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
Agenda

1. Work-Flow of Existing Buildings
2. Work-Flow of New Construction Buildings
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Photos: Jimmy Salasovich, NREL
Work-Flow of Energy Projects

Existing Buildings

- Energy management & tracking
- Prioritize buildings
- Energy audit
- Financing options*
- Select contractor & implement

• 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

- Financing options for new buildings
- Building design
- Energy modeling
- Final design
- Select contractors & construct

*Tony Jimenez will be presenting on financing options in the following presentation
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/](https://www.eia.gov/consumption/commercial/)
- Compare your building’s energy performance to similar building types
  - Offices, schools, hospitals, etc.
  - Units: kBtu/ft²/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**

1. **STEP 1**
   - Compile monthly electricity and heating fuel bills for the last three years

2. **STEP 2**
   - Develop annual energy use metric for each building (kBtu/ft²/year)

3. **STEP 3**
   - Group buildings by type and usage patterns

4. **STEP 4**
   - Prioritize buildings to audit based on energy analysis
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
  - Collect building information and consult with staff/occupants
  - Identify potential modifications to reduce energy and cost
  - Perform engineering and economic analysis
  - Prepare a prioritized list of recommendations
  - Report results

Pre-audit

Audit

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

---

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

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](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](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

✓ 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

These concepts also apply to existing buildings
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)
  ▪ 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=Cj0KCQiw6sHzBRCbARIsAF8FMpWoWZMa6f9GVOLj_HRkgo_G6b9I_pBTnkxVSUdhLVh3FD8pbIEGLmsaAjrrEAiLw_wcB
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Photos: Jimmy Salasovich, NREL
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

<table>
<thead>
<tr>
<th>Market Segment</th>
<th>Concessional Financing</th>
<th>EE Loan</th>
<th>EE Mortgage</th>
<th>PACE(^1)</th>
<th>On-bill Financing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicability on the reservation</td>
<td>High</td>
<td>High (in theory) Low (in practice)</td>
<td>Low</td>
<td>Low</td>
<td>High (where available)</td>
</tr>
<tr>
<td>Requires strong credit</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available nationwide</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-traditional repayment options</td>
<td>Possibly</td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Lender may foreclose if you default</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

• 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?

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


• The web site of your local utility
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Photos: Jimmy Salasovich, NREL
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)
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

- 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

**Building**
- Type & ID#: #8 (Tonya’s House)
- Use: 29'x60’ Prefab House
- # stories: 1
- # occupants: 6
- Windows & type: Vinyl Double Casement
- Heat type (Btu): Toyo Laser 73
- DW type: Oil filter (not currently connected but soon)

**Lighting**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Watts</th>
<th># RXT</th>
<th># BULBS</th>
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<tbody>
<tr>
<td>CFL-A</td>
<td>13</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CFL-A</td>
<td>13</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CFL-A</td>
<td>13</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>FLOR T12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLOR T8</td>
<td></td>
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</tr>
</tbody>
</table>

**Plug Loads**
- PC: 1
- DVD Print: 1

**Refrigeration**
- refer: 1 freezer standard efficiency
- freezer: 1 freezer Energy Star

**Notes**
- Wall R-value: 2”x6”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 3-lamp CFL light fixtures had only 1 lamp in them
- 42” flat screen TV
- Pre-paid electric meter
- Toyo has programmable t-stat
- This is a 29’x60’ prefabricated house

Photo: Jimmy Salasovich, NREL
**BEopt Energy Modeling Results**

**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

13% Savings with no 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 ft² 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

- 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

<table>
<thead>
<tr>
<th></th>
<th>Boiler for Radiant Heating with DX Air-Conditioning</th>
<th>Furnace with DX Air-Conditioning</th>
<th>Air-Source Heat Pumps</th>
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</thead>
<tbody>
<tr>
<td><strong>EUI</strong> (kBtu/ft²/year)</td>
<td>57.8</td>
<td>59.5</td>
<td>47.5</td>
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<tr>
<td><strong>Electricity Use</strong> (kWh/year)</td>
<td>271,772</td>
<td>294,586</td>
<td>344,067</td>
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<tr>
<td><strong>Electricity Cost</strong> ($/year)</td>
<td>$48,919</td>
<td>$53,025</td>
<td>$61,932</td>
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<tr>
<td><strong>Fuel Oil Use</strong> (gallons/year)</td>
<td>3,572</td>
<td>3,324</td>
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<tr>
<td><strong>Fuel Oil Cost</strong> ($/year)</td>
<td>$9,823</td>
<td>$9,140</td>
<td>$0</td>
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<tr>
<td><strong>Total Cost</strong> ($/year)</td>
<td>$58,742</td>
<td>$62,165</td>
<td>$61,932</td>
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</table>
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Photos: Jimmy Salasovich, NREL
### Summary: Work-Flow of Energy Projects

#### Existing Buildings

**Energy management & tracking**
- ✓ Utility bills

**Prioritize buildings**
- ✓ CBECS database

**Energy audit**
- ✓ Collect data
- ✓ Perform audit
- ✓ Analysis

**Financing options**
- ✓ ESPC
- ✓ 3rd party
- ✓ Direct purchase

**Select contractor & implement**
- ✓ Get multiple quotes
- ✓ Licensed & insured
- ✓ Certified
- ✓ Local

#### New Construction

**Financing options for new buildings**
- ✓ Offices
- ✓ Rec centers
- ✓ Health centers
- ✓ Housing

**Building design**
- ✓ Schematic Design
- ✓ Design
- ✓ Development
- ✓ Construction
- ✓ Documents

**Energy modeling**
- ✓ Residential
- ✓ Commercial
- ✓ Used in existing and new buildings

**Final Design**
- ✓ Passive
- ✓ Envelope
- ✓ Lighting
- ✓ Plugs
- ✓ HVAC

**Select contractors & construct**
- ✓ Get multiple quotes
- ✓ Licensed & insured
- ✓ Certified
- ✓ Local
Thank you!

Jimmy Salasovich
Engineer
National Renewable Energy Lab
james.salasovich@nrel.gov

Photos: Jimmy Salasovich, NREL