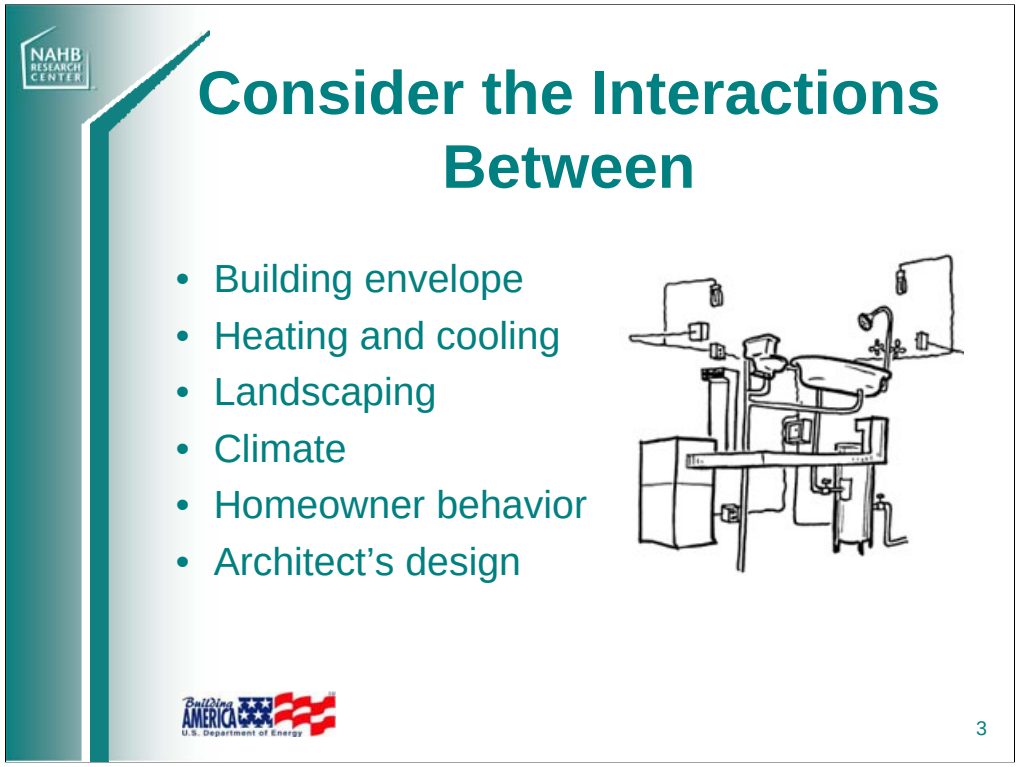


Key Concepts
The house is a system of components (building envelope, space conditioning equipment and distribution system, lighting, appliances, and water heating) that interact. How they interact will determine the home's performance (e.g., cost, energy consumption, humidity level, durability, structural integrity). A home's performance impacts the occupant's satisfaction (e.g., health, safety, comfort). A systems approach to remodeling involves understanding the impact of remodeling on whole house performance and looking for opportunities to make improvements.

Explanation

Action Items
Understand that decisions made during remodeling can affect the home's performance. Help your customer make informed decisions up front that will increase their satisfaction and avoid future problems.

Resources
Systems Engineering – http://www.eere.energy.gov/buildings/building_america/se_research.html
ENERGY STAR http://www.energystar.gov
Home Energy Magazine http://www.homeenergy.org
No Regrets Remodeling (available through Home Energy Magazine), an over 200-page guide to energy efficiency in remodeling. Includes diagrams, worksheets, definitions, and concise explanations. An excellent resource for a remodeler interested in energy efficiency.
Energy Efficient Rehab Advisor (U.S. HUD) http://rehabadvisor.pathnet.org.

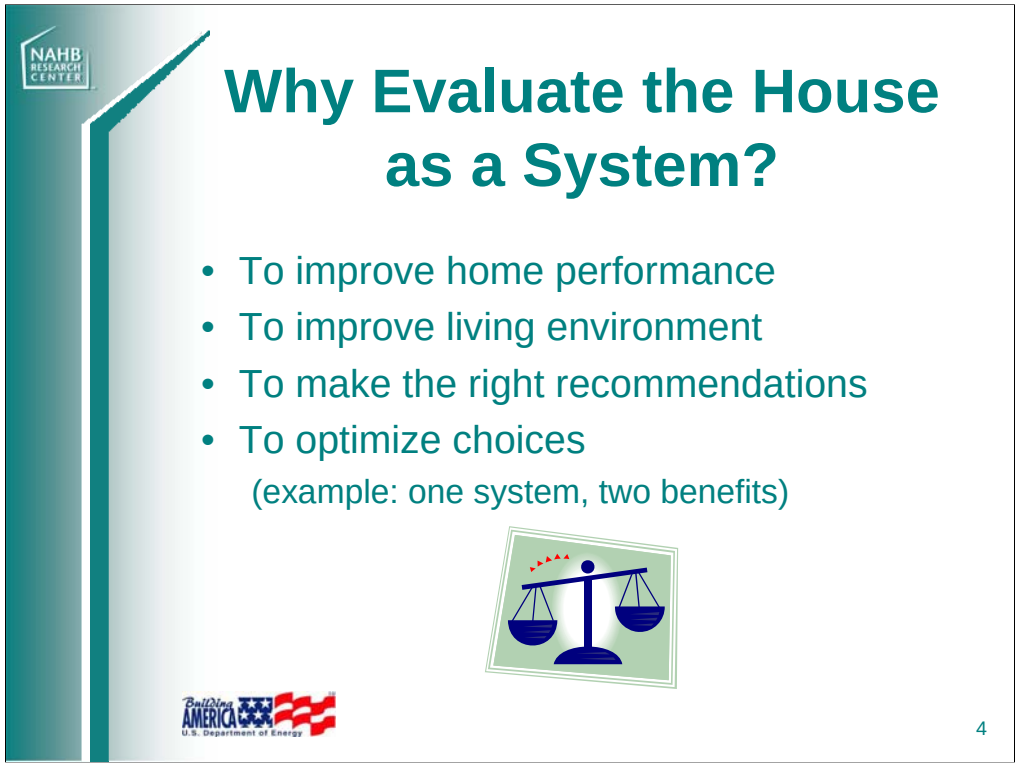


Key Concepts
Considering the interactions between the parts of the house system is key to making the best choices in a remodeling project.

Explanation
The interactions between the building envelope, space conditioning, other components, and climate will be shown in upcoming examples. The lifestyle of the occupants also plays an important role in the outcome. Understanding how your customers will use their house after remodeling is complete can help you recommend the best options. Homeowners who consume more energy (e.g., a household with a number of teens that take long showers and leave lights on in unoccupied rooms) are likely to save more through efficiency upgrades than those with more conservative lifestyles (e.g., a two-person household that sets the temperature back at night or when leaving for the day).

Action Items
Develop an understanding of your customer's lifestyle. This will assist you in designing a remodeling project to best suit the customer's needs while maximizing energy savings.

Resources
Building Envelope, Cooling Systems, Heating Systems, - http://pix.nrel.gov:8020/BASIS/nich/www/bapublic/SF

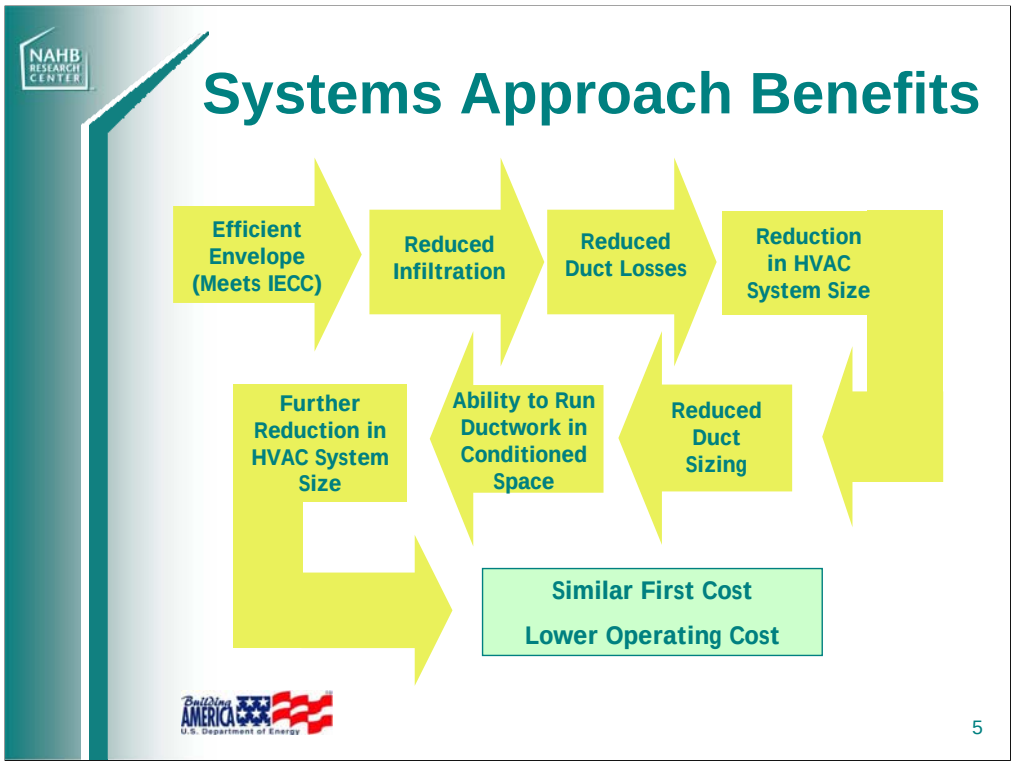


Key Concepts

Understanding the interactions between components of the house makes it possible to improve performance. Evaluating trade-offs will help you provide the best overall value for the customer.

Explanation

There are usually a number of ways to provide the basic functions of a house (e.g., heating, cooling, lighting, appliances). Understanding

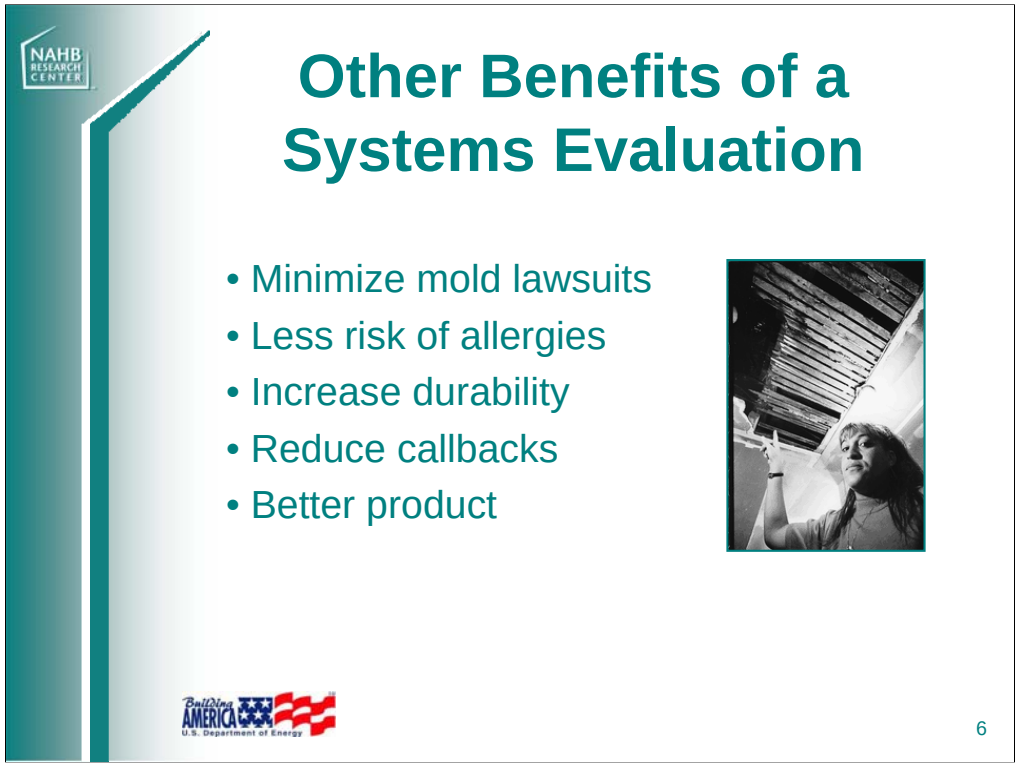


Key Concepts
Each improvement in energy efficiency allows additional adjustments in the system to be made, further reducing energy consumption by the system as a whole.

Explanation
As an example of the benefits of a systems approach, start by considering a building that is compliant with the Model Energy Code. By reducing air leakage through the building shell and through ducts, a smaller HVAC system with smaller ducts can be used to provide the same level of comfort in the home. Smaller ducts may be more easily run through conditioned space, reducing duct energy losses and allowing a further reduction in HVAC system size. This entire process frequently occurs with little or no impact to the project's first costs and with significantly lower operating costs for the finished product.

Action Items
Look for ways that the improvements your customer wants can work together as a system to give customers what they want and more.

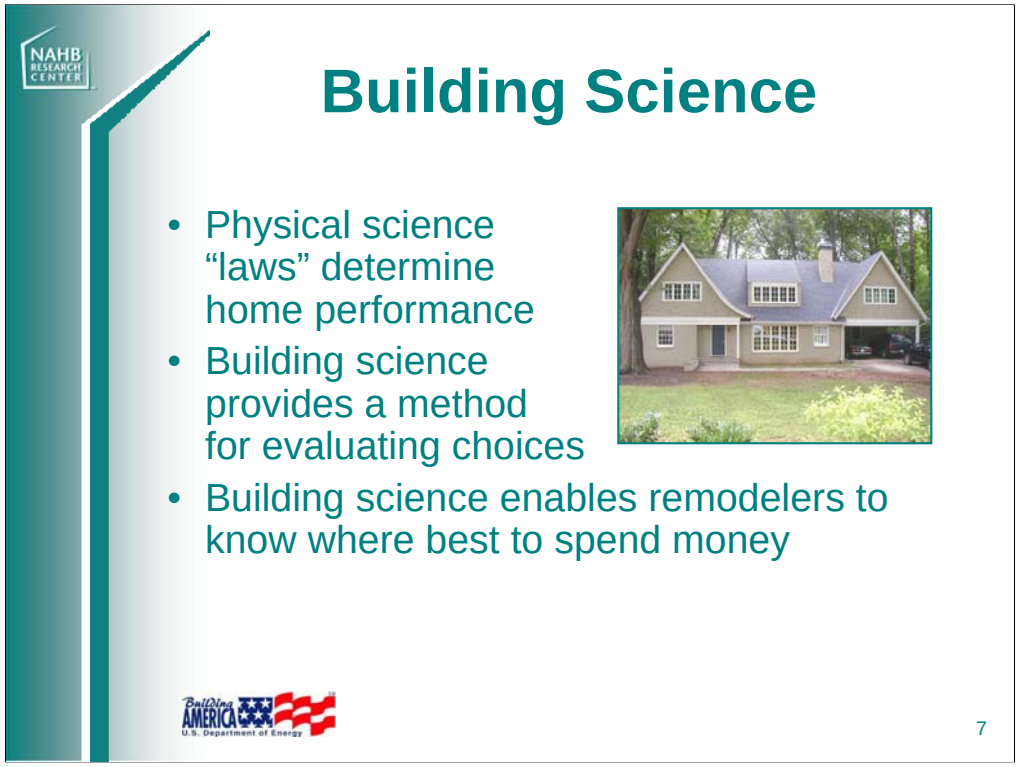
Resources



Key Concepts

Understanding how parts of the systems interact may enable you to see why problems have occurred in the existing house and how to avoid them in the remodeled home. A systems approach will also help you to avoid potentially costly mistakes such as mold, premature deterioration, and other callback (or lawsuit!) issues.

Explanation

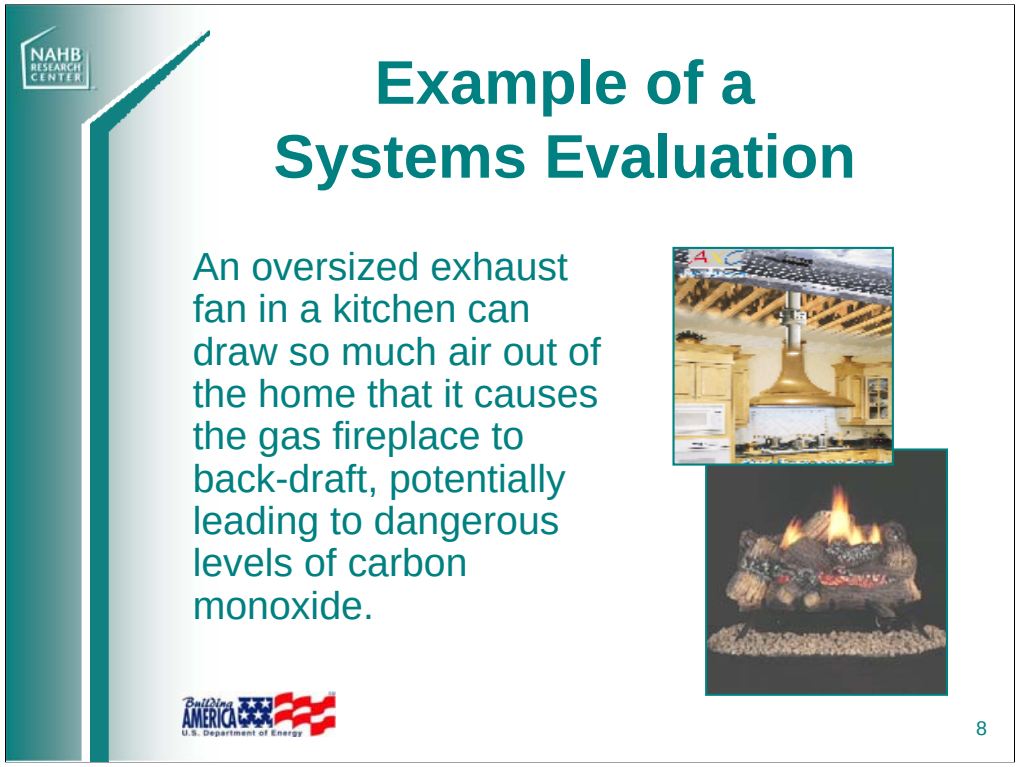


Key Concepts

The physical science "laws" (recall Building Science Basics) help us understand why houses perform as they do. Measuring and evaluating performance can help us evaluate potential changes before they occur, thereby maximizing potential improvements and avoiding costly mistakes.

Explanation

For more information on this topic,

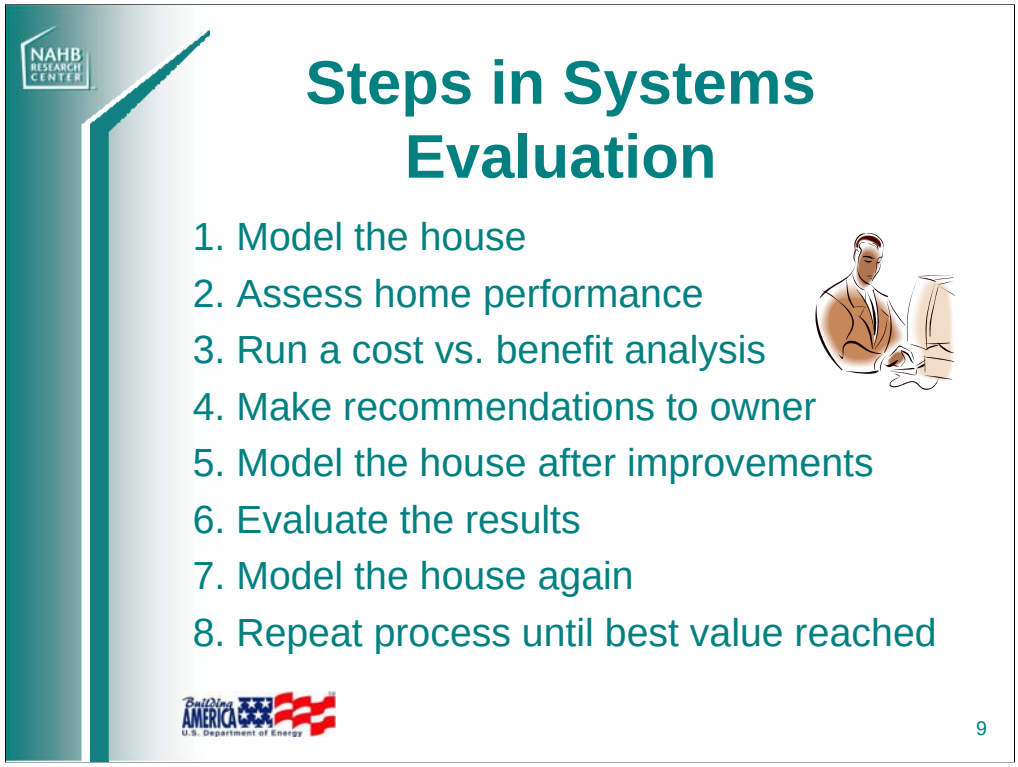


Key Concepts
Look beyond what you are doing to determine the impact of your actions on other components of the house.

Explanation
It is often easy to focus only on the particular reason that you were requested to improve or alter the home and ignore other potential areas. As homes have generally become tighter and better insulated and equipment more sophisticated and often “bigger”, it is essential to look beyond the scope of the job that you have been hired to do to determine the effect of the project on the function of a home. Without this foresight, callbacks or in the worst case, legal action can result as your work impacts other portions of the house (such as in the case of the example described on the slide).

Action Items
Consider how the actions you take in the remodeling project will impact the rest of the house. Will the impact be “positive” or “negative”?

Resources



Key Concepts

A systems evaluation is an iterative process that seeks the best value for each component of the house. The steps include:

1. Identify and obtain simulation model
2. Collect data on existing house and occupant lifestyle
3. Input model, run simulation, and save
4. Identify changes for base case remodel
5. Input model, run simulation, and save
6. Evaluate the results of simulations and look for improvement opportunities
7. Test opportunities with the model
8. Repeat process until the best value has been reached

Explanation

Simulation models enable the remodeling project designer to evaluate the impact of various options and alternatives relatively easily and quickly. Most models provide reasonably good results when looking at the various options based on a set of assumptions. However, because the results are based on assumptions, the actual energy consumption associated with a particular strategy or option may not reflect reality. It is generally unwise to quote specific savings to the homeowner based on modeling.

When selecting among options in the evaluation process, it is prudent to look for large or significant changes or differences. Small differences in energy savings (a few percent) are unlikely to make a noticeable difference in actual conditions (that are affected by other factors such as weather and occupant behavior).

Key Concepts

•Become familiar with tools available to help you and your client understand the costs and benefits of energy improvements.

Explanation

•TREAT is the first all-inclusive tool that allows one to model different energy improvements and provides a summary of the reduction in energy use and associated monthly expenses. Developed by Ithaca-based company, Performance Systems Development, the software enables you to enter a description of the existing home and location and data regarding current utility bill and energy usage. Then, various upgrades can be entered to determine the costs and savings. Projects can be uploaded to a universal database that not only continues to serve the underlying "brains" of the software, but also can be readily accessed by program administrators to document the progress of a project. For instance, an agency who has funded a weatherization project might want to track how much work had been completed. The cost of the TREAT software is $495.

•REM Design is very similar to REM Rate, the ENERGY STAR approved software for certifying new homes. A description of the existing home—including square footage of walls, windows, and floors, R-value of attics and floors, and other factors—and current utility rates is entered. The program provides a summary of estimated annual space heating and cooling costs/energy use, water heating costs, lighting and appliances, etc. Recommendations are also given for the most cost effective energy improvements. Proposed energy improvements can be entered and the program estimates energy use reductions for the improvements. The energy use of the baseline as well as the improved home is "estimated" based on typical usage for a home that size. It may or may not accurately reflect your clients' situation. It does, however, provide an idea of the relative benefits and savings to be achieved by the energy improvements.

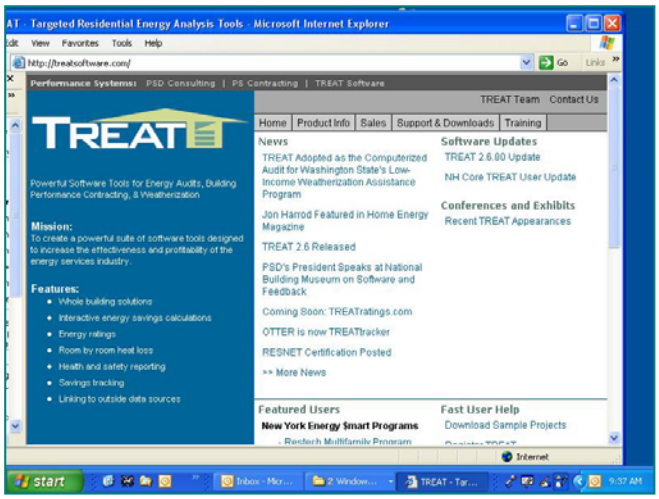
Action Items

•Consider investing in the energy modeling software.

Resources

• *TREAT* – Available from Performance Systems Development, Inc., Ithaca, NY

TREAT Software



http://www.TREATsoftware.com $495

Building America U.S. Department of Energy

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Key Concepts

Explanation

TREAT is a whole-house energy analysis program designed for examining the energy benefits of remodeling and renovation projects. It is challenging to use and the cost is fairly high. It is geared more towards weatherization programs and building performance contractors or energy specialists rather than the typical remodeler. However, it is the only tool available that can perform detailed analysis of an existing home and model the energy impact of improvements.

Action Items

Resources

Key Concepts

Explanation

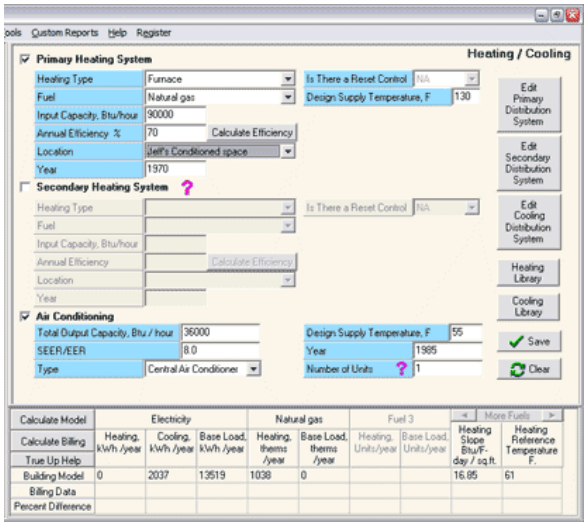
REM Design is a whole-building analysis program and would be appropriate in cases where your client may want a detailed picture of the energy performance of his current home versus the home once improvements have been made. It requires detailed inputs from the user regarding window and wall geometry, R-values, construction materials, type of HVAC system, water heater, and other inputs. It requires quite a bit of time to enter an existing home accurately, but once this is completed, it is very easy to make modifications and view the impact on energy use and cost.

Energy-10 is a more sophisticated hourly simulation tool for energy design. It is suited for architects and building designers to determine the most cost effective energy saving measures. These software tools are shown to give you an idea of what is available for energy simulation and modeling.

Action Items

Resources

TREAT-Input Screen



Key Concepts

Sample input screen for TREAT. Note detailed inputs required.

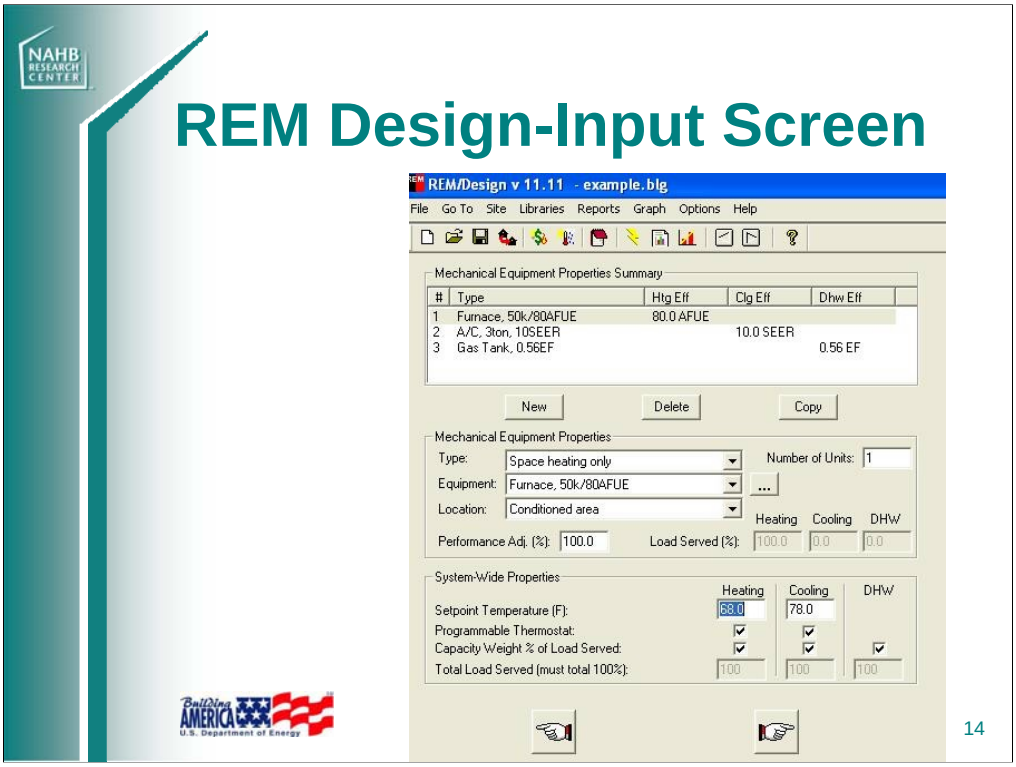
Explanation

Action Items

Resources

Instructor's Note

Point out the type of data needed to be input and show the students where it goes on this screen.



Key Concepts

Sample input screen for REM Design – Mechanical Systems.

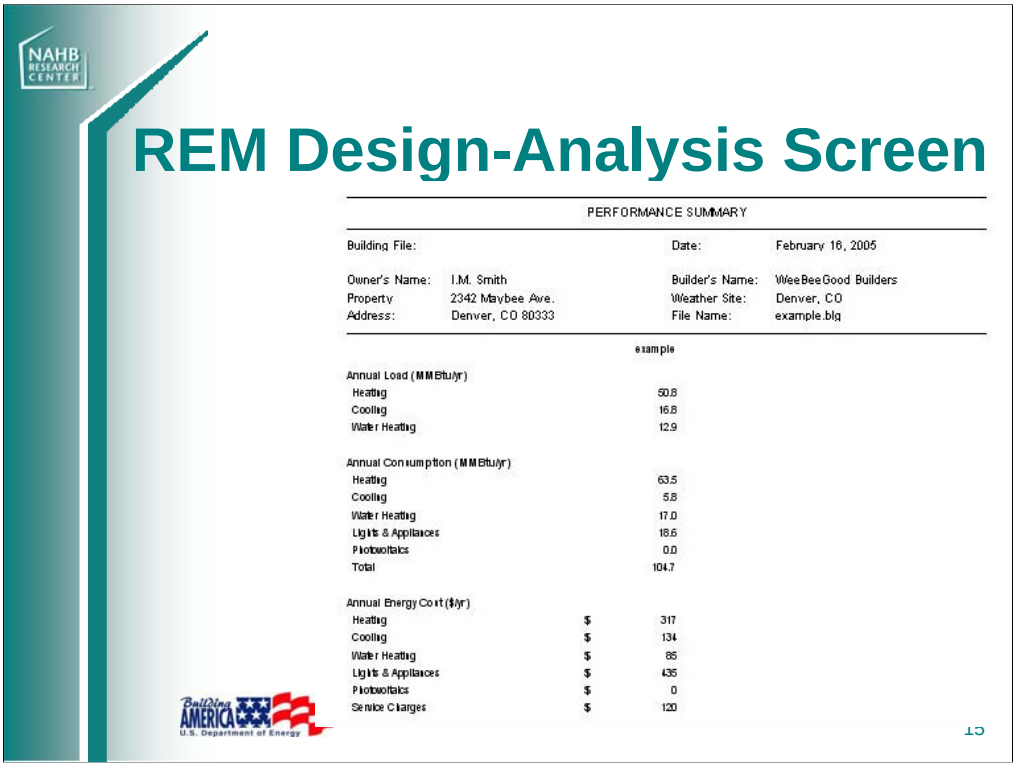
Explanation

Action Items

Resources

Instructor's Note

Point out the type of data needed to be input and show the students where it goes on this screen.



Key Concepts

Sample analysis screen for REM Design.

Explanation

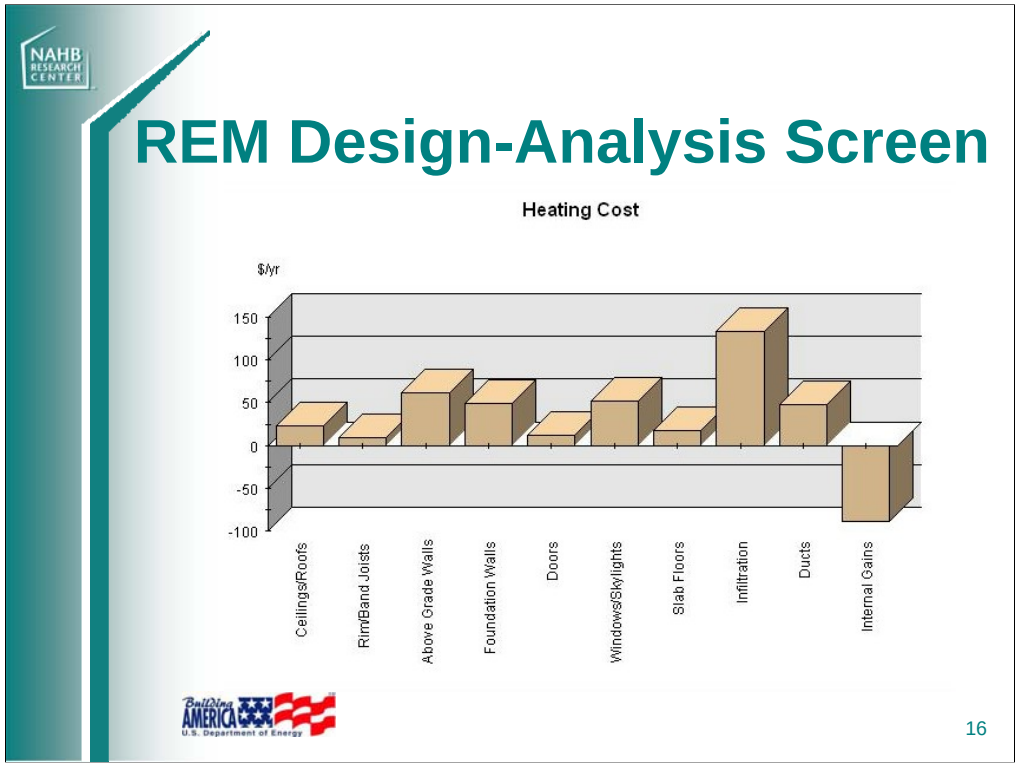
There are numerous project summaries and formats that REM Design will output – tables, bar charts, energy use by component, cost summaries, and suggested improvements.

Action Items

Resources

Instructor's Note

Point out the type of output data that is provided and discuss how your students would use it.



Key Concepts

Sample analysis screen for REM Design.

Explanation

Action Items

Resources

Instructor's Note

Point out the type of output data that is provided and discuss how students could use it.

Key Concepts

This example shows how the systems evaluation process works with space additions. This home is located where there will be a significant cooling as well as heating load.

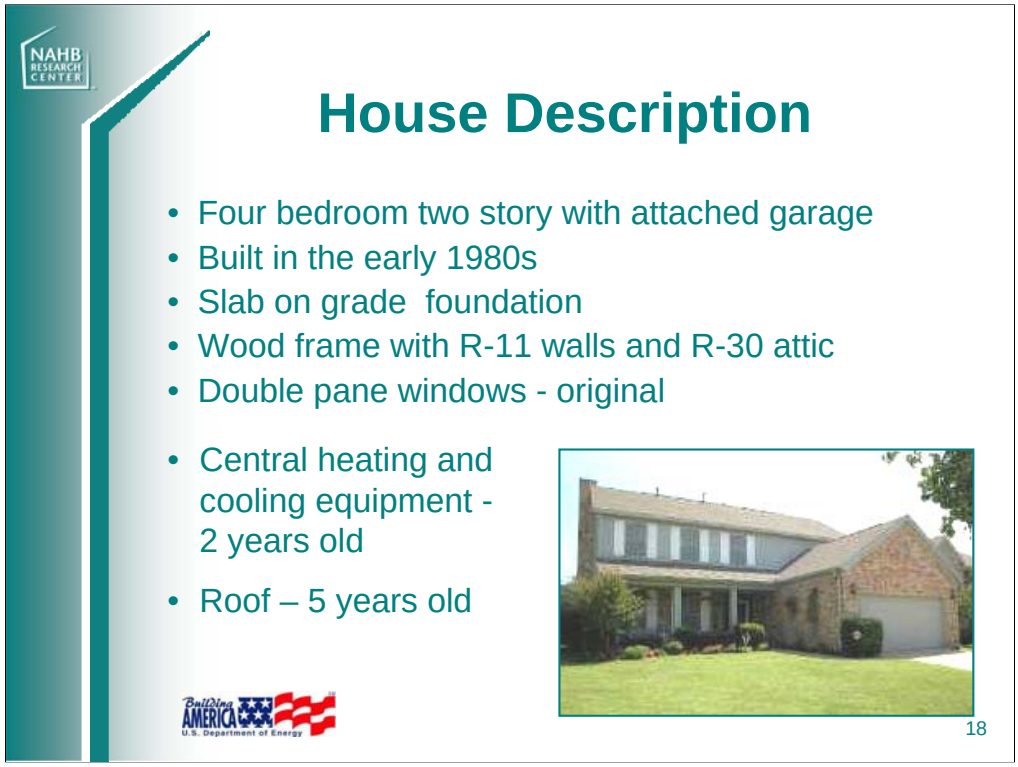
Explanation

This example will show that the planned addition will increase the heating and cooling design load beyond the capacity of the relatively new furnace and air conditioner. This could be an “unpleasant surprise” to the homeowners. However, further evaluation of potential energy efficiency improvements will demonstrate how the existing furnace and air conditioner can continue to be used (a cost savings of ~$5000 over replacement) while saving about $200 annually in utility bills. The costs of these improvements is well below the cost HVAC system replacement. This kind of information should bring smiles to the homeowners’ faces.

Action Items

Resources

Building Science Topics, FAQs - http://www.southface.org/home/media/articles/articleFAQ.html
Hot-Humid Climate Homes - http://pix.nrel.gov:8020/BASIS/nich/www/bapublic/SF



Key Concepts

Gathering information about the home will help you make decisions about cost-effective improvements.

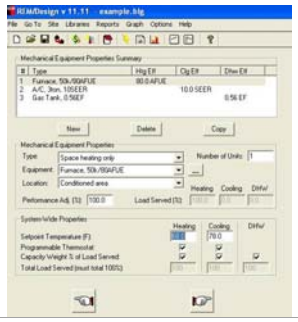
Explanation

Current House Description

The current house is a two story, four bedroom, 2.5 bath, 2296 ft^2 home built in

Information for Evaluation

- 2296 Square Feet
- Un-insulated slab on grade
- R-11 Walls R-30 Attic
- Double pane windows with aluminum frames (14 @ 3'-0" x 4'-0)
- Moderately high infiltration (1.0 Air Change Per Hour - ACH)
- Gas furnace (80% AFUE), air conditioner (10.0 SEER)



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Key Concepts

Explanation

Using the inputs needed for the simulation program, gather the information you will need to perform a systems evaluation.

Note that highly detailed and "accurate" data (e.g., 6'-10 1/2") is not generally required and that simplified inputs (e.g., 7') will usually suffice. In the field, major dimensions should be measured, but minor ones can be estimated. For example, the overall size of the house is important, but the exact width of a door is less critical.

In addition to the existing house information shown on the screen you will need to input the following kinds of information before running the model.

•wood frame and wood lap siding, attached garage

•windows are double pane aluminum frame without thermal break (14 @ 3'-0" x 4'-0", four per N&S walls, three per E&W walls)

•R-30 attic insulation, no foundation insulation, 6 panel solid wood front door (north facing), and aluminum frame with double pane glass patio door 6'-0" x 6'-8" (south facing)

•ducts in interstitial space between floors, moderately leaky

Once you have completed the inputs, you should run the model for the existing home. This simulation will also give you the design loads for the existing heating and cooling equipment.

Note: As measured by a blower door, 1 Air Change per Hour is a fairly leaky building envelope. In new construction, the goal is to strive for .35 ACH or less; in existing homes, one should try to achieve at least .7 ACH or less if possible.

Key Concepts

Explanation

After the current home has been described you will need to gather data on the remodeling work to be accomplished, in this case an addition to the existing home.

Space Addition Description

The owner desires to add an ~840 ft2 two story addition to the west side of the existing home that will house two additional bedrooms and a bath on the second level and will permit the expansion of the family room and kitchen on the first level. In addition, the high cost of cooling the existing home has the homeowner open to considering paying the added costs of upgrading this home where these improvements will pay back in less than three years.

Base Case Remodel

Add the additional space as described above without considering efficiency upgrades for other portions of the house. This addition is to be done to a minimum code compliant level. Determine if the two year old furnace and/or air conditioner will have to be replaced because they are too small. If they will, identify upgrades to the existing structure and addition to reduce the heating and cooling design load sufficiently to fit, if possible, within the capacities of the existing equipment.

Potential Energy Efficiency Upgrades

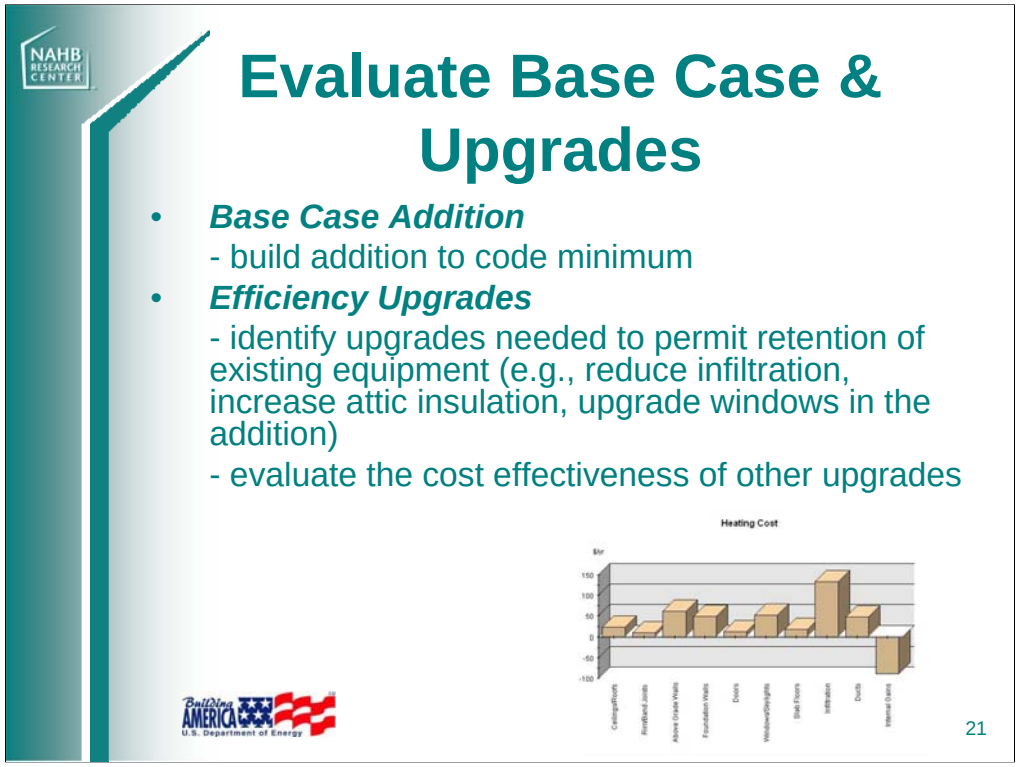
Identify the best available technologies to upgrade the base case and permit retention of the existing heating and cooling equipment.

In addition, the following potential upgrades are to be evaluated to determine their annual energy savings:

- Upgrade front door to steel with urethane foam core
- Upgrade new windows and replace existing windows with double pane low-E argon filled glazing in a vinyl frame
- Increase existing attic insulation to R-60.

In determining the payback for items above, you should use the full cost increase since these items are not included in the base case. Divide the additional costs by the energy saving to determine the payback for each item.

Action Items



Key Concepts

Explanation

After completing the simulation for the existing home you can copy that file and then modify it to reflect the base case addition. The base case addition is based on code minimums. This simulation will also give you the heating and cooling design loads for the addition.

- *Base Case* - build to minimum code compliant level.

  - Determine if two year old furnace and/or air conditioner have adequate capacity to serve the enlarged house

  - If they do not have the capacity, identify upgrades to structure to reduce load to fit, if possible, within capacities of existing equipment.

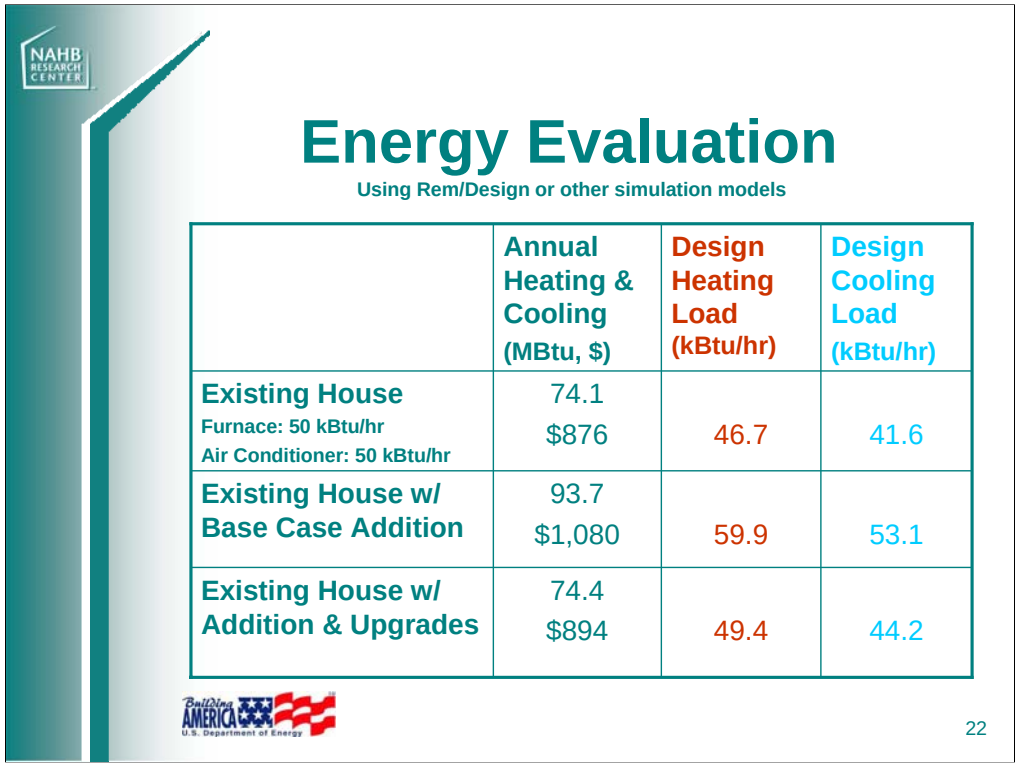
- *Efficiency Upgrades*

  - identify upgrades needed to permit retention of existing heating and cooling equipment including:

    reduce infiltration from 1.0 to 0.7 ACH

    increase attic insulation in addition from R-30 to R-38

    upgrade windows in addition to double pane, low-E,



Key Concepts

Explanation

Using Rem/Design or other residential energy simulation models, determine the annual heating and cooling energy consumption and cost for both the existing home and the home following the space addition. Also evaluate potential energy efficiency upgrades for their annual energy savings. The results from an analysis using Rem/Design are shown.

Existing house

Annual heating and cooling energy consumption - 74.1MBtu/yr, and cost - $876

Design load for heating - 46.7kBtu/hr, and cooling - 41.6kBtu/hr

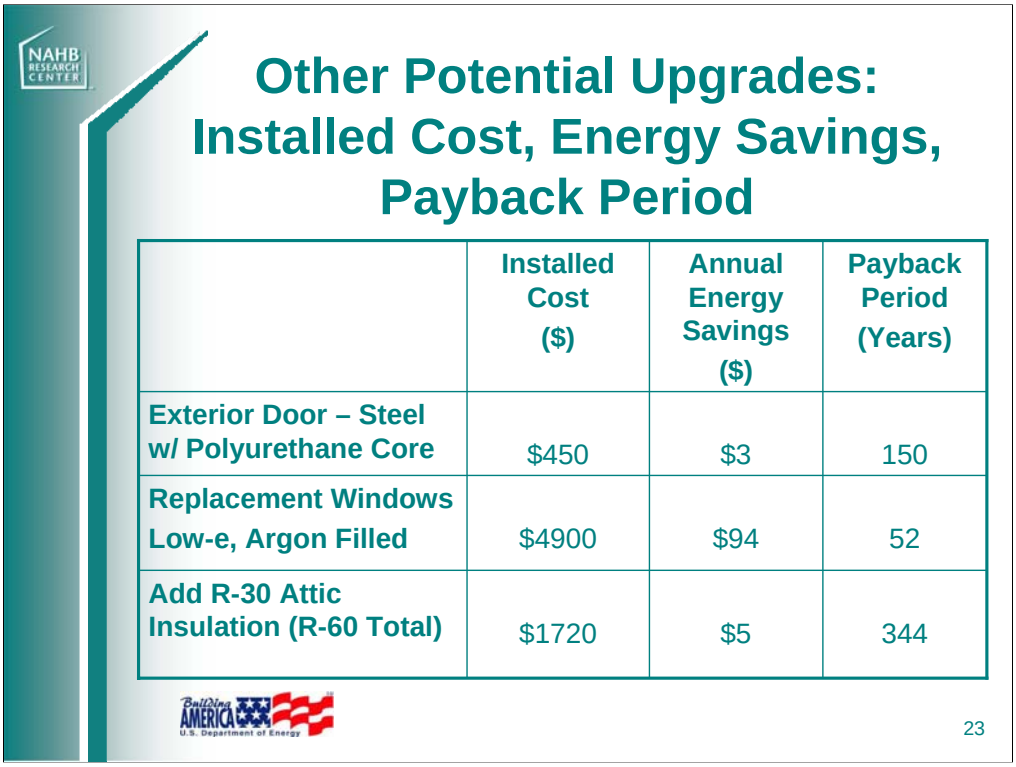
Base case addition (code minimum)

Annual heating and cooling energy consumption – 93.7MMBtu/yr, and cost - $1080

Design load for heating – 59.9kBtu/hr, and cooling – 53.1kBtu/hr

Base case addition with upgrades

Upgrades include: reduce infiltration from 1.0ACH to 0.7ACH, increase attic insulation in addition from (R-30 to R-38, and upgrade windows used in the



Key Concepts

Explanation:

The evaluation of other potential energy efficiency upgrades can be accomplished easily by "plugging-in" each upgrade into the "Existing house with base case addition and upgrades" file and simulating the impacts. While none of these upgrades is cost-effective, the evaluation took only a couple of minutes with the simulation model.

Other potential upgrades costs savings and paybacks

Rough estimates of installed costs and projected annual energy cost savings follow:

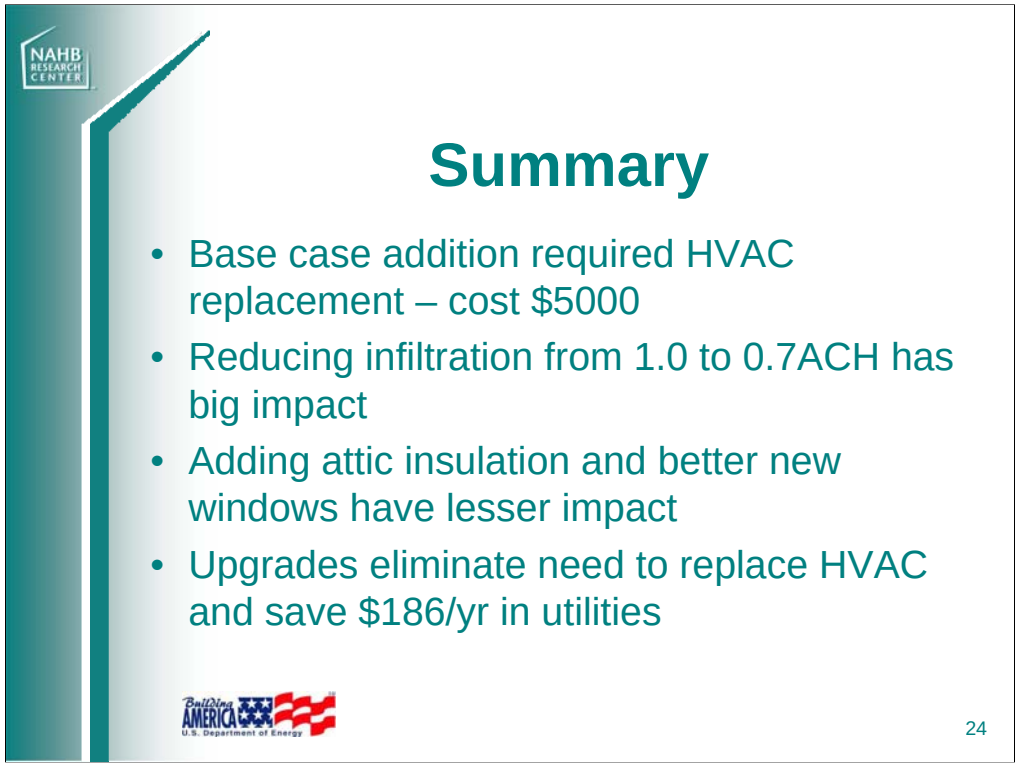
Replacement door - steel with urethane foam core and thermal break: $450 cost, $3 savings (150 years)

Replacement/new windows - double pane, low-E, argon filled, vinyl frame: $4900 cost, $94 savings (52 years)

Add R-30 attic insulation (R-60 total): $1720 cost, $5 savings (344 years)

Having this kind of information available to share with your customer will help them get the best value from their remodeling budget.

Action Items



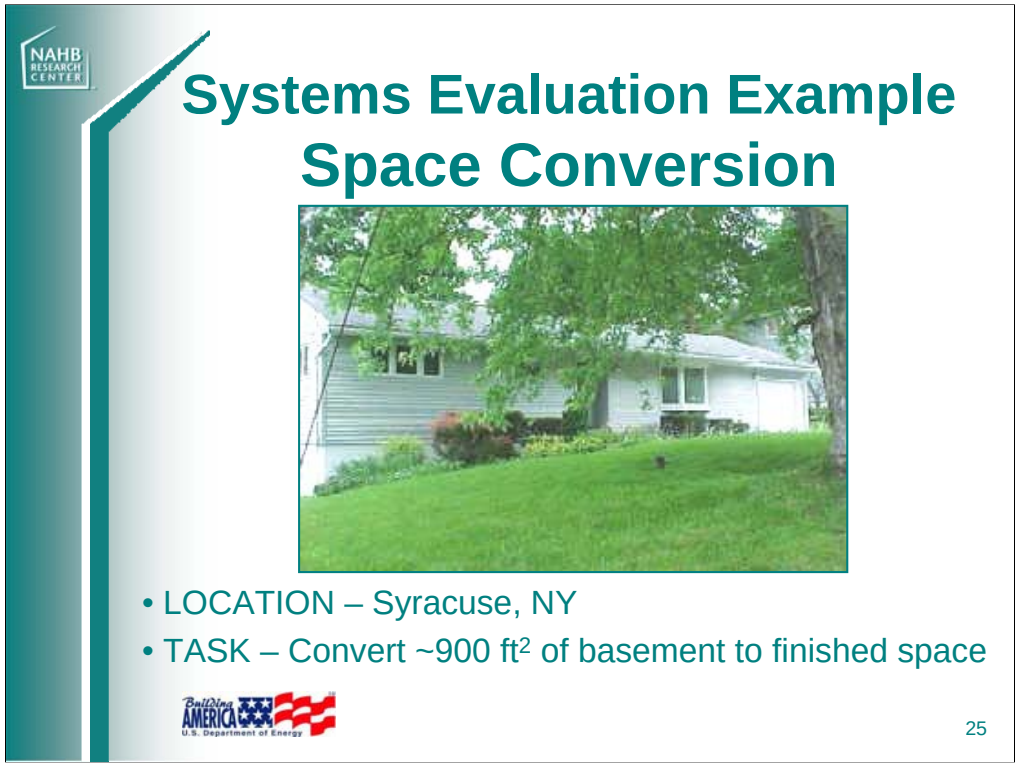
Key Concepts

Explanation

The base case house addition increases the design load for both heating and cooling beyond the capacity of the existing two and five year old equipment. Replacing this relatively new equipment would add about $5000 to the project. Given the situation it is prudent to investigate upgrades to the existing house and addition that would reduce the design load of the enlarged home to within the capacity of the existing equipment.

Reducing the infiltration from 1.0ACH to 0.7ACH through sealing the envelope is relatively inexpensive and has a large impact. Adding insulation in the existing attic, while having less impact, is easy to accomplish while the addition in insulated. Upgrading the windows used in the addition helps to reduce load and can be accomplished for only the incremental cost above the standard windows used in the base case.

While these improvements may not have attractive paybacks on the basis of energy savings alone, the fact that they permit avoiding the replacement of the furnace and air conditioner ($5000 savings) makes them economically justified. In addition the homeowner will save $186 per year on utilities.

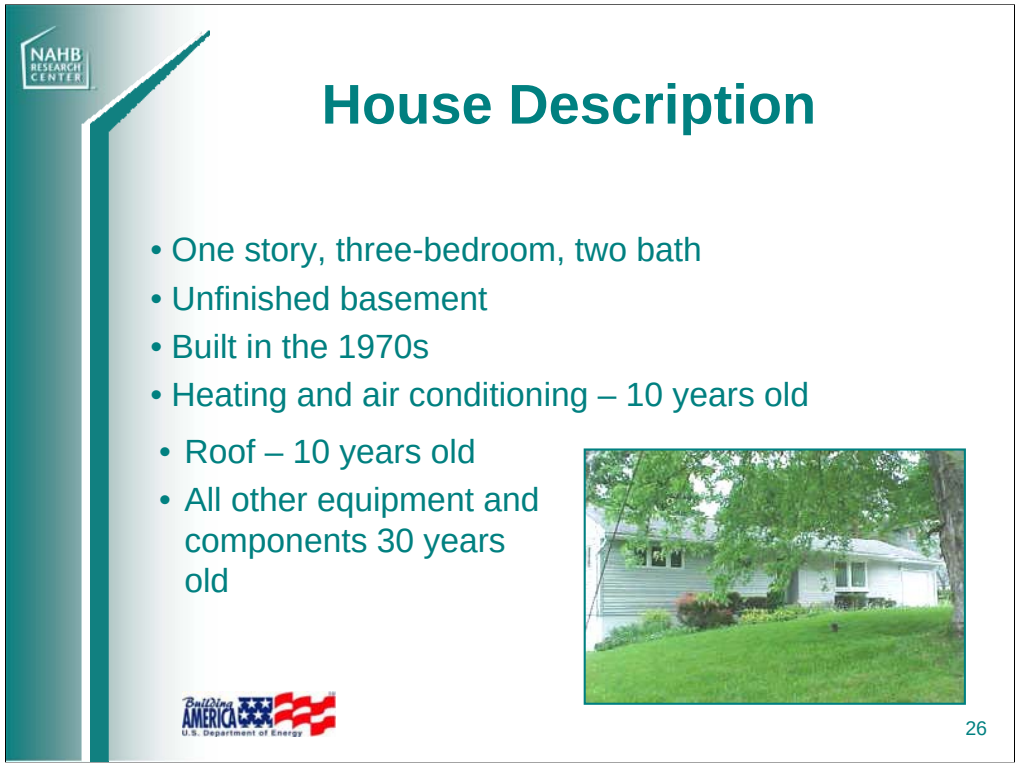


Key Concepts

An example of how the systems evaluation process works with space conversions. This home is located where there will be a significant heating load and a minor cooling load.

Explanation

This example will show that the planned conversion will increase the finished space in the house while lowering the heating and cooling



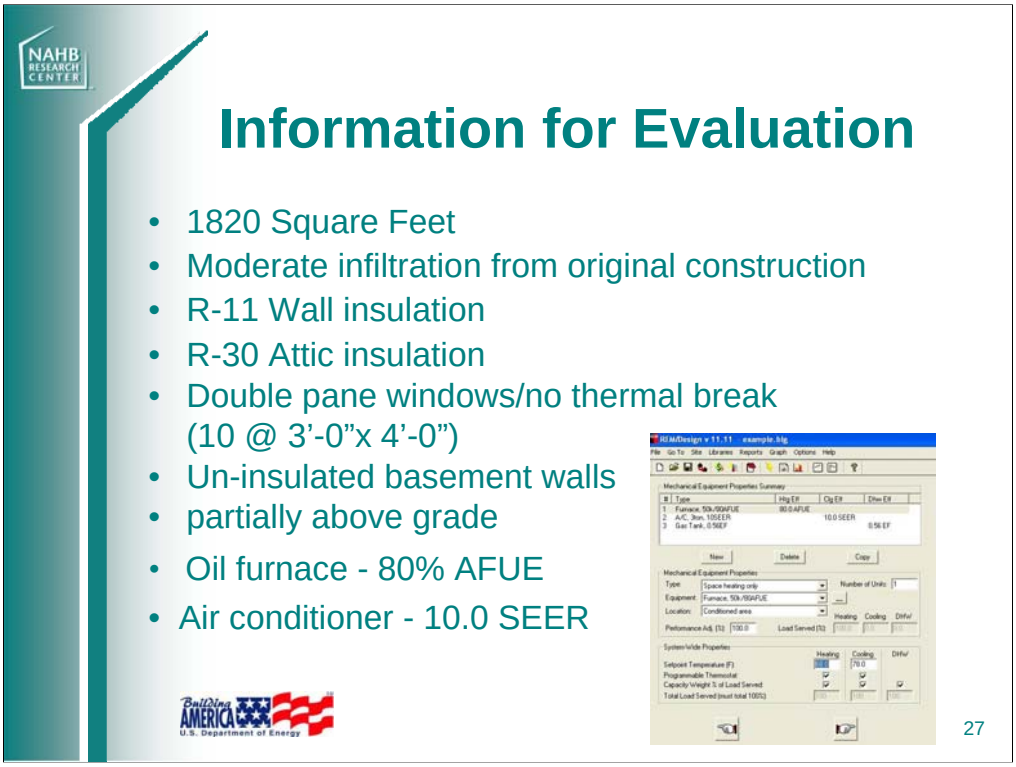
Key Concepts

Gathering information about the home will help you make decisions about cost-effective improvements.

Explanation

Current House Description

The current house is .



Key Concepts

Explanation

In addition to the existing house information shown on the screen, you will need to input the following kinds of information before running the model:

•half of basement is a garage; walls are exposed above grade 3 ft on the south and west exposures and fully covered on the north and east.

•main floor walls are wood frame with wood lap siding and R-11 insulation; R-30 attic insulation; no floor, foundation or band joist insulation.

•front door is 6 panel solid wood (south), wood frame, single pane patio doors 6'-0" x 6'-8" (north).

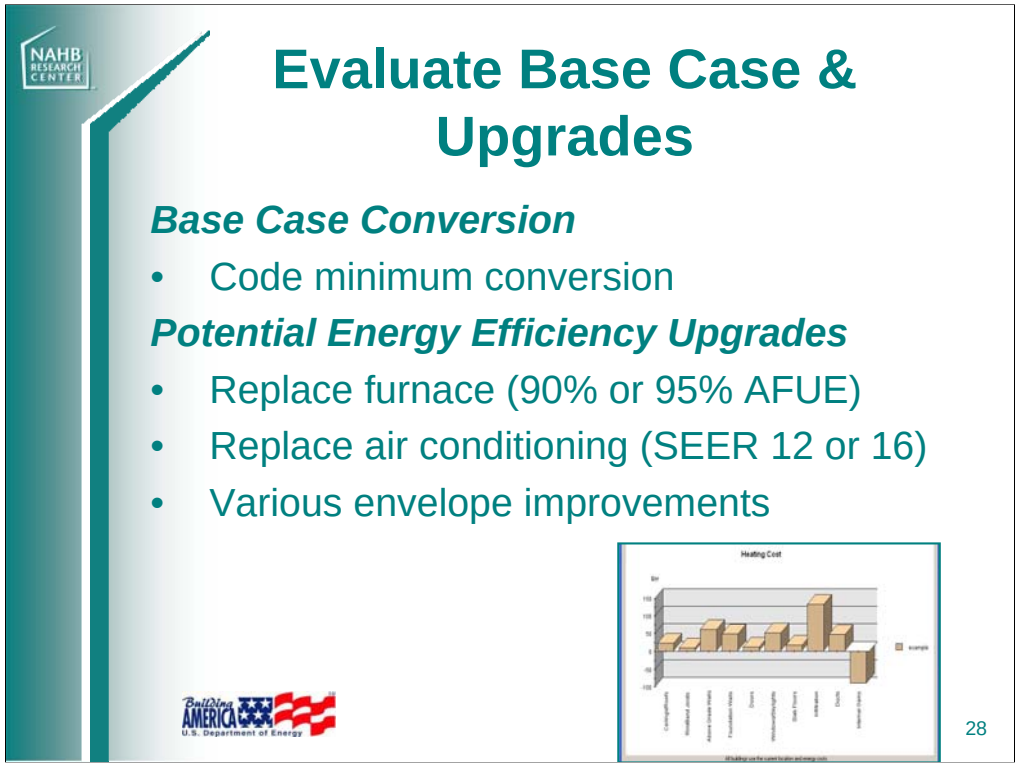
•windows are double-pane aluminum frame windows without thermal break (10@ 3'-0" x 4'-0"- two per east & west wall, three per north & south wall).

•moderately leaky ducts are in the unconditioned basement space.

Once you have completed the inputs, you should run the model for the existing home. This simulation will also give you the design loads for the existing heating and cooling equipment.

Action Items

Resources



Key Concepts

Explanation

Base Case - Convert the basement alone without considering efficiency upgrades for other portions of the house. This conversion is to be done to a minimum code compliant level. Determine if the ten year old furnace and/or air conditioner have to be replaced because they are too small. If they are, identify cost effective upgrades to the existing structure to reduce the design load sufficiently to fit, if possible, within the capacities of the existing equipment.

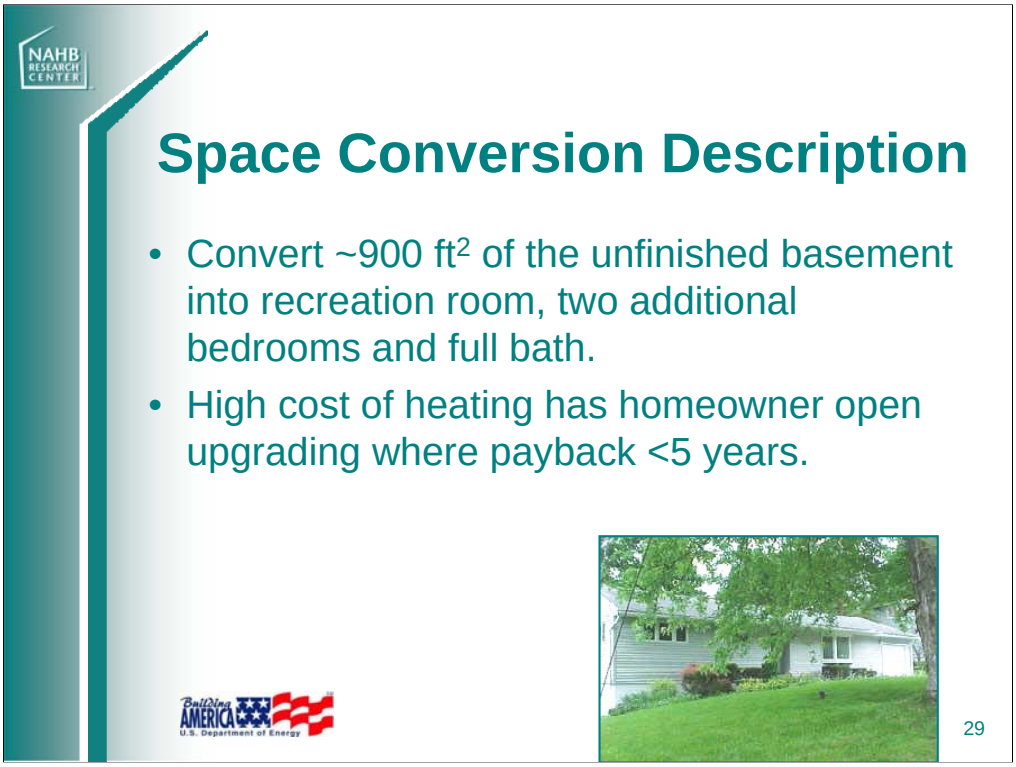
Potential Energy Efficiency Upgrades - In addition to identifying the best available technologies for the base case, evaluate the following potential upgrades to determine their annual energy savings and whether they can provide a three to five year payback:

- Upgrade replacement furnace to 90% or 95% AFUE and air conditioning to SEER 12 or 16.
- Install replacement door (steel with urethane foam core) and replacement windows with double pane low-E argon filled glazing in a vinyl frame.
- Increase attic insulation from R-30 to R-60.
- Insulate floor to R-19.
- Reduce infiltration to 0.7ACH.

In determining the payback for the furnace, use the incremental cost increase if the existing furnace and air conditioner are too small and must be replaced. Otherwise use the full cost of these items. These incremental costs are usually only the increase in the material costs since the installation labor in most cases is about the same. Divide the additional costs by the energy saving to determine the payback for each item.

Action Items

Resources



Key Concepts

Explanation

Space Conversion Description - The owner desires to convert ~900 ft2 of the unfinished basement into a recreation room, two additional bedrooms and a full bath. In addition, the high cost of heating with fuel oil has the homeowner open to considering upgrading his home where these improvements will payback in three to five years.

Base Case - Convert the basement alone without considering efficiency upgrades for other portions of the house. This conversion is to be done to a minimum code compliant level. Determine if the ten year old furnace and/or air conditioner have to be replaced because they are too small. If they are, identify cost effective upgrades to the existing structure to reduce the design load sufficiently to fit, if possible, within the capacities of the existing equipment.

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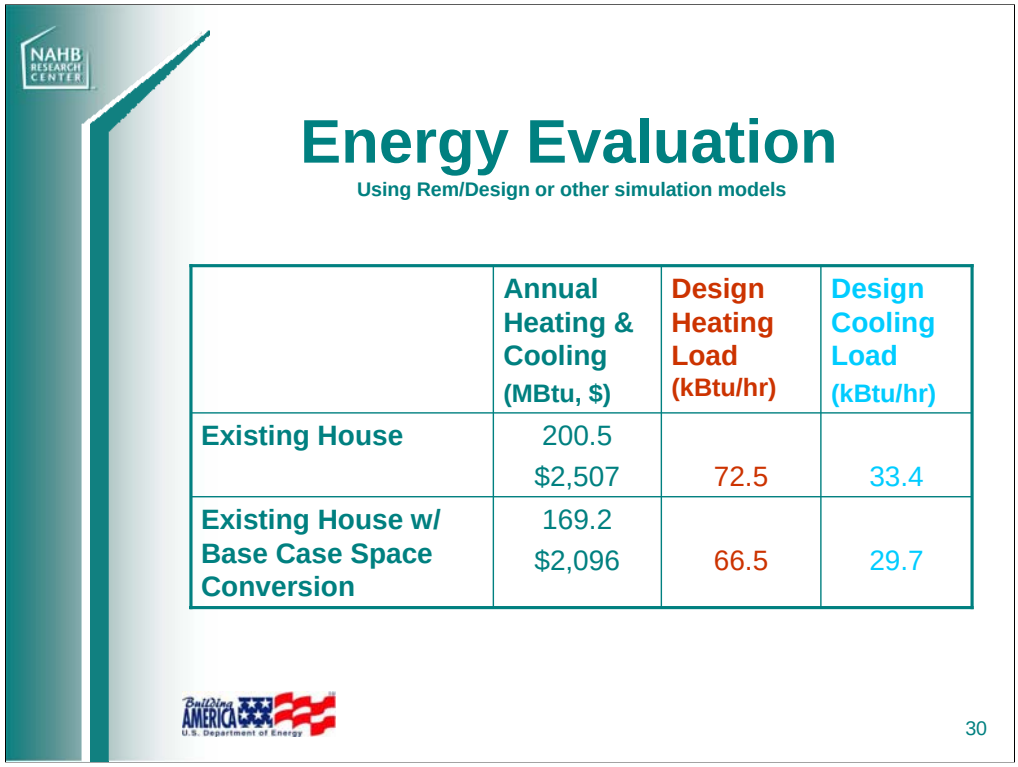
- Install replacement door (steel with urethane foam core) and replacement windows with double pane low-E argon filled glazing in a vinyl frame.
- Increase attic insulation from R-30 to R-60.
- Insulate floor over the garage to R-19.
- Reduce infiltration from 1.0ACH to 0.7ACH.

In determining the payback for each item use the full cost of these items. Divide the additional costs by the energy savings to determine the payback for each item.

Action Items

Resources



Key Concepts

Explanation

Using Rem/Design or other residential energy simulation models, determine the annual heating and cooling energy consumption and cost for both the existing home and the home following the space conversion. Also evaluate potential energy efficiency upgrades for their annual energy savings. The results from an analysis using Rem/Design are shown.

The simulation of the existing and base case space conversion shows that the design loads actually drop as the unconditioned space in the basement is insulated and added to the conditioned space. The existing ten year old furnace and air conditioner will not need to be replaced reducing potential costs by about $5000. This conclusion could be missed if the increased amount of conditioned space was the only factor considered.

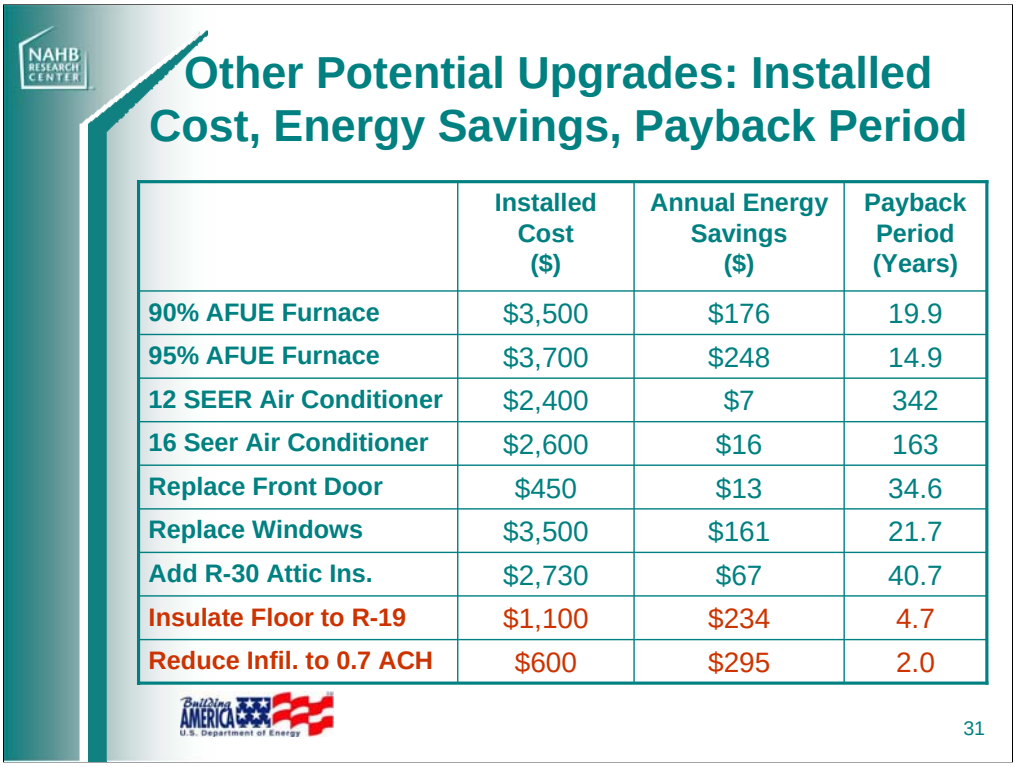
Existing house

Annual heating and cooling energy consumption - 200.5MBtu/yr, and cost - $2507

Design load for heating - 72.5kBtu/hr, for cooling - 33.4kBtu/hr

Base case space conversion

Annual heating and cooling energy consumption - 169.2MMBtu/yr and cost - $2096



Key Concepts

Explanation:

Because furnace, air conditioner, window and door replacement is not required, upgrading these items to higher efficiency replacements requires the full cost of the replacement must be used. This will extend the payback well beyond the homeowner's desires.

Potential energy efficiency upgrades with rough estimate of installed costs and annual energy cost savings.

90% AFUE furnace - $3500 cost, $176 savings (19.9 years)

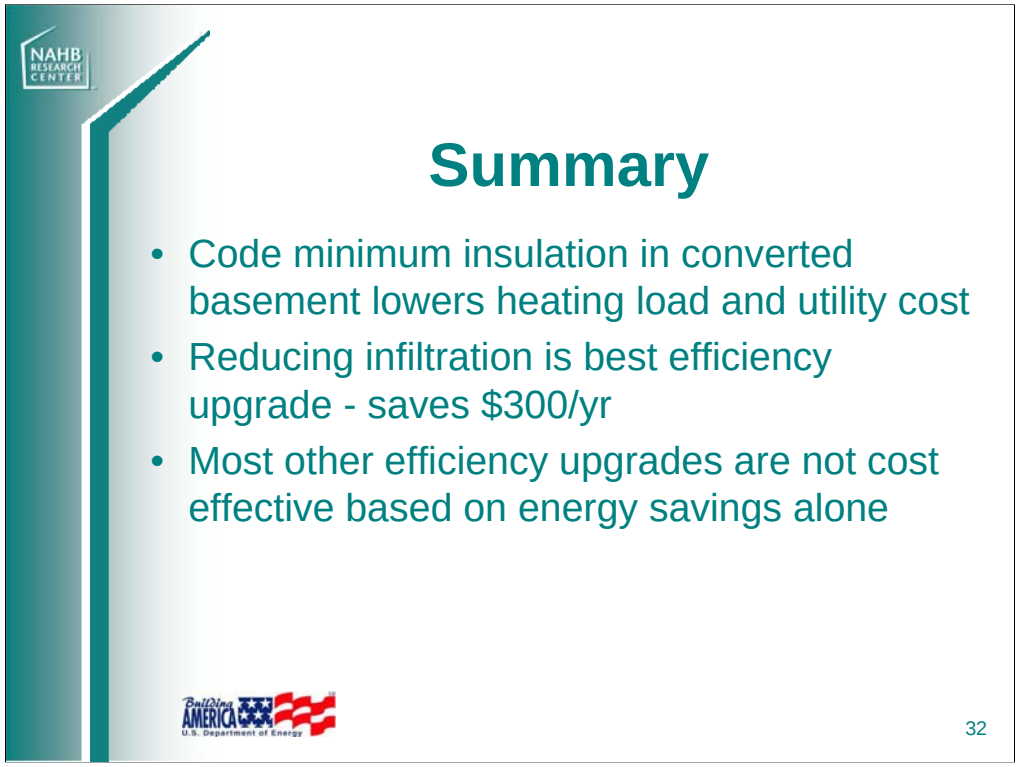
95% AFUE furnace - $3700 cost, $248 savings (14.9 years)

12 SEER air conditioner - $2400 cost, $7 savings (342 years)

16 SEER air conditioner - $2600 cost, $16 savings (163 years) Note that the higher SEER air conditioner only costs $200 more than the 12 SEER and will have a much shorter payback period – even though it is still over 100 years. If the existing equipment were older or in need of replacement, it would certainly be to the homeowners' advantage to go with the higher SEER unit. Keep in mind that if the existing equipment does need to be replaced, "payback" is a non-issue for the most part.

Replace front door with steel door with urethane foam core and thermal break - $450 cost, $13 savings (34.6 years)

Replace windows with double pane, low-E, argon-filled glazing in vinyl frame - $3500 cost, $161 savings (21.7 years)



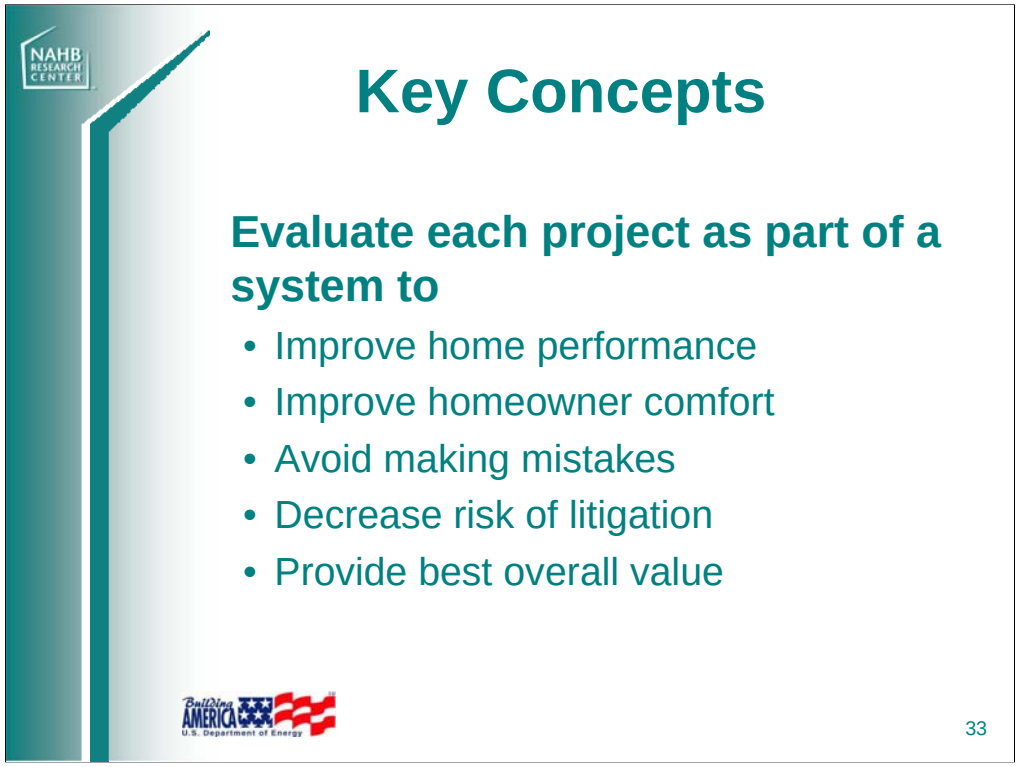
Key Concepts

Explanation

The simulation of the existing and base case space conversion shows that the design loads actually drop as the unconditioned space in the basement is insulated and added to the conditioned space. The existing ten year old furnace and air conditioner will not need to be replaced reducing potential costs by about $5000. This conclusion could be missed if the increased amount of conditioned space was the only factor considered. Because replacement is not required, upgrading these items to higher efficiency replacements requires the full cost of the replacement must be used. This will extend the payback well beyond the homeowner's desires.

Action Items

Resources



Key Concepts
Using the systems approach to remodeling can make a BIG difference in a project's outcome.

Explanation
In addition to saving your customer on utility bills and making a home more comfortable, you'll be benefiting yourself by avoiding potential mistakes (e.g., mold, combustion safety) and the risk of litigation. In short, you'll be able to help customers get the best value for each dollar they have spent on their remodeling project.

Action Items
Attend seminars and conferences (e.g., EEBA's *Houses that Work*, Affordable Comfort) to learn more and share experiences. Set up a log of your accomplishments using the systems approach, and share these accomplishments with potential future clients.

Resources
Houses that Work Seminar information: (http://www.eere.energy.gov/buildings/building_america/rh_0604_houses_seminars.html)
Affordable Comfort regional conferences and training events, http://www.affordablecomfort.org/html/events.html