NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Tribal Webinar

Energy Efficiency Basics

February 26th, 2020

Jimmy Salasovich, NREL

Agenda

1. Background on Building Energy Efficiency
2. Things to Consider
3. Identifying Energy Efficiency Measures
4. Summary

Photos: Jimmy Salasovich, NREL

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1. **Background on Building Energy Efficiency**
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Why is Energy Efficiency in Buildings Important?

- Identifying and implementing energy efficiency measures in buildings has many potential benefits:
  - Saves money on utility bills
  - Can reduce maintenance costs
  - Can increase comfort levels in buildings
    - Increased comfort levels increases productivity
  - Lowers impacts on the environment
  - Can increase energy resilience for critical buildings
    - Example: buildings that can serve as community shelters in the event of a natural disaster can operate longer on backup generators if the building is energy efficient

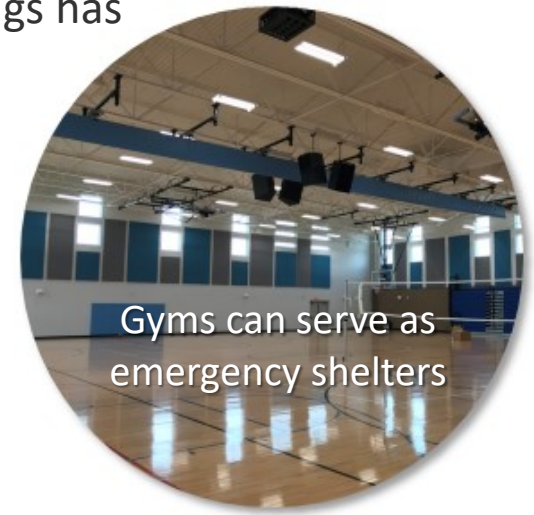

Gyms can serve as emergency shelters

Photo: Jimmy Salasovich, NREL

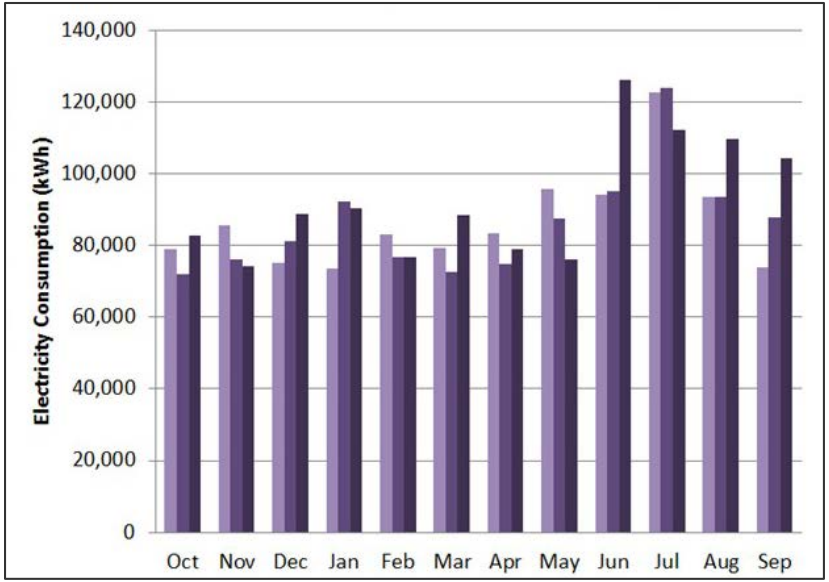
Common Types of Tribal Buildings

- Common types of Tribal buildings:
  1. Homes
  2. Tribal Government buildings
  3. Commercial Tribal buildings
- The person responsible for identifying Energy Efficiency Measures (EEMs) in each building type typically varies
  - In homes, it is typically the homeowner who identifies EEMs
  - In Tribal Government buildings, there is typically a government employee who focuses on energy for the Tribe
  - In larger commercial Tribal buildings, there might be facilities staff who operate and do maintenance on the buildings
- The process for identifying EEMs, however, is similar for each building type

Photos: Jimmy Salasovich, NREL

Energy Management: Compile & Track Utility Bills

- Compile current and past utility bills
- Track energy use throughout time
- Benchmark energy consumption
- Track Green House Gas (GHG) emissions
- Set agency goals
  - Implement financially viable EEMs
  - Reduce building energy intensity
  - Increase energy efficiency
- Conduct building energy assessments/audits
- Implement energy efficiency projects that are financially viable



Track Energy and Prioritize Buildings

- Analyze past/current energy consumption in buildings
  - Gather monthly utility bills for all energy types
    - Electricity, natural gas, propane, fuel oil, steam, chilled water
  - Identify building energy use patterns
    - Is the energy use for a particular building much higher than a comparable building?
    - Is energy use highest in the summer or winter months?
    - Is heating energy the highest annual energy cost?
- Prioritize buildings to assess
  - Use the three years of monthly utility bills to develop annual energy use metrics for each building with an electric meter
  - Group buildings by type and usage patterns
  - Consider building age, schedule, condition, etc.

Conduct Building Energy Assessments/Audits

- Identify opportunities to reduce energy consumption and cost
- Provide information to owner/operator to decide which recommendations to implement
- Typical steps in an energy assessment/audit:
  - Collect/analyze historical energy use data
  - Study building and operating trends

  } Pre-audit

  - Collect building information and consult with staff/occupants
  - Identify potential modifications to reduce energy and cost

  } Audit

  - Perform engineering and economic analysis
  - Prepare a prioritized list of recommendations
  - Report results

  } Post-audit

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Things to Consider when Implementing EEMs

- There are competing interests/expenses in all Tribal buildings
- Most people are not experts in energy efficiency
- It takes time and money to implement energy efficiency measures (EEMs)
  - People often focus on capital costs and not net present value or simple payback
- The climate affects what works well in buildings
  - There is no single best design – what works well in Colorado might not work well in Oklahoma
  - Some EEMs like LEDs work well in any climate
- Rebates and grant opportunities are oftentimes complicated, and you might have to wait for the money
- Low utility rates can make it difficult to justify implementing EEMs
  - Conversely, high utility rates can make it easy to justify implementing EEMs

Photo: Jimmy Salasovich, NREL

Other Things to Consider

- Are the buildings small homes or large commercial buildings?
  - EEM options vary depending on the size of the building
- Are the buildings new construction or existing buildings?
  - **It is easier to implement EEMs into new construction**
  - **It is still very important to retrofit existing buildings**
  - Sequencing projects in existing buildings can be an issue
  - It can be difficult to determine what is in an existing buildings (e.g., wall insulation)
  - EEMs like adding wall insulation to an existing building can be very difficult and costly
- How old are the buildings?
  - There could be issues with having to bring the entire building up to code if you do any work
  - There could be other issues like lead-based paint or asbestos

Photos: Jimmy Salasovich, NREL

New Construction vs. Existing Buildings

- It is easier to implement EEMs into new construction
  - It is much less expensive to design a building right the first time
  - Building energy modeling can be used to determine the optimal building orientation, window-to-wall ratios, and design measures (e.g., insulation, lighting, plug loads, HVAC)
    - See appendix A2 slides for more information on building energy modeling
- It is still very important to retrofit existing buildings
  - Some EEMs can't be easily implemented into existing buildings (e.g., building orientation)
  - Consider implementing EEMs at the end of the equipment life

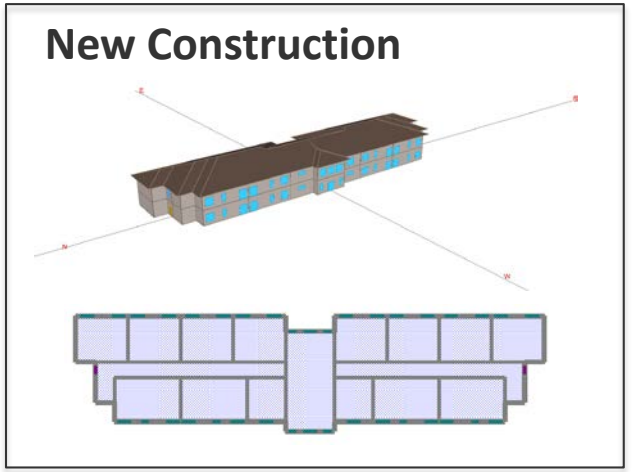

Photo: Jimmy Salasovich, NREL

Living in Remote Regions

Photos: Jimmy Salasovich, NREL

- Oftentimes Tribes are located in very remote regions
  - Limited access to the high efficiency equipment
  - Limited access to specialized labor force
  - Difficult to attract the specialized labor force

Harsh Climates & High Utility Rates

- Oftentimes Tribes are located in relatively harsh climates
  - There might be limited seasonal windows for construction/renovation
  - High space conditioning requirements
  - This opens opportunities to make energy improvements
    - Example: increased insulation levels can have the highest savings in extremely cold climates
- Oftentimes Tribes have very high utility rates
  - This makes it difficult to save up any extra money to implement EEMs
  - High utility rates can improve the financial viability of implementing EEMs
    - The higher the utility rate, the more money you're saving from EEMs

Photos: Jimmy Salasovich, NREL

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3. **Identifying Energy Efficiency Measures**
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Types of Energy Efficiency Measures

- Types Energy Efficiency Measures:
  - Passive building design
  - Building envelope
  - Lighting
  - Plug loads
  - Heating, Ventilating, and Air-Conditioning (HVAC)

Photos: NREL Pix #12319, and Jimmy Salasovich, NREL

Passive Building Design

- Passive design utilizes the local climate (sun angles, wind patterns, etc.) to minimize energy use in a building while maintaining human comfort
- Passive design strategies include:
  - Building orientation with long façade facing south
  - Window placement based on climate and daylighting
  - Window overhangs to allow for solar gains to the building in winter months, while keeping the windows shaded during summer months
  - Operable windows for natural ventilation
  - High thermal mass walls and floors
- Passive design is much easier to incorporate into new construction buildings
- Some passive design elements can be incorporated into existing buildings

Photos: NREL Pix #12319

Building Envelope

- Roof/attic insulation
  - Typically cost effective especially in cold climates
- Wall insulation
  - Difficult to implement in existing homes
- Floor/ground insulation
  - Difficult to implement in existing homes
- Air sealing
  - Typically cost effective in any climate
  - Mechanical ventilation could be required for super tight homes
- High performance windows & doors
- Overhangs and shading devices

Photos: Jimmy Salasovich, NREL

Lighting

- **Install LED lighting**
  - Replace incandescent lightbulbs
    - Very high energy use (60W equivalent LED is 9W)
  - Replace CFLs
    - Contains small amounts of Mercury making them hard to dispose of
  - Replace linear fluorescents
- Turn off lights when not in use
- Lighting occupancy sensors
  - Limited use in homes
  - Consider using in storage areas

Photos: Jimmy Salasovich, NREL

LED Lighting

- More energy efficient than fluorescent, compact fluorescent (CFL), and incandescent lighting (e.g., an incandescent 60-watt equivalent LED is 10 watts)
- Can be used in residential and commercial buildings and for exterior lighting
- New LED lamp types are entering the market in order to simplify lamp replacements by not requiring full fixture replacements (e.g., you would just have to replace the light bulb and not the entire lighting fixture)
- 50,000 hrs life-time rating
  - Life-time not affected by frequent switching
  - Work well in cold climates
- No mercury in LEDs and so disposal is straight forward (fluorescent and CFL lighting has mercury)
- LEDs are offered in a wide range of color temperatures from warm light to cooler (e.g., blue) light in order to meet any lighting application's needs
- Require no "warm-up" time
- No UV or IR light emitted
- No breakable glass or filaments

Photo: Jimmy Salasovich, NREL

Lighting Occupancy Sensors

Lighting occupancy sensors are most commonly used in larger buildings and not in homes

Infrared

- Small enclosed rooms: private office, conference room, supply room, classroom
- The sensor detects small amounts of movement
- Wall-mounted are most common

Ultrasonic

- Large open spaces: open office, large conference room, lecture halls, hallways, large lunchrooms, and lobbies
- The sensor detects small amounts of noise
- Ceiling-mounted are most common

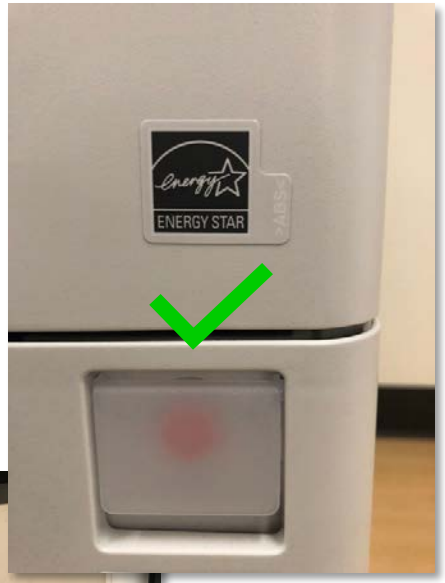
Combination

- Infrared + ultrasonic

Photo: Jimmy Salasovich, NREL

Plug Loads

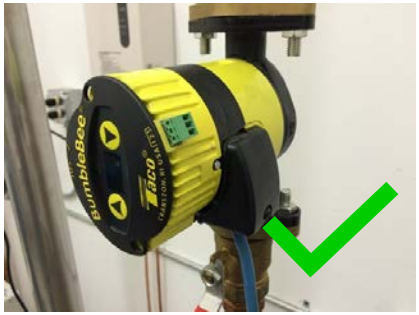
- Use EnergyStar™ rated plug load devices
  - Refrigerators & freezers
  - Televisions
  - Washing machines
  - Computers, printers, monitors
  - **Use EnergyStar™ for anything with a plug**
- Turn off or unplug appliances when not in use
  - There are smart power strips that have built-in occupancy sensors
  - Phantom loads

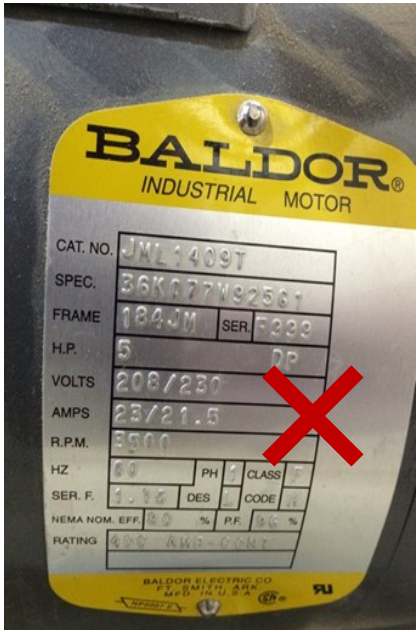


Photos: Jimmy Salasovich & Jal Desai, NREL

Heating Ventilating & Air-Conditioning (HVAC)

- Use high efficiency equipment
  - Air conditioners & mini-split heat pumps
  - Condensing furnaces
  - Traditional and biomass boilers
  - Air-source & ground-source heat pumps
  - **Use high efficiency for any heating or cooling equipment**
- Use programmable thermostats
- For larger buildings:
  - Use high-efficiency motors
  - Variable speed drives

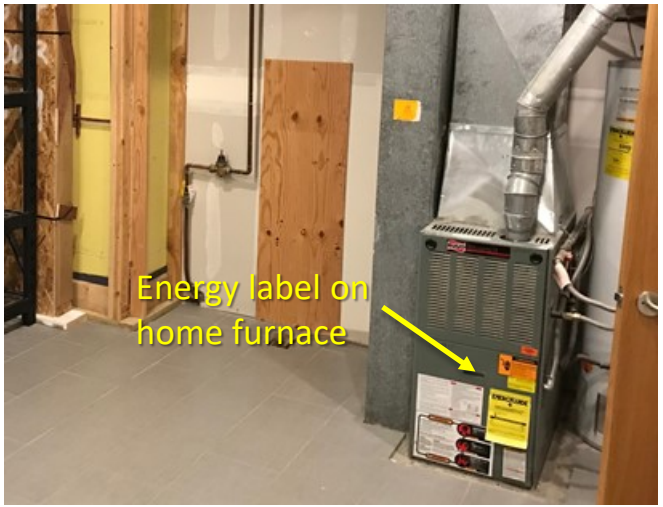


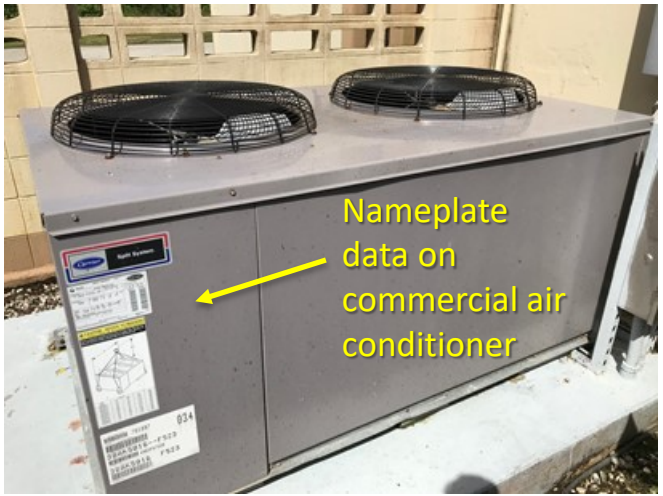


Photos: Jimmy Salasovich, NREL

Install High-Efficiency HVAC Equipment

- Specify the highest efficiency HVAC equipment, which includes all heating and cooling equipment for any building type
  - Air conditioners & mini-split heat pumps
  - Condensing furnaces
  - Traditional and biomass boilers
  - Air-source & ground-source heat pumps
- Look at the nameplate when purchasing or talk to the local installer
  - Oftentimes the nameplate will say EnergyStar for residential HVAC
  - Local installers have good knowledge of what works well in a given area





Photos: Jimmy Salasovich, NREL

Programmable Thermostats

- Programmable Thermostat Applications
  - Controls the temperature of a house for residential applications
  - Controls the temperature of a zone or multiple zones in larger building applications
- Programmable Thermostat Requirements
  - EASY TO PROGRAM
  - Minimum of 7-day scheduling capability
  - Able to turn zone or unit on-off based on time and temperature
  - Adjustable dead-band (differential where thermostat remains neutral – no heating or cooling)
- Programmable Thermostat Optional
  - Occupied/unoccupied control
  - Heating only
  - Cooling only

Photos: Jimmy Salasovich, NREL

Water Heating & Water Efficiency

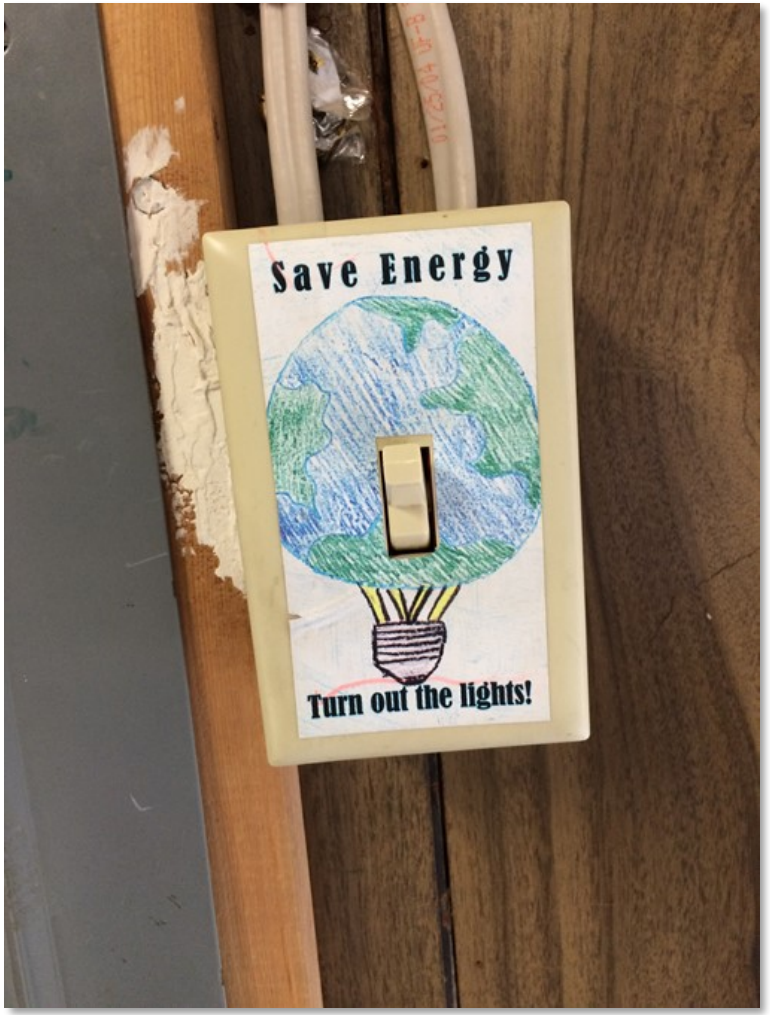
- Use high-efficiency water heaters
  - Heat pump water heaters
  - Instantaneous water heaters
  - Point of use water heaters
- Reduce hot water use (and water use)
  - Use high efficiency fixtures
    - Showerheads, faucets & aerators
  - Use high efficiency appliances
    - Front-load washing machines

Photos: Jimmy Salasovich, NREL

Energy Awareness Fairs and Educational Programs

- Energy Awareness Fairs can help educate the general public on easy ways to save money on utility bills

- Energy activities and educational programs can be developed for schoolkids
  - Children are quick learners and can help bring what they learn in school back to their homes



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Summary: General Energy Challenges

- General energy challenges
  - Competing interests/expenses
  - Sometimes difficult to justify energy efficiency in home rentals or leased buildings
  - Time & money
  - Most people aren't experts in energy efficiency
  - Different EEMs work well in different climates
    - LEDs work in any climate
  - Rebates and grants can be confusing
  - Low utility rates

Photos: Jimmy Salasovich, NREL

Summary: Identifying Energy Efficiency Measures

- Types Energy Efficiency Measures:
  - Passive design
    - Building orientation, window placement, overhangs, operable windows, thermal mass
  - Building envelope
    - Increase insulation levels and reduce air infiltration
  - Lighting
    - Install LEDs and occupancy sensors
  - Plug loads
    - Purchase EnergyStar appliances & office equipment
  - Heating, Ventilating, and Air-Conditioning (HVAC)
    - Install the most efficient HVAC equipment
    - Install programmable thermostats

Photos: Jimmy Salasovich, NREL

Summary: General Considerations

- The EEM options can vary depending on the size of the building
- Are the buildings new construction or existing buildings?
  - It is easier to implement EEMs into new construction
    - Capital costs might be higher to design energy efficient buildings, but the life-cycle cost can be lower due to much lower operating costs
  - It is still very important to retrofit existing buildings given the large number of existing buildings that need upgrades
- How old are the buildings?
  - Possible code issues or issues related to lead-based paint, asbestos, etc.

Photos: Jimmy Salasovich, NREL

Summary: Tribal Specific Energy Challenges

- Oftentimes Tribes are located in very remote regions
  - Limited access to the high efficiency equipment
  - Limited access to specialized labor force
  - Difficult to attract the specialized labor force
- Located in harsh climates
  - Opens opportunities to implement EEMs
- High utility rates
  - High utility rates can greatly improve the financial viability of implementing EEMs

Photos: Jimmy Salasovich, NREL

Thank you!

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Photos: Jimmy Salasovich, NREL

Backup Slides

A1 **Examples of Tribal Building Analyses**

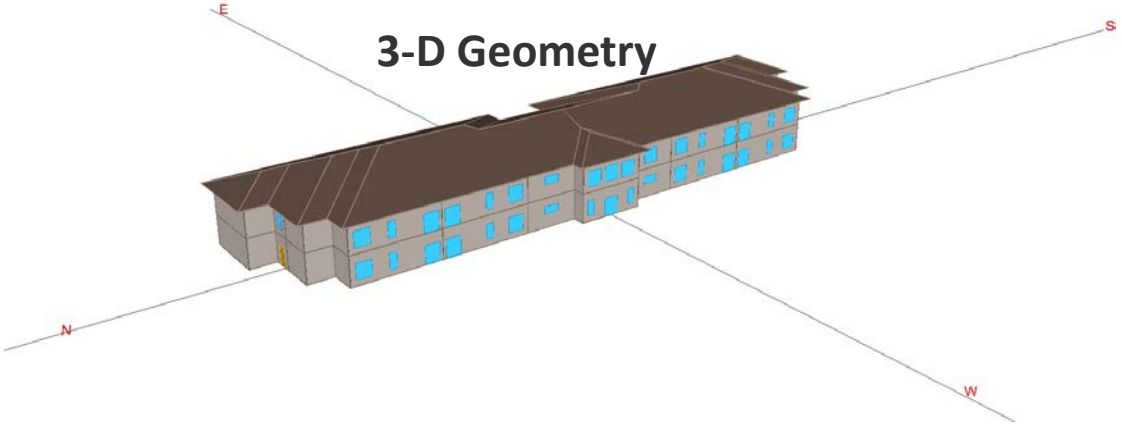
A2 Building Energy Modeling Tools

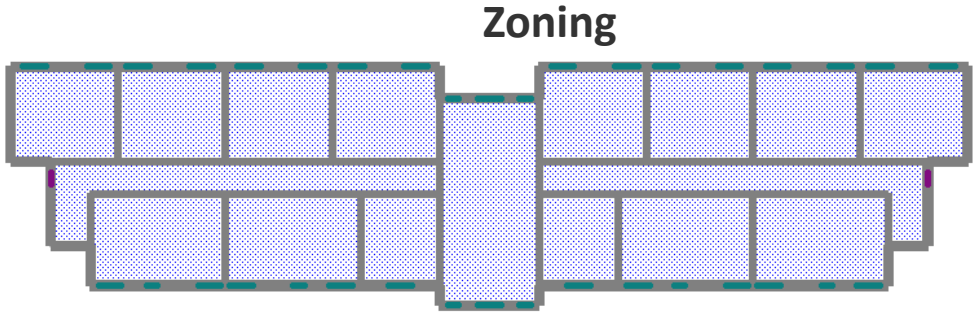
Photos: Jimmy Salasovich, NREL

Case Study #1: Multi-Family New Construction Housing

- The challenge was to determine the most cost-effective HVAC system
- Create building energy model of the future Senior Housing using design drawings
- The site is in Maine and has cold winters
- Analyze three Heating, Ventilating, and Air-Conditioning (HVAC) options for the Senior Housing
  1. Fuel oil boiler for radiant floor or baseboard heating with direct expansion (DX) air-conditioners
  2. Fuel oil furnace with DX air-conditioners
  3. Air-source heat pump for heating and cooling (electric resistance supplemental heating)

eQUEST Energy Model





- An eQUEST energy model was created for the Senior Housing to analyze various HVAC options
  - 24,000 ft^2 senior living facility
  - 2 floors and 24 units (8x 2-bedroom, 16x 1-bedroom)
  - Commercial kitchen and dining area that serves meals Mon-Fri
  - R-30 Walls, R-50 Roof, U-0.25 windows

General Design Review

- Design drawings and specifications were provided by the design team
- Overall, the Senior Housing is designed to be energy efficient
  - High levels of wall and roof insulation and high performance windows
  - High performance HVAC options are being considered
- LED lighting is incorporated into the design
- High efficiency appliances (e.g., refrigerators, washing machines, dryers) are incorporated into the design)

HVAC Comparison

	Boiler for Radiant Heating with DX Air-Conditioning	Furnace with DX Air-Conditioning	Air-Source Heat Pumps
EUI (kBtu/ft^2/year)	57.8	59.5	47.5
Electricity Use (kWh/year)	271,772	294,586	344,067
Electricity Cost ($/year)	$48,919	$53,025	$61,932
Fuel Oil Use (gallons/year)	3,572	3,324	0
Fuel Oil Cost ($/year)	$9,823	$9,140	$0
Total Cost ($/year)	$58,742	$62,165	$61,932

Lowest energy use

Lowest energy cost

- The energy model was used to analyze 3 HVAC options
  - Electric rate of $0.18/kWh
  - Fuel oil rate of $2.75/gallon
- The design team has to consider first costs when analyzing the tradeoffs of each HVAC option

Case Study #2: Existing Single-Family Homes

- Identify financially viable energy conservation and renewable energy measures from these options:
  1. Programmable thermostats
  2. LED lighting
  3. Air sealing
  4. Blown-in cellulose in the attic up to R-60
  5. Solar photovoltaics up to 5 kW in 1 kW increments

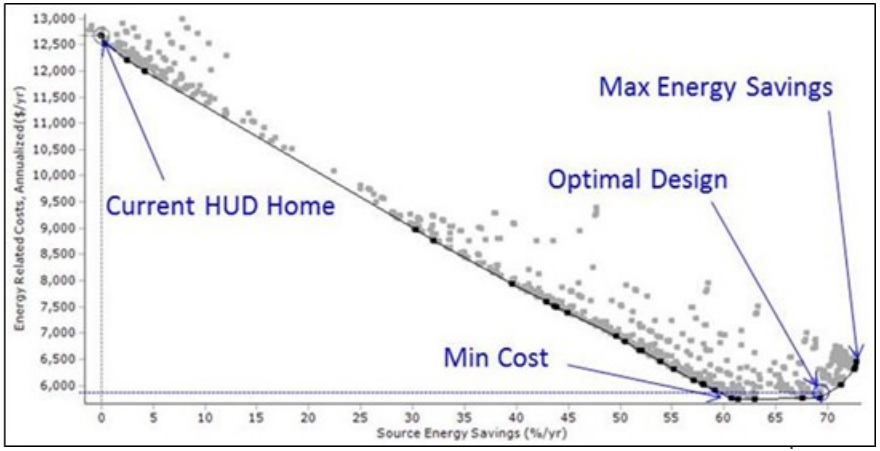
- The major challenges at this site include:
  - ✓ Very high utility rates
  - ✓ Remote (in rural Alaska)
  - ✓ Harsh climate
  - ✓ Limited renovation window
  - ✓ Subsistence living (many freezers)

Photo: Jimmy Salasovich, NREL

BEopt Energy Modeling Software

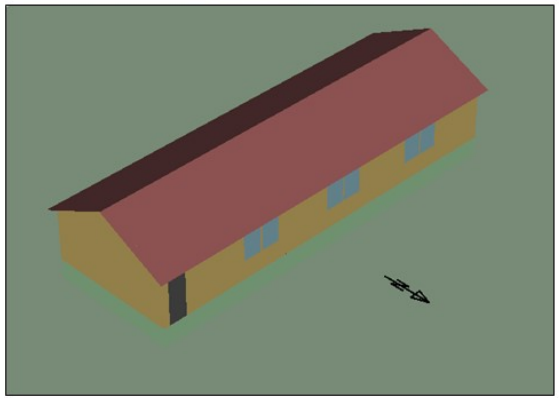
- BEopt is a residential building software simulation
  - Based on EnergyPlus simulation engine
  - Models single-family and multi-family residences
- Finds cost-optimal building design
- Provides a path to Net Zero Energy (NZE) residences

Photo: Jimmy Salasovich, NREL



Single-Family Home Model

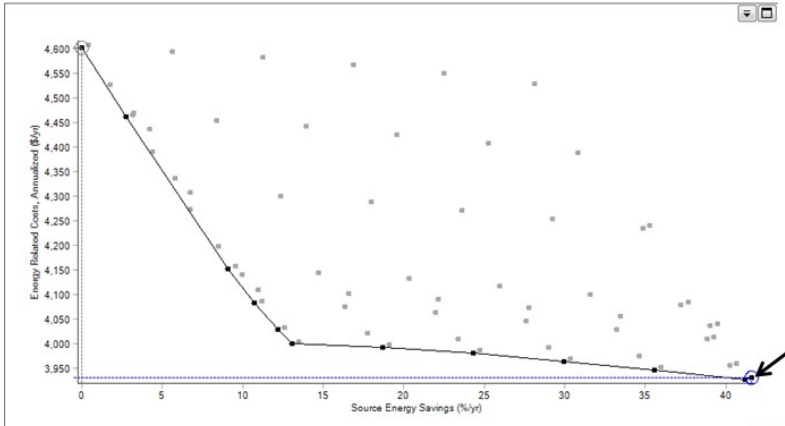
BUILDING			
Type & ID#	#8 (Tanya's House)		
Use	20'x60' Prefab House		
# stories	1		
# occupants	6		
Hrs/wk			
# windows & type	Vinyl Double Casement	4x (2'x4'); 2x (4'x4')	
Heat type (B/F)	Toyo Lazer 73		
DHW type (oil/elec)	Oil Mizer (not currently connected but soon)		
LIGHTING			
TYPE	**Watts**	**# FIXT**	**# BULBS**
CFL-A	13	9	1
CFL-A	13	2	1
CFL-A	13	1	1 (exterior)
CFL-A			
FLOR T12			
FLOR T8			
PLUG LOADS			
TYPE	**QTY**		
PC			
Pers Print			
REFRIGERATION (age)			
refer	1 newer	standard efficiency	
freezer	1 newer	Energy Star	
NOTES			
Wall R-value: 2x6 wood frame (assumed)			
Attic R-value: Estimated R-30			
Floor R-value: Estimated R-30			
Wood stove for backup			
Top loading clothes washer; electric dryer			
All 2-lamp CFL light fixtures had only 1 lamp in them			
1x 40" flatscreen TV			
Pre-paid electric meter			
Toyo has programmable t-stat			
This is a 20'x60' pre-fab house			

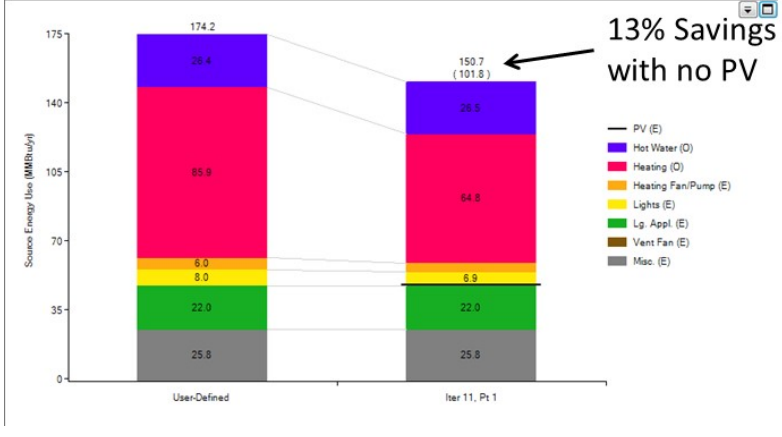


- This single-family home is in a remote Alaskan village
  - R-30 attic insulation
  - R-30 floor insulation
  - CFL lighting
  - Standard refrigerator
  - Standard washing machine
  - EnergyStar™ freezer
  - Woodstove
  - Toyo stove
  - Programmable t-stat
- This type of analysis was done for a total of 10 homes in this village

Photo: Jimmy Salasovich, NREL

BEopt Energy Modeling Results





13% Savings with no PV

Optimal Design:

1. Programmable T-stats
2. 100% LEDs
3. Air sealing to 7-12 CFM50
4. R-60 attic blown-in cellulose
5. 5 kW of PV

* 42% savings with 5kW of PV

- It is important to note, installed costs weren't analyzed as part of this analysis or in the previous case study but could have been

BEopt Results Summary for 10 Homes

- The optimal/cost -effective design:
  - Programmable thermostats
  - 100% LED lighting
  - Air sealing to 7-12 CFM50
  - R-60 blown-in cellulose insulation in the attic
  - 5 kW solar photovoltaics system
- Source energy savings @ optimal design
  - 8-13% without PV system
  - 28-52% with PV system
- Due to higher energy cost and cold climate, NREL also recommends to focus on
  - Reduce space heating requirements with tight construction, increased wall/ceiling insulation, floor insulation, insulated door and window
  - Efficient HVAC and heat recovery ventilator
  - Efficient water heater
  - Efficient appliances such as EnergyStar™

Backup Slides

A1 Examples of Tribal Building Analyses

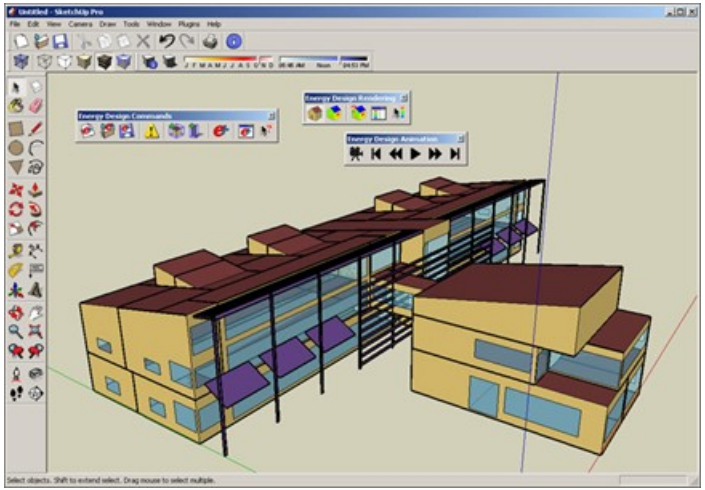
A2 **Building Energy Modeling Tools**

Photos: Jimmy Salasovich, NREL

Commercial Building Energy Modeling Tools

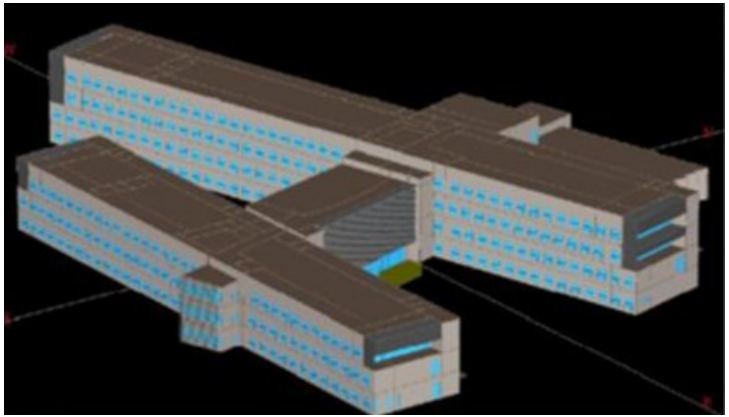
EnergyPlus

- Commercial building energy modeling tool
- Free web download
  - https://energyplus.net/downloads



eQUEST

- Commercial building energy modeling tool
- Free web download
  - http://www.doe2.com/equest/



Residential Building Energy Modeling Tool

BEopt

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