# Energy Conservation Standards for Distribution Transformers

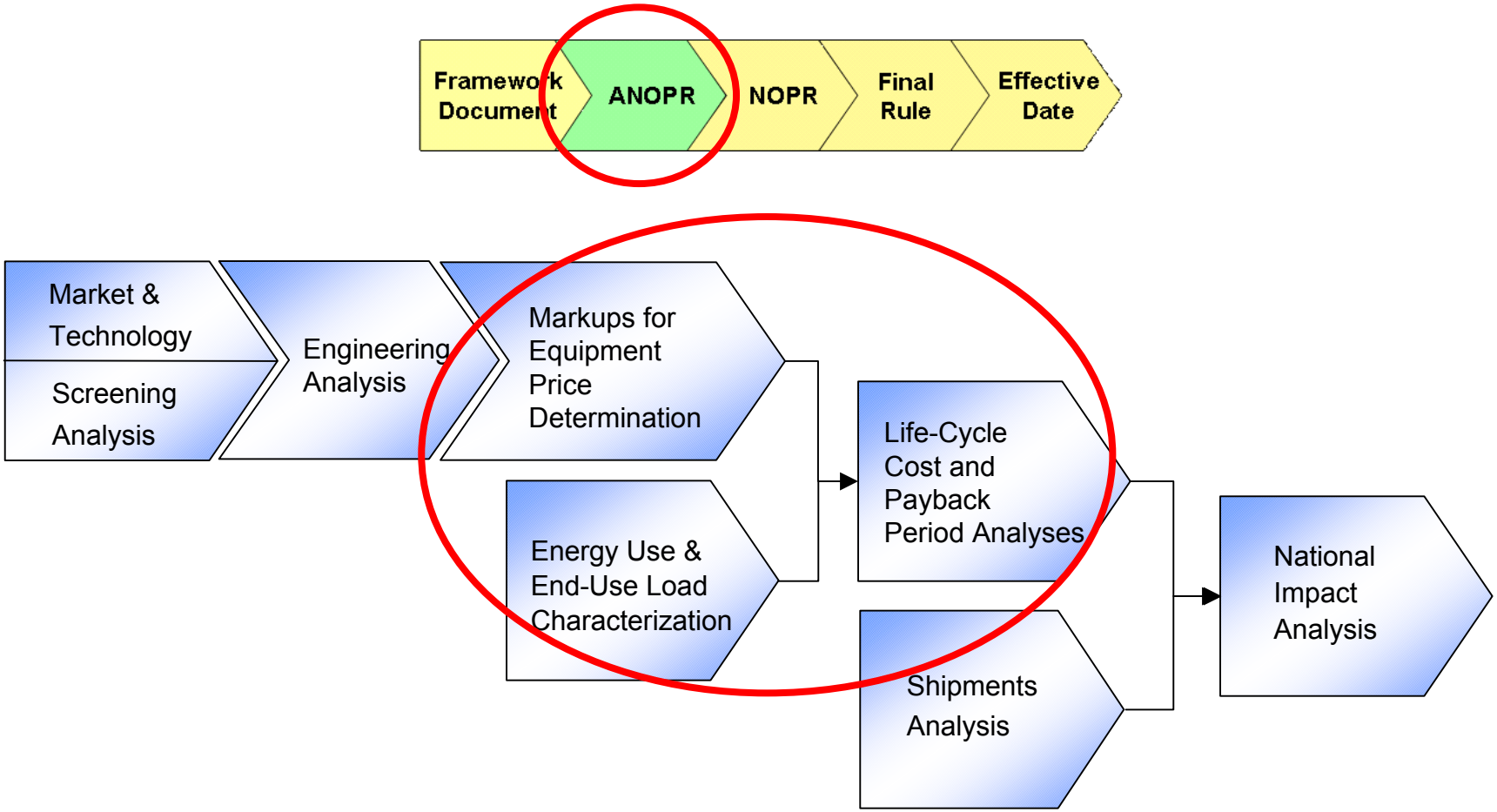
## ANOPR Public Meeting

# Life-Cycle Cost Analysis

**Building Technologies Program**
**Office of Energy Efficiency and Renewable Energy**
**U.S. Department of Energy**

**September 28, 2004**

# ANOPR Analyses Flow Diagram



# Purpose

- **Markups for Equipment Price Determination**
  - To characterize the channels for how distribution transformers are distributed from the manufacturer to the customer.
  - To determine prices paid by customers based on manufacturer prices of base case and higher efficiency equipment.

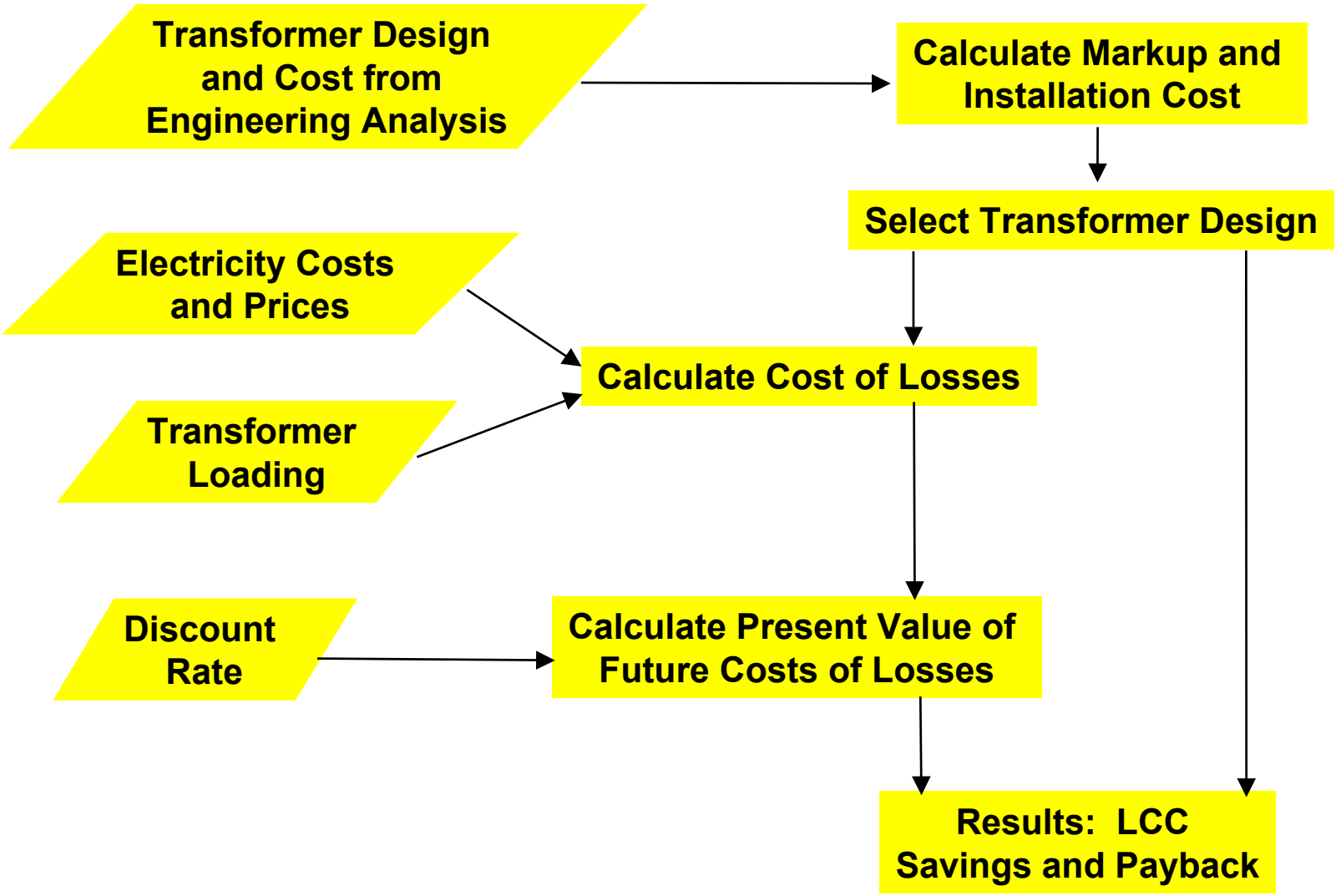
- **Energy Use & End-Use Load Characterization**
  - To develop electrical energy use and peak electrical consumption characteristics for distribution transformers.
  - To provide these characteristics for selected equipment efficiency levels across a diverse set of applications.

- **Life-Cycle Cost and Payback Period Analyses**
  - To develop the customer life-cycle cost savings and payback periods of higher efficiency equipment.
  - To evaluate the economic effects of potential standards from the customer perspective.

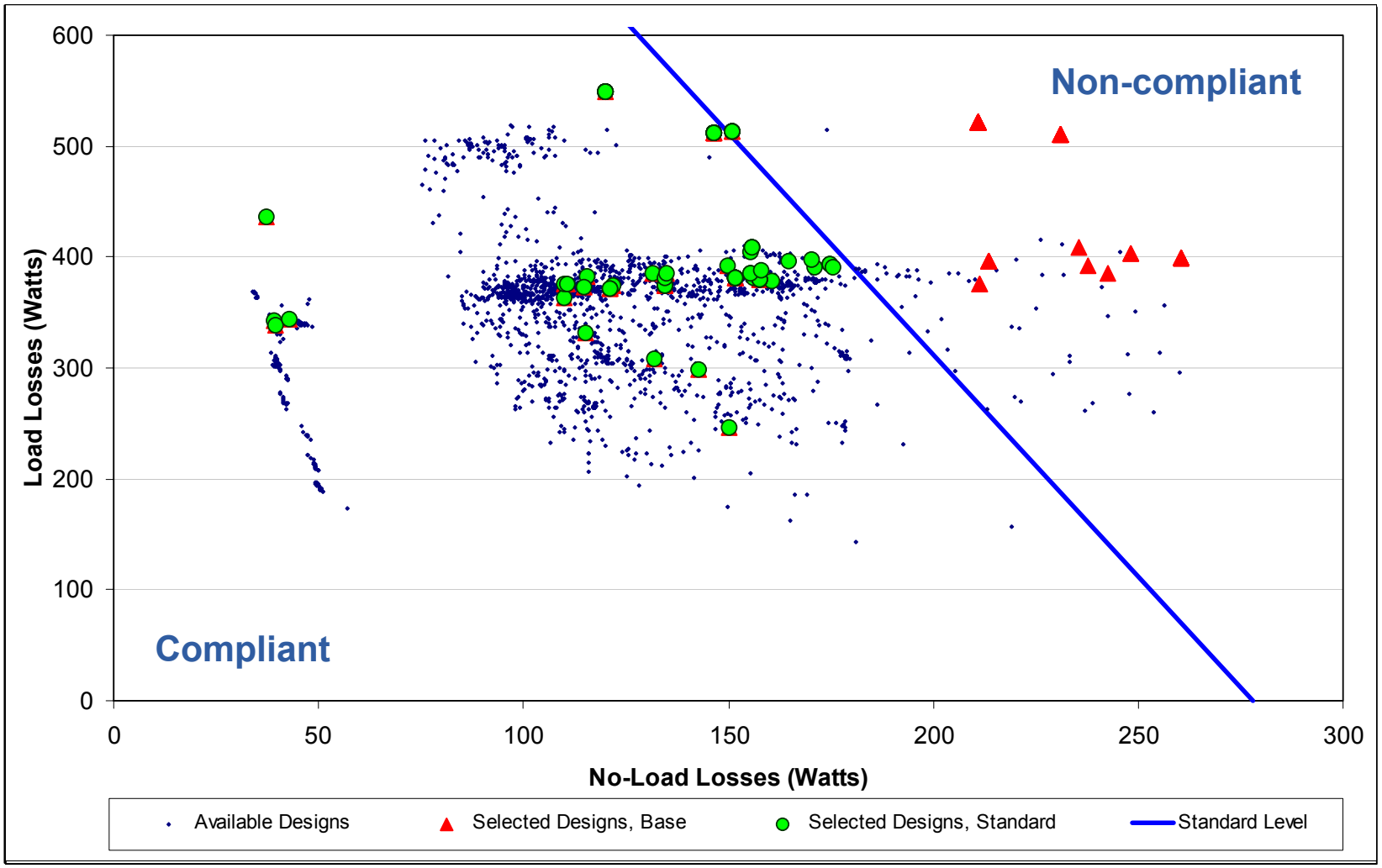
# Issues for Public Comment

- Modeling of Transformer Load Profiles (ANOPR Issue #6)
- Distribution Chain Markups (ANOPR issue #7)
- Discount Rate Selection and Use (ANOPR Issue #8)
- Baseline Determination Through Purchase Evaluation Formulae (ANOPR Issue #9)
- Electricity Prices (ANOPR Issue #10)
- Load Growth Over Time (ANOPR Issue #11)

# Process Flowchart



# DL1 at 50% Load Example Design Selection



# Baseline Determination Through Purchase Evaluation Formulae (ANOPR Issue #9)

Common industry descriptors, A and B, capture current market purchase decision criteria.

- A = equivalent first cost of no-load (core) losses ($/watt)
- B = equivalent first cost of load (winding) losses ($/watt)

Distributions of A and B represent variability (fixed over analysis period).

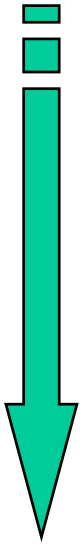
Different evaluation percentages applied to liquid-immersed and dry-type.

**The Department seeks stakeholder comments on the purchase decision model.**

# Distribution Channels

**Liquid-immersed**

Manufacturer



Customer

**Dry-type**

Manufacturer

Distributor

Contractor

Customer

# Markup and Installation Cost Examples

**Design Line #1: 50 kVA Liquid-immersed, Single-phase**

| | |
|---|---|
| Manufacturer's selling price | $1,275 |
| Shipping | $77 |
| Sales tax | $151 |
| Cost of installation | $1,441 |
| Installed price | $2,944 |

**Design Line #7: 75 kVA Dry-type, Three-phase, Low-voltage**

| | |
|---|---|
| Manufacturer's selling price | $963 |
| Distributor markup | $337 |
| Shipping | $109 |
| Contractor markup | $141 |
| Sales tax | $146 |
| Cost of installation | $1,160 |
| Installed price | $2,855 |

# Distribution Chain Markups (ANOPR Issue # 7)

Average markup factor for 50 kVA liquid-immersed transformer from manufacturer selling price to installed price is 2.1.

Average markup factor for 75 kVA dry-type transformer from manufacturer selling price to installed price is 2.5.

**The Department seeks stakeholder comments on factors, methods, and data used to determine distribution chain markups.**

# Electricity Costs

- **Liquid-immersed transformers**
  - Hourly marginal electricity costs
  - Both capacity and energy components
  - FERC and electricity market data

- **Dry-type transformers**
  - Monthly electricity bills
  - Both demand and energy charges
  - Tariff data from about 100 utilities

# Electricity Prices (ANOPR Issue #10)

For liquid-immersed analysis, weighted national average wholesale marginal cost

- 3.8 cents no-load loss, 4.5 cents load loss

For dry-type analysis, weighted national average commercial marginal rate, including demand charges

- 6.4 cents no-load loss, 7.4 cents load loss

**The Department seeks stakeholder feedback on the two methods used for this rulemaking to determine the cost of electricity.**

# Transformer Loading

- **Average transformer loading**
  - < 100 kVA liquid-immersed ~ 30% RMS
  - > 100 kVA liquid-immersed ~ 50% RMS
  - Dry-type low- and medium-voltage ~ 35% RMS

- **References**
  - Technical Support Documents: technical details
  - IEEE Transformer Loss Evaluation Guide: background

# Modeling of Transformer Load Profiles (ANOPR Issue #6)

For liquid-immersed, initial average loading ranges from 30% for 25 kVA to nearly 60% for 1500 kVA.

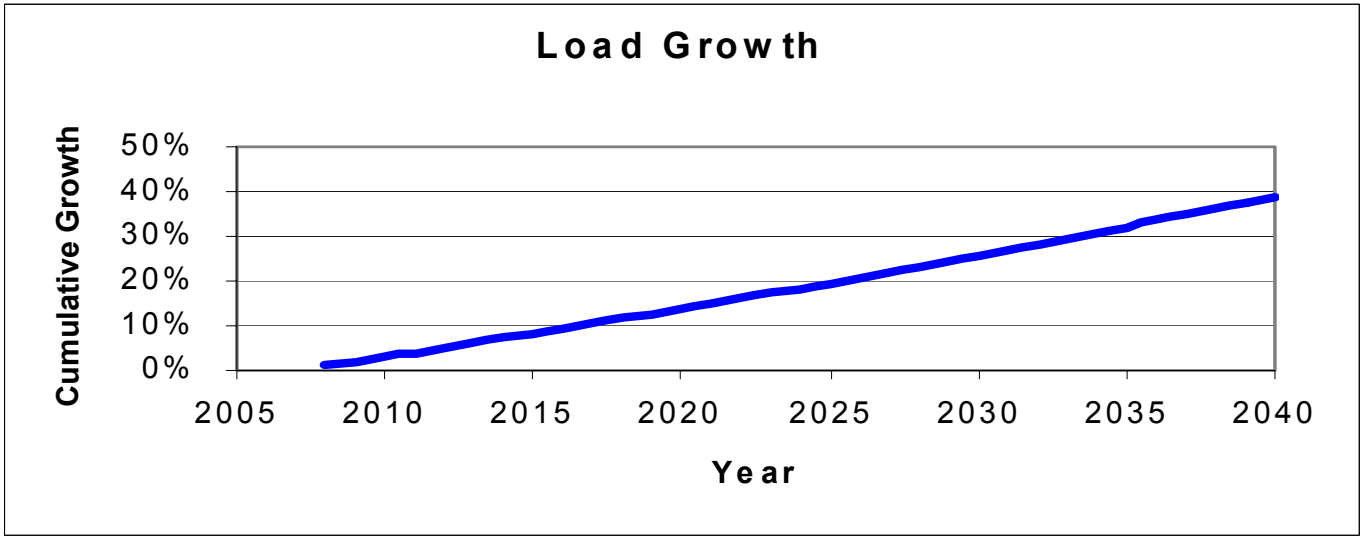
For dry-type, initial average loading ranges from 32% for 25 kVA to 37% for 2000 kVA.

Initial peak loading assumptions directly impact load model results.

**The Department seeks stakeholder feedback on the loading model used in the ANOPR analysis, especially initial peak loading assumptions.**

# Load Growth Over Time (ANOPR Issue #11)

One percent load growth used as default for liquid-immersed, zero percent load growth for dry-type.




Zero percent and two percent used for sensitivity for liquid-immersed.

**The Department seeks stakeholder comments on these assumptions.**

# Discount Rates

- **Relative (time) value of money**
  - Now versus later
- **Determined by the interest rate for borrowed money and the rate of return on equity**
- **Interest rates are borrower-dependent**
- **DOE analysis determines discount rate by owner type**
- **Analysis, and consequently the discount rate, are in real terms**

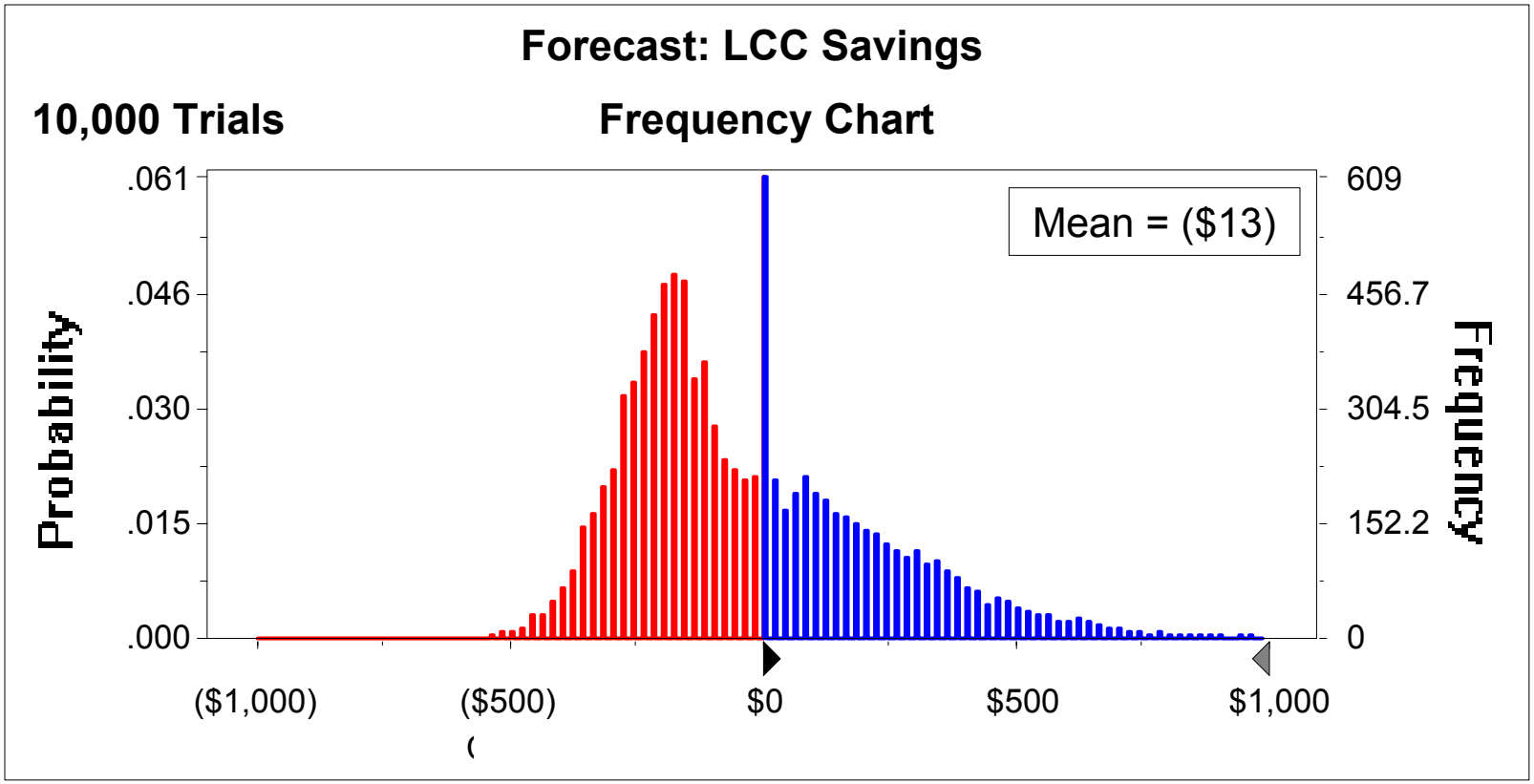
# Discount Rate Selection and Use (ANOPR Issue # 8)

Average Discount Rate by Ownership Category

- 4.35% Property Owner
- 7.55% Industrial Companies
- 7.46% Commercial Companies
- 4.16% Investor Owned Utilities
- 4.31% Publicly Owned Utilities
- 3.33% Government

**The Department invites comments on these discount rates**

# Example of LCC Results
# DL 1: 50kVA, Liquid-immersed, Single-phase



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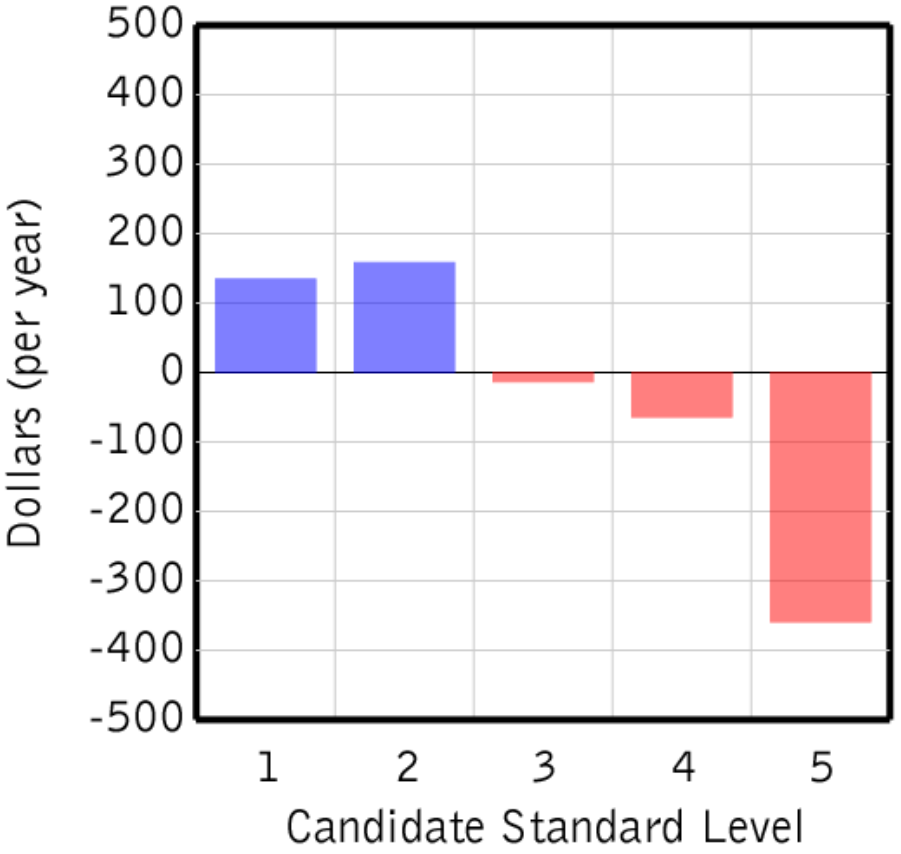
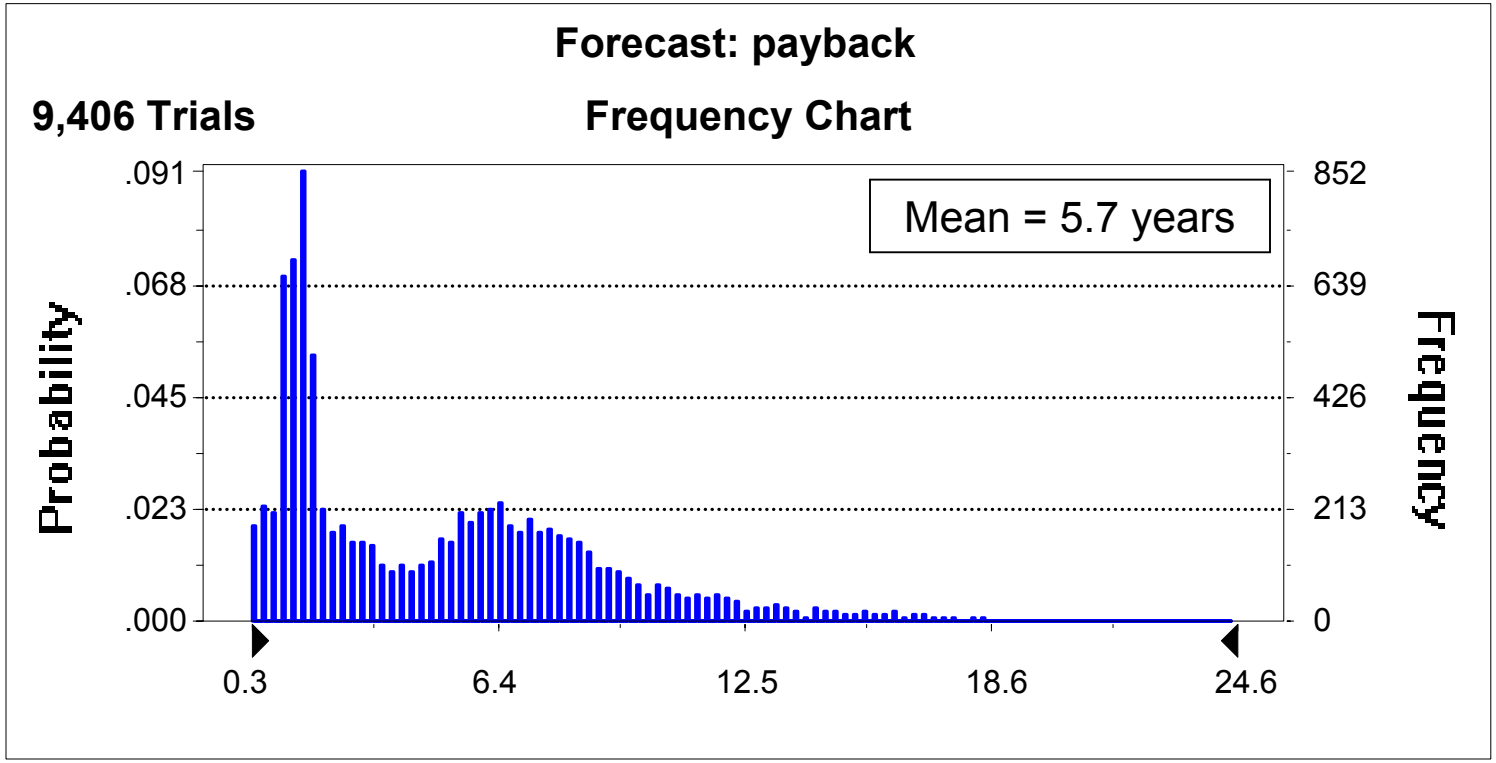



| Candidate Standard Levels | Efficiency Rating (percent) | Mean LCC Savings |
|---|---|---|
| 1 | 98.90 | $134 |
| 2 | 99.10 | $158 |
| 3 | 99.30 | ($13) |
| 4 | 99.40 | ($64) |
| 5 | 99.58 | ($359) |
| | | |
| **Mean LCC w/o Standard** | | $4,914 |

# Example of Payback Results
# DL 9: 300 kVA, Dry-type, Three-phase, Medium-voltage



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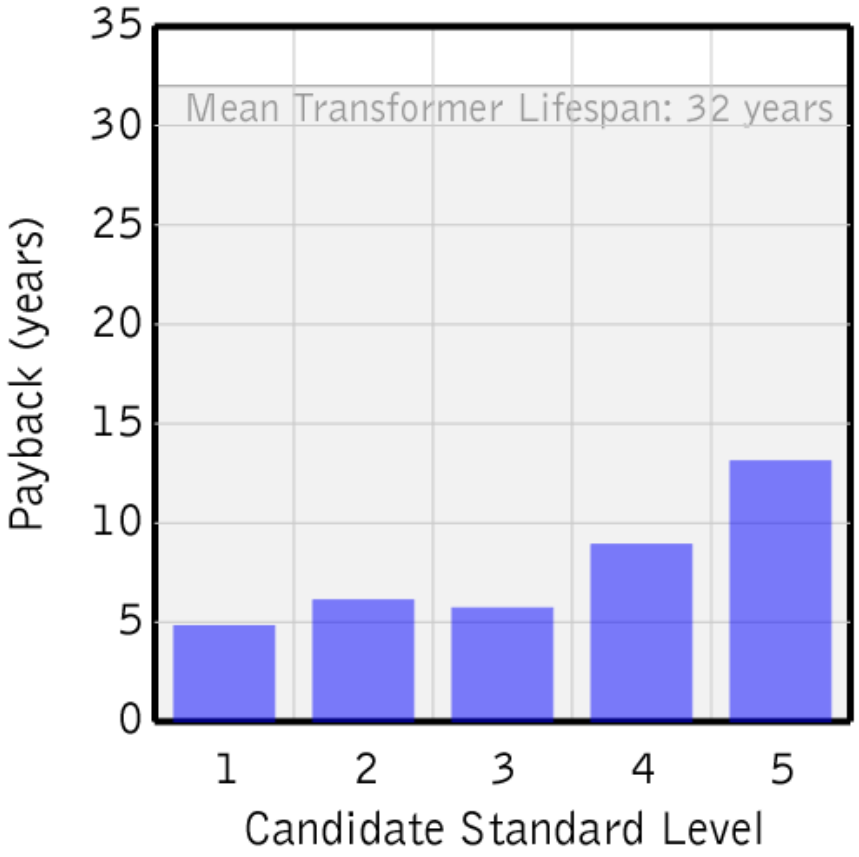


| Candidate Standard Level | Efficiency Rating (percent) | Mean Payback (years) |
|---|---|---|
| **1** | 98.90 | 4.8 |
| **2** | 99.10 | 6.1 |
| **3** | 99.30 | 5.7 |
| **4** | 99.40 | 8.9 |
| **5** | 99.58 | 13.1 |

# Other Issues

**The Department seeks input on whether income tax effects are significant enough to warrant inclusion in the LCC analysis for the NOPR.**

**The Department requests specific stakeholder comments on the power factor of 1.0 assumption.**

**The Department seeks comments and recommendations from stakeholders on any other aspects related to the Life-Cycle Cost Analysis.**