Assessment of Analyses Performed for the California Energy Efficiency Regulations for Consumer Electronics Products

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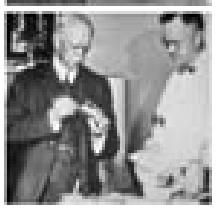
Reference: D5503

TIAX emerged from Arthur D. Little, advancing its 116-year heritage of helping clients realize the power of technology & innovation.

Arthur D Little
technology & innovation


- T&I Heritage
- People
- IP & Know-How
- Facilities & Equipment
- Resources & Relationships

- Independent company formed in May of 2002
- More than 150 scientists, engineers, and industry experts
- Headquartered in Cambridge, MA
- West Coast presence in Cupertino, CA
- Laboratories and field test facilities
- ISO 9001 Registered



TIAX has a century-long track record of implementing innovations …

1886

1920's

40's

50's

60's

70's

80's

90's

2000

2005

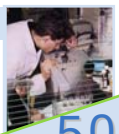
NEXT INNOVATION

Griffin & Little established 1886

Nonflammable **motion picture** film (sold to Eastman Kodak)

Patented technology leads to development of F**iberglas**

Flavor Profile method



First **iso-octane** (later adopted as antiknock gas standard)

Commercialized & **patented synthetic penicillin**

Developed **SABRE** with IBM

Sent five experiments on **first moon mission**

Non-CFC **aerosol** device

Commercialized **scroll technology** for automotive applications

New **reformer technology** expands fuel options for fuel-cell vehicles

Formulated **Slim Fast** line of drinks

Advanced **protective clothing** used by industrial & agricultural workers

Helped design & launch 1st **fiber-optic** interactive cable TV system

Non-toxic foam neutralizes chemical & biological agents

Heat-pump water heater has 60% m… efficiency

New line of **cooking appliances** for SubZero/Wolf

TIAX LLC founded

APTAC chemical reactor measures process risk

Advanced lithium ion battery technology

TIAX has extensive experience analyzing the energy consumption, energy savings potential, and economics of building equipment, systems, and technologies for the U.S. Department of Energy's Building Technologies Program (DOE/BT).

- **Recent DOE Rulemaking Support:**
  - *Commercial Unitary A/C and Heat Pump*
  - *Residential Furnace and Boiler*
  - *Prioritization of Products – Scoping Analyses for: TVs, audio equipment, set-top boxes, ceiling fans, commercial refrigeration equipment, personal computers, monitors, dishwashers, dryers, large unitary air conditioners, and EPACT motors*
  - *Residential A/C*
- **Energy Consumption Analysis**
  - *Miscellaneous Residential Electric Loads (one complete, one in progress)*
  - *Non-Residential and Residential Office and Telecommunications Equipment (2)*
  - *Commercial HVAC*
- **Technology Assessment: Energy Savings, Economics, Barriers and Drivers**
  - *Office and Telecommunications Equipment*
  - *Commercial HVAC*
  - *Commercial Building Controls and Diagnostics*

The Consumer Electronics Association (CEA) asked TIAX to perform an independent assessment of the analyses used to determine the cost-effectiveness of the California standards for several consumer electronics products and external power supplies used by consumer electronics.

- Televisions
- Compact Audio Products
- DVD Players and Recorders
- Digital Television Adapters (DTAs)
- External Power Supplies (EPSs)

We analyzed the key assumptions for the cost-effectiveness calculations.

Net Savings to Consumer = NPV Energy Savings (product lifetime) - Incremental Cost

- ***Incremental Cost*** *= Cost increase for typical new non-compliant product to meet the standard*
- ***NPV Savings*** *= Discounted energy savings from standard for typical new non-compliant product*
  - *Calculate annual energy savings in kWh for typical new non-compliant product in each relevant mode – equals the product of:*
    - Hours spent in mode
    - Difference in average power draw by mode
  - *Multiply the energy savings (kWh) by the electricity price ($0.115/kWh)*
  - *Discount the annual energy savings*
    - For every year except the first year
    - Over the average product lifetime

The analysis for televisions suffers from outdated power draw estimates.

- 2005 Shipments – 3.2 million (note: majority projected to be digital)
  - Excludes combo units (e.g., TV-VCR)
- Standby Power Draw Value – Original analysis Uses 7.3W
  - Cites DOE (2002), original source Rosen and Meier (1999)
  - EnergyStar® program launched in 1998, 22% market share in 2004; mean power draw of units in database = ~0.7W
  - More recent study uses 3.9W (Ostendorp et al. 2005) – we used this value
- Annual Hours in Standby – Original analysis Uses 6,205
  - Cites DOE (2002), very close to Rosen and Meier (1999)
  - More recent study uses 7,285 (Ostendorp et al. 2005) – re-analysis uses this value
- First-Year Energy Savings – Original analysis estimates 68GWh
  - New estimate: 21GWh
  - No savings for 22%+ of market

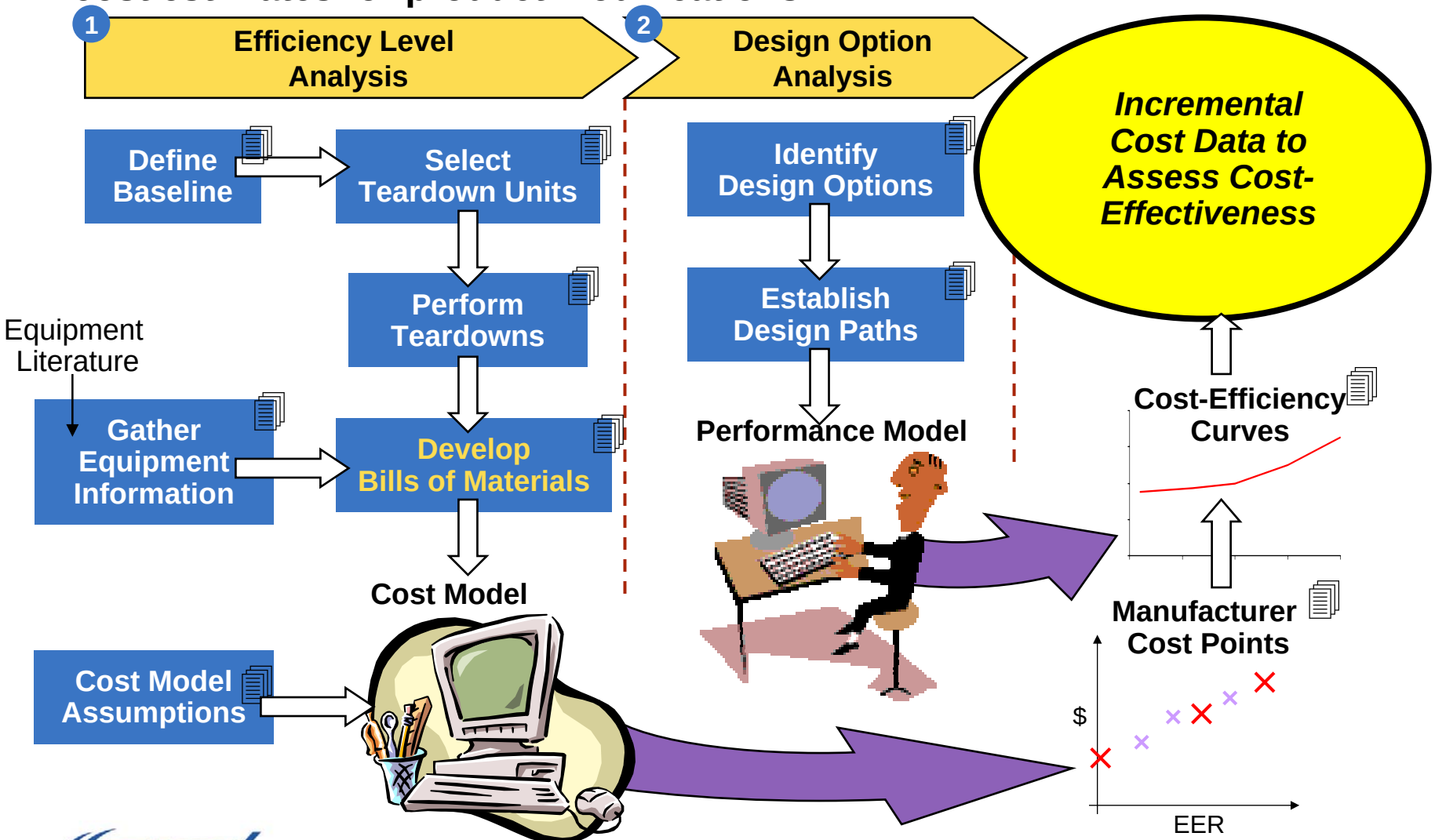
No support exists to corroborate the incremental cost estimate used for non-compliant televisions to meet the standard.

- Incremental cost: $3
  - Authors state: “incremental costs for most of the standby energy efficiency measures are difficult to quantify, but are expected to be very low"
  - No citation for estimate
  - No design path presented to achieve 3W standby for typical new non-compliant device
  - No manufacturing cost analysis appears to have been performed

∴ Incremental cost estimate lacks a solid foundation

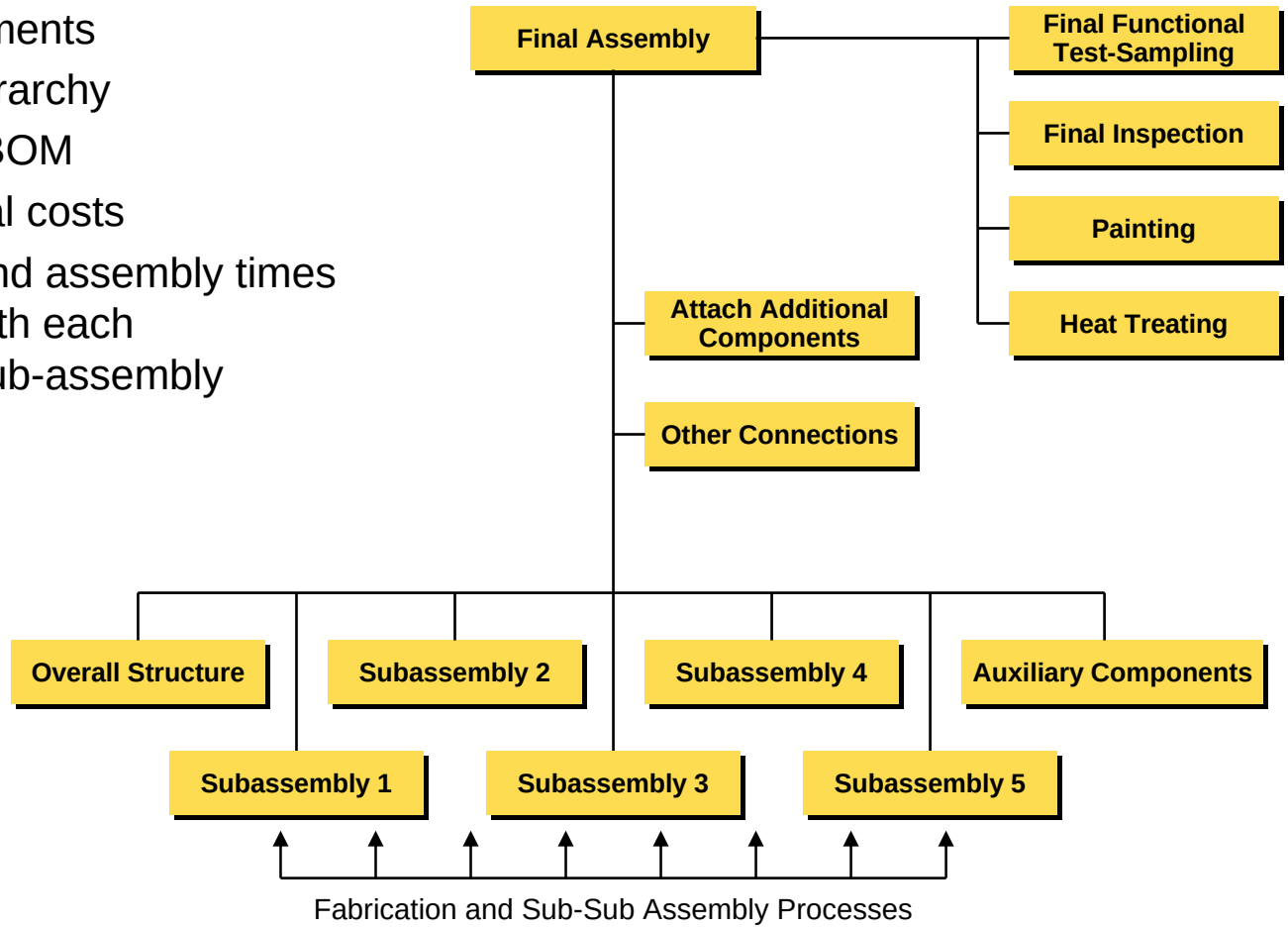
This precludes a meaningful cost-effectiveness assessments for these products, i.e., it is not possible either to conclude that either the standards are cost-effective or not cost-effective.

Manufacturing cost analysis is a way to develop accurate and verifiable cost estimates for product modifications.

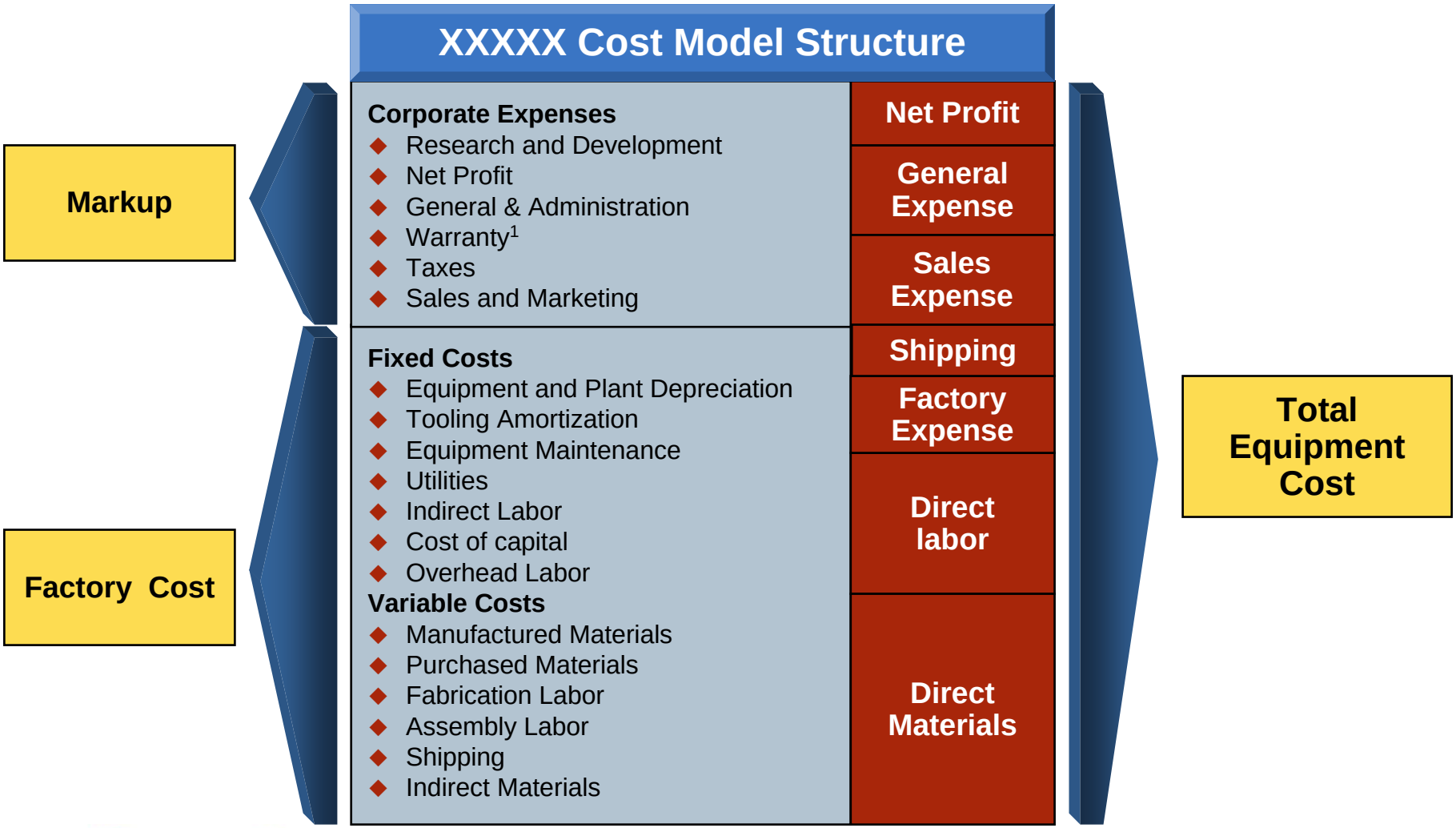


Manufacturing cost models are used to develop comprehensive bottom-up cost estimates.

- Cost Model Elements
  - Assembly hierarchy
  - "Structured" BOM
  - Direct material costs
  - Fabrication and assembly times associated with each component/sub-assembly



The selected units are broken down (physically or using catalog/design data) to create a bill of materials that is fed into the cost model.



[1] Some manufacturers consider warranty a manufacturing cost, not a corporate expense.
[2] Based on analysis of industry corporate financial records.

The analysis for DVD players and recorders suffers from outdated power draw data and highly uncertain usage estimates.

- Standby Power Draw Value – Original analysis uses 4.2W
  - Cites DOE (2002), original source Rosen and Meier (1999)
    - 20 measurements from 1999 or earlier (report date: March, 1999)
  - Installed base of DVD players has increased more than 15-fold since 1999
  - 62% of DVD players sold in 2004 were EnergyStar® units
    - Mean standby power draw = 1.1W
  - Re-Analysis Assumption – other typical new units draw 4.2W (significant uncertainty)
- Annual Standby Hours – Original Analysis uses 6,307
  - Cites DOE (2002), original source appears to be Rosen and Meier (1999)
    - Hours when not in use apportioned by 25% idle / 75% standby split
    - Reflects “a rough estimate based on our experience" (Rosen and Meier)
  - Survey of 300 UK residents found ~60% of VCRs on in evening – used this value in re-analysis, yields 3,400 standby hours
- Original Analysis Estimates First-Year Energy Savings of 12GWh
  - Re-analysis indicates none for typical new product
  - ~4GWh (or less) for remaining units (note: shipments increased by ~50%)

No support for the incremental cost estimate used for DVD players and recorders is provided in the original analysis.

- Incremental cost: $1
  - Authors state: “incremental costs for most of the standby energy efficiency measures are difficult to quantify, but are expected to be very low,"
  - No citation for estimate
  - No design path presented to achieve 3W standby for typical new non-compliant device
  - No manufacturing cost analysis appears to have been performed

∴ Incremental cost estimate lacks foundation.

Incomplete analysis precludes a meaningful cost-effectiveness assessments for DVD players and recorders. That is, it is not possible to conclude that the standards are cost-effective or not cost-effective.

The analysis for compact audio products also suffers from outdated power draw and highly uncertain usage estimates.

- Original Analysis Standby Power Draw Value – 9.8W
  - Cites DOE (2002), original source Rosen and Meier (1999)
    - Measurements of 19 units, primarily found in retail shops.
    - "measurements were taken randomly; no conscious effort was taken to select a representative sample of manufacturers or quality levels"
    - EnergyStar® for audio came into existence in 1999
  - 28% of compact audio products sold in 2004 were EnergyStar® units, mean standby power draw = ~0.7W
  - Limited other recent measurements suggest ~3W, appreciable uncertainty remains
  - Our Assumption – average typical new units draw 3W
- Original Analysis Annual Hours in Standby - 6,570 hours
  - Cites DOE (2002), very close to Rosen and Meier (1999)
  - Hours not in use apportioned 20% "idle" / 80% in standby
    - Comes from a survey of 30 LBNL employees
    - Rosen and Meier "have little reason to believe that 20% is an accurate estimate"
  - Initial re-analysis uses 6,470, but highly uncertain
- Original Analysis First-Year Energy Savings – 56GWh
  - Re-analysis finds ~5GWh, but highly uncertain

The incremental cost estimate used for compact audio products has no supporting data.

- Incremental cost: $1
  - Authors state: “incremental costs for most of the standby energy efficiency measures are difficult to quantify, but are expected to be very low,"
  - No citation for estimate
  - No design path presented to achieve 2W standby for typical new non-compliant device
  - No manufacturing cost analysis appears to have been performed

∴ Incremental cost estimate lacks foundation

This precludes a meaningful cost-effectiveness assessments for compact audio products, i.e., it is not possible to conclude that the standards are cost-effective or not cost-effective.

The analysis for basic digital television adapters (DTAs) relies upon highly uncertain assumption for power draw by mode and incremental cost, most notably because these products have yet to enter the U.S. market.

- Original Analysis: Active Power Draw Value – ~19W
- Original Analysis Standby Power Draw Value – 8W
  - Based on units for UK and Australia
  - Weighted average of values for basic DTAs in UK, in 2004 (MTP 2004)
    - ~8.5W active, ~6.5W standby
  - Appreciable differences exist between U.S. and European DTV standards, including potentially large variations in data rates
  - According to CEA, no basic DTA products are available in the in U.S., so no value used for current analysis
- Original Analysis First-Year Energy Savings – 1.1GWh
  - No existing products in U.S. – re-analysis = 0.0GWh

Because basic DTAs are not yet available in the U.S., it is not possible to assess if the standard will save any energy and its cost-effectiveness.

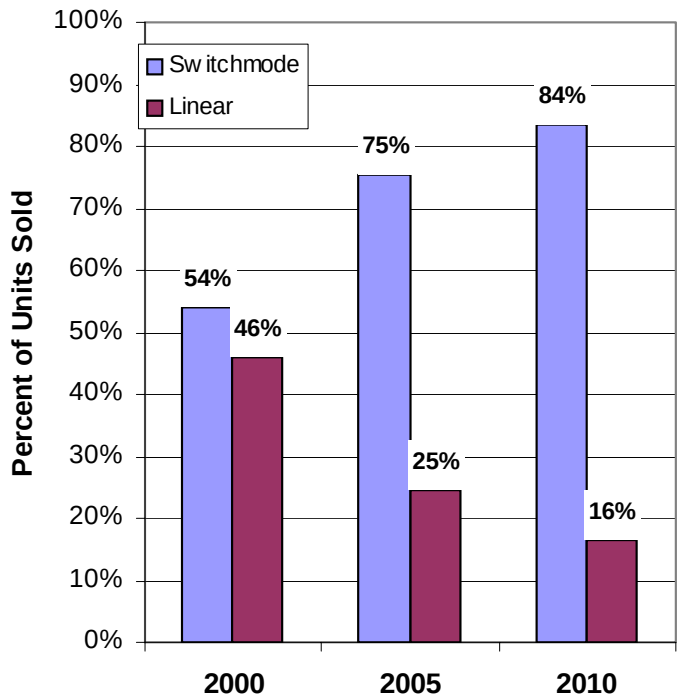
TIAX also assessed the original external power supply (EPS) analysis.

- Annual Shipments – Original Analysis: 27 million
  - Re-Analysis: 38 million (Darnell Group 2005)
- Average EPS Lifetime – Original Analysis: 5 years
  - Re-Analysis: Assumed EPS lifetime = device lifetime
  - Weighted averages based on shipments and energy consumption yields 4.1 – 4.3 year range – *Re-Analysis uses 4.3 years*
- Usage by Mode: Original analysis assumes similar usage by wattage bin
  - Re-analysis uses same values
  - Current assumption – invariant with product type served by EPS
    - Future analyses should use separate product-by-product usage estimates if incremental costs also vary significantly by product type

The analysis for external power supplies (EPSs) suffers from outdated energy performance estimates due to over-sampling of linear EPSs. Switchmode EPS market share is expected to continue to grow.

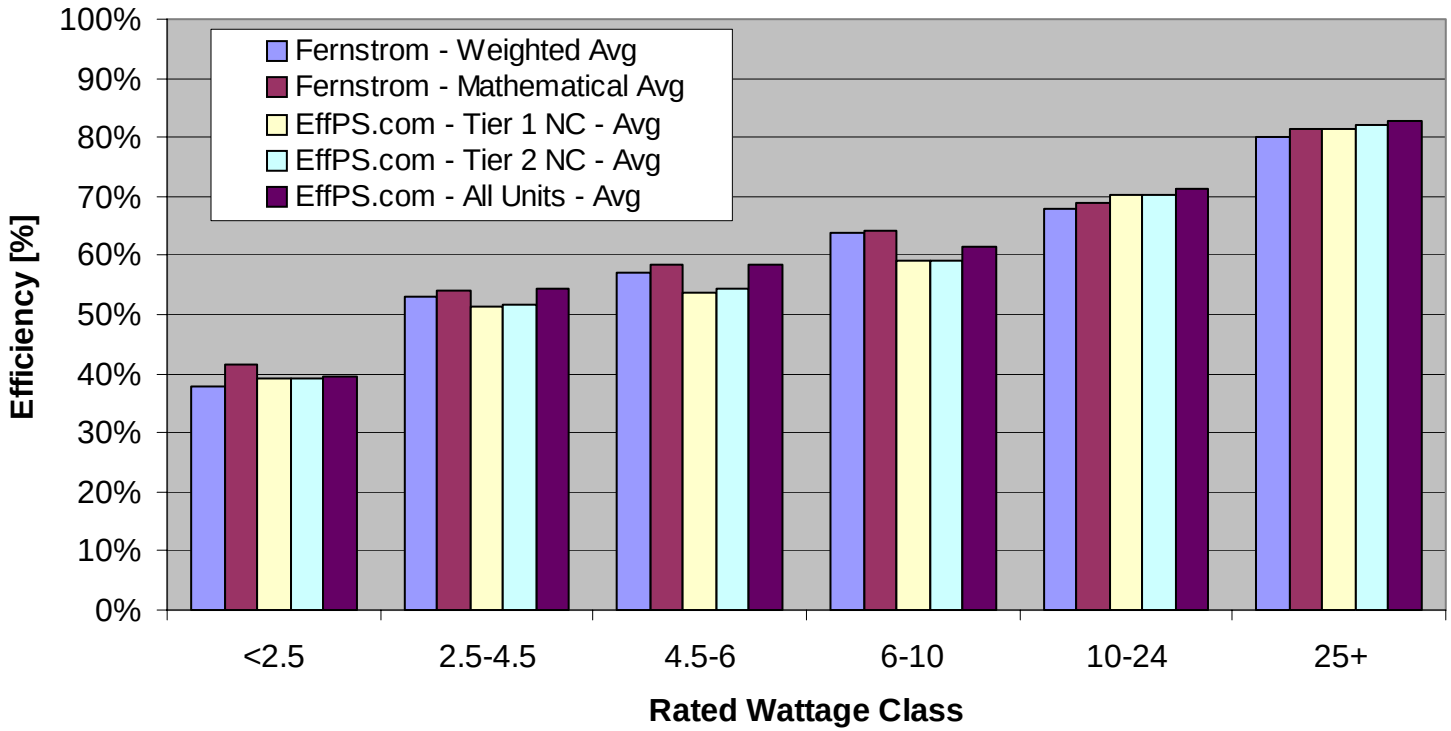
- Original analysis assumed a significantly higher market share for linear EPSs than market share, i.e., 46% versus 25%.
- This has a major impact on the baseline energy consumption – switchmode EPSs are more efficient than linear EPS:
  - Linear: 25- 60% efficiency
  - Switchmode: 60 – 90% efficiency

Sources: PG&E (2004a), Darnell Group (2005)



Source: Darnell Group

TIAX analysis of a database developed by the lead consultant for the original analysis appears to have similar performance characteristics as the data presented in the original analysis.



The percentage of linear EPSs (~70%) in the database is roughly the inverse of the 2005 market reality (~25%), which would tend to decrease the energy consumption and savings estimates.

All three sources used to develop the incremental cost estimates in the original analysis may have significant shortcomings that compromise their accuracy.

- Citation 1: Personal communication, two employees of an EPS manufacturer
- Citation 2: “a leading manufacture [sic] of switch mode power supply integrated circuits”
- Citation 3: Anecdotal comparison of a linear and a switchmode power supply with same outputs sold by the same electronics supplier
- Several issues can confound estimates from these sources, including:
  - Manufacturing volumes
  - Sales volumes
  - Purchasing volumes and sourcing
  - Purchasing negotiations
  - Product line maturity

Independent engineering-based manufacturing cost analyses can help to develop incremental cost estimates independent of these factors. It appears that no such assessments were performed.

A preliminary re-analysis of the original incremental costs may be comparable with actual incremental OEM costs to go from a linear EPS to a switchmode EPS *without taking into account markups*.

- Re-Analysis Values based on Darnell Group (2005)
  - <5W: ~18% OEM cost premium for switchmode
  - 5-10W: ~17% OEM cost premium for switchmode

Table: Typical Incremental Cost

Wattage class	Re-Analysis: Linear-to-Switchmode, OEM Price	Tier 1	Tier 2
<2.5	$0.23	$0.30	$0.45
2.5 to <4.5	$0.23	$0.30	$0.45
4.5 to <6	$0.30	$0.40	$0.60
6 to <10	$0.38	$0.45	$0.75
10 to <24	N/A	$0.63	$0.98
24+	N/A	$0.80	$1.30

The re-analysis values under-estimate, however, the cost to replace a linear EPS with a *compliant* EPS because a majority of switchmode EPSs appear to not meet the Tier 1 or Tier 2 standards.

Sources: Darnell Group (2005), Fernstrom (2004a), EfficientPowerSupplies.com

Markups significantly increase the incremental cost to the consumer relative to OEM costs and need to be investigated and applied to all incremental costs. Typical markups associated with specific types of consumer electronics products can vary appreciably from one product to another.

Table: Sample Markups for Televisions (from ADL 2001)

Markup	High	Low
Factory-to-retailer	2.5	1.5
Retailer-to-consumer	1.35	1.2
CA Tax	1.0775[1]	
TOTAL	3.64	1.94

TIAX believes that the shortcomings outlined for the EPS energy performance and cost data preclude a arriving at a conclusion that the Tier 1 and Tier 2 standards are cost-effective or are not cost-effective.

In general, the original analyses rely upon outdated power draw values that do not reflect the performance of typical new products and tenuous incremental cost estimates that preclude arriving at a conclusion that the standards are either cost-effective or are not cost-effective

- *Televisions*
  - *Outdated typical standby power draw*
- *DVD Players and Recorders*
  - *Outdated typical standby power draw*
  - *Highly uncertain annual standby hours*
- *Compact Audio Products*
  - *Outdated typical standby power draw*
  - *Uncertain annual standby hours*
- ***Basic Digital Television Adapters (DTAs)***
  - *Product yet to come to market in California, characteristics not known*

- ***Incremental Costs:*** *No sources or design paths to attain standard levels provided for all four products – prevents assessment of incremental costs*

The original analysis of EPSs appears to rely upon outdated assumptions for baseline energy performance, as well as incremental cost estimates prone to significant uncertainty.

- *Energy Performance*
  - Original analysis assumed linear EPS market share of 46% versus 25% market share in 2005
  - Dataset apparently used for original analysis ~70% linear EPS
  - Switchmode generally more efficient than linear

  ∴ *Original analysis significantly overestimates total and typical new energy-savings potential*

- *Incremental Cost*
  - All sources cited potentially have confounding factors and not independently validated, e.g., via manufacturing cost analysis
  - Modifications required to many switchmode EPSs to meet standard
  - Appears that full markups were not applied

  ∴ **These issues preclude arriving at a conclusion that the Tier 1 and Tier 2 standards are cost-effective or are not cost-effective.**

TIAX recommends the following activities to provide quality information to assess the cost-effectiveness of the standards.

Incremental Costs: Perform Design Option Analyses for All Products

- Manufacturing Cost Modeling – Costs independent of manufacturing volumes, purchasing volumes, purchasing negotiations, sourcing, pricing, and company practices
- Evaluate and apply typical markups associated with each product
- EPSs selected from product categories/applications accounting for significant portions of EPS energy consumption, devices with significant market share.

Measurements of Power Draw Characteristics: Compact Audio and EPS

- Compact Audio Products – Targeted measurement of an appreciable quantity of units that account for a majority of current sales
- EPSs – Measurements of currently for-sale units in each of the desired wattage classes to develop a statistically significant estimate for baseline energy performance in each class
  - Selected should be associated with product types accounting for significant portions of EPS energy consumption and come from products that account for a significant portion of each product's market share.

TIAX also recommends investigating usage patterns for selected products applying a 7% real discount rate, and eliminating the 230V testing requirement from the EPS test procedure.

- ***Usage Patterns:*** **DVD Players and Compact Audio**
  - Data gathering activities, such as demographically representative and statistically significant phone surveys or end-metering activities, to develop more accurate estimate for the annual usage of these products in idle and standby modes.
  - Possibly for EPS
- ***Discount Rate:*** **Consistent with prior DOE Rulemaking analyses, TIAX recommends using a ~7% real discount rate (versus 3%)**
- ***EPS Test Procedure*** – **Eliminate the 230V test requirement**
  - Only ~115V power is used in California
  - 230V performance not relevant to EPS energy performance in CA
  - Inclusion of 230V requirement inhibits development of designs optimized for 115V
  - Need to fulfill efficiency and standby power standards at both input voltages tends to increases cost of compliance