Technical and Economic Feasibility Studies for Existing Building Commissioning
Learning Objectives

Gain An Understanding Of The Basic Concepts And Methodologies For The Economic Evaluations Used In EBCX Reports

- End Use Reconciliation
- Raw Electric Data Analysis
- Financial Calculations
- More Detailed Calculations
  - Spreadsheet Calculations
  - Hourly Modeling Calculations
End Use Reconciliation and Calibration

- A quick but powerful way to put energy project estimates into a reasonable range
- Check energy savings calc results for reasonableness
- Calibration is checking the estimated energy use against actual history
Start with electricity

- Electricity typically has the widest variety of end-uses
- Applies to other fuels and total utility bills as well
What do you need to know?

- kW vs. kWh
- Equivalent Full Load Hours
  - Varies by location and type of business
  - Use ASHRAE HVAC Applications and other sources
Need to know (cont)

- Lighting – W/ft$^2$
- Plug loads – W/ft$^2$
- HVAC Fans – total kW
- HVAC Cooling - total kW
- Other – electric heat, air compressors, process loads, large kitchen, data centers, etc.
End Use Calculations

- \((W/ft^2) \times (\text{Building or Space ft}^2) \times (\text{EFLH}) / 1000 = \text{kWh}\)
- \((\text{Connected kW}) \times (\text{EFLH}) = \text{kWh}\)
Square Footage = 105,000 ft²

<table>
<thead>
<tr>
<th>Equipment</th>
<th>W/ft²</th>
<th>kW</th>
<th>EFLH</th>
<th>kWh</th>
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<td>441,000</td>
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<tr>
<td>Plug Loads, Misc equip</td>
<td>1.0</td>
<td>3000</td>
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<tr>
<td>HVAC Fans</td>
<td>68</td>
<td>5000</td>
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<td>HVAC Cooling</td>
<td>195</td>
<td>1000</td>
<td>194,700</td>
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<tr>
<td>Electric Heat</td>
<td>180</td>
<td>1400</td>
<td>252,000</td>
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</tr>
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</table>

| Total                 |       |     |      |      |
|                       |       |     | 1,542,130 |
| Total Annual from Bills|       |     |      | 1,579,200 |

% diff 2%
- Electric Heat: 16%
- Lighting: 29%
- Plug Loads, Misc equip: 20%
- HVAC Cooling: 13%
- HVAC Fans: 22%
Square Footage = 167,000 ft$^2$

<table>
<thead>
<tr>
<th>Equipment</th>
<th>W/ft$^2$</th>
<th>kW</th>
<th>EFLH</th>
<th>kWh</th>
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<td>Pumps</td>
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<td>Boiler</td>
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<td>500</td>
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<td>285,000</td>
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<tr>
<td>Data Center</td>
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<td>3,791,725</td>
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<tr>
<td>Total</td>
<td></td>
<td>851</td>
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<td>8,213,009</td>
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Total Annual from Bills EPO Cal 2009 8,151,408

% diff -1%
A pie chart showing energy consumption. The chart includes the following categories:

- **Data Center**: 3,791,725 kWh, 46%
- **WSHPs**: 2,049,922 kWh, 25%
- **Pumps**: 315,181 kWh, 4%
- **Boiler**: 285,000 kWh, 4%
- **Kitchen**: 48,117 kWh, 1%
- **Plug Loads Misc equip**: 445,932 kWh, 5%
- **AC1 & AC2**: 441,539 kWh, 5%

The chart indicates that the Data Center is the largest consumer of energy, followed by WSHPs and other categories like Pumps and Boiler.
End-Use Reconciliation Method

- Gather equipment information and building characteristics
- Estimate EFLH of equipment
- Sum total kWh
- Compare to utility bills
End-Use Reconciliation Method (cont)

- Is your estimate within 10%?
- Are the utility bills correct? Right building? Right account?
- What would you change to get the estimates to be closer?
- Are you missing equipment?
Example: End Use off by 20%

- Would need to change lighting and plug loads to > 3500 EFLH to true-up to < 10%
- Possible explanations:
  - Missing equipment in the End-Use
  - Other equipment (cooling, heating, etc) actually running with more EFLH
  - Lighting and/or plug loads are actually running far too many hours => a quick, easy, inexpensive energy efficiency measure
Example: Cooling

- From the first end use reconciliation, estimated about 195,000 kWh/yr in cooling.
- You (or a vendor) estimate savings of 10% = 19,500 kWh/yr.
- At $0.10/kWh = $1,950/yr.
- Owner desires < 3 yr payback.
- Can support ~ $6,000 project before incentives.
Example: Cooling (cont)

- Supports RCx, controls upgrades, re-programming controls, etc.
- Does not support major capital projects, cooling equipment replacement, etc.
Example: Lighting

- Lighting vendor does a study
- Says they can save you 220,000 kWh/yr on lighting
- Does this make sense?
- From the end-use reconciliation, lighting accounted for ~440,000 kWh/yr. Estimating approximately 50% savings.
- Makes sense for some types of projects (some controls, Metal Halide->High Intensity Fluorescent) but not for others T8->HE T8
Raw Electric Data Analysis

- Examining 15 minute electric data for opportunities
- 2D Map powerful method of viewing every 15 minutes of data for an entire year
Average Profiles

- Weekend vs. Weekday
- Late night, early morning (10pm->6am)
- Spring, Summer, Fall, Winter
  - Extra emphasis on summer, many regions the electric rates are (much) higher
- Annual Peak vs. Summer Peak vs. Weekday
  - Average
- Profile of a day you know a lot about
Average Profiles (cont)
Load Duration Curve

- % of time at or above the listed demand
- Quickly shows if you are hitting an infrequent peak
- Quickly shows if operating hours are similar to what’s expected
At ~1275 kW or above 10% of the year (876 hrs)

Sharp 200 kW spike for 1% of year => May need demand limiting

Sharp drop at 42%

Shoulder hours of occupancy

Unoccupied operation 50% of the hours of the year
Economic Feasibility

- Simple Payback
- Return on Investment
- Cash Flow Opportunity Tool Calculator
The Business Case for Energy Efficiency

- Often energy projects are looked at simply in terms of simple payback
- Many good business reasons to get serious about energy management
Business Case

- Reduced Operating Costs
- Increased Productivity and Sales (e.g. Daylighting study)
- Reduced Vulnerability to Energy Price Fluctuations
- Enhanced Public Image
- Enhanced Reputation within the Financial Community as a Well Managed Company
- Enhanced Appeal to Socially Responsible Investors and Shoppers/Patrons
- Market Opportunity for Energy Efficient Product Sales
Simple Payback

- Frequently Used
- Poor Indicator Of Success of Project
- Uses very few inputs
- Energy Projects often suffer when using this indicator, compared to other types of projects
- What’s the simple payback of leather seats in a car? Of building an atrium in a building?
- Simple, easily understood
Simple Payback - Calculation

- SPB = Investment Amount / Yearly Benefit
- Example
  - SPB = $100,000 / $50,000 = 2 yrs
- Provides guidance to determine if energy calculations are reasonable
Return on Investment

- Less frequently used, but a better indicator
- Still very simple
- Frames the conversation differently – does not have the stigma of “years”
- Expressed in %
- Many different ways to calculate, we’ll use the simple one
ROI Calculation

- **ROI** = Yearly Benefit / Investment Amount

- **Example**
  - SPB = $50,000 / $100,000 = 50%

- We can relate this to things we know, such as current interest rates from a bank.
Re-Framing the Conversation with ROI

- If ROI > Cost of Capital, it’s generally a good project.
  - Cost of Capital is the interest paid on debt (and the dividends paid to investors).

- Re-frames the conversation, because we’re NOT talking about:
  - How much money does the company have for projects
  - What’s in the budget for next year
  - What was in the budget last year
Re-Framing the Conversation with ROI

- Now we’re talking about whether there are any better investments on the table
  
  AND

- Can we obtain funds somehow (loans, lease) at a rate that is lower than the energy project ROI
Cash Flow Opportunity Tool Calculator

- Tool created by EPA to help re-frame the conversation around energy projects
- Available for free download:
  http://www.energystar.gov/index.cfm?c=assess_value.financial_tools
Cash Flow Opportunity Calculator

- Cash Flow
  - Fast-track financing vs. waiting for cash

- Cost of Delay
  - Waiting for a better interest rate
**Cash Flow**

**COST OF DELAY and CASH FLOW ANALYSIS**

### Project Cost Impact

- **Project Cost:** $100,000
- **Simple Payback:** 3 years
- **Interest Rate:** 5.00%
- **Financing Term:** 10 years
- **Year(s) Postponed:** 1 year
- **Project Cost Increase Due to Postponement:** 0.00%
- **Estimated Energy Cost Change in Year 2:** 0.00%
- **Annual Change in Energy Cost After Year 2:** 0.00%
- **Estimated Energy Savings in Year 1:** 0.00%

These cash flow calculations are on a pretax basis. For purposes of this calculation, all cash flows are being discounted at the interest rate indicated in cell G7 - financing paid monthly in arrears.

### Net Present Value

- **Net Present Value of Option A (Fast Track Financing):** $146,853
- **Net Present Value of Option B (Waiting for Cash):** $78,846

**Fast Track Financing generates $68,008 or 86% more cash than waiting!**

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**Option A (Fast Track Financing)**

**Option B (Waiting for Cash)**

**Cumulative Cash Flow**
## Cost of Delay

### Comparative Interest Rate Analysis

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<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
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<td>Interest rate of higher financing</td>
<td>5.00</td>
<td>%</td>
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<td>Interest rate of a lower financing</td>
<td>4.00</td>
<td>%</td>
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<td>Cost of the equipment</td>
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<td>Simple payback</td>
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<td>year(s)</td>
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<td>Potential annual savings</td>
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<td>Term of financing</td>
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<td>year(s)</td>
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<td>Lower interest rate savings*</td>
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<tr>
<td>Amount lost in utility bills</td>
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<td>/month</td>
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<tr>
<td>Break-Even Point</td>
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<table>
<thead>
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<th>Month</th>
<th>Lower Interest rate savings balance at beginning of month</th>
<th>Amount lost in monthly utility bills</th>
<th>Lower Interest rate savings balance at end of month</th>
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<td>-$28,600</td>
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</table>

*Lower Interest Rate Savings number is calculated by taking the NPV of the difference between the two monthly payments (immediate versus lower financing rates), discounted at the lower interest rate.

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**Important Notice**
Opportunity Cost

- Very real – energy savings is a real profit center like any other
- Delaying energy projects can mean throwing money away
Energy Savings Calculations

- Methods
  - Spreadsheet modeling
  - Building Information Modeling (BIM)

- Pros/Cons for each

- “Best” approach depends on complexity of project as well as financial elements (incentive structure – shared savings vs. one-time check vs. pay-for-performance)
Spreadsheet Modeling

- A way to target specific end-uses quickly
- Lots of control over the variables and calculation methodologies
- Easy to create spreadsheets that can be used repeatedly for a number of situations
- But... tend to ignore interactive effects
### Example

<table>
<thead>
<tr>
<th>Weather</th>
<th>Existing</th>
<th>Typical Occupancy</th>
<th>Low Occupancy</th>
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**TOTALS**: 8,760 45.415 3,171 16,360 6,569 5,234 23,822 0
Hourly Modeling

- Lots of programs to use...
- eQUEST, Trane TRACE, EnergyPro, HAP, etc.
- **Pros:** Can get very detailed models with nearly unlimited energy efficiency measures
- **Cons:** Black box; often have to obtain and understand many details of the model to get good results.
eQUEST

- eQUEST can be tried for free
- Built in wizard has many efficiency measures
- But...  
  - No tech support – users have to rely on each other via internet forums for assistance
  - Steep learning curve once you dig into the details
eQUEST for EBCx

- Outside air flow
- Economizer operation
- Setpoints of many kinds
- Schedules of many kinds
- Equipment efficiency
- VAV box minimum positions
- Constant vs. Variable speed
- Control strategies (optimum start/stop, resets, etc.)
- Many more with some creativity and patience…
Summary

- Use end use reconciliations and simple calculations to get a reasonable estimate.
- Use detailed modeling:
  - If it passes the simple calculations,
  - If required or if it is worth the expense.
- Use financial tools such as ROI and the CFO Tool to reframe the conversation of energy projects.