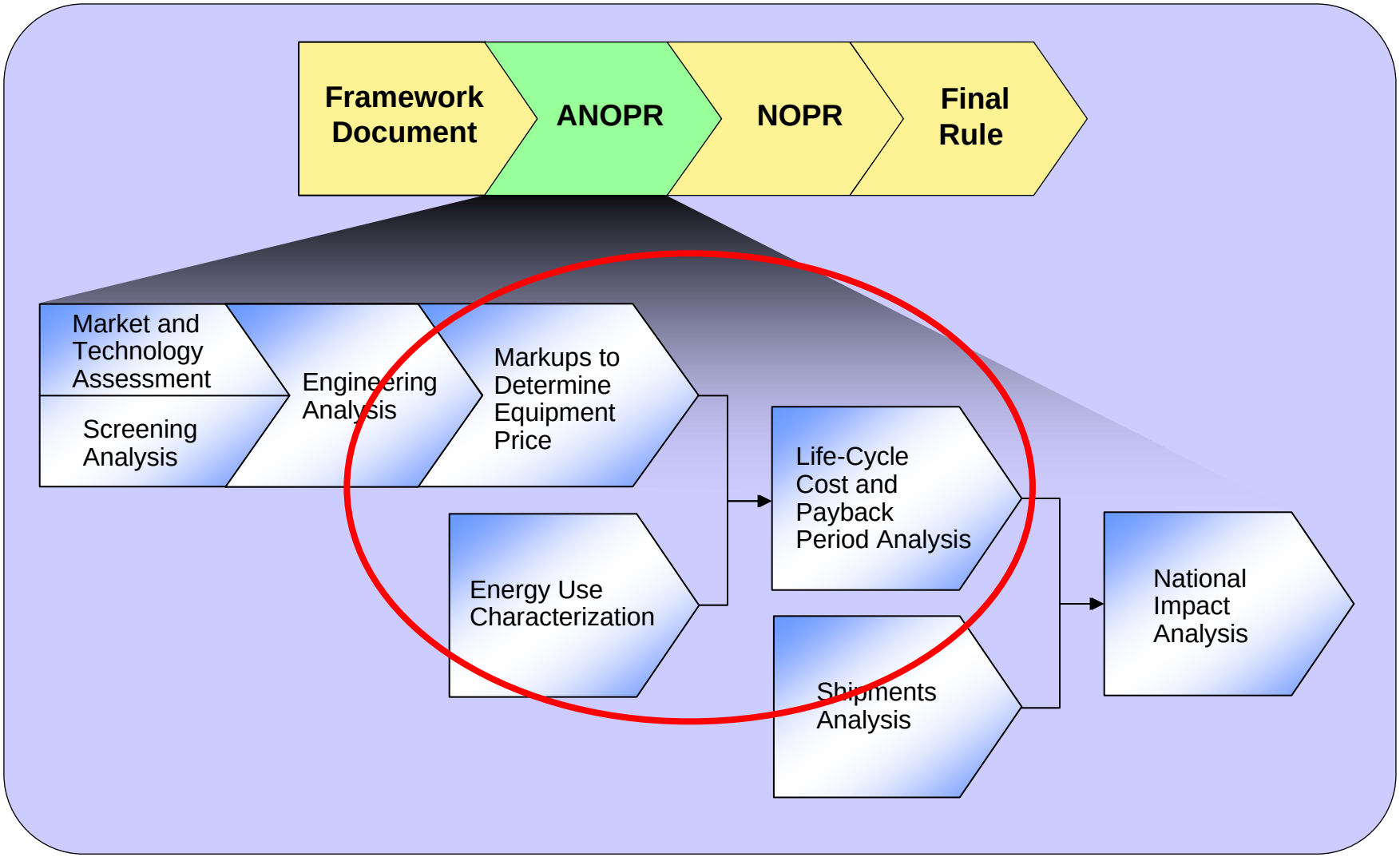
Life-Cycle Cost Analysis

ANOPR Analyses Flow Diagram



Purpose

- **Markups to Determine Equipment Price**
  - Characterize the channels for how BVM equipment is distributed from the manufacturer to the customer.
  - Determine prices paid by customers based on manufacturer selling prices for baseline and higher efficiency BVM equipment.
- **Energy Use Characterization**
  - Develop electrical energy consumption savings estimates for selected BVM equipment efficiency levels.
  - Validate the energy savings estimates from the engineering analysis.
- **Life-Cycle Cost and Payback Period Analyses**
  - Develop the customer life-cycle cost savings and payback period for higher efficiency BVM equipment.

Markups to Determine Equipment Price
Purpose, Inputs, and Output

- **Purpose**
  - Determine customer prices under a standards scenario based on manufacturer costs.
  - Characterize equipment distribution channels and market segments.
  - Describe BVM equipment distributor/wholesaler direct costs, expenses, and profits.
- **Inputs**
  - Firm balance sheets.
    - Wholesalers: U.S. Census Bureau Financial Data on Other Commercial Equipment Merchant Wholesalers from *Wholesale Trade, Miscellaneous Subjects (*2002).
- **Output**
  - Baseline and incremental markups.

BVM Equipment Distribution Channels

- **Estimated Fraction (%) of Equipment Shipments by Distribution Channels***

Channel 1	Channel 2	Channel 3
Manufacturer ↓ Beverage Bottler/Distributor	Manufacturer ↓ Equipment Wholesaler/Distributor ↓ Vending Machine Operator	Manufacturer ↓ Equipment Wholesaler/Distributor ↓ Site Owner
68%	**27%**	**5%**

*DOE assumed the same market shares by distribution channel for all new BVMs.

Baseline and Incremental Markups

- ***Markups* relate customer price to cost of goods sold (COGS)**
- ***Baseline markups* relate price to cost prior to a change in efficiency**
  - Baseline markups indicate a customer price that covers all of a wholesaler's or contractor's expenses plus profit.
  - Direct labor costs (salaries, payroll, rental and occupancy) are included.
- ***Incremental markups* relate the incremental change in customer price to the incremental change in COGS beyond baseline**
  - Some distribution costs remain constant with COGS increases.
  - Incremental markups cover only expenses that vary with COGS – in this case, expenses that increase due to an increase in equipment efficiency.
    - For example, direct labor costs (salaries, payroll, rental and occupancy) do not vary with efficiency-induced changes in COGS.
  - DOE assumes other operating costs and profit will scale proportionally with COGS.

Distribution Expenses and Markups

- Wholesaler markup estimated from Census Financial Data
- Manufacturer direct sales to beverage bottlers occur at the manufacturer selling price (with zero markup), before application of sales tax.
- Sales tax is applied based on each specific State's tax data.
- National average estimates for sales tax require estimates of relative shipments of beverage vending machines by State.
- Since relative shipments at a State level are unknown, DOE used census data for population by State as a proxy for BVM equipment shipments.

Distribution Expenses and Markups (cont.)

- **Resulting Average Baseline Markups**

	Manufacturer Direct	Wholesaler/Distributor	Overall Weighted Average
Markup	1.000	1.46	1.147
Sales Tax	1.068	1.068	1.068
Overall Markup	1.068	1.559	1.226

Distribution Expenses and Markups (cont.)

- **Resulting Average Incremental Markups**

	Manufacturer Direct	Wholesaler/Distributor	Overall Weighted Average
Markup	1.000	1.20	1.064
Sales Tax	1.068	1.068	1.068
Overall Markup	1.068	1.282	1.137

Energy Use Characterization

- **Class A beverage vending machines are fully-cooled machines (certified for indoor use only) and were assumed to be subject to the constant indoor air temperature and relative humidity of 75°F/45% RH equivalent to one of the test conditions in the DOE test procedure**
- **Class B beverage vending machines are all other machines (certified for indoor-outdoor use). DOE assumed that 25% of Class B machines are placed outdoors and 75% are indoors**
  - 75% of Class B machines installed indoors are subject to the same indoor DOE test condition of 75°F/45% RH as the Class A machines
  - For the 25% of the Class B machines located outdoors, DOE developed a modified version of the engineering spreadsheet-based energy performance model to determine the annual energy consumption under varying dry bulb temperature and humidity conditions using binned weather data.
  - Annual energy (E) consumed by all Class B machines was calculated as:

$$E_{annual} = 0.25 \times E_{outdoor} + 0.75 \times E_{indoor}$$

Energy Use Characterization (cont.)

- Outdoor climate data was represented by TMY2 city data split into temperature and relative humidity bins
- Sum of the hourly energy consumption for all bins for each TMY2 city provides the annual energy consumption; DOE then mapped each city to the State using population weights
- DOE calculated annual energy consumption figures for nine selected efficiency levels and three sizes (vendible capacities) of beverage vending machines for each equipment class

Equipment Classes (Issue #1)

- **DOE assumed two equipment classes A and B:**
  - Class A machines are fully cooled machines (certified for indoor use only).
  - Class B machines are all other machines (certified for indoor or outdoor use).
  - DOE further assumed that 25% of class B machines were installed outdoors and subject to outdoor ambient conditions.
- **All Class A machines and 75% of Class B machines were subject to relatively constant indoor conditions of 75°F/45% RH matching one of the DOE test conditions.**

DOE invites comments on the use of the two equipment classes (Class A and Class B) for energy use characterization analysis.

DOE invites comments on the assumption for the split of installation location (75% indoor and 25% outdoor) for the Class B machines.

Compressor and Lighting Operating Hours (Issue #2)

- DOE assumed that there are no controls that limit display lighting or compressor operation in a beverage vending machine to certain hours of the day or that display lighting would be affected by occupancy patterns in the building
- DOE understands that such controllers exist and can either be added on or enabled in certain beverage vending machines

DOE invites comments on the need to incorporate such controls in its energy analysis and how DOE might do so in the NOPR analysis.

Equipment Refurbishment Cycles (Issue #3)

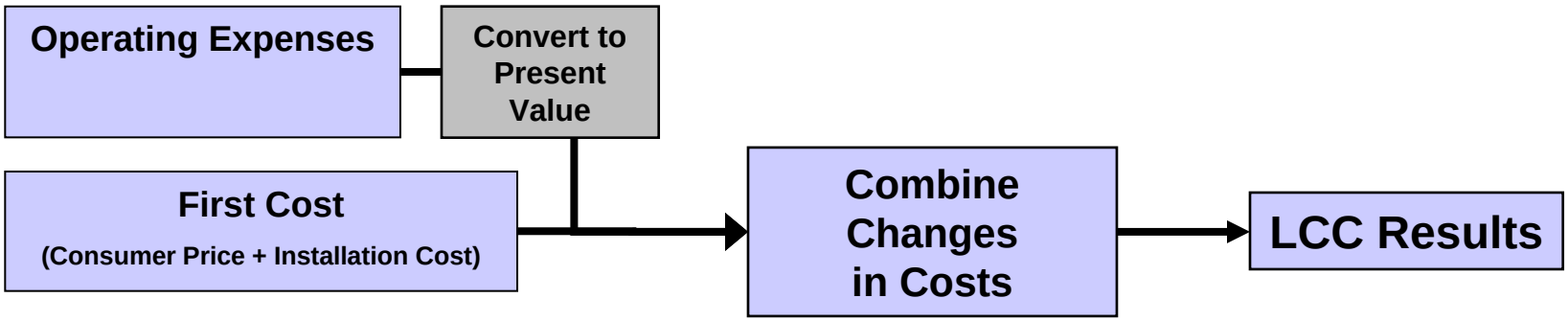
- **DOE assumed that there are typically two refurbishment cycles for beverage vending machines during their lifetime.**

DOE invites comments on refurbishment cycles for beverage vending machines and the effect of refurbishment cycles on annual energy consumption. Specifically, DOE requests comments on:

- *The typical frequency of refurbishment cycles.*
- *How refurbishing a vending machines might affect its energy use.*
- *Whether and how DOE might account for these changes in assessing the overall impacts of the candidate standards levels for beverage vending machines.*

Life-Cycle Cost Analysis

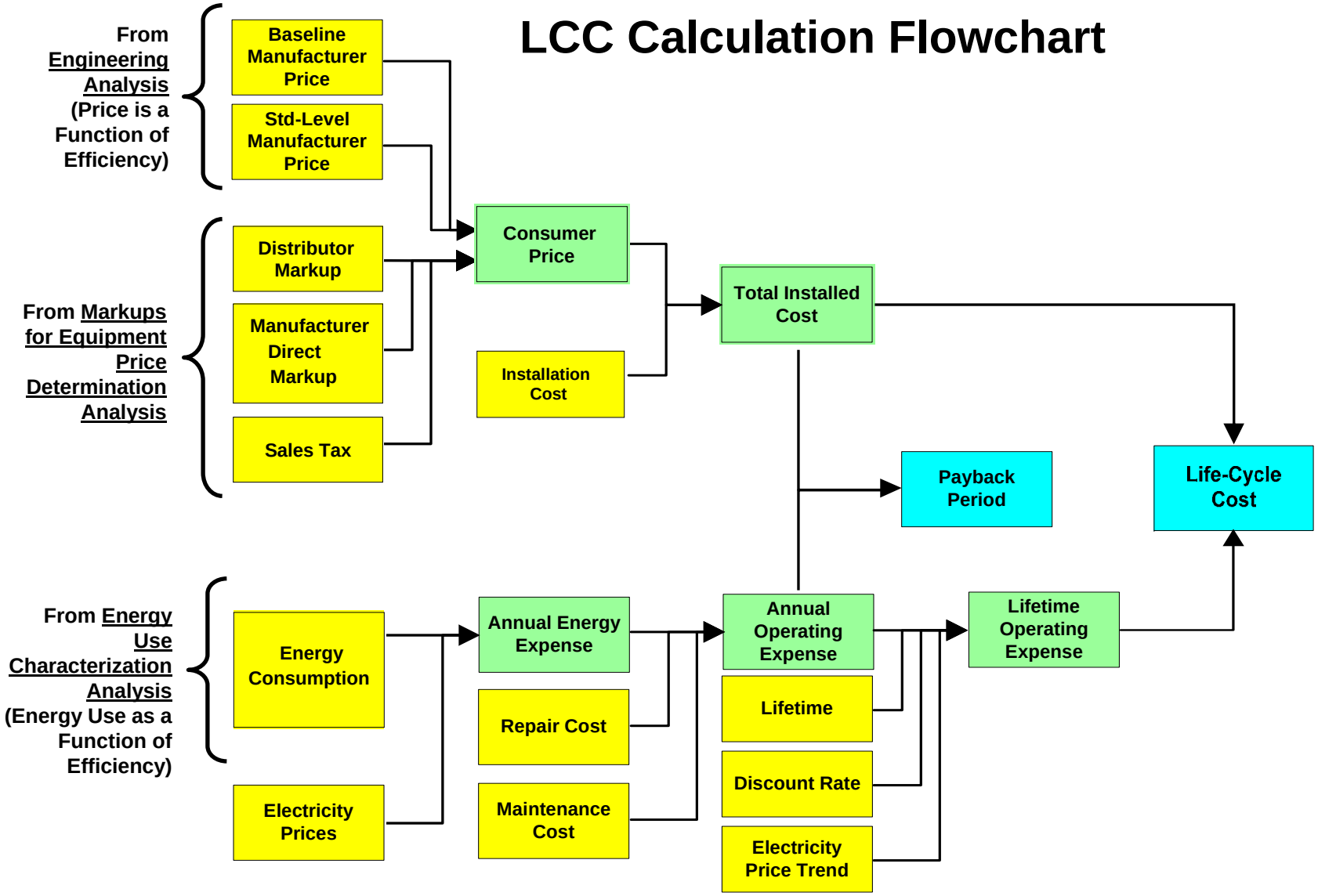
- Economic evaluation from the customer perspective.
- Life-cycle cost (LCC) equals customer price plus the sum of annual operating costs discounted to a particular base year.
- Results are expressed as LCC difference of the baseline (Level 1) minus the standard level.
- Simple payback period (PBP - in years) is also calculated and reported in this analysis.



Selection of Efficiency Levels for Analysis

- **Up to 13 efficiency levels were examined for equipment in the engineering analysis.**
- **Nine efficiency levels were selected for the LCC analysis.**
  - Level 0 represented the current market level of BVMs.
  - Level 1 represented the ENERGY STAR Tier 1 level and is the baseline efficiency level from which the remaining proposed standard levels (2–8) are compared.
  - Levels 2–8 are the proposed standard levels analyzed for LCC and payback period compared to the baseline efficiency Level 1.

LCC Calculation Flowchart



Life-Cycle Cost Baseline Level (Issue #4)

- **DOE selected ENERGY STAR Tier 1 as the baseline efficiency level (Level 1) for the LCC and payback period analysis.**

DOE invites comments on the use of a single level (Level 1) rather than a distribution of efficiencies for LCC and payback period analysis.

DOE seeks data that could be used to populate such a distribution.

Electricity Prices

- **Analysis was based on State-by-State average electricity prices paid by seven business types using BVM equipment.**
- **Electricity prices by business type were developed using the ratio of average price in 2003 CBECS by business type[1] to the commercial average price for four of the business types, and industrial average price for two of the business types (military and manufacturing).**
  - Bottler/distributors are assumed to experience a market share-weighted mix of the prices experienced by the other six business types.
- **These ratios are then applied to the State-by-State average electricity prices projected for 2012 and out years by EIA.**
- **Electricity price projections based on EIA/AEO reference case for commercial sector.**
- **AEO high growth and low growth cases can be run as sensitivities.**

[1]These business types represent the selected businesses (e.g., manufacturing).

Other Inputs

- **Installation Costs**
  - DOE assumed a $72 installation cost (2007$)
  - Costs were based on an article by Foster-Miller, Inc. in 2002, adjusted to 2007$
  - Installation costs assumed not to vary with equipment price or efficiency level, but do vary by location
- **Discount Rates**
  - Derived from estimates of the cost of capital of companies that purchase beverage vending machines by business type.
  - Cost of capital is calculated from the weighted-average cost of capital (WACC) to the company to obtain equity and debt financing.
  - Weighted-average value (real) is: 4.49% for bottler/distributors; 6.19% for manufacturers; 5.42% for office/health care; 5.77% for retail outlets; 1.81% for schools; 2.83% for military installations; and 5.15% for other (primarily warehouses).

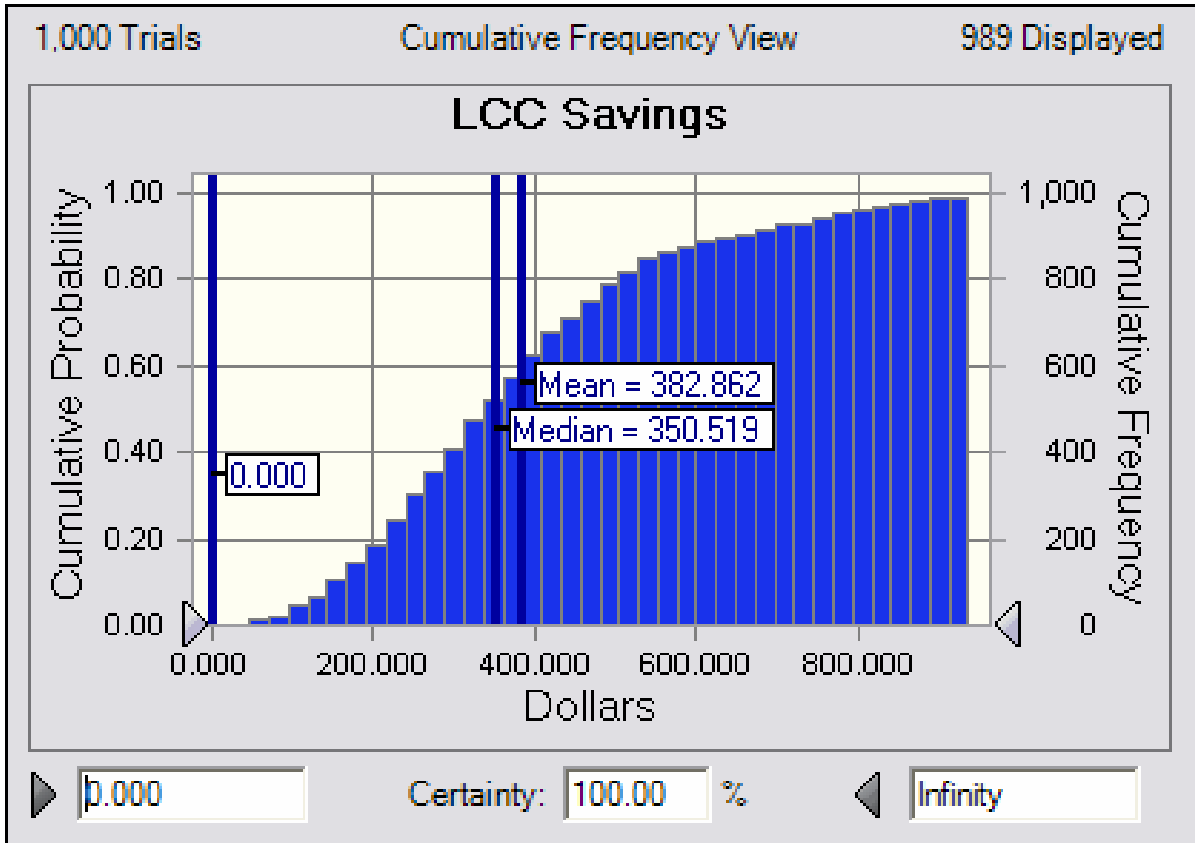
Other Inputs (cont.)

- **Equipment Lifetime**
  - Used average age of 14 years based upon a literature survey and industry input.
  - DOE assumed equipment would be refurbished every three to five years and would undergo two refurbishment cycles in a typical lifetime.
- **Repair Costs**
  - Annualized repair costs were based on Foster-Miller 2002 report for BVM equipment, averaging $115.
  - Repair costs were assumed to increase proportionately with equipment price.
- **Maintenance Costs**
  - Preventative maintenance cost is $165/year (2007$) based on Foster-Miller 2002 report for BVM equipment. DOE used a flat rate for preventative maintenance for all equipment classes and efficiency levels.
  - Preventative maintenance includes routine maintenance cost of $33/year and two refurbishment cycles (every four years) at $930 each.

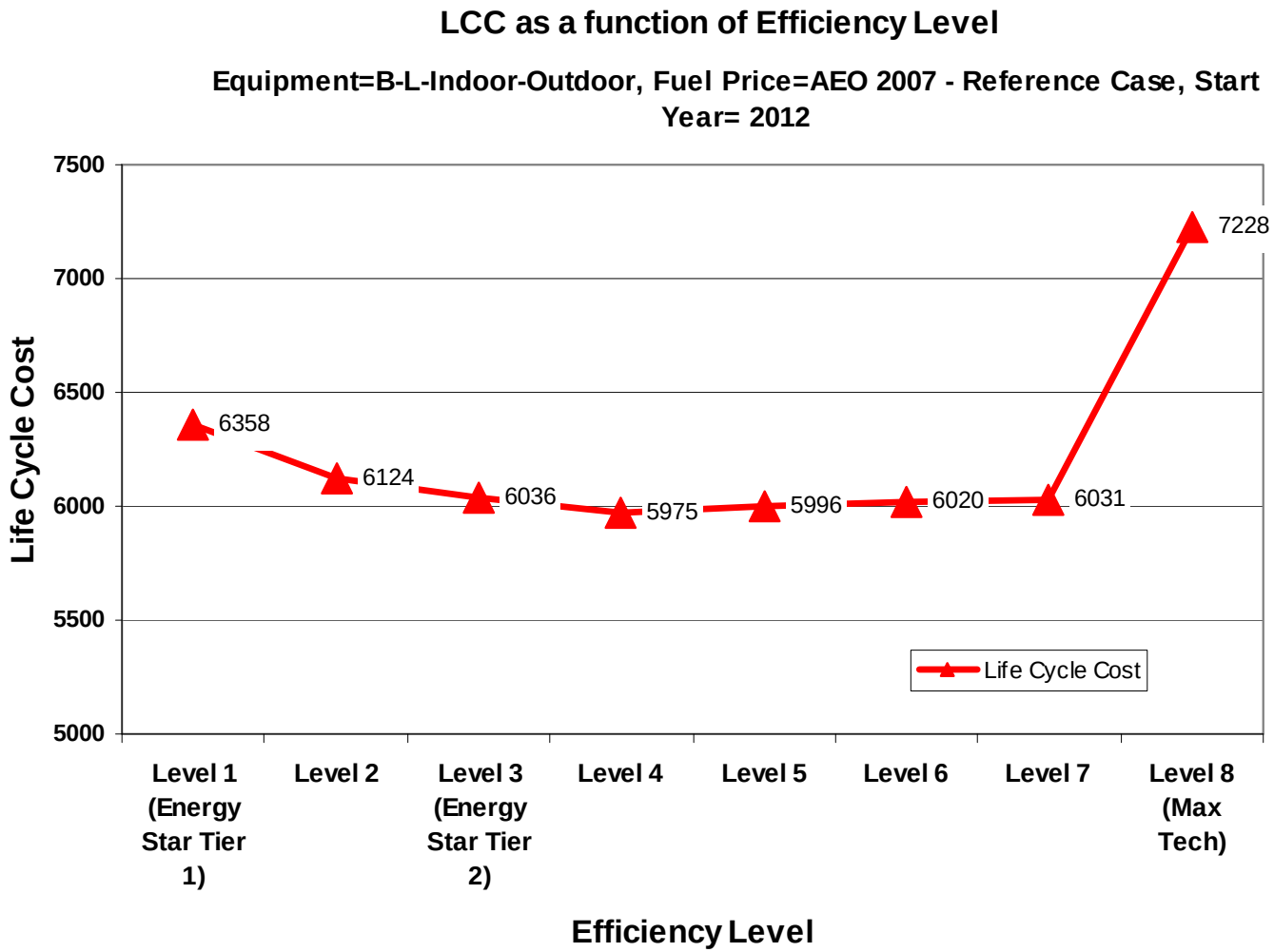
Example of LCC Analysis Results

Cumulative LCC Savings

(B-L-IO Equipment Class, Level 4 Efficiency)



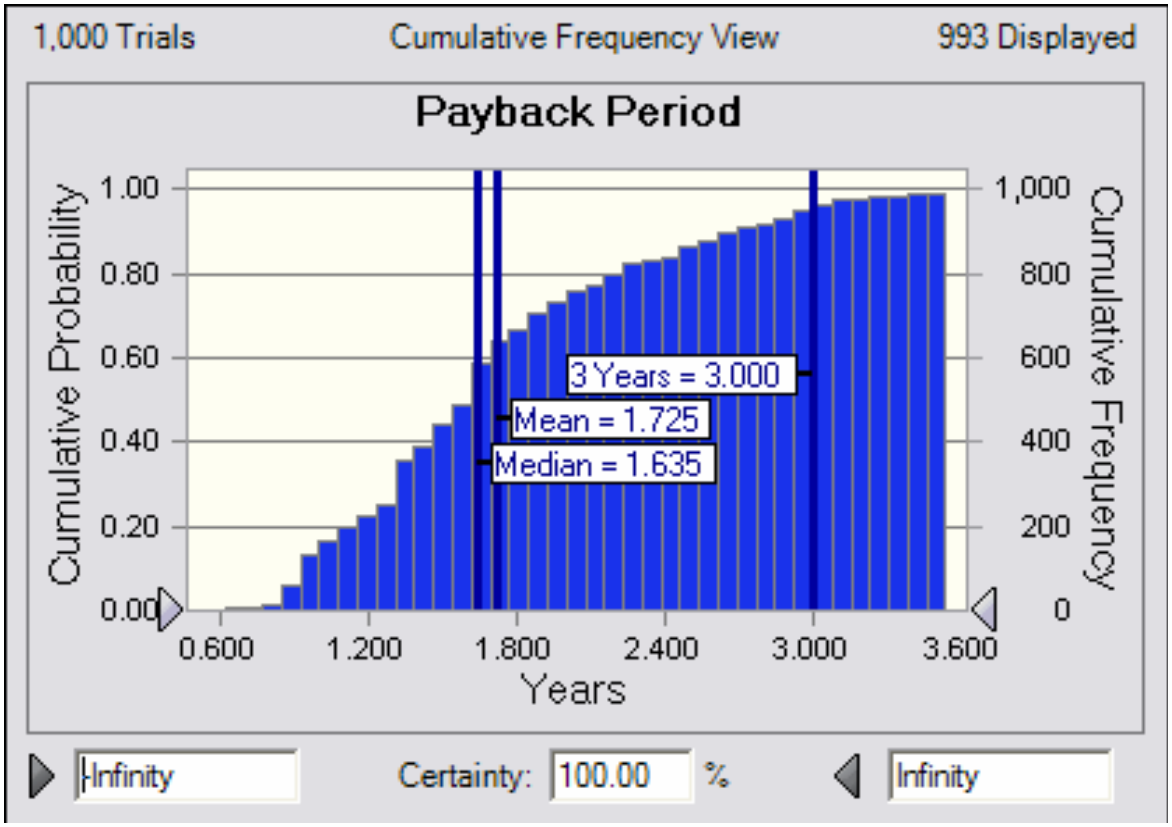
U.S. National Average LCC Analysis Results



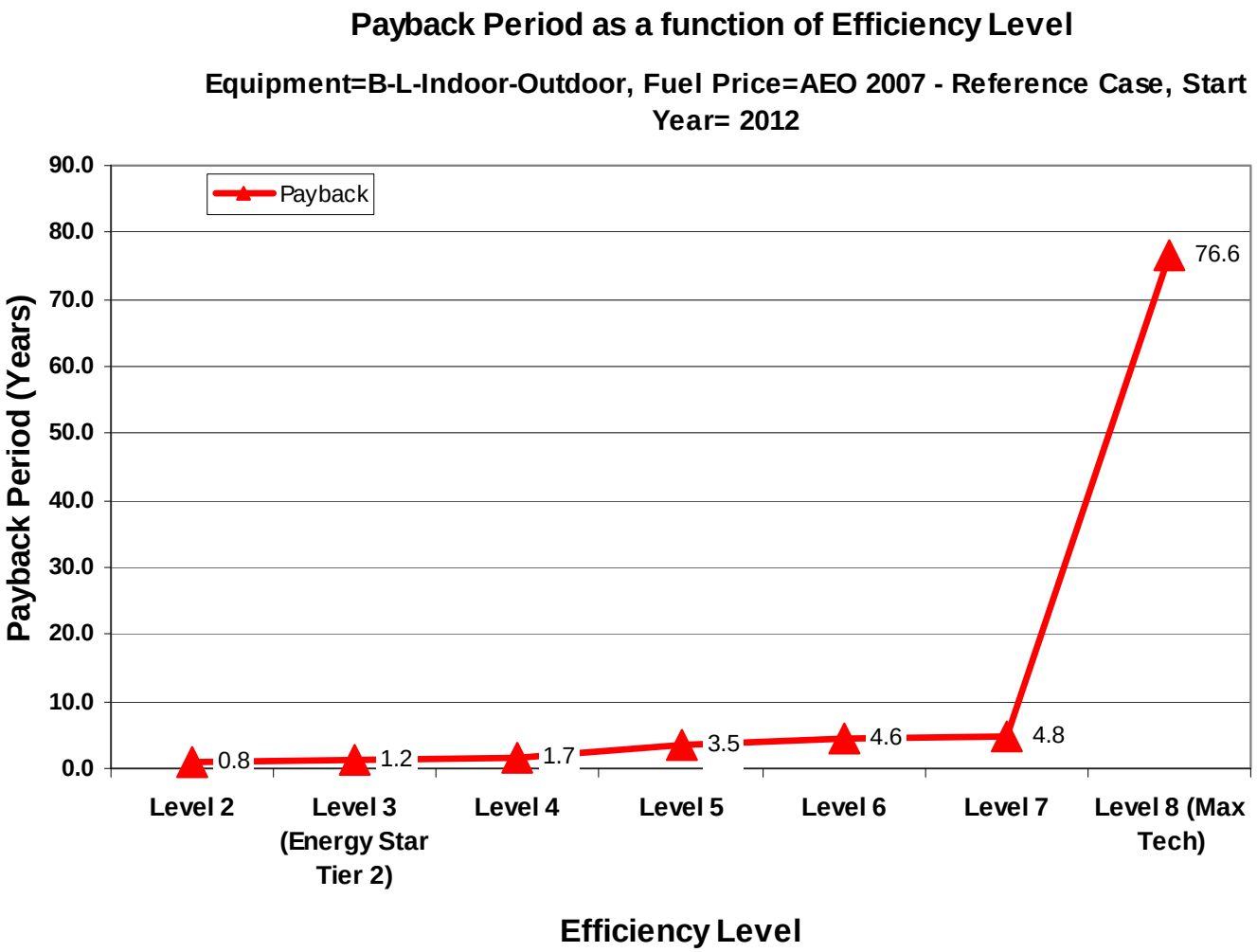
Example of Payback Period Analysis Results

Cumulative LCC Savings

(B-L-IO Equipment Class Level 4 Efficiency)



U.S. National Average Payback Period Results



National Average LCC Savings by Equipment Class and Proposed Standard Level

(Baseline efficiency level is Level 1)

Equipment Class	National Average LCC Savings (2007$)							
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
A-L-IN	NA	$145	$254	$339	$363	$359	$181	-$792
A-M-IN	NA	$141	$237	$318	$334	$328	$175	-$739
A-S-IN	NA	$136	$233	$309	$317	$310	$159	-$590
B-L-IO	NA	$234	$322	$383	$362	$338	$327	-$870
B-M-IO	NA	$235	$306	$361	$338	$306	$294	-$798
B-S-IO	NA	$233	$290	$310	$279	$240	$225	-$702
	Percent of Units with Positive LCC Savings							
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
A-L-IN	NA	100%	100%	100%	99%	99%	77%	1%
A-M-IN	NA	100%	100%	100%	99%	99%	79%	1%
A-S-IN	NA	100%	100%	100%	99%	99%	77%	1%
B-L-IO	NA	100%	100%	100%	99%	95%	93%	1%
B-M-IO	NA	100%	100%	100%	99%	93%	91%	1%
B-S-IO	NA	100%	100%	100%	95%	89%	85%	1%

A=fully-cooled machine (indoor use only)
B=all other machines (indoor or outdoor use)

S=small M=medium L=large
IN=indoor only IO=indoor/outdoor

National Average Payback Period by Equipment Class and Proposed Standard Level

(Baseline efficiency level is Level 1)

Equipment Class	National Average Payback Period (Years)							
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
A-L-IN	NA	1.2	1.6	1.9	2.4	2.7	7.4	64.0
A-M-IN	NA	1.3	1.6	2.0	2.6	2.9	7.2	67.5
A-S-IN	NA	1.3	1.5	1.9	2.5	2.8	7.4	66.3
B-L-IO	NA	0.8	1.2	1.7	3.5	4.6	4.8	76.6
B-M-IO	NA	0.8	1.3	1.8	3.7	4.9	5.2	76.0
B-S-IO	NA	0.8	1.4	2.0	4.3	5.7	6.1	78.1
	Percent of Units with Payback Period less than 3 Years							
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
A-L-IN	0%	100%	99%	91%	79%	71%	1%	0%
A-M-IN	0%	100%	99%	89%	73%	65%	1%	0%
A-S-IN	0%	100%	99%	91%	77%	67%	3%	0%
B-L-IO	0%	100%	100%	95%	43%	23%	21%	0%
B-M-IO	0%	100%	100%	91%	39%	21%	19%	0%
B-S-IO	0%	100%	99%	85%	25%	17%	13%	0%

A=fully-cooled machine (indoor use only)
B=all other machines (indoor or outdoor use)

S=small M=medium L=large
IN=indoor only IO=indoor/outdoor

Life-Cycle Cost Baseline Level Sensitivity Analysis

- **LCC sensitivity analyses were performed for AEO 2007 high growth and low growth fuel escalation rate scenarios.**
  - The choice of fuel escalation rate scenario impacted the life-cycle cost for all equipment classes.
  - For the high growth scenario, the minimum life-cycle cost efficiency level (maximum life-cycle cost savings level) did not differ from the AEO reference case for all equipment classes.
- **Sensitivity of LCC savings and PBP to the assumed baseline efficiency level was also examined.**
  - The minimum LCC is unaffected by the choice of baseline efficiency level (Level 1), but the magnitude of the savings is affected.
  - The PBP increases when higher baseline efficiency levels are assumed.

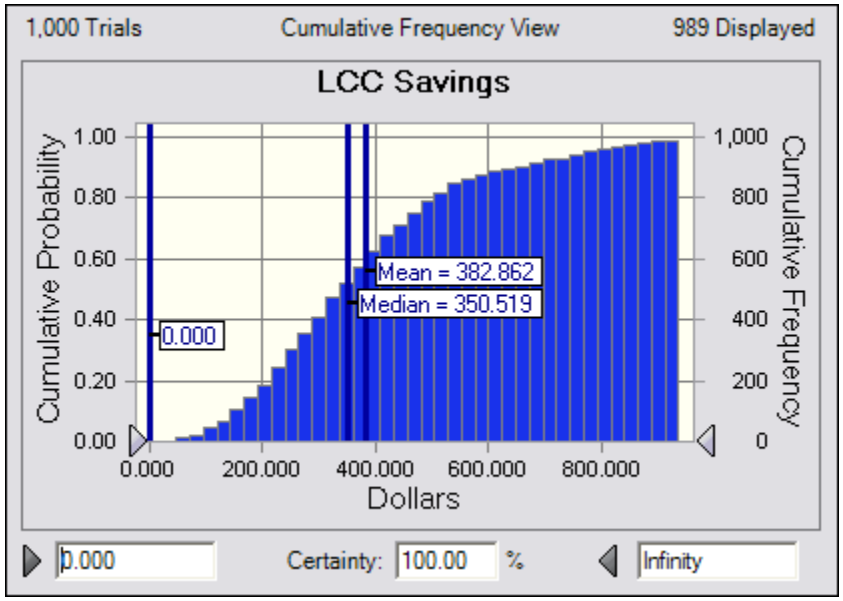
Split Incentive

- **A bottler/vendor BVM owner/operator may or may not pay some or all of the energy costs, depending on the agreement with the customer at the site where the BVM is located.**
- **DOE assumes that energy cost savings are transferred to owner/operator of the BVM through the coin-box revenue allocation agreement.**
  - This assumption results in the maximum LCC savings accruing to the equipment owner for higher efficiency equipment.
- **Limited sensitivity analysis was conducted with the energy cost savings split 50/50 between the BVM owner/operator and the customer at the site where the BVM is located.**

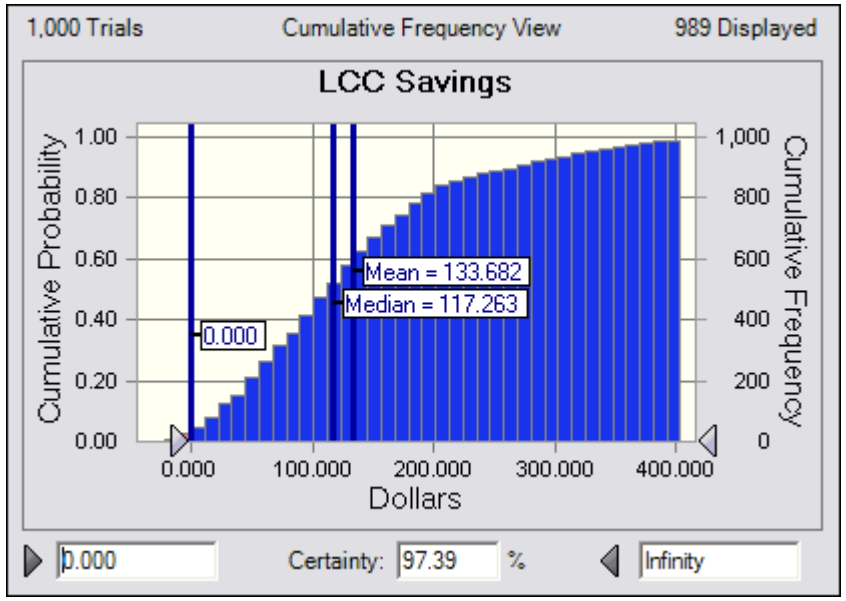
Split Incentive (cont.)

- **Sample LCC Sensitivity Analysis Results**

Operator Pays Energy Costs



50/50 Energy Cost Split



Other Issues

DOE invites comments and recommendations from stakeholders on any other aspects related to the life-cycle cost and payback period analysis.