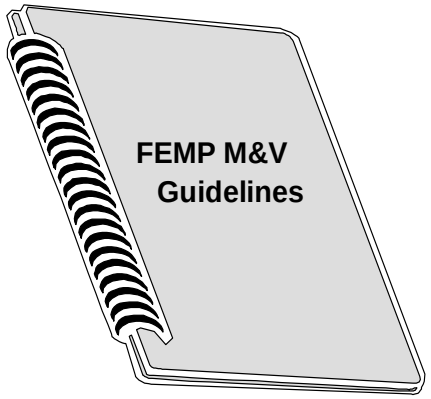
Module 4

ABCDs of M&V

FEMP M&V Methods

- FEMP M&V Guidelines
  - Definitions
  - Stipulations
- Explanation of Options (A, B, C, D)
- Examples & Applications

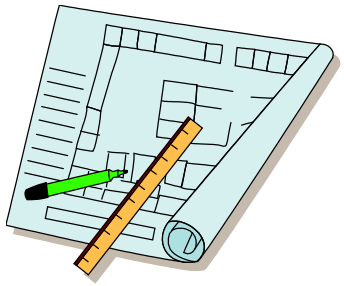
FEMP M&V Guidelines



- Application of International Performance Measurement & Verification Protocol (IPMVP) for federal energy projects
- Current version is 3.0 (2008)
- Available on FEMP's Super ESPC website

FEMP M&V Compliance

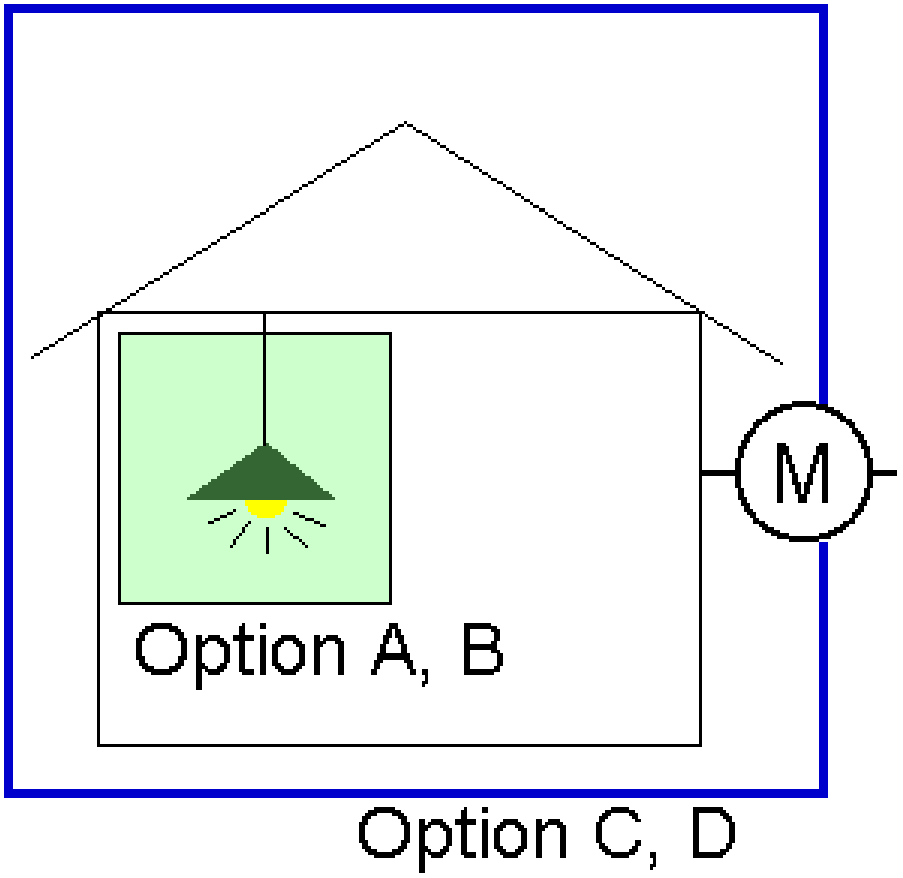
- Complying with the FEMP guidelines requires:
  - Developing an M&V plan using the defined methods
  - Following the M&V plan
- The important consideration is what is in the plan.



FEMP and IPMVP M&V Options

M&V Option	How savings are calculated
Option A: "Retrofit Isolation, Key Parameter" – Based on *measured* equipment performance, measured or *estimated* operational factors, and annual verification of "*potential to perform.*"	Engineering calculations using measured and estimated data
Option B: "Retrofit Isolation, All Parameters" – Based on *measurements* (usually *periodic or continuous*) taken of all relevant parameters.	Engineering calculations using measured data
Option C: Based on *whole-building* or facility-level utility meter data adjusted for weather and/or other factors.	Analysis of utility meter data
Option D: Based on *computer simulation* of building or process; simulation is calibrated with measured data.	Comparing different models

Options A and B vs. Options C and D



Options A&B are retrofit-isolation methods.

Options C&D are whole-facility methods.

The difference is where the boundary lines are drawn.

Option A

- Simple approach (and low cost)
- Performance parameter(s) is measured (before and after); usage parameters may be measured or *estimated.*
- Used where the "*potential to perform*" needs to be verified but highly accurate savings estimation is simple or not necessary.
- ***Option A is NOT "stipulated savings" !***

Stipulate

- To stipulate is to agree to a term or condition.
- Under IPMVP, to stipulate means to *estimate without measurement*.
- Under FEMP, measured values may be stipulated.

Appropriate Use of Stipulations

- Parameter is well understood
- Agency willing to accept risk
- Agency has previous experience
- Probable success of ECM
- Small savings and/or small uncertainty
- Greater M&V costs not justified
- Stipulations don't add to uncertainty
- Monitoring serves no other purpose

Inappropriate Use of Stipulations

- Agency unwilling to assume risk
- Parameters not known with reasonable certainty
- Potential for technical problems
- Monitoring provides valuable information
- Stipulation significantly contributes to overall uncertainty

Sources of Stipulations

Acceptable

- Measurements
- Engineering analysis
- Measurement-based models
- Manufacturer's data
- Standard tables
- TMY weather
- ANSI/ARI/ASHRAE
- Facility logs

Unacceptable

- Undocumented assumptions
- Proprietary algorithms
- Unsupported handshake agreements
- Guesses at parameters
- Models based on questionable data
- Other buildings

Option B

- Under Option B, all relevant parameters are measured, usually periodically or continuously.
- Measurement frequency consistent with expected variations.
- Applicable where accurate savings estimation is necessary and where long-term performance needs to be tracked.
- Reduces uncertainty, but requires more effort.

Option C

- Option C looks at energy use and cost of entire facility, not at specific equipment.
- Considers weather, occupancy, etc. for *baseline adjustments*
- Applicable where total savings need to be quantified but component-level savings do not AND where savings > 15% of energy use
- Easily implemented, commercial software is available

Option D

- Option D treats building as computer model
- Flexible, but requires significant effort
- Applications:
  - New construction
  - Energy management & control systems
  - Multiple interacting measures
  - Building use changes
  - Building modifications (e.g., windows)

Examples

- Option A: Lighting
- Option B: Variable-Speed Drive
- Option C: Heating Plant
- Option D: New Construction

Example Lighting Project

Consider the following lighting project:

- Upgrade 5,000 fixtures
- Existing performance: 86 Watts
- New performance: 56 Watts
- Operating hours: 3,000/year
- Electricity: $0.10 / kWh +
  $10 / kW-mo

Option A

Performance:

- Baseline power consumption is 86 Watts.
- Proposed power consumption is 56 Watts.
- Difference is 30 Watts.

Usage:

- Baseline and New: 3,000 hours / year

Financial:

- Energy = $0.10/kWh + $10/kW-mo

Lighting Savings

- Energy Svgs = QTY*(Before - After) * Hours
  - ES = (5,000) * (86 W - 56 W) * (3,000 hours) * (1 kW / 1000 W)
  - ES = 450,000 kWh / year
- Demand Svgs = QTY * (Before - After) * DF
  - DS = (5,000)*(86 W - 56 W)*(1 kW/1000 W)*DF
  - DS = 150 kW * DF
- DF: Diversity Factor. % of lights operating when peak demand is set.

Lighting Cost Savings

- Cost Savings = (Unit Cost) (Energy Savings) + (Unit Cost) (Demand Savings)
  - CS = (450,000 kWh) * ($0.10/kWh) +
    (150 kW) * (75%) * ($10/kW) * 12 mo.
- Cost Savings = $45,000 + $13,500
  = $58,500 / year
- Assumes diversity factor of 75%.

Example VSD Project

Variable-Speed Drive on HVAC Fan

- Baseline Fan: Operates continuously at a single speed and power no matter what the cooling load is.
- VSD Fan: Speed and power change with cooling load (outside temperature).

Option B

Fan Performance

- Baseline fan: Constant power (140 kW).
- VSD Fan: Power changes w/ weather.

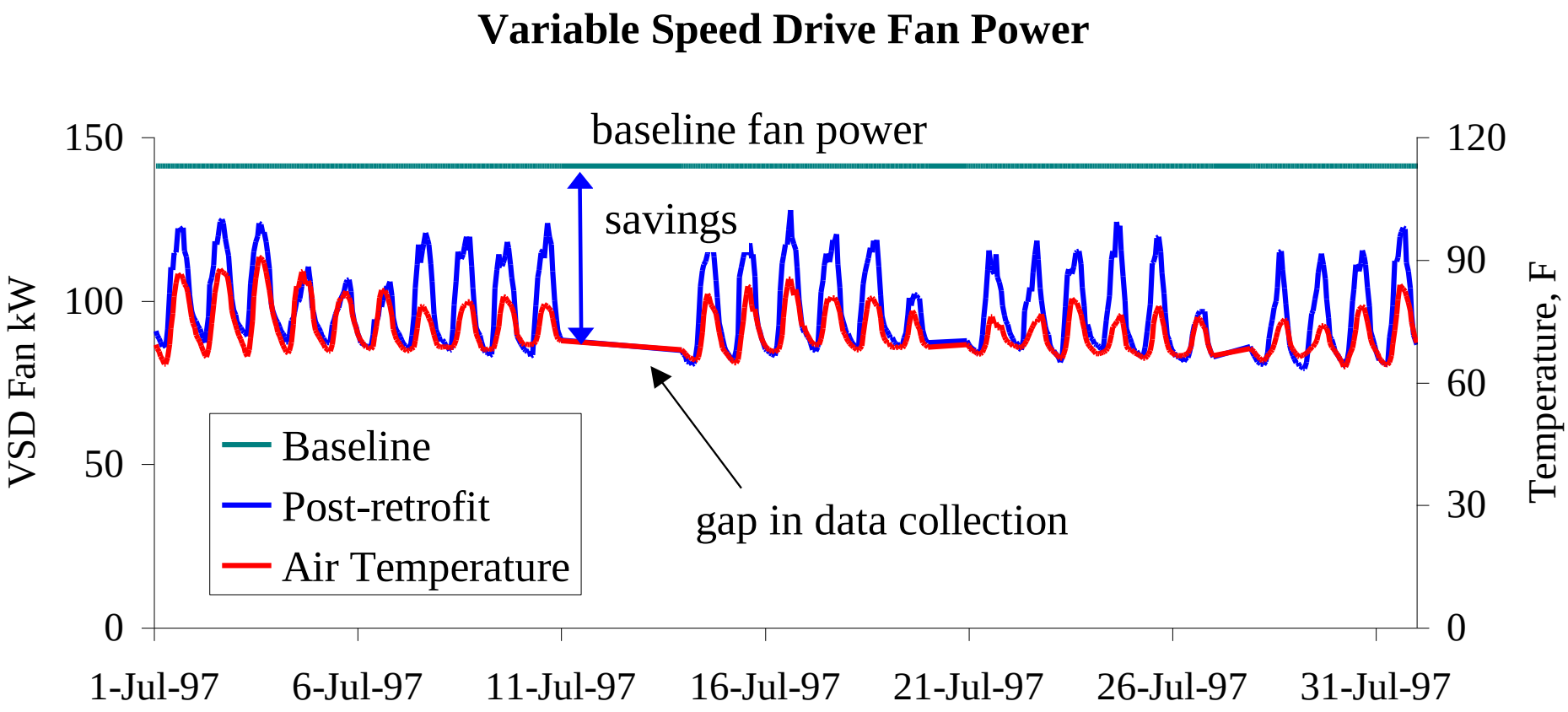
Fan Usage

- Fan power changes hourly with cooling load (outside temperature and sunshine).

Financial

- Energy = $0.10 / kWh +
  $10 / kW-mo

Monitor Fan Performance



Calculate Monthly Energy Savings

E Savings = Σ (kW_{Before} - kW_{After}) * (1 Hour)

Cost Savings = (Unit Cost) (Energy Savings)

Month	kWh Saved	Cost Savings
July	27,592	$2,759
August	24,316	$2,432
September	26,870	$2,687
October	34,724	$3,472
November	40,858	$4,086

Calculate Monthly Demand Savings

D Savings = kW_{Before} - Max(kW_{After})

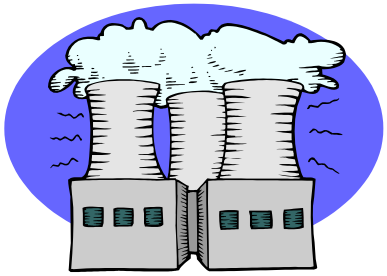
Cost Savings = (Unit Cost) (Demand Savings)

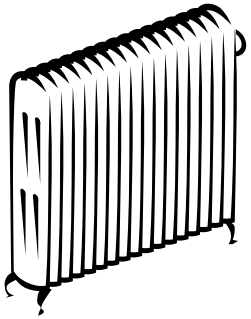
Month	kW Saved	Cost Savings
July	59	$587
August	71	$712
September	64	$645
October	74	$737
November	85	$849

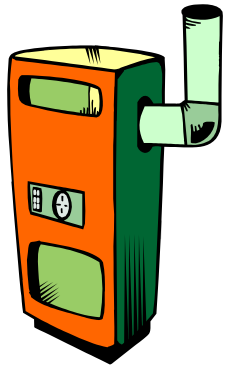
Example Heating Project

Heating system upgrade at eastern U.S. military base

- Baseline: Oil-fired boilers with central steam plant provide heat to buildings.
- New System: Shut down steam plant. Install gas furnaces in all buildings.







Heating System Characteristics

Baseline Performance:

- Oil-fired, low-efficiency, and steam loss

New Performance:

- Gas-fired, high efficiency, no steam loss

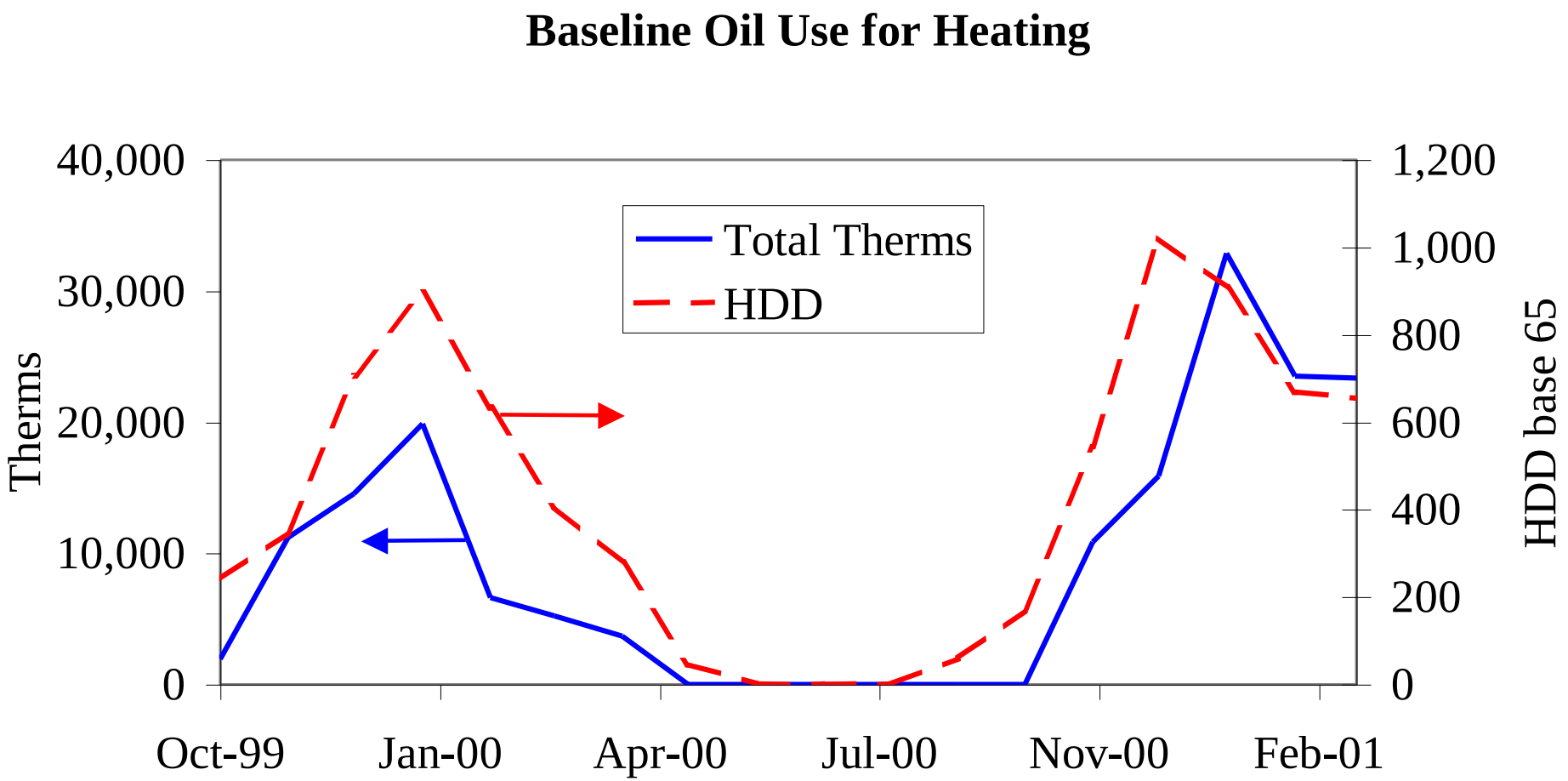
Usage:

- Driven by weather

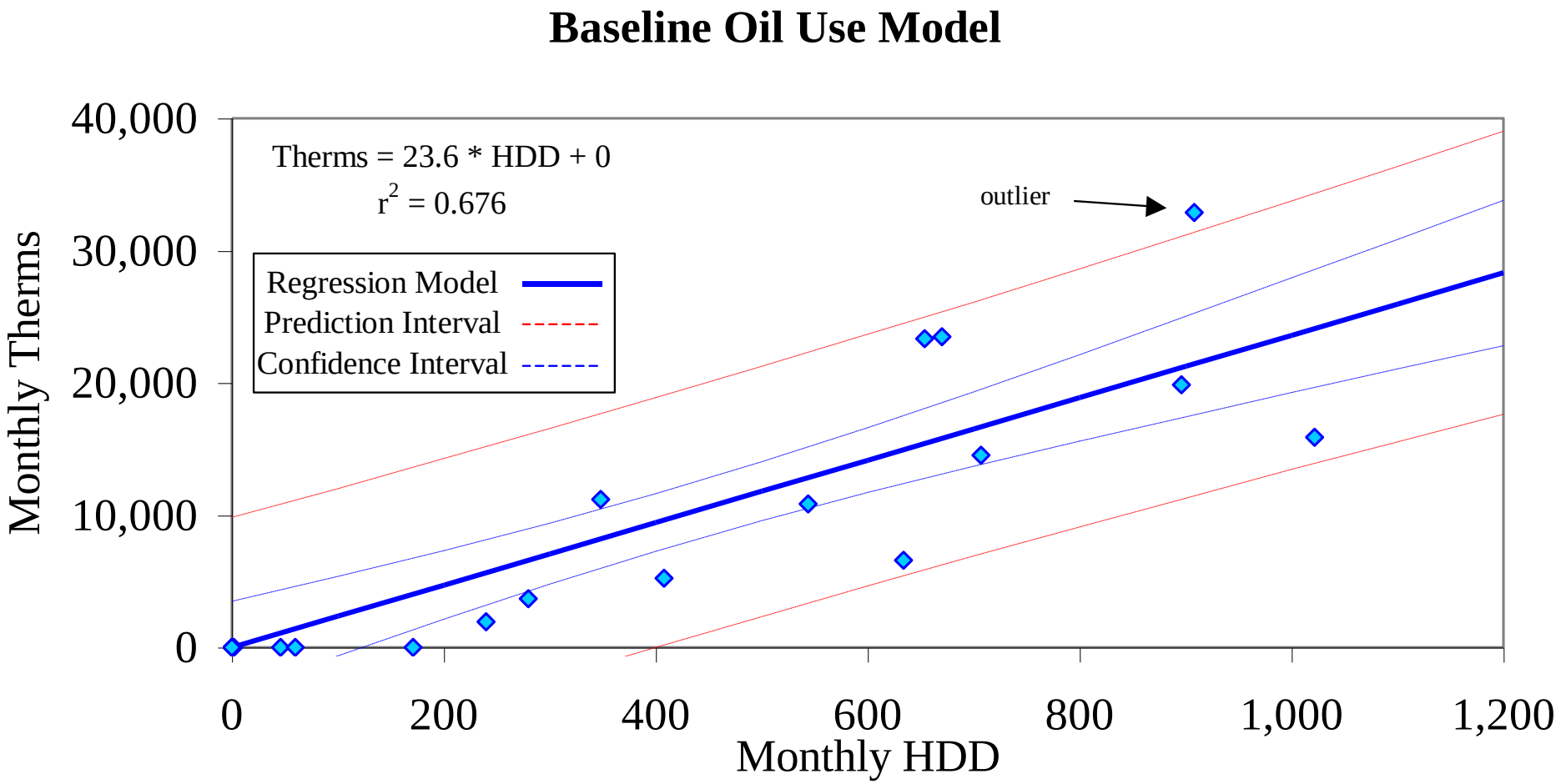
Financial:

- Oil was $ 1.50 / gallon (1.4 therms / gal)
- Gas is $0.75 / therm

Compare Oil Use to Temperature



Develop Baseline Model



Calculate Monthly Energy Savings

Baseline therms = 23.6 * HDD

Month	HDD	Baseline Therms	New Therms	Energy Savings, Therms
January	915	22,046	15,432	6,614
February	742	17,617	12,332	5,285
March	520	11,934	8,354	3,580
April	348	7,531	5,272	2,259
May	91	952	666	285
June	9	0	0	0
July	0	0	0	0
August	1	0	0	0
September	112	1,489	1,042	447
October	364	7,940	5,558	2,382
November	442	9,937	6,956	2,981
December	823	19,691	13,784	5,907
Total	**4,367**	**99,137**	**69,396**	**29,741**

Calculate Monthly Cost Savings

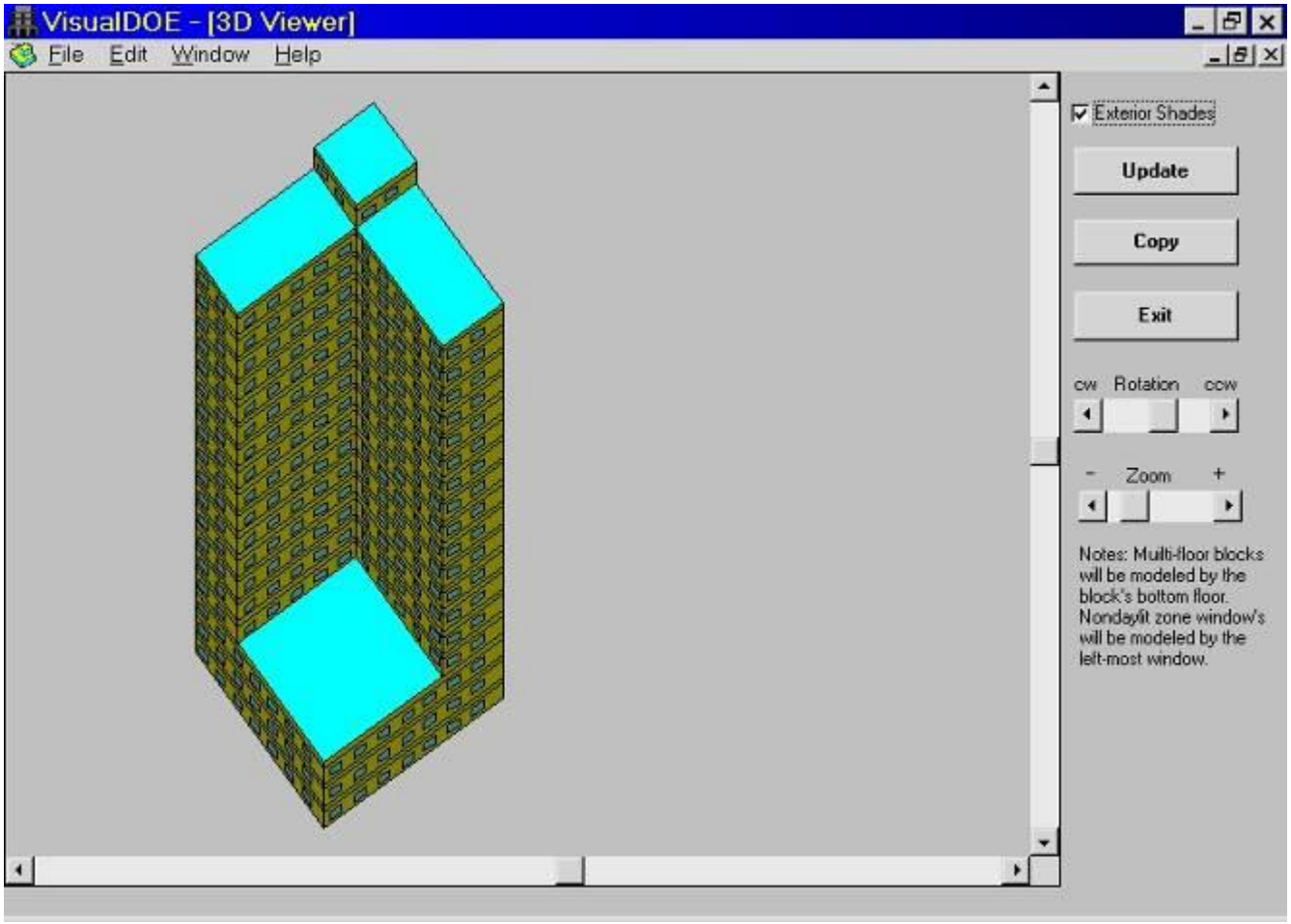
Oil = ($1.5/gal) / (1.4 therms/gal) = $1.07 / therm
Gas = $0.75 / therm

Month	Baseline Cost	New Cost	Cost Savings
January	$23,621	$11,574	$12,047
February	$18,876	$9,249	$9,627
March	$12,786	$6,265	$6,521
April	$8,069	$3,954	$4,115
May	$1,020	$500	$520
June	$0	$0	$0
July	$0	$0	$0
August	$0	$0	$0
September	$1,596	$782	$814
October	$8,508	$4,169	$4,339
November	$10,647	$5,217	$5,430
December	$21,097	$10,338	$10,760
Total	**$106,218**	**$52,047**	**$54,171**

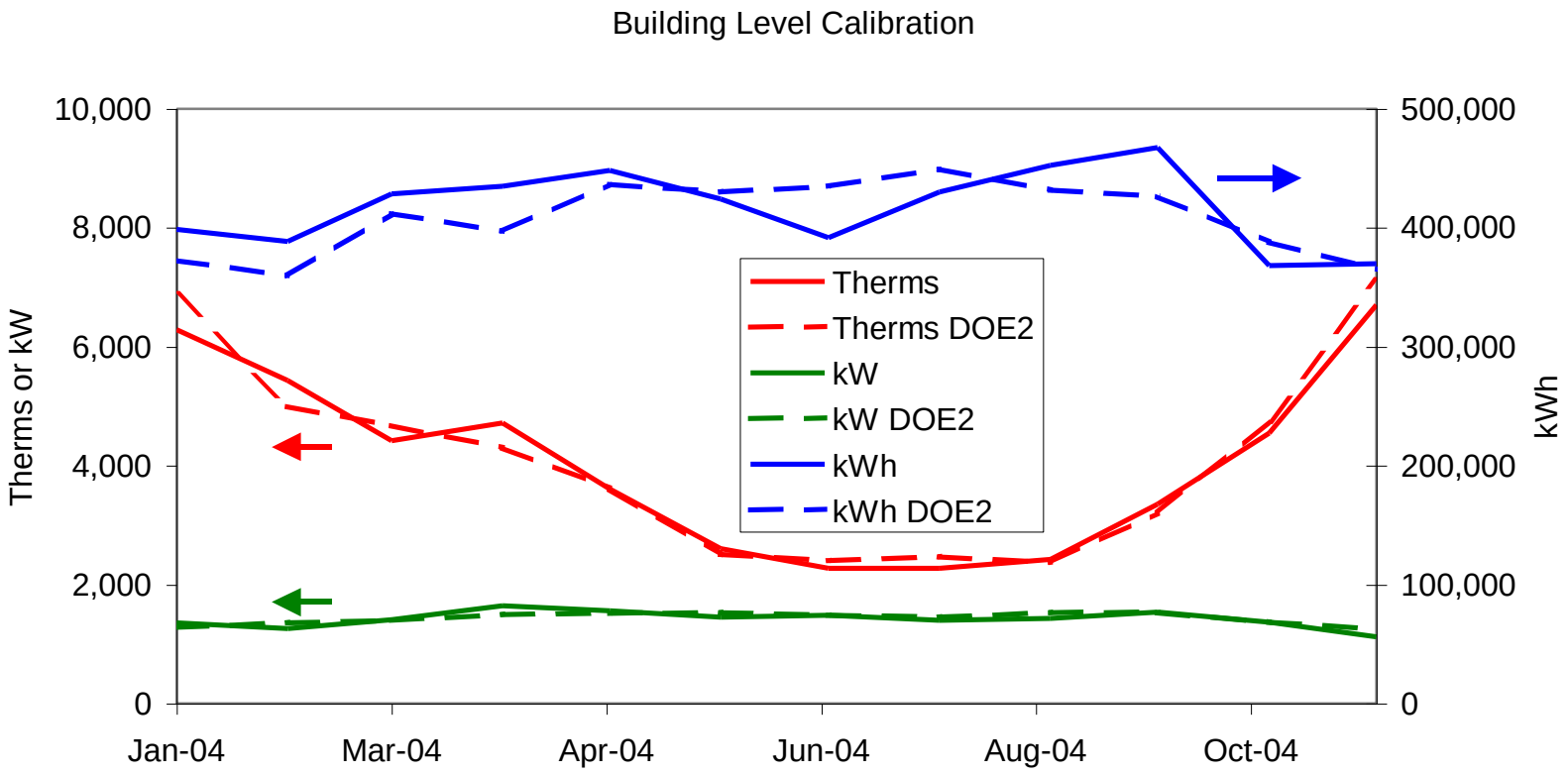
Example New Construction

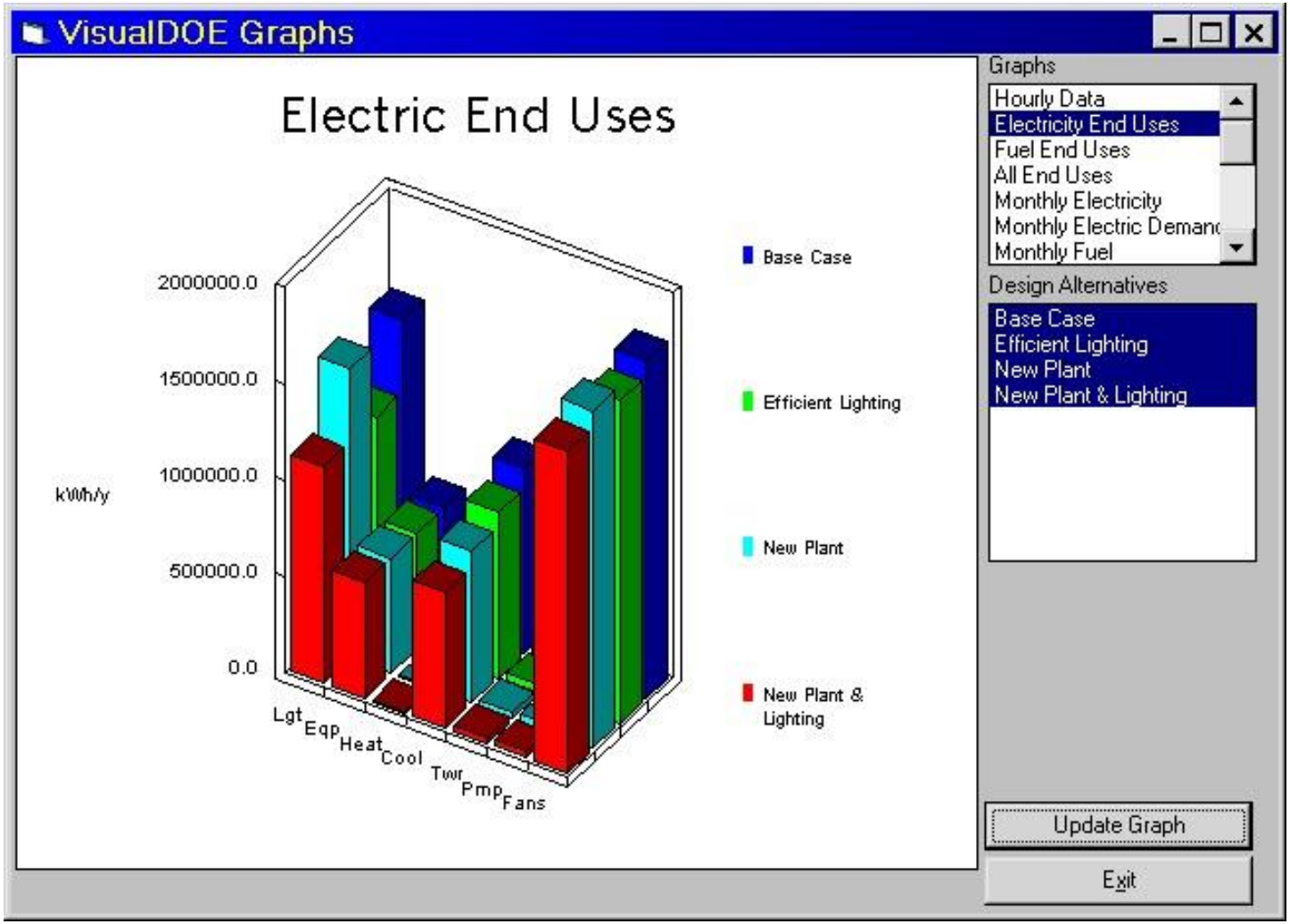
- Proposed building incorporates energy-efficient design features selected and implemented by ESCO.
- Baseline building is existing design before ESCO modifications.

Develop Computer Model...



... Calibrate Model ...




VisualDOE Graphs
Electric End Uses
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Pmp
Fans
Base Case
Efficient Lighting
New Plant
New Plant & Lighting
Graphs
Hourly Data
Electricity End Uses
Fuel End Uses
All End Uses
Monthly Electricity
Monthly Electric Demand
Monthly Fuel
Design Alternatives
Base Case
Efficient Lighting
New Plant
New Plant & Lighting
Update Graph
Exit

Calculate Savings

- Evaluate energy use for each scenario.
- Calculate savings for each scenario relative to base case.

	Energy Use, kWh				
Alternative	**Lights**	**Cooling**	**Other**	**Total**	**Savings**
Base Case	1,500,298	955,263	2,447,979	4,903,540	-
Efficient Lighting	1,125,240	860,062	2,365,638	4,350,940	**552,600**
Efficient Chiller	1,500,298	788,681	2,426,812	4,715,791	**187,749**
Chiller & Lighting	1,125,240	708,933	2,346,427	4,180,600	**722,940**

Option D Risk Allocation

	Usage	Performance
Option D (savings based on TMY weather)	Agency	ESCO

Review and Discussion

- Total energy use and savings are a function of both usage and performance.
- Options A and B are retrofit-isolation methods.
- Options C and D are whole-facility methods.
- Can mix and match methods.
- Selection of M&V method based on need to verify savings cost-effectively.

Questions?

Click on picture
to go to Module 5