Technical and Economic Feasibility Studies for Existing Building Commissioning

B2Q Associates, Inc. ©

Part 7

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

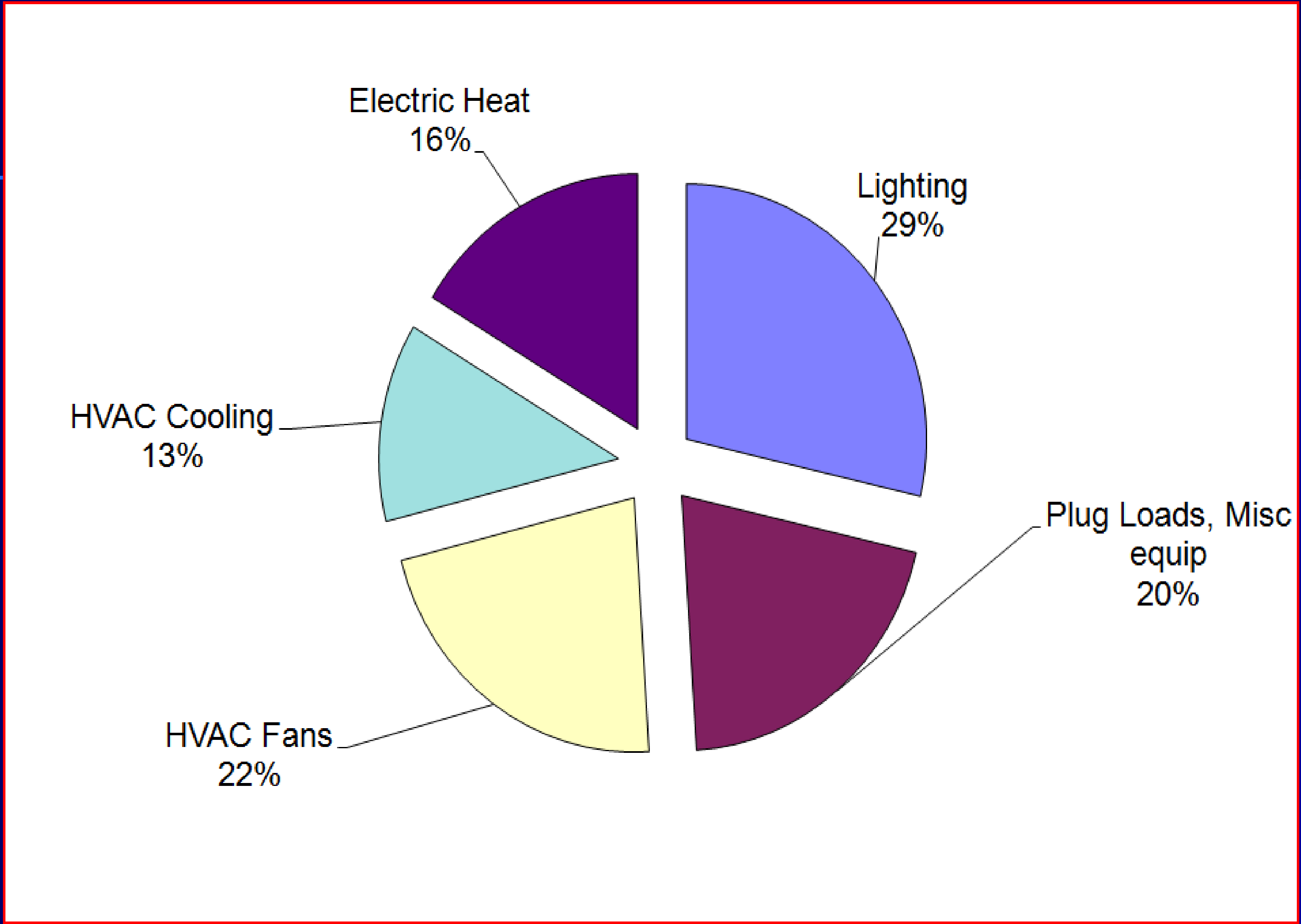
- (W/ft^2) x (Building or Space ft^2) x (EFLH) / 1000 = kWh
- (Connected kW) x (EFLH) = kWh

Square Footage = 105,000 ft^2

Electricity End Use
Reconciliation Estimate

Equipment	W/ft2	kW	EFLH	kWh
Lighting	1.4		3000	441,000
Plug Loads, Misc equip	1.0		3000	315,000
HVAC Fans		68	5000	339,430
HVAC Cooling		195	1000	194,700
Electric Heat		180	1400	252,000
Total				1,542,130
Total Annual from Bills				1,579,200
% diff				2%

-

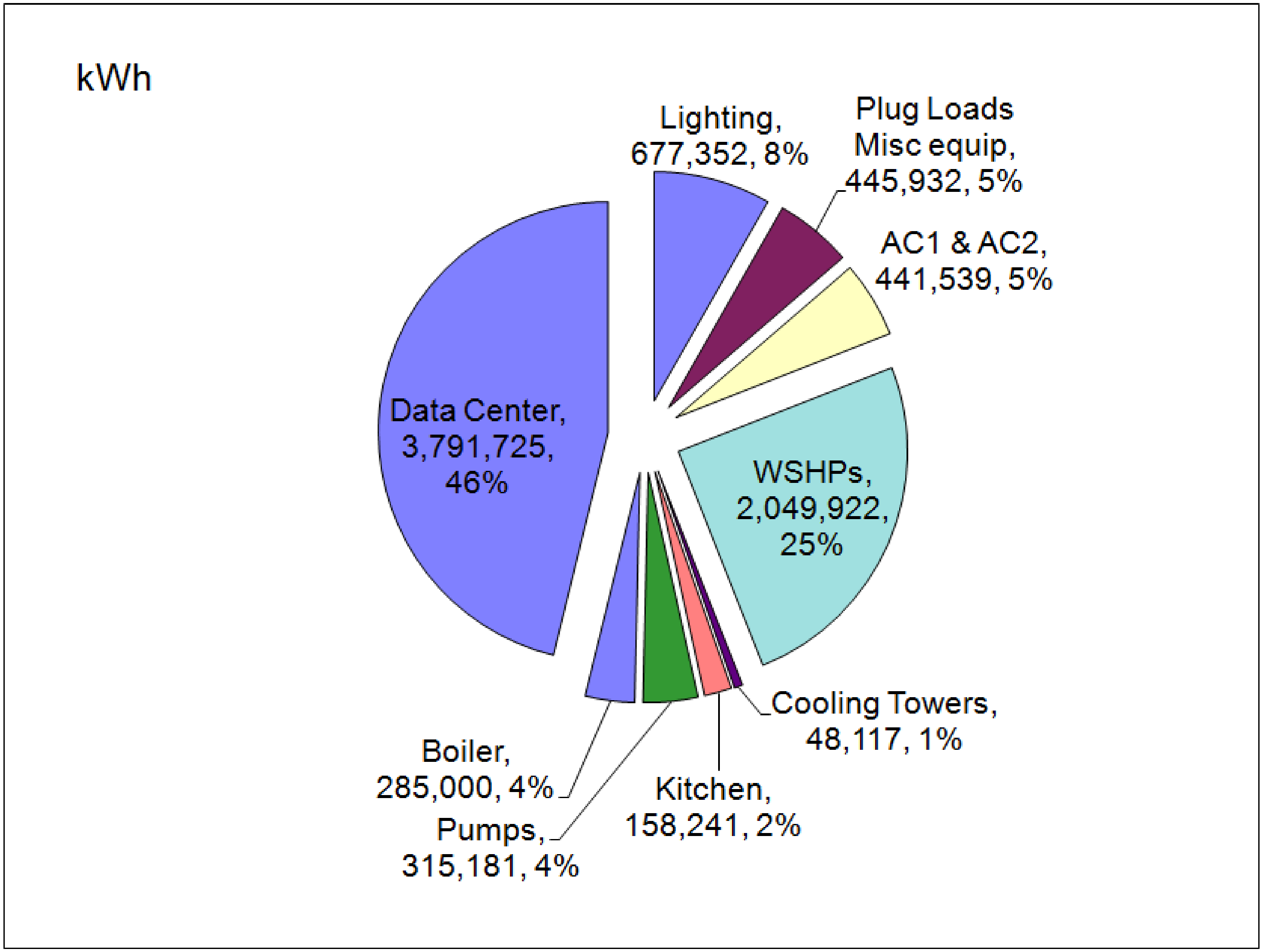


Electric Heat
16%
Lighting
29%
HVAC Cooling
13%
Plug Loads, Misc
equip
20%
HVAC Fans
22%

Square Footage = 167,000 ft^2

Electricity End Use
Reconciliation Estimate

Equipment	W/ft2	kW	EFLH	kWh
Lighting	1.2		3380	677,352
Plug Loads Misc equip	0.75		3380	445,932
AC1 & AC2		201	2200	441,539
WSHPs				2,049,922
Cooling Towers		45	1075	48,117
Kitchen				158,241
Pumps		36	8760	315,181
Boiler		570	500	285,000
Data Center				3,791,725
Total		851		8,213,009
Total Annual from Bills	EPO Cal 2009			8,151,408
			% diff	-1%


kWh
Lighting, 677,352, 8%
Plug Loads Misc equip, 445,932, 5%
AC1 & AC2, 441,539, 5%
WSHPs, 2,049,922, 25%
Cooling Towers, 48,117, 1%
Kitchen, 158,241, 2%
Pumps, 315,181, 4%
Boiler, 285,000, 4%
Data Center, 3,791,725, 46%

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

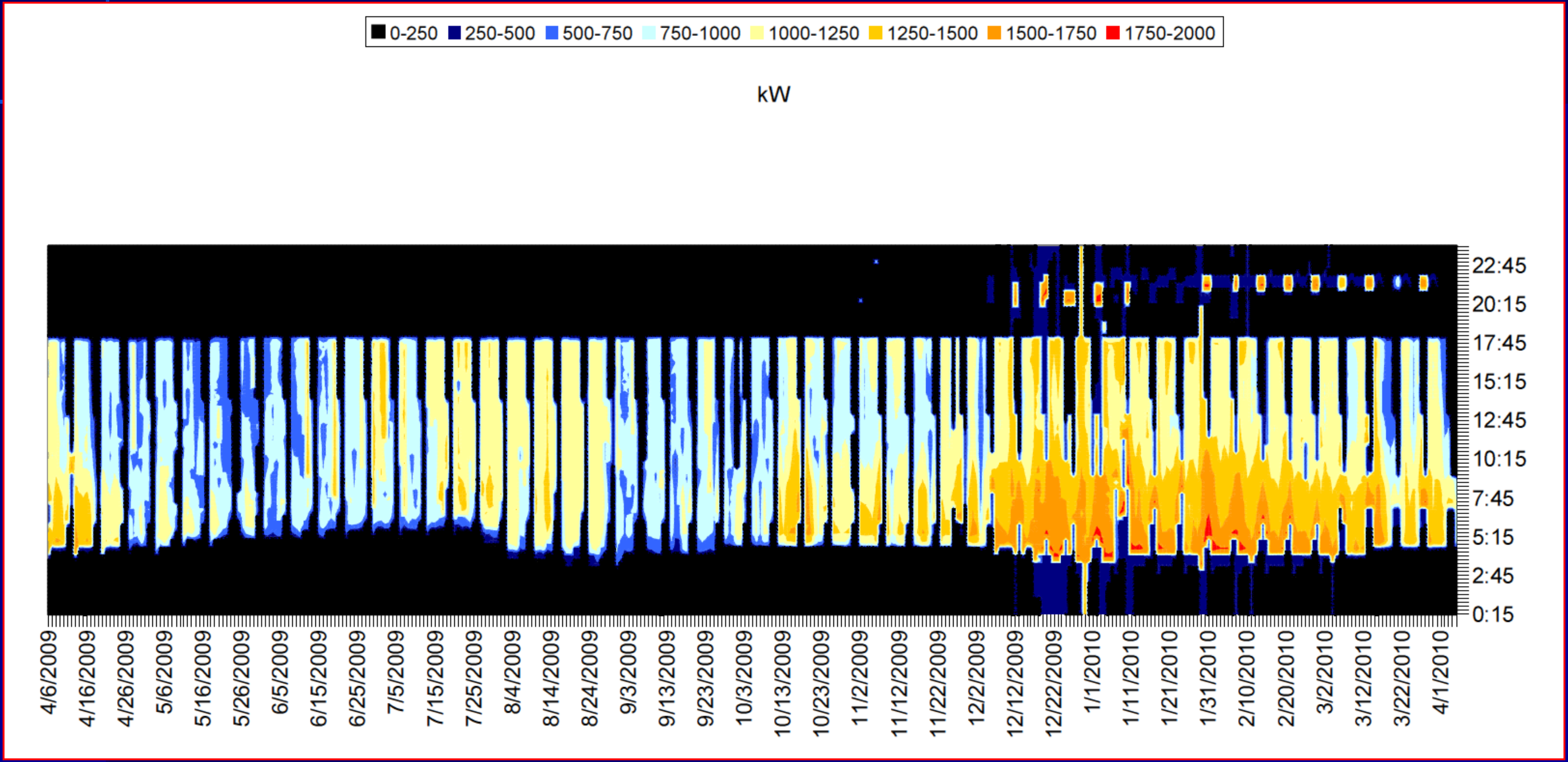
- Lighting vendor does a study
- Says they can save you 220,000 kWh/yr on lighting
- Does this make sense?
- From the end-use reconciliation, lighting accounted for ~440,000 kWh/yr. Estimating approximately 50% savings.
- Makes sense for some types of projects (some controls, Metal Halide->High Intensity 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

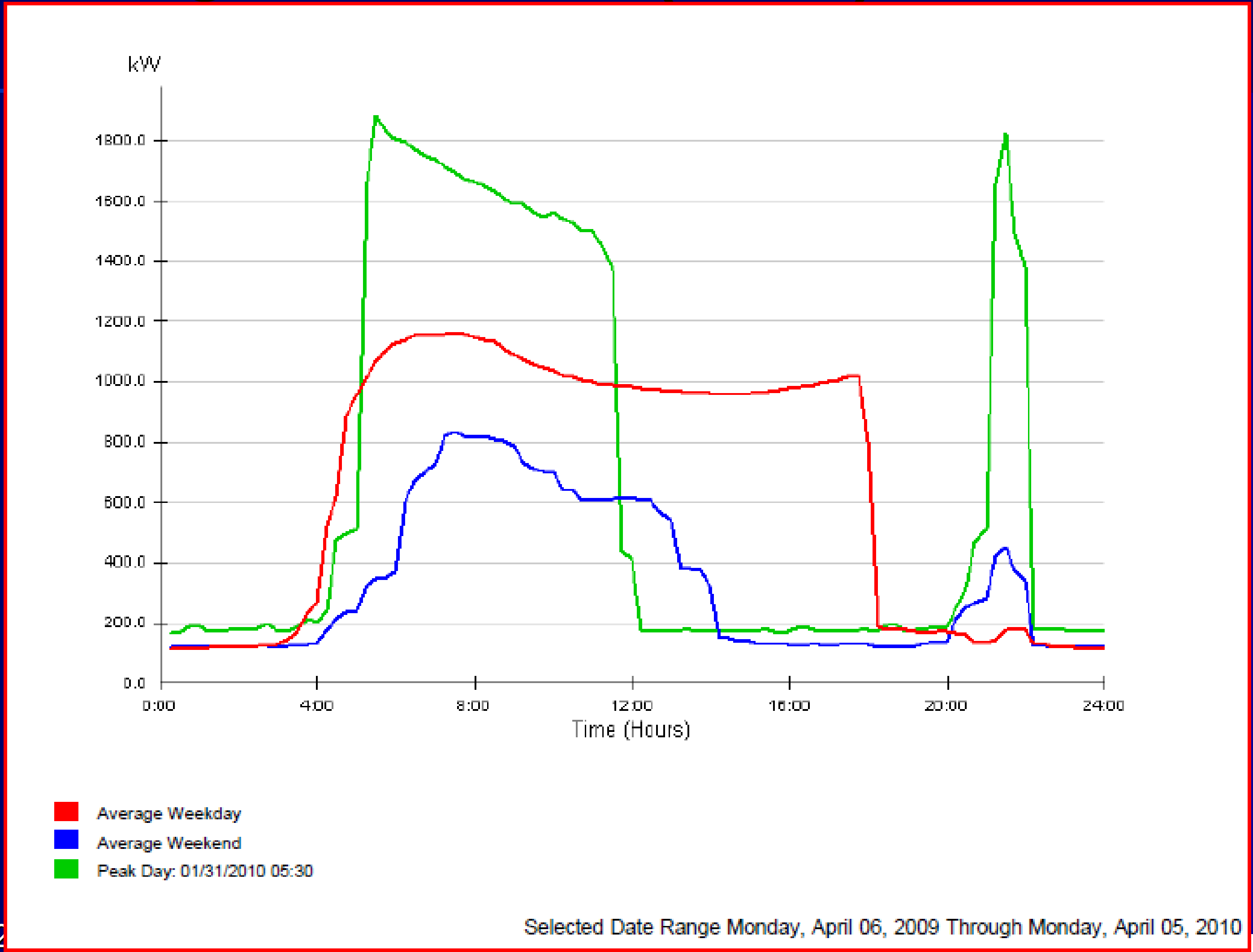
-


0-250
250-500
500-750
750-1000
1000-1250
1250-1500
1500-1750
1750-2000
kW
22:45
20:15
17:45
15:15
12:45
10:15
7:45
5:15
2:45
0:15
4/6/2009
4/16/2009
4/26/2009
5/6/2009
5/16/2009
5/26/2009
6/5/2009
6/15/2009
6/25/2009
7/5/2009
7/15/2009
7/25/2009
8/4/2009
8/14/2009
8/24/2009
9/3/2009
9/13/2009
9/23/2009
10/3/2009
10/13/2009
10/23/2009
11/2/2009
11/12/2009
11/22/2009
12/2/2009
12/12/2009
12/22/2009
1/1/2010
1/11/2010
1/21/2010
1/31/2010
2/10/2010
2/20/2010
3/2/2010
3/12/2010
3/22/2010
4/1/2010

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

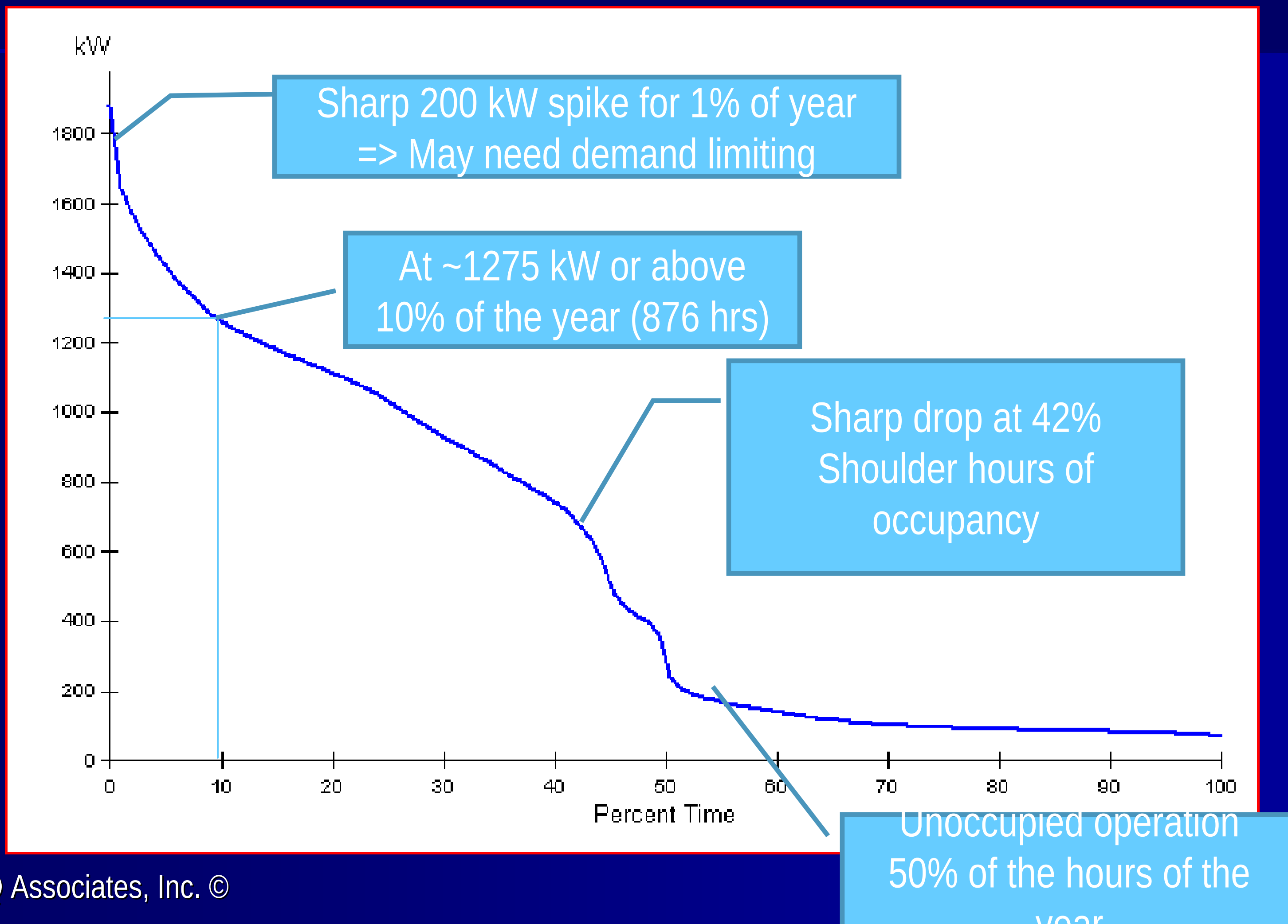
Average Profiles (cont)



B2

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


kW
1800
1600
1400
1200
1000
800
600
400
200
0
0
10
20
30
40
50
60
70
80
90
100
Percent Time
Sharp 200 kW spike for 1% of year
=> May need demand limiting
At ~1275 kW or above
10% of the year (876 hrs)
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

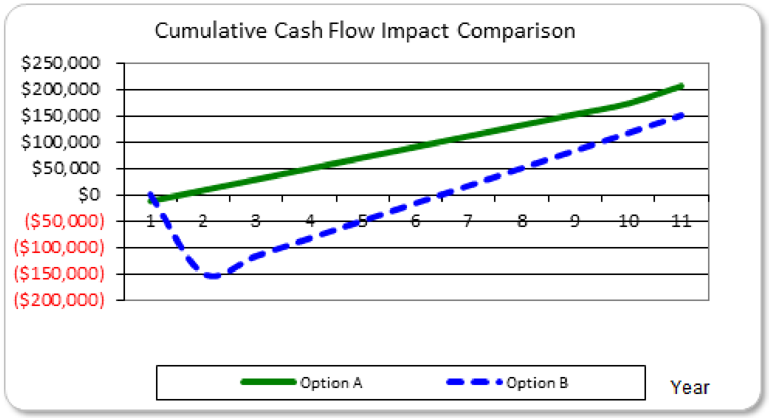
- Cash Flow
  - Fast-track financing vs. waiting for cash
- Cost of Delay
  - Waiting for a better interest rate

Cash Flow

HELP SAMPLE VALUES

COST OF DELAY and CASH FLOW ANALYSIS

Project cost	100,000	$
Simple payback	3	years
	0	month(s)
Interest rate	5.00	%
Financing term	10	years
Year(s) postponed	1	years
Project cost increase due to postponement	0.00	%
Estimated energy cost change in year 2	0.00	%
Annual change in energy costs 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 of Option A (Fast Track Financing)	**$146,853**	**$78,846**	**Net Present Value of Option B (Waiting for Cash)**

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

	Option A (Fast Track Financing)				Option B (Waiting for Cash)			
Year	Savings	Project Cost including financing	Annual Cash Flow	Cumulative Cash Flow	Savings	Project Cost	Annual Cash Flow	Cumulative Cash Flow
1	$0	($12,728)	($12,728)	($12,728)	$0	$0	$0	$0
2	$33,333	($12,728)	$20,605	$7,878	$0	($150,000)	($150,000)	($150,000)
3	$33,333	($12,728)	$20,605	$28,483	$33,333	$0	$33,333	($116,667)
4	$33,333	($12,728)	$20,605	$49,089	$33,333	$0	$33,333	($83,333)
5	$33,333	($12,728)	$20,605	$69,694	$33,333	$0	$33,333	($50,000)

Cost of Delay

ENERGY STAR

HELP

SAMPLE VALUES

COST OF DELAY - Comparative Interest Rate Analysis

Interest rate of higher financing	5.00	%
Interest rate of a lower financing	4.00	%
Cost of the equipment	$100,000	
Simple payback	3	year(s)
	0	month(s)
Potential annual savings	$33,333	
Term of financing	10	year(s)
Lower interest rate savings*	**$4,800**	
Amount lost in utility bills	$2,800	/month
Break-Even Point	**1.7**	month(s)

*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.

Month	Lower Interest rate savings balance at beginning of month	Amount lost in monthly utility bills	Lower Interest rate savings balance at end of month
1	**$4,800**	$2,800	$2,000
2	$2,000	$2,800	-$800
3	-$800	$2,800	-$3,600
4	-$3,600	$2,800	-$6,400
5	-$6,400	$2,800	-$9,100
6	-$9,100	$2,800	-$11,900
7	-$11,900	$2,800	-$14,700
8	-$14,700	$2,800	-$17,500
9	-$17,500	$2,800	-$20,200
10	-$20,200	$2,800	-$23,000
11	-$23,000	$2,800	-$25,800
12	-$25,800	$2,800	-$28,600

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

	Total CFM	OA CFM	OA%
Existing CFM	18,182	4,545	25%
Proposed High CFM		3,864	21%
Proposed Low CFM		909	5%
High%OA Red	15%		
Low % OA Red	80%		
Cooling Enthalpy	18.2	BTU/lb	
Heating Setpoint	72.0	°F	
Cooling Efficiency	1.1	kW/ton	
Heating Efficiency	0%		
Fuel Heating Value	100	kBtu/therm	

Savings Estimate

Total kWh	23,822
Total therms	0

Supply Fan hp	20
CFM known?	No
if Yes, enter Total CFM	
if No, estimated Total CFM	18182

Weather		Existing						Proposed Demand Controlled Ventilation												Savings	
								Typical Occupancy						Low Occupancy							
Avg. DB Bin Temp °F	OA Enthalpy Btu/lb	Occupied Bin HOURS	OA CFM	Cooling Load kBtu/h	Heating Load kBtu/h	Cooling kWh	Heating therms	Occupied Bin HOURS	OA CFM	Cooling Load kBtu/h	Heating Load kBtu/h	Cooling kWh	Heating therms	Occupied Bin HOURS	OA CFM	Cooling Load kBtu/h	Heating Load kBtu/h	Cooling kWh	Heating therms	Cooling kWh	Heating therms
92.5	34.8	7	4,545	(340)		218		6	3,864	(289)		159		1	909	(68)		6		53	
87.5	34.5	73	4,545	(297)		1,988		52	3,864	(253)		1,204		21	909	(59)		114		670	
82.5	31.8	252	4,545	(255)		5,883		158	3,864	(216)		3,135		94	909	(51)		439		2,309	
77.5	29.4	387	4,545	(212)		7,528		201	3,864	(180)		3,324		186	909	(42)		724		3,481	
72.5	27.6	707	4,545	(170)		11,003		277	3,864	(144)		3,664		430	909	(34)		1,338		6,000	
67.5	25.4	690	4,545	(127)		8,054		211	3,864	(108)		2,093		479	909	(25)		1,118		4,842	
62.5	23.7	970	4,545	(85)		7,548		299	3,864	(72)		1,978		671	909	(17)		1,044		4,526	
57.5	21.3	821	4,545	(42)		3,194		243	3,864	(36)		804		578	909	(8)		450		1,941	
52.5	18.7	641	4,545		32		0	244	3,864		27		0	397	909		6		0		0
47.5	16.2	689	4,545		63		0	253	3,864		54		0	436	909		13		0		0
42.5	14.1	691	4,545		95		0	193	3,864		81		0	498	909		19		0		0
37.5	12.3	969	4,545		127		0	349	3,864		108		0	620	909		25		0		0
32.5	10.3	778	4,545		158		0	278	3,864		135		0	500	909		32		0		0
27.5	8.3	514	4,545		190		0	185	3,864		161		0	329	909		38		0		0
22.5	6.8	258	4,545		222		0	99	3,864		188		0	159	909		44		0		0
17.5	5.2	234	4,545		253		0	91	3,864		215		0	143	909		51		0		0
12.5	3.6	46	4,545		285		0	22	3,864		242		0	24	909		57		0		0
7.5	2.4	33	4,545		317		0	10	3,864		269		0	23	909		63		0		0
TOTALS		**8,760**				45,415	0	3,171				16,360	0	5,589				5,234	0	**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
  – http://doe2.com/equest/index.html
- 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