

Draft 2 ENERGY STAR Imaging Equipment Program Requirements (Version 1.0) Supplemental Rationale for EPA Decisions Informed by Manufacturer-submitted TEC Data

January 17, 2006

In developing the Eligibility Criteria for products addressed by the Typical Electricity Consumption (TEC) approach in the Draft 2 ENERGY STAR Imaging Equipment Program Requirements (Version 1.0), EPA considered a TEC test dataset of 164 imaging equipment models. The data were provided to EPA by manufacturers following the release of the final TEC Test Procedure in the summer of 2005.

Stakeholders were given until November 1, 2005, to submit any data they were interested in having EPA consider in preparing Draft 2. Included within this dataset were color and monochrome copier, digital duplicator, multifunction device (MFD), and printer models using marking technologies defined in the final TEC test procedure. The data helped inform the proposed requirements presented in the Draft 2 specification related to product and marking technology groupings, duplexing, digital front-ends (DFEs), and the resulting ENERGY STAR Eligibility Criteria in kilowatt-hours/week (kWh/week).

This document provides supplemental rationale in support of Section 3.A. of the Draft 2 ENERGY STAR Imaging Equipment Program Requirements (Version 1.0), dated December 21, 2005. It is EPA's intention that this document serve as a reference to aid stakeholders in better understanding how this section of the specification was developed, and in particular, the data that informed the TEC specification levels.

Accompanying this rationale document is the masked TEC dataset EPA considered in the development of the TEC Eligibility Criteria. Figures 1 through 4 included at the end of this rationale graphically illustrate the dataset and the energy specification criteria derived from this manufacturer-reported data.

Product Categorization

Copiers and MFDs

The TEC data show that in general, copiers consume more energy than similar-speed MFDs. Color copiers use more energy than color MFDs, and monochrome copiers use more energy than monochrome MFDs. This finding is unexpected considering that copiers provide fewer distinct functions and should spend more hours per week in Off mode than MFDs according to the TEC test procedure formulas. Because of an ongoing market shift toward multifunctionality, and because copiers and MFDs often serve the same consumer and business market, the Draft 2 specification categorizes these products together for ENERGY STAR eligibility consideration.

Digital Duplicators

EPA evaluated manufacturer-reported TEC data for digital duplicators against TEC data for copiers and MFDs and found that the reported digital duplicators consume an order of magnitude less energy than the reported copiers and MFDs. Due to this high efficiency, and because digital duplicators share operational similarities with copiers and MFDs, EPA has decided to require that digital duplicators meet the copier/MFD TEC criteria to determine eligibility for ENERGY STAR. EPA did not see the need to differentiate individual digital duplicators from other digital duplicators with such similar and minimal energy consumption.

Fax Machines and MFDs

No stand-alone fax machines were included in the TEC test data submitted to EPA. The TEC dataset included only fax machine models marketed as MFDs. Fundamentally, a fax machine is an MFD because of its scan and copy capability, though it is expected to use less energy than a comparable MFD due to its more limited scan and print capability and lack of network connections. Thus, the data did not support separating fax machines from MFDs when considering the ENERGY STAR eligibility of these products in the Draft 2 specification.

Serial and Parallel

When considering the data, EPA could find no clear evidence that Serial Color Electrophotographic (EP) products are more or less energy efficient than Parallel Color EP products for monochrome imaging, per the TEC test procedure. In addition, previous EPA analysis has found little variation in energy consumption between color and monochrome imaging for color-capable products. Thus, as presented in Draft 2, EPA combined Serial and Parallel products in the specification.

DFEs

In Drafts 1 and 2, EPA has proposed that externally-powered DFEs not be considered as part of the TEC value of the imaging product with which it operates, and thus, not considered under the imaging equipment specification. If the DFE is shipped with the imaging product, the DFE must either be an ENERGY STAR qualified computer, or meet the ENERGY STAR computer specification when tested to the ENERGY STAR computer test method. This decision recognizes the fact that imaging-equipment manufacturers have limited control over DFE design.

However, to avoid penalizing high-speed imaging products with physically- and functionally-integrated DFEs, EPA has proposed subtracting the energy consumed by such DFEs from the total TEC value when considering products against the imaging product's Eligibility Criteria. Upon the effective date of the Version 1.0 Imaging Equipment specification, EPA will expect manufacturers to document the additional product energy consumption caused by the physically- and functionally-integrated DFEs or especially powerful print controllers. This proposal was included in the Draft 2 specification for stakeholder feedback. Guidance on measuring and/or estimating the energy consumed by the DFE will be provided in the final draft specification.

Duplexing

In preparing the Draft 2 specification, EPA carefully considered the effect that the new duplexing requirements would have on the percentage of products that could meet the proposed ENERGY STAR criteria. When preparing the Eligibility Criteria, EPA adjusted the stringency of the TEC levels accordingly. For example, if roughly 25% of models were expected to meet the TEC Eligibility Criteria levels prior to the duplexing requirement, and only 20% were expected to meet the TEC Eligibility Criteria following the introduction of the duplexing requirement, EPA raised the TEC energy Eligibility Criteria stringency to 30% to account for the effect of requiring duplexing.

TEC Eligibility Criteria

Energy per Image

At the October 14, 2005, ENERGY STAR imaging-equipment stakeholder meeting, EPA presented a figure illustrating the metric of energy per image, based on the TEC data submitted by that point in time. In the imaging equipment industry, literature^{1,2} has long included calculations of energy per image from products and from the physics of heating paper to fusing temperature. By this measure, products with faster imaging production rates are considered more energy efficient than slower products.

¹ Acquaviva, T., G.C. Hartmann, "Survey of Energy and Power Usage in Copiers, Duplicators, and Electronic Reprographic Devices", Joseph C. Wilson Center for Technology, Xerox Corporation, Webster, NY; undated but no later than 1994. 1994a.

² Acquaviva, Thomas, "Techniques for Measuring Energy Consumption of Reprographic Devices", Joseph C. Wilson Center for Technology, Xerox Corporation, Webster, NY; undated but no later than 1994. 1994b.

From the energy/image data presented at the October 14, 2005, meeting, a reasonable minimum value for what is truly needed to make incremental images is between 0.5 and 1.0 Wh/image. As the ENERGY STAR TEC test procedure varies the number of images made during the TEC test per the square of the speed in ipm, the effect of energy per image is most apparent for the fastest machines. In principle, it is logical for energy/image to be a component of a TEC specification formula. However, for the speed ranges where most of the submitted imaging equipment models reside and, therefore, make up the most imaging-equipment energy consumption, the difference between a 1-Wh/image criteria line and a linear approximation of it is not so great that the additional complexity is warranted. Two linear segments adequately approximate the additional energy needed for additional images. As a result, EPA decided not to use energy/image as an explicit component of the TEC Eligibility Criteria in Draft 2, and strove to minimize the number of linear formula segments provided.

Eligibility Criteria Formulas

Staying true to the principles established in the February 2004 ENERGY STAR Directional Draft, the specification lines in the Draft 2 specification provide no sudden step increases, but rather are composed of one or more linear connected segments.

Draft 2 presents four distinct categories of TEC products:

- Monochrome copiers, digital duplicators, fax machines, and MFDs;
- Color copiers, digital duplicators, fax machines, and MFDs;
- Monochrome printers; and
- Color printers.

Table 1, below, outlines the four categories, alongside the corresponding energy-efficiency criteria levels in kWh/week, where *x* is the speed of the product in ipm.

For all products, the specification line increases at the rate of 0.15 kWh/ipm per week up to 55 ipm, and then continues at a slope of 0.90 kWh/ipm. For monochrome copiers, digital duplicators, fax machines, and MFDs, 3 kWh/week was added to the base allowance for printers. For color products, similarly, 3 kWh/week was added to the monochrome level. Therefore, color copiers, digital duplicators, fax machines, and MFDs would add 6 kWh/week to the base allowance for printers. Any printer that consumes 1 kWh/week or less would meet the specification.

Table 1. Tier I Specification Limits proposed for TEC products in Draft 2

Product Type	Spec. Limit ≤ 55 ipm (kWh/week)	Spec. Limit > 55 ipm (kWh/week)
Mono Copiers, Digital Duplicators, Faxes, and MFDs	(0.15 kWh/ipm)x + 3 kWh	(0.90 kWh/ipm)x – 38.25 kWh
Color Copiers, Digital Duplicators, Faxes, and MFDs	(0.15 kWh/ipm)x + 6 kWh	(0.90 kWh/ipm)x – 35.25 kWh
Mono Printers	(0.15 kWh/ipm)x	(0.90 kWh/ipm)x – 41.25 kWh
Color Printers	(0.15 kWh/ipm)x + 3 kWh	(0.90 kWh/ipm)x – 38.25 kWh

55 ipm was chosen as the point at which the specification adopts a different criteria formula because EPA found that models above this speed tend to fall too often above the specification line, thereby greatly reducing the percentage of models meeting the requirements. Note that the change in slope at 55 ipm principally affects monochrome products, although the maximum speed of color products is expected to increase over time. The formulas used for models above 55 ipm capture roughly 25% of models in those speed bands within each table, after accounting for the effects of duplexing and DFEs. Note that the dataset EPA considered included few models above this speed. Market research EPA conducted outside of the TEC data submitted by manufacturers suggests that the scarcity of TEC data in this speed band reasonably reflects the size of this market; however, EPA hopes that data received for qualification under Tier I will help EPA confirm the appropriateness of levels proposed for Tier II, prior to Tier II's effective

date. The Tier II levels proposed in Draft 2 are provided below. EPA will consider these levels and inform stakeholders of the Tier II criteria six months in advance of the Tier II effective date.

Table 2. Tier II Specification Limits proposed for TEC products in Draft 2

Product Type	Spec. Limit ≤ 55 ipm (kWh/week)	Spec. Limit > 55 ipm (kWh/week)
Mono Copiers, Digital Duplicators, Faxes, and MFDs	<i>Tier I levels remain unchanged</i>	<i>0.50 kWh/ipm – 16.25 kWh</i>
Color Copiers, Digital Duplicators, Faxes, and MFDs	<i>Tier I levels remain unchanged</i>	<i>0.50 kWh/ipm – 13.25 kWh</i>
Mono Printers	<i>Tier I levels remain unchanged</i>	<i>0.50 kWh/ipm – 19.25 kWh</i>
Color Printers	<i>Tier I levels remain unchanged</i>	<i>0.50 kWh/ipm – 16.25 kWh</i>

Digital-duplicator TEC data was found to be far below the criteria levels proposed for TEC Tables 1 and 2. Because of the inherent high energy-efficiency of these products, EPA chose not to include the digital-duplicator TEC values in the analysis when determining the criteria levels for TEC Tables 1 and 2, to avoid setting criteria too low for copiers, fax machines, and MFDs to meet. Digital-duplicator data was also removed from Figures 1 and 2 below, since these products' high speeds distorted the quality of the figures and made it difficult to see all data points clearly.

Table 3 below summarizes the TEC test data EPA considered in preparing the Draft 2 specification, by product type and color capability.

Table 3. TEC Data Summary – Number of Models Submitted Per Product Category

	Copiers	Digital Duplicators	Fax Machines	MFDs	Printers
Monochrome	24	4	0	52	32
Color	4	1	0	24	23
Total	28	5	0	76	55

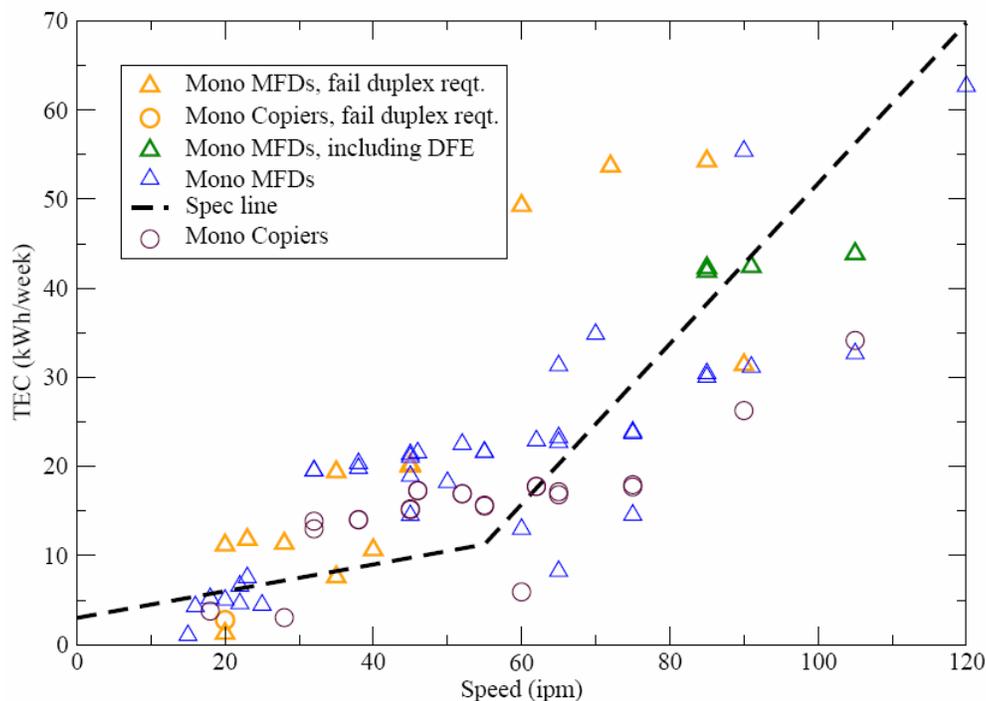
Figures 1 through 4 below illustrate the Tier I energy Eligibility Criteria corresponding to TEC Tables 1 through 4 in the Draft 2 specification.

EPA considered various methodologies for drawing the specification lines in the Draft 2 specification such that the top 25% of products in terms of energy performance met the eligibility criteria. As explained earlier in this rationale document, some concerns that EPA considered in the development of these criteria included the following:

- A smaller percentage of products in the higher speed ranges tend to meet a single linear energy-eligibility formula;
- A greater percentage of products in the lower speed ranges tend to meet a single linear energy-eligibility formula;
- Digital duplicators consume much less energy than other operationally-similar imaging products (e.g., copiers, MFDs), and thus might cause the energy Eligibility Criteria to be too stringent for these other products if data were analyzed together;
- Duplexing requirements affect the percentage of products that can meet the TEC energy Eligibility Criteria; and
- Physically- and functionally-integrated DFEs affect the TEC values of high-speed imaging products.

EPA determined the product categorization and groupings for eligibility, as proposed in TEC Tables 1 through 4, based on operational and performance characteristics shared among certain groups of product types, color capability, and marking technology. Then, EPA determined the appropriate specification formulas to ensure that the top 25% of products in terms of energy performance in each product category met the specification. This process included a review of manufacturer and brand information to ensure that more than one or two manufacturers would be able to meet the specification within each product category and speed band.

Figure 1. TEC Table 1 – Standard-size Monochrome Copiers and MFDs



The energy Eligibility Criteria in TEC Tables 1 through 4 utilize a different formula for products with speeds of 56 ipm and higher because EPA found that it was in this speed range that a smaller percentage of models could meet the originally single, linear formula. As a result, two linear formula segments were developed to address products above and below the “elbow” of 55 ipm.

Once the two linear segments were developed for TEC Tables 1 through 4, EPA next considered the effects of the duplexing requirements on the percentage of products that could meet the specification within each product category. As an example, per the description in the **Duplexing** section of this rationale document, if only 20% of models were expected to meet the TEC Eligibility Criteria following the introduction of the duplexing requirement, EPA raised the TEC energy Eligibility Criteria stringency to 30% to account for the effect of the duplexing requirement.

For higher-speed products where physically- and functionally-integrated DFEs are common, EPA next considered the effect of these DFEs' energy consumption on the TEC of these products. Since it may not be feasible to meter physically- and functionally-integrated DFEs separately from the imaging product with which they operate, EPA determined that the most fair way to avoid penalizing these higher-functionality imaging product-DFE combinations would be to subtract the energy consumed by the DFE from the total TEC before considering that product's TEC for eligibility. Following this decision, EPA subtracted the reported DFE energy supplied by manufacturers who reported TEC values for such products from the total TEC value and adjusted the criteria formula accordingly. Since EPA only received DFE energy data for monochrome products, only Figures 1 and 3 were altered to account for this.

Figure 2. TEC Table 2 – Standard-size Color Copiers and MFDs

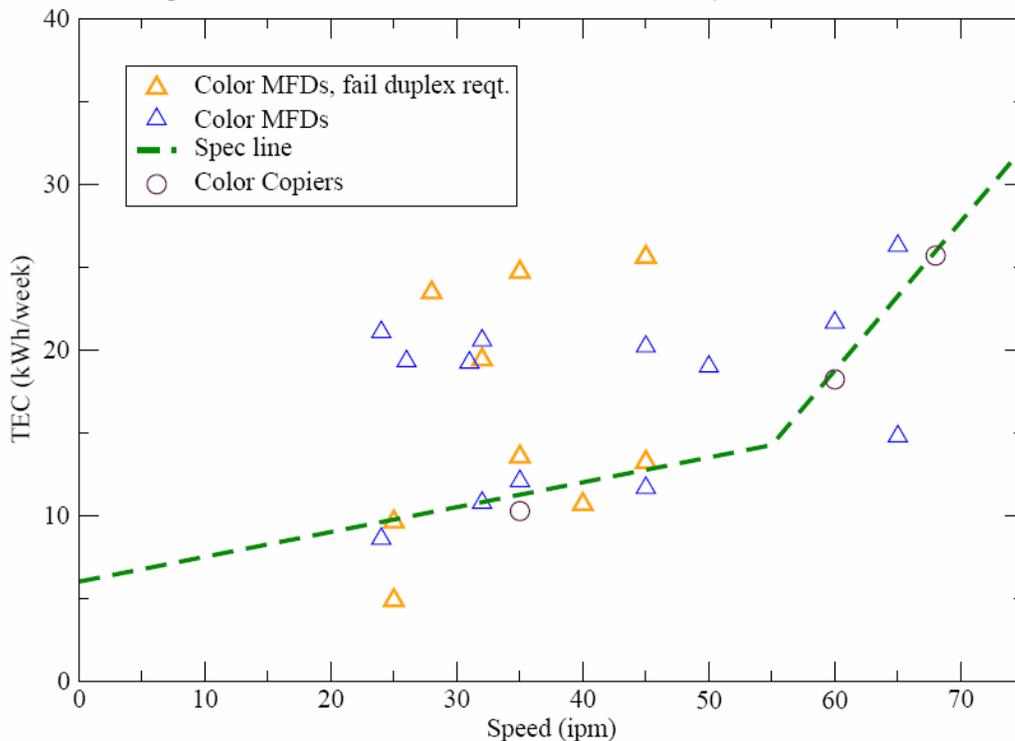


Figure 3. TEC Table 3 – Standard-size Monochrome Printers

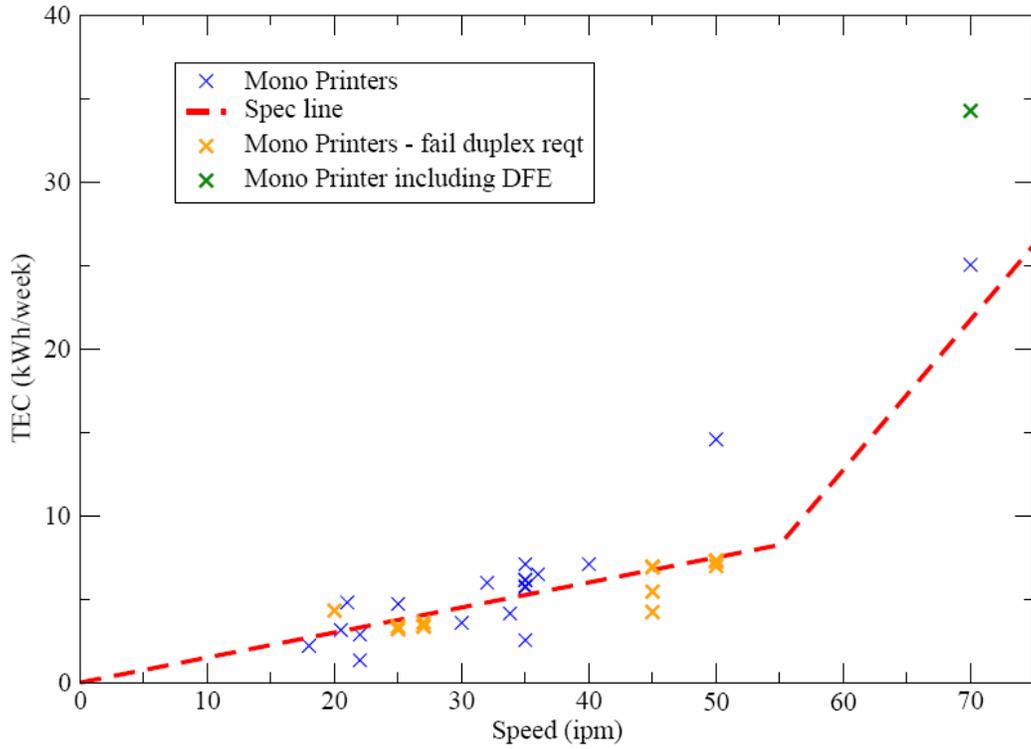


Figure 4. TEC Table 4 – Standard-size Color Printers

