NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Tribal Webinar

Energy Efficiency Projects From Concept to Completion

March 25th, 2020

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Agenda

1. Work-Flow of Existing Buildings
2. Work-Flow of New Construction Buildings
3. Financing Options
4. Case Studies
5. Summary

Photos: Jimmy Salasovich, NREL

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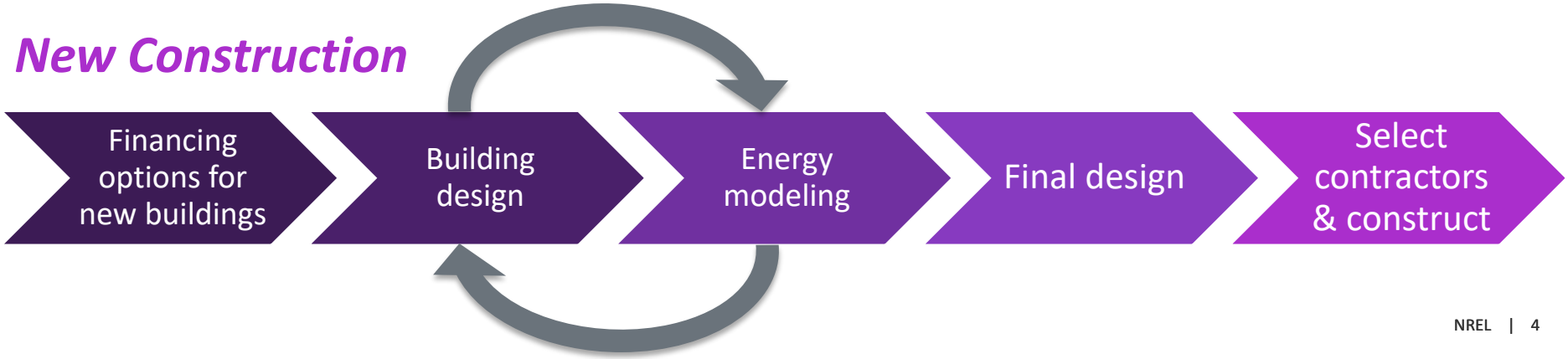
Work-Flow of Energy Projects

**Tony Jimenez will be presenting on financing options in the following presentation*

Existing Buildings

- *Some steps in the work-flow might be omitted based on the size and complexity of the building*
- *Financing options should be considered early and often*

New Construction



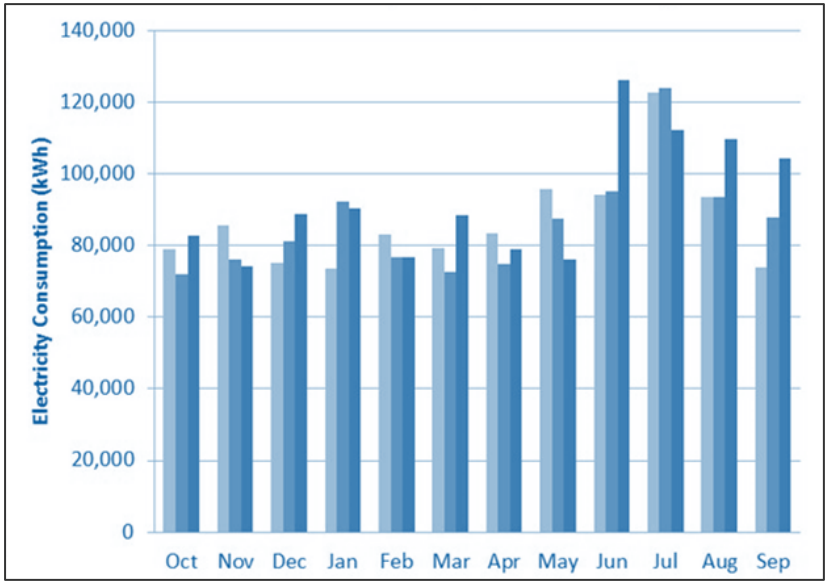
Existing Building: Work-Flow of Energy Projects

Existing Buildings

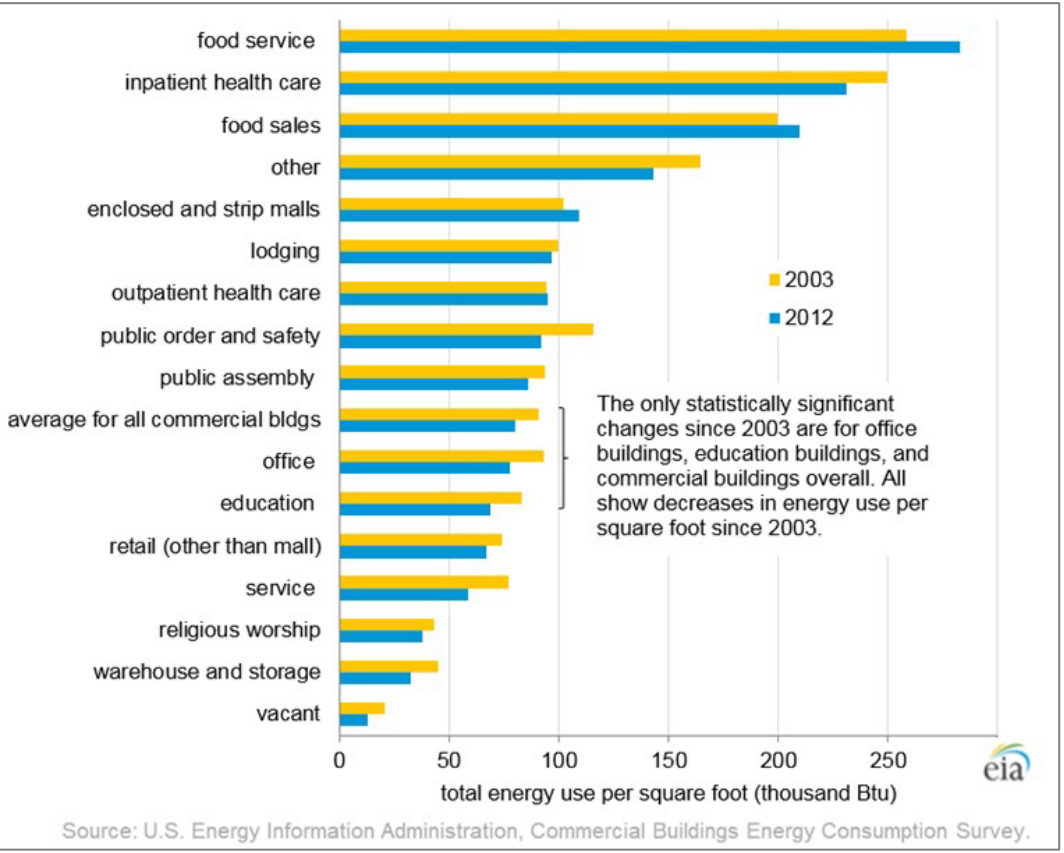
- The following three steps for existing buildings will be discussed in more detail
  - Energy management & tracking
  - Prioritize buildings
  - Energy audit

Existing Buildings: Energy Management

- Only done on existing buildings
- Compile current and past utility bills
- Track energy use throughout time
  - Spreadsheet tracking
- Benchmark energy consumption
  - CBECS database
- 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



Existing Buildings: Benchmark Buildings CBECS

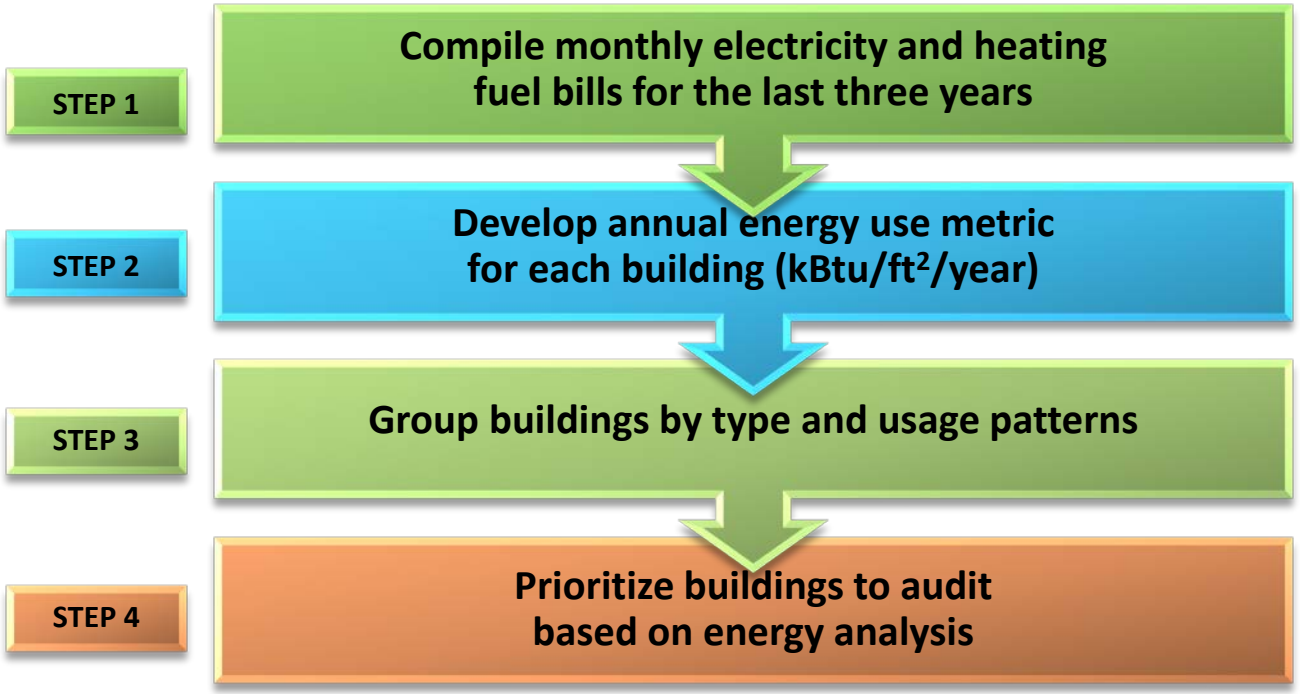


- Commercial Buildings Energy Consumption Survey (CBECS) database
  - https://www.eia.gov/consumption/commercial/
- Compare your building's energy performance to similar building types
  - Offices, schools, hospitals, etc.
  - Units: kBtu/ft^2/year
- If your building has much higher energy used compared to CBECS, this might be a good indicator that there are opportunities to save energy/money

Existing Buildings: 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?
  - Compare to CBECS database
- Prioritize buildings to assess
  - Use monthly utility bills to develop annual energy use metrics for each building
  - Group buildings by type and usage patterns
  - Consider building age, schedule, condition, etc.

Existing Buildings: Baseline Energy Consumption



Existing Buildings: Energy Audit

- 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

Existing Buildings: ASHRAE Audit Levels

- Level 1
  - Walk-through analysis
- Level 2
  - Energy survey and analysis
- Level 3
  - Detailed analysis of capital-intensive modifications

ASHRAE Process Tasks	Level I Audit	Level II Audit	Level III Audit
Conduct preliminary energy analysis (PEA)	X	X	X
Conduct walk through survey	X	X	X
Identify low-cost/no-cost recommendations	X	X	X
Identify capital improvements	X	X	X
Review mechanical and electrical (M&E) design and condition and O&M practices		X	X
Measure key parameters		X	X
Analyze capital measures (savings and costs, including interactions)		X	X
Meet with owner/operators to review recommendations		X	X
Conduct additional testing/monitoring			X
Perform detailed system modeling			X
Provide schematic layouts for recommendations			X
ASHRAE Reporting Tasks	**Level I Audit**	**Level II Audit**	**Level III Audit**
Estimate savings from utility rate change	X	X	X
Compare EUI to EUIs of similar sites	X	X	X
Summarize utility data	X	X	X
Estimate savings if EUI were to meet target	X	X	X
Estimate low-cost/no-cost savings		X	X
Calculate detailed end-use breakdown		X	X
Estimate capital project costs and savings		X	X
Complete building description and equipment inventory		X	X
Document general description of considered measures		X	X
Recommend measurement and verification (M&V) method		X	X
Perform financial analysis of recommended EEMs		X	X
Write detailed description of recommended measures			X
Compile detailed EEM cost estimates			X

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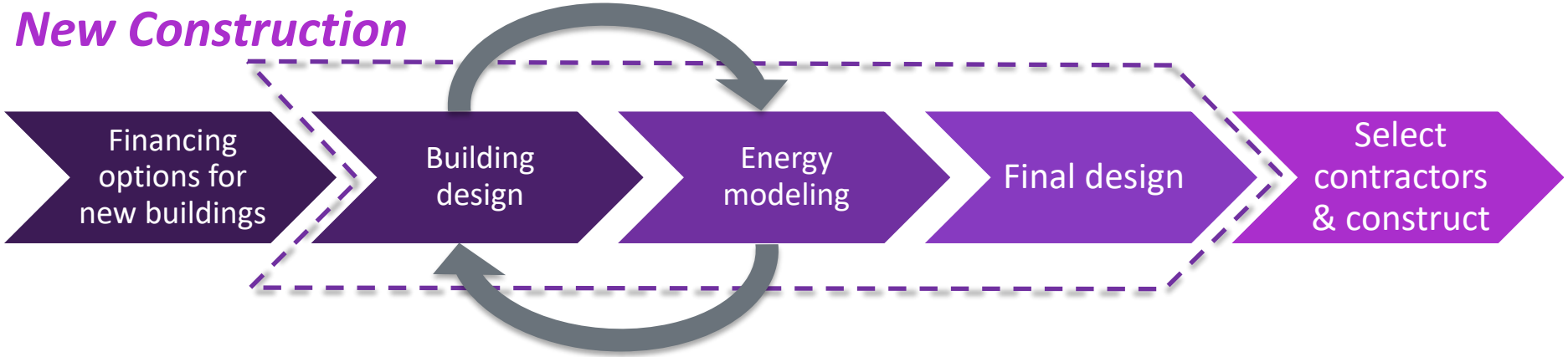
New Construction: Work-Flow of Energy Projects



- The following three steps for new construction buildings will be discussed in more detail
  - Building design
  - Energy modeling
  - Final design

New Construction: Building Design

- Three steps to building design:
  - Schematic Design
    - Define the use of the building
    - Define size and form
    - Define site location
  - Design Development
    - Advance the design to include specific wall types, lighting, HVAC, etc.
  - Construction Documents
    - The drawings & specifications used to build a building

Iterative building energy modeling is performed throughout these phases to optimize building designs in terms of capital cost and energy performance

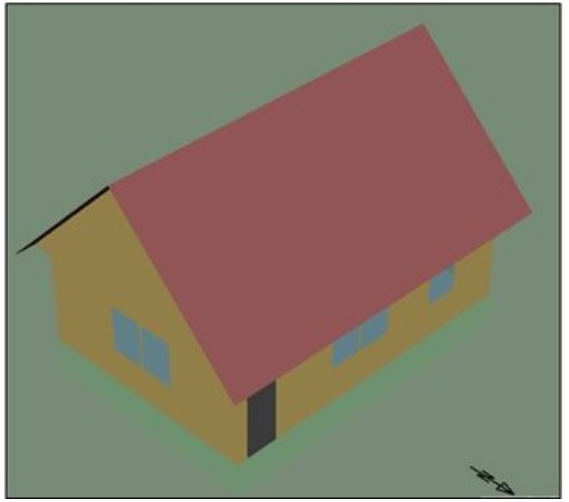
New Construction: Residential Energy Modeling

BEopt

- Residential building energy modeling tool
- Free web download
  - https://beopt.nrel.gov/downloadBEopt2

AKWarm

- Residential & commercial building energy modeling tool
- Free web download
  - https://www.ahfc.us/efficiency/tools/akwarm-energy-rating-software



*Energy modeling can also be used in the energy audit phase for existing buildings

New Construction: Commercial Energy Modeling

EnergyPlus

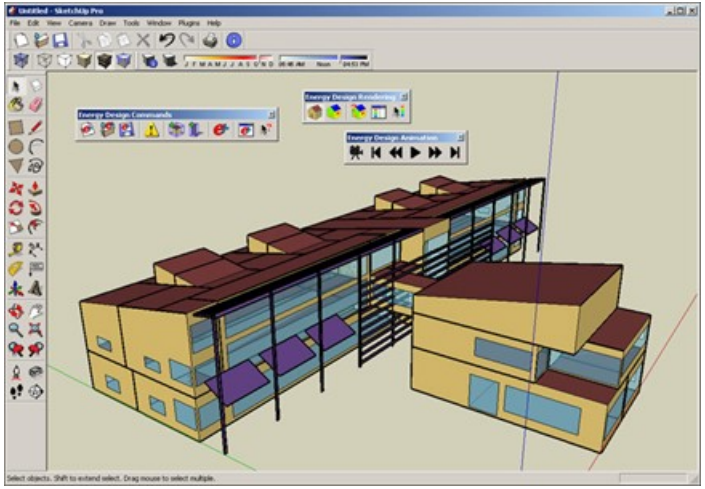
- Commercial building energy modeling tool
- Free web download
  - https://energyplus.net/downloads

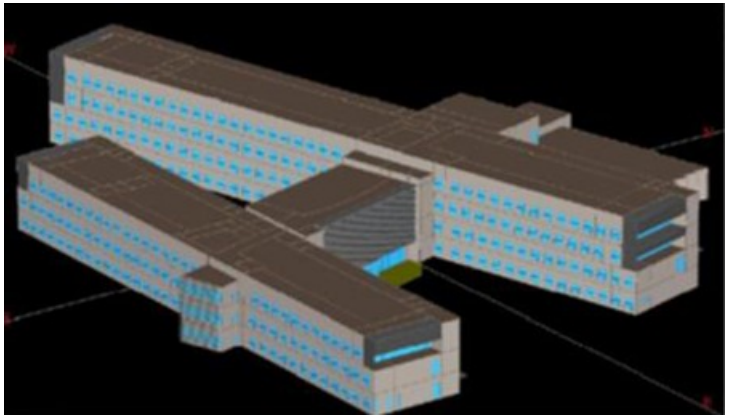
eQUEST

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

AKWarm

- Residential & commercial building energy modeling tool
- Free web download
  - https://www.ahfc.us/efficiency/tools/akwarm-energy-rating-software





*Energy modeling can also be used in the energy audit phase for existing buildings

New Construction: Final Design

These concepts also apply to existing buildings

- ✓ Passive building design
  - ❑ Building orientation, window placement, overhangs, operable windows, thermal mass
- ✓ Efficient envelope
  - ❑ Roof & wall insulation, high-performance windows & doors, air-sealing
- ✓ Efficient lighting
  - ❑ LED lighting, lighting occupancy sensors
- ✓ Efficient plug loads
  - ❑ EnergyStar appliances & equipment
- ✓ Efficient HVAC
  - ❑ Efficient heating & air-conditioning equipment, programmable thermostats, premium efficiency motors, variable frequency drives

Selecting a Contractor

- ✓ Get several quotes
  - Make decisions based on best value, and not necessarily the lowest bid
- ✓ Licensed & insured
  - Ensure the contractors are well-established and accountable
- ✓ Certified energy professionals
  - There are many types of certification programs
  - More information provided on the following slide
- ✓ Local
  - Ensures that the contractors understand how local climate conditions impacts building energy use
  - Allows site owner to verify that similar energy projects have been implemented by the contractor with a high level of quality

Common Certifications for Energy Professionals

- Certified energy professionals for commercial buildings
  - The Association of Energy Engineers: Certified Energy Auditor (CEA)
    https://www.aeecenter.org/certifications/certifications/certified-energy-auditor
  - The Association of Energy Engineers: Certified Energy Manager (CEM)
    https://www.aeecenter.org/certifications/certifications/certified-energy-auditor
  - ASHRAE: Building Energy Assessment Professional (BEAP)
    https://www.ashrae.org/professional-development/ashrae-certification/certification-types/beap-building-energy-assessment-professional-certification
  - ASHRAE: Building Energy Modeling Professional (BEMP)
    https://www.ashrae.org/professional-development/ashrae-certification/certification-types/bemp-building-energy-modeling-professional-certification

- Certified energy professionals for homes
  - The Building Performance Institute: Home Energy Professional (HEP)
    https://bpi.org/certified-professionals/energy-auditor?gclid=Cj0KCQjw6sHzBRCbARIsAF8FMpWoWZMa6f9GVOLj_HRkgo_G6b9I_pBTnkxVSUdhLVh3FD8pbIEGLmsaAjrrEALw_wcB

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Funding Options

- Pay out of Pocket
- Loans
- Energy Performance Contracting
- Grants/Rebates

A given project will often be financed using a combination of the above items

Pay out of Pocket

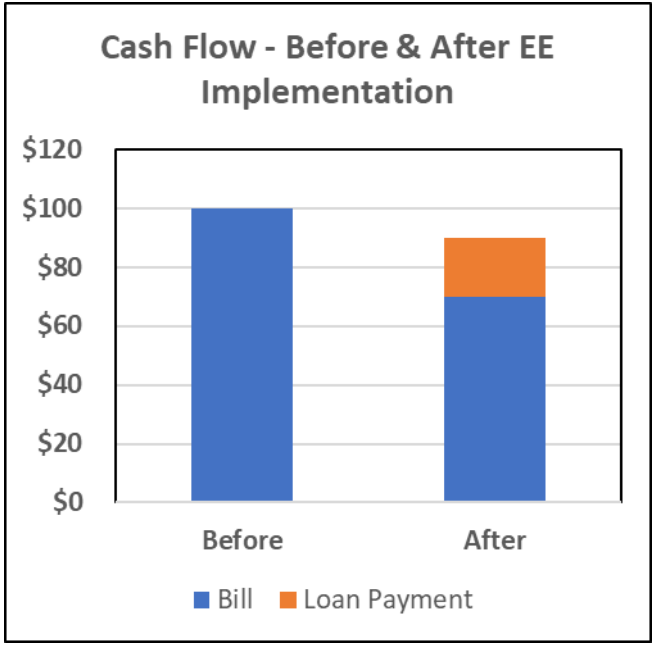
- Applicable to both commercial & residential
- Advantages
  - Simplest
  - Tribe/resident has total control
- Disadvantages
  - Need to have the funds available

Loans - Overview

- Applicable to both commercial & residential
- Wide variety of types of loans

- Advantages
  - Provides capital that may otherwise be unavailable
  - Depending upon the EEMs may be able to structure the loan so as to be cash flow positive even while paying off the loan

- Disadvantages
  - May not be cash flow positive while paying off the loan



Loans - Types

	Concessional Financing	EE Loan	EE Mortgage	PACE[1]	On-bill Financing
Market Segment	Residential? Commercial	Residential Commercial	Residential Commercial	Residential Commercial	Residential Commercial
Applicability on the reservation	High	High (in theory) Low (in practice)	Low	Low	High (where available)
Requires strong credit		Yes	Yes		
Available nationwide		Yes	Yes		
Non-traditional repayment options	Possibly			Yes	Yes
Lender may foreclose if you default			Yes	Yes	

Source: Energy Sage https://www.energysage.com/energy-efficiency/financing/

1. Property Assessed Clean Energy (PACE)

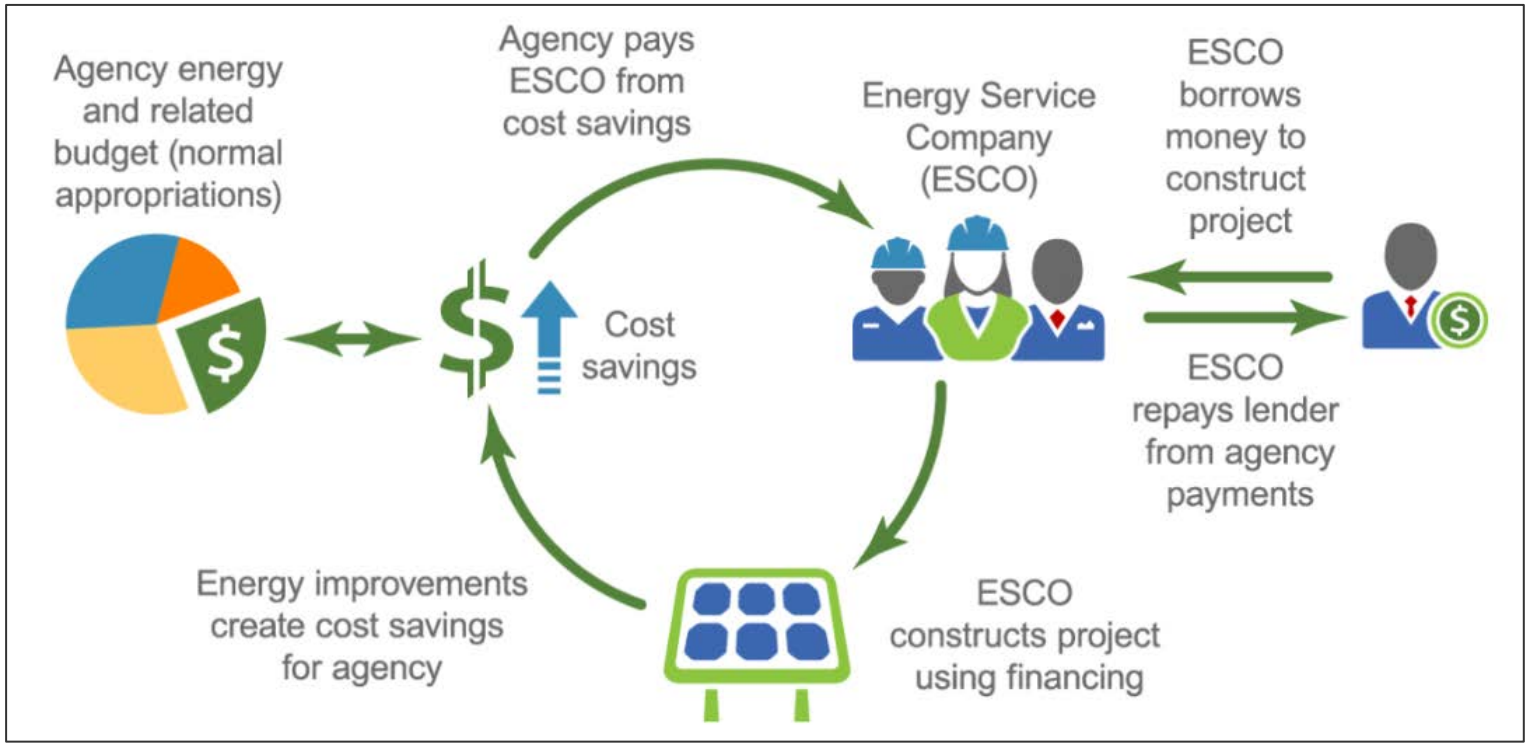
Energy Performance Contracting - Overview

- Applicability: commercial
- Only suitable for large projects: >~$200,000
- More information: https://www.energy.gov/eere/femp/about-federal-energy-savings-performance-contracts

- Advantages
  - Energy Services Contractor (ESCo) funds and executes the project
  - Guaranteed savings (depending upon the contract vehicle) => cash flow positive

- Disadvantages
  - Performance contracts require a lot of effort to manage
  - Don’t have total control over the project
  - You pay a premium for going this route

Energy Performance Contracting – What is It?



Source: DOE-FEMP https://www.energy.gov/eere/femp/about-federal-energy-savings-performance-contracts

Energy Performance Contracts – Types (Federal)

- Energy Savings Performance Contract (ESPC)
  - Guaranteed savings
  - Energy Conservation Measures (ECMs): Any
  - Minimum Project Size: $2,000,000
- ESPC ENABLE
  - Guaranteed savings
  - Streamlined ESPC vehicle/process but only for specific ECMs
  - Minimum Project Size: ~ $200,000 (in practice)
- Utility Energy Services Contract (UESC)
  - An energy performance contract with a utility
  - Somewhat different regulations than with an ESPC. For example, savings not guaranteed.
  - Minimum project size: ??? (Needs to be large enough to justify the transaction costs/effort

Grants / Rebates / Tax Deductions

- Applicability: commercial & residential
- Most utilities have some sort of rebate program
- Expenditures on EE may be eligible for a tax deduction

- Advantages
  - Free money!!!!!

- Disadvantages / Caveats
  - Not enough grant money to meet all the need
  - Some grant vehicles, such as tax credit financing, are complex
  - Need to meet grant reporting and other requirements
  - Grant timeline may not mesh with other timelines
  - Use of tax deductions requires an appropriate tax liability

Grants / Rebates – Where to Look

- Database of State Incentives for Renewable Energy (DSIRE) (Comprehensive listing of federal, state, & utility incentives): https://www.dsireusa.org/
- Department of Energy - Office of Indian Energy: List of funding sources https://www.energy.gov/indianenergy/funding/current-funding-opportunities
- Department of Energy - Office of Indian Energy: Energy Development Assistance Tool https://www.energy.gov/indianenergy/energy-development-assistance-tool
- The web site of your local utility

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Case Study #1: 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

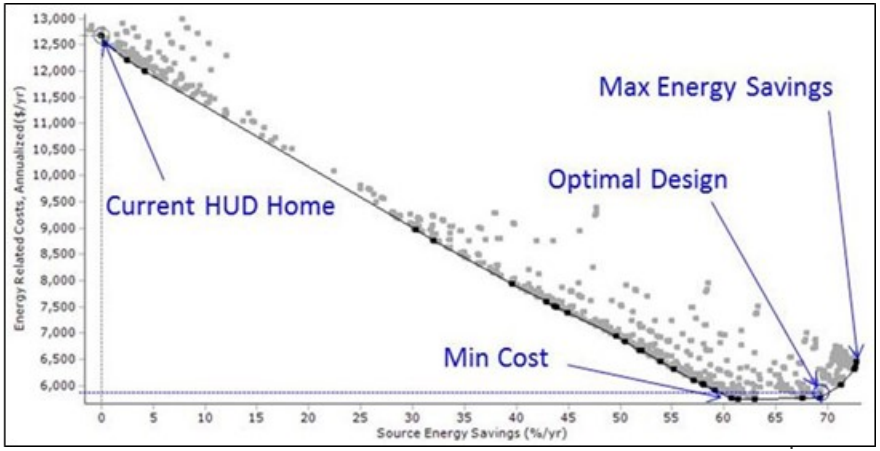
- The major challenges at this site include:
  - ✓ Very high utility rates
  - ✓ Remote (in rural Alaska)
  - ✓ Harsh climate
  - ✓ Limited renovation window
  - ✓ Subsistence living (many freezers)

Photo: Jimmy Salasovich, NREL

BEopt Energy Modeling Software

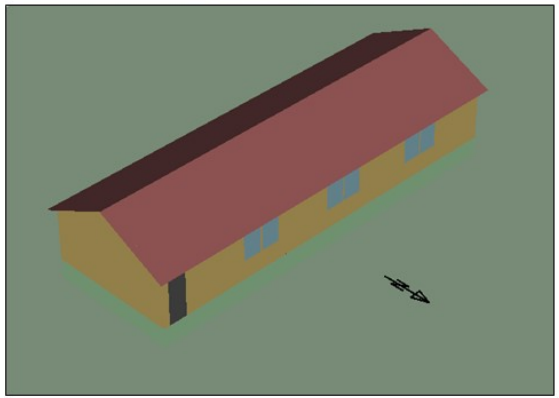
- BEopt is a residential building software simulation
  - Based on EnergyPlus simulation engine
  - Models single-family and multi-family residences
- Finds cost-optimal building design
- Provides a path to Net Zero Energy (NZE) residences

Photo: Jimmy Salasovich, NREL



Single-Family Home Model

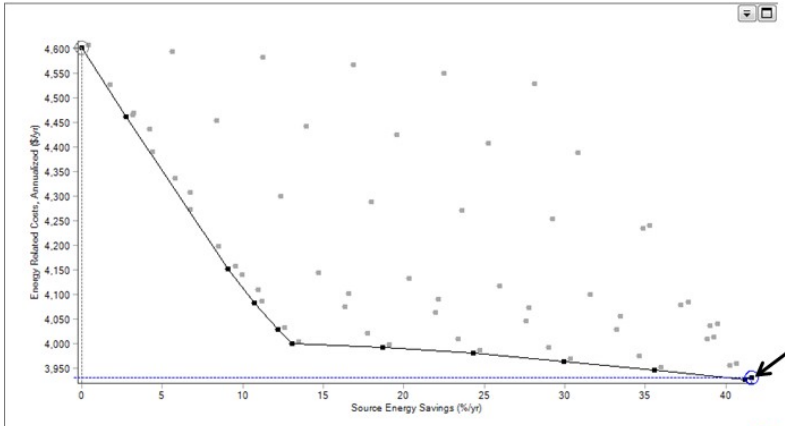
BUILDING			
Type & ID#	#8 (Tanya's House)		
Use	20'x60' Prefab House		
# stories	1		
# occupants	6		
Hrs/wk			
# windows & type	Vinyl Double Casement	4x (2'x4'); 2x (4'x4')	
Heat type (B/F)	Toyo Lazer 73		
DHW type (oil/elec)	Oil Mizer (not currently connected but soon)		
LIGHTING			
TYPE	**Watts**	**# 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			

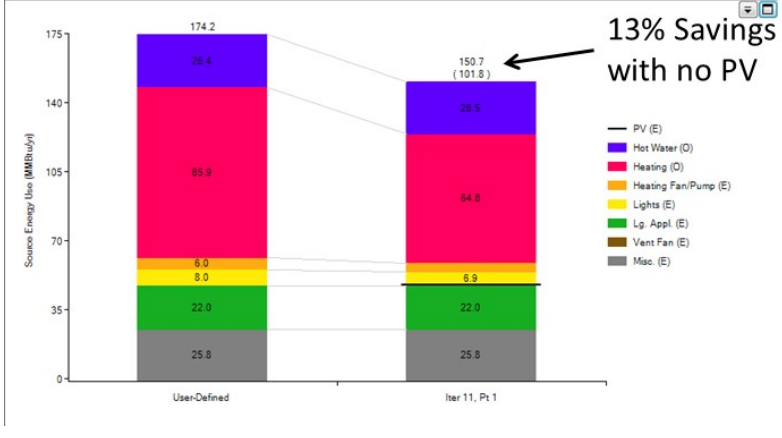


- This single-family home is in a remote Alaskan village
  - R-30 attic insulation
  - R-30 floor insulation
  - CFL lighting
  - Standard refrigerator
  - Standard washing machine
  - EnergyStar™ freezer
  - Woodstove
  - Toyo stove
  - Programmable t-stat
- This type of analysis was done for a total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

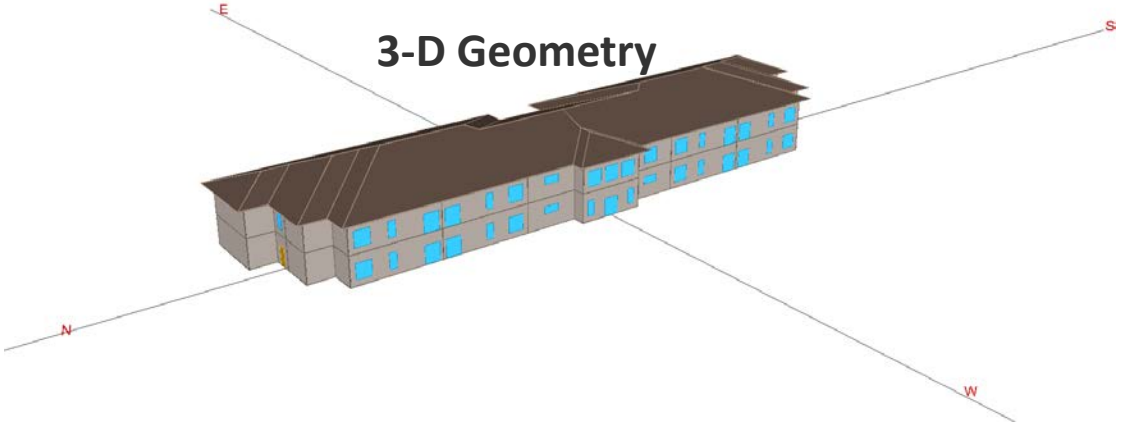
BEopt Results Summary for 10 Homes

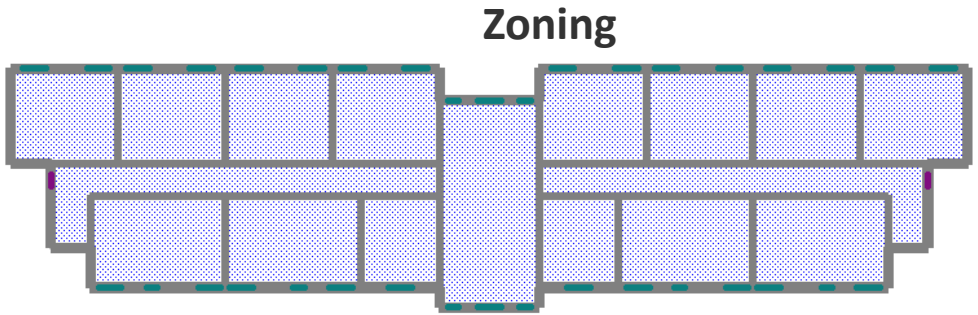
- The optimal/cost -effective design:
  - Programmable thermostats
  - 100% LED lighting
  - Air sealing to 7-12 CFM50
  - R-60 blown-in cellulose insulation in the attic
  - 5 kW solar photovoltaics system
- Source energy savings @ optimal design
  - 8-13% without PV system
  - 28-52% with PV system
- 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™

Case Study #2: 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

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Summary:
Work-Flow of Energy Projects

Existing Buildings

Energy management & tracking	Prioritize buildings	Energy audit	Financing options	Select contractor & implement
✓ Utility bills	✓ CBECS database	✓ Collect data ✓ Perform audit ✓ Analysis	✓ ESPC ✓ 3rd party ✓ Direct purchase	✓ Get multiple quotes ✓ Licensed & insured ✓ Certified ✓ Local

New Construction

Financing options for new buildings	Building design	Energy modeling	Final Design	Select contractors & construct
✓ Offices ✓ Rec centers ✓ Health centers ✓ Housing	✓ Schematic Design ✓ Design Development ✓ Construction Documents	✓ Residential ✓ Commercial ✓ Used in existing and new buildings	✓ Passive ✓ Envelope ✓ Lighting ✓ Plugs ✓ HVAC	✓ Get multiple quotes ✓ Licensed & insured ✓ Certified ✓ Local

Thank you!

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