ENERGY STAR® Qualified Imaging Equipment
Typical Electricity Consumption (TEC) Test Procedure

*This document presents the test procedure for the **Typical Electricity Consumption (TEC)** method for the Version 1.0 ENERGY STAR Imaging Equipment (IE) specification. The procedure is to be used to obtain and evaluate the TEC of Standard-size IE products such as copiers, digital duplicators, fax machines, multifunction devices (MFDs), and printers that use high-temperature technologies such as Electrophotography (EP) and Solid Ink (SI), and those that provide comparable functionality. It is not intended for low-temperature technologies such as conventional Ink Jet (IJ) or Impact, nor for Large-format or Small-format products. The key result of this test procedure is a value for typical weekly electricity consumption.*

This test procedure document describes the following:

1. Types of products covered;
2. Test parameters;
3. Job structure;
4. Measurement procedures;
5. Calculation methods; and
6. References.

The full TEC test procedure consists of this narrative document and the accompanying **Test Conditions and Equipment for ENERGY STAR Imaging Equipment Products**, which provides the ambient test conditions and equipment requirements that should be established when performing the energy or power measurements to determine a product's ENERGY STAR qualification status.

1. Types of Products Covered

The TEC test procedure is for the measurement of Standard-size products defined in Section 2, Table 1 of the **ENERGY STAR Program Requirements for Imaging Equipment**.

2. Test Parameters

This section describes the test parameters to use when measuring a product under the TEC test procedure. This section does *not* cover test conditions, which are outlined in **Test Conditions and Equipment for ENERGY STAR Imaging Equipment Products**.

Testing in Simplex
Products shall be tested in simplex mode. Originals for copying shall be simplex images.

Test Image
The test image is Test Pattern A from ISO/IEC standard 10561:1999. It shall be rendered in 10 point size in a fixed-width Courier font (or nearest equivalent); German-specific characters need not be reproduced if the product is incapable of doing so. The image shall be rendered on an 8.5" x 11" or A4 sheet of paper, as appropriate for the intended market. For printers and MFDs that can interpret a page description language (PDL) (e.g., PCL, Postscript), images shall be sent to the product in a PDL.

Testing in Monochrome
Color-capable products shall be tested making monochrome images unless incapable of doing so.

Auto-off and Network Enabling
The product shall be configured **as-shipped and recommended for use**, particularly for key parameters such as power-management default-delay times and resolution (except as specified below). All

information from the manufacturer about recommended delay times shall be consistent with the as-shipped configuration, including those in operating manuals, on Web sites, and that provided by installation personnel. If a printer, digital duplicator or MFD with print-capability, or fax machine has an Auto-off capability and it is enabled as shipped, it shall be disabled prior to the test. Printers and MFDs that are capable of being network-connected as-shipped[1] shall be connected to a network. The type of network connection (or other data connection if not capable of being networked) is at the discretion of the manufacturer, and the type used shall be reported. Print jobs for the test may be sent over non-network connections (e.g., USB), even on those units that are network-connected.

Product Configuration

Paper source and finishing hardware shall be present and configured as-shipped and recommended for use; however, their use in the test is at the manufacturer's discretion (e.g., any paper source may be used). Anti-humidity features may be turned off if user-controllable. Any hardware that is part of the model and intended to be installed or attached by the user (e.g., a paper feature) shall be installed prior to this test.

Digital Duplicators

Digital duplicators should be set up and used in accordance with their design and capabilities. For example, each job should include only one original image. Digital duplicators shall be tested at maximum claimed speed, which is also the speed that should be used to determine the job size for performing the test, not at the default speed as-shipped, if different. Digital duplicators shall be otherwise treated as printers, copiers, or MFDs, depending on their capabilities as shipped.

3. Job Structure

This section describes how to determine the number of ***images per job*** to use when measuring a product under the TEC test procedure, and ***jobs per day*** for the TEC calculation.

For purposes of this test procedure, the speed of the product that is used to determine the job size for the test shall be the manufacturer's reported maximum claimed simplex speed for making monochrome images on standard-sized paper (8.5" x 11" or A4), rounded to the nearest integer. This speed will also be used for reporting purposes as the Product Speed of the model, according to the **ENERGY STAR Program Requirements for Imaging Equipment**. The default output speed of the product, which shall be used in the actual testing, is not measured and may differ from the maximum claimed speed due to factors such as settings for resolution, image quality, printing modes, document scan time, job size and structure, and paper size and weight.

Fax machines should always test with one image per job. The number of images per job to be used for all other IE products shall be computed according to the following three steps. For convenience, Table 4 at the end of this document provides the resultant images per job computation for each integral Product Speed up through 100 images per minute (ipm).

1. Calculate the number of *jobs per day*. The number of jobs per day varies with Product Speed:
   - For units with a speed of eight ipm or less, use eight jobs per day.
   - For units with a speed between eight and 32 ipm, the number of jobs per day is equal to the speed. For example, a 14 ipm unit shall use 14 jobs per day.
   - For units with a speed of 32 ipm and above, use 32 jobs per day.
2. Calculate the nominal amount of *images per day*[2] from Table 1. For example, a 14 ipm unit shall use 0.50 x 14[2], or 98 images per day.

[1] The type of network connection shall be reported. Common types are Ethernet, 802.11, and Bluetooth. Common non-network data connection types are USB, Serial, and Parallel.

[2] Interim Images/Day in Table 4

Table 1. Imaging Equipment Job Table

Product type	**Rating to use**	**Formula** (images per day)
Monochrome (except fax)	monochrome speed	0.50 x ipm^2
Color (except fax)	monochrome speed	0.50 x ipm^2

3. Calculate the number of *images per job* by dividing the number of images per day by the number of jobs per day. Round down (truncate) to the nearest integer. For example, a figure of 15.8 indicates that 15 images should be made per job, rather than rounding to 16 images per job.

For copiers below 20 ipm, there shall be one original per required image. For jobs with large numbers of images, such as those for machines greater than 20 ipm, it may not be possible to match the number of required images, particularly with limits on the capacity of document feeders. Therefore, copiers 20 ipm and above may make multiple copies of each original as long as the number of originals is at least ten. This may result in more images being made than required. As an example, for a 50 ipm unit that requires 39 images per job, the test may be done with four copies of ten originals or three copies of 13 originals.

4. Measurement Procedures

To measure time, an ordinary stopwatch and timing to a resolution of one second is sufficient. All energy figures are to be recorded as watt-hours (Wh). All time is to be recorded in seconds or minutes. “Zero meter” references are to the "Wh" readout of the meter. Tables 2 and 3 outline the steps of the TEC procedure.

Service/maintenance modes (including color calibration) should generally not be included in TEC measurements. Any such modes that occur during the test shall be noted. If a service mode occurs during a job *other than the first*, that job may be dropped and a substitute job added to the test. In the case a substitute job is needed, do not record the energy values for the dropped job and add the substitute job immediately after Job 4. The 15-minute job interval shall be maintained at all times, including for the job that is dropped.

MFDs without print capability are to be treated as copiers for all purposes of this test procedure.

4.a. Procedure for Printers, Digital Duplicators and MFDs with Print Capability, and Fax Machines

Table 2. The TEC Test Procedure — Printers, Digital Duplicators and MFDs with Print Capability, and Fax Machines

Step	**Initial State**	**Action**	**Record** (at end of step)	**Possible States Measured**
1	Off	Plug the unit into meter. Zero the meter; wait test period (five minutes or more).	Off *energy* Testing Interval *time*	Off
2	Off	Turn on unit. Wait until unit indicates it is in Ready mode.	–	–
3	Ready	Print a job of at least one output image but no more than a single job per Job Table. Record time to first sheet exiting unit. Wait until the meter shows that the unit has entered its final Sleep mode.	Active0 *time*	–
4	Sleep	Zero meter; wait one hour.	Sleep *energy*	Sleep
5	Sleep	Zero meter and timer. Print one job per Job Table. Record time to first sheet exiting unit. Wait	Job1 *energy*	Recovery, Active,

Step	Initial State	Action	Record (at end of step)	Possible States Measured
		until timer shows that 15 minutes have elapsed.	Active1 *time*	Ready, Sleep
6	Ready	Repeat Step 5.	Job2 *energy*	*Same as above*
			Active2 *time*	
7	Ready	Repeat Step 5 (without Active time measurement).	Job3 *energy*	*Same as above*
8	Ready	Repeat Step 5 (without Active time measurement).	Job4 *energy*	*Same as above*
9	Ready	Zero meter and timer. Wait until meter and/or unit shows that unit has entered its final Sleep mode.	Final *time*	Ready, Sleep
			Final *energy*	–

Notes:

- Before beginning the test, it is helpful to check the power management default-delay times to ensure they are as-shipped, and to confirm that there is plenty of paper in the device.
- "Zero meter" references may be accomplished by recording the accumulated energy consumption at that time rather than literally zeroing the meter.
- Step 1 – The Off measurement period can be longer if desired to reduce measurement error. Note that the Off power is not used in the calculations.
- Step 2 – If the unit has no Ready indicator, use the time at which the power consumption level stabilizes to the Ready level.
- Step 3 – After recording the Active0 time, the remainder of this job can be canceled.
- Step 5 – The 15 minutes is from the job initiation. The unit must show increased energy consumption within five seconds of zeroing the meter and timer; it may be necessary to initiate the printing before zeroing to assure this.
- Step 6 – A unit that is shipped with short default-delay times might begin Steps 6-8 from Sleep.
- Step 9 – Units may have multiple Sleep modes so that all but the last Sleep mode are included in the Final period.

Each image shall be sent separately; they all may be part of the same document, but shall not be specified in the document as multiple copies of a single original image (unless the product is a digital duplicator, as specified in Section 2).

For fax machines, which only use one image per job, the page shall be fed into the unit's document feeder for convenience copying, and may be placed in the document feeder before the test begins. The unit need not be connected to a telephone line unless the telephone line is necessary for performing the test. For example, if the fax machine lacks convenience copying capability, then the job performed in Step 2 shall be sent via phone line. On fax machines without a document feeder, the page should be placed on the platen.

4.b. Procedure for Copiers, Digital Duplicators, and MFDs without Print Capability

Table 3. The TEC Test Procedure — Copiers, Digital Duplicators, and MFDs without Print Capability

Step	Initial State	Action	Record (at end of step)	Possible States Measured
1	Off	Plug the unit into meter. Zero the meter; wait test period (five minutes or more).	Off *energy*	Off
			Testing Interval *time*	
2	Off	Turn on unit. Wait until unit indicates it is in Ready mode.	–	–
3	Ready	Copy a job of at least one image but no more than a single job per Job Table. Record time to first	Active0 *time*	–

Step	Initial State	Action	Record (at end of step)	Possible States Measured
		sheet exiting unit. Wait until the meter shows that the unit has entered its final Sleep mode.		
4	Sleep	Zero meter; Wait one hour. If unit turns Off in less than one hour, record time and energy in Sleep, but wait full hour before moving to Step 5.	Sleep *energy* Testing Interval *time*	Sleep
5	Sleep	Zero meter and timer. Copy one job per Job Table. Record time to first sheet exiting unit. Wait until timer shows that 15 minutes has elapsed.	Job1 *energy* Active1 *time*	Recovery, Active, Ready, Sleep, Auto-off
6	Ready	Repeat Step 5.	Job2 *energy* Active2 *time*	*Same as above*
7	Ready	Repeat Step 5 (without Active time measurement).	Job3 *energy*	*Same as above*
8	Ready	Repeat Step 5 (without Active time measurement).	Job4 *energy*	*Same as above*
9	Ready	Zero meter and timer. Wait until meter and/or unit shows that unit has entered its Auto-off mode.	Final *energy* Final *time*	Ready, Sleep
10	Auto-off	Zero the meter; wait test period (five minutes or more).	Auto-off *energy*	Auto-off

Notes.

- Before beginning the test, it is helpful to check the power management default-delay times to ensure they are as-shipped, and to confirm that there is plenty of paper in the device.
- "Zero meter" references may be accomplished by recording the accumulated energy consumption at that time rather than literally zeroing the meter.
- Step 1 – The Off measurement period can be longer if desired to reduce measurement error. Note that the Off power is not used in the calculations.
- Step 2 – If the unit has no Ready indicator, use the time at which the power consumption level stabilizes to the Ready level.
- Step 3 – After recording the Active0 time, the remainder of this job can be canceled.
- Step 4 – If the unit turns off within this hour, record the Sleep energy and time at that point in time, but wait until a full hour has elapsed since the final Sleep mode was initiated before beginning Step 5. Note that the Sleep power measurement is not used within the calculation, and the unit may enter Auto-off within the full hour.
- Step 5 – The 15 minutes is from the job initiation. In order to be evaluated by this test procedure, products must be able to complete the required job per the Job Table within the 15-minute job interval.
- Step 6 – A unit that is shipped with short default-delay times might begin Steps 6-8 from Sleep or Auto-off.
- Step 9 – If the unit has already entered Auto-off before the start of Step 9, then the values for final energy and final time are zero.
- Step 10 – The Auto-off testing interval may be longer to improve accuracy.

Originals may be placed in the document feeder before the test begins. Products without a document feeder may make all images off of a single original placed on the platen.

4.c. Additional Measurement for Products with a Digital Front End (DFE)

This step applies only to products that have a DFE as defined in Section 1 of the **ENERGY STAR Program Requirements for Imaging Equipment**.

If the DFE has a separate mains power cord, regardless of whether the cord and controller are internal or external to the imaging product, a five-minute energy measurement of the DFE alone shall be made while the main product is in Ready mode. The unit must be connected to a network if network-capable as shipped.

If the DFE does not have a separate mains power cord, the manufacturer shall document the ac power required for the DFE when the unit as a whole is in a Ready mode. This will most commonly be accomplished by taking an instantaneous power measurement of the dc input to the DFE and increasing this power level to account for losses in the power supply.

5. Calculation Methods

The TEC value reflects assumptions about how many hours a day the product is in general use, the pattern of use during those hours, and the default-delay times that the product uses to transition to lower power modes. All electricity measurements are made as accumulated energy over time, and then converted to power by dividing by the length of the time period.

The calculations are based on imaging jobs being in two clusters each day with the unit going to its lowest power mode in between (as during a lunch break), as illustrated in Figure 2, which can be found at the end of this document. It is assumed that weekends have no usage, and no manual switching-off is done.

Final Time is the period of time from the last job being initiated to the start of the lowest power mode (Auto-off for copiers, digital duplicators and MFDs without print-capability; and Sleep for printers, digital duplicators and MFDs with print-capability, and fax machines) minus the 15-minute job interval time.

The following two equations are used for all product types:

Average Job Energy = (*Job2* + *Job3* + *Job4*) / 3
Daily Job Energy = *(Job1* × *2) + [(Jobs per Day – 2)* × *Average Job Energy)]*

The calculation method for **printers, digital duplicators and MFDs with print-capability, and fax machines** also uses the following three equations:

Daily Sleep Energy = *[24 hours – ((Jobs per day / 4) + (Final Time* × *2))]* × *Sleep Power*
Daily Energy = *Daily Job Energy + (2* × *Final Energy) + Daily Sleep Energy*
TEC = *(Daily Energy* × *5) + (Sleep Power* × *48)*

The calculation method for **copiers, digital duplicators, and MFDs without print-capability** also uses the following three equations:

Daily Auto-off Energy = *[24 hours – ((Jobs per day / 4) + (Final Time* × *2))]* × *Auto-off Power*
Daily Energy = *Daily Job Energy + (2* × *Final Energy) + Daily Auto-off Energy*
TEC = *(Daily Energy* × *5) + (Auto-off Power* × *48)*

The specifications of the metering equipment and ranges used in each measurement shall be reported. Measurements must be conducted so as to result in a total potential error of the TEC value of no more than 5%. Accuracy does not need to be reported for cases where the potential error is below 5%. When the potential measurement error is close to 5%, manufacturers should take measures to confirm that it complies with the 5% limit.

6. References

ISO/IEC 10561:1999. Information technology — Office equipment — Printing devices — Method for measuring throughput — Class 1 and Class 2 printers.

Table 4. Job Table Calculated

Speed	Jobs/ Day	Interim Images/ Day	Interim Images/ Job	Images/ Job	Images/ Day	Speed	Jobs/ Day	Interim Images/ Day	Interim Images/ Job	Images/ Job	Images/ Day
1	8	1	0.06	**1**	8	51	32	1301	40.64	**40**	1280
2	8	2	0.25	**1**	8	52	32	1352	42.25	**42**	1344
3	8	5	0.56	**1**	8	53	32	1405	43.89	**43**	1376
4	8	8	1.00	**1**	8	54	32	1458	45.56	**45**	1440
5	8	13	1.56	**1**	8	55	32	1513	47.27	**47**	1504
6	8	18	2.25	**2**	16	56	32	1568	49.00	**49**	1568
7	8	25	3.06	**3**	24	57	32	1625	50.77	**50**	1600
8	8	32	4.00	**4**	32	58	32	1682	52.56	**52**	1664
9	9	41	4.50	**4**	36	59	32	1741	54.39	**54**	1728
10	10	50	5.00	**5**	50	60	32	1800	56.25	**56**	1792
11	11	61	5.50	**5**	55	61	32	1861	58.14	**58**	1856
12	12	72	6.00	**6**	72	62	32	1922	60.06	**60**	1920
13	13	85	6.50	**6**	78	63	32	1985	62.02	**62**	1984
14	14	98	7.00	**7**	98	64	32	2048	64.00	**64**	2048
15	15	113	7.50	**7**	105	65	32	2113	66.02	**66**	2112
16	16	128	8.00	**8**	128	66	32	2178	68.06	**68**	2176
17	17	145	8.50	**8**	136	67	32	2245	70.14	**70**	2240
18	18	162	9.00	**9**	162	68	32	2312	72.25	**72**	2304
19	19	181	9.50	**9**	171	69	32	2381	74.39	**74**	2368
20	20	200	10.00	**10**	200	70	32	2450	76.56	**76**	2432
21	21	221	10.50	**10**	210	71	32	2521	78.77	**78**	2496
22	22	242	11.00	**11**	242	72	32	2592	81.00	**81**	2592
23	23	265	11.50	**11**	253	73	32	2665	83.27	**83**	2656
24	24	288	12.00	**12**	288	74	32	2738	85.56	**85**	2720
25	25	313	12.50	**12**	300	75	32	2813	87.89	**87**	2784
26	26	338	13.00	**13**	338	76	32	2888	90.25	**90**	2880
27	27	365	13.50	**13**	351	77	32	2965	92.64	**92**	2944
28	28	392	14.00	**14**	392	78	32	3042	95.06	**95**	3040
29	29	421	14.50	**14**	406	79	32	3121	97.52	**97**	3104
30	30	450	15.00	**15**	450	80	32	3200	100.00	**100**	3200
31	31	481	15.50	**15**	465	81	32	3281	102.52	**102**	3264
32	32	512	16.00	**16**	512	82	32	3362	105.06	**105**	3360
33	32	545	17.02	**17**	544	83	32	3445	107.64	**107**	3424
34	32	578	18.06	**18**	576	84	32	3528	110.25	**110**	3520
35	32	613	19.14	**19**	608	85	32	3613	112.89	**112**	3584
36	32	648	20.25	**20**	640	86	32	3698	115.56	**115**	3680
37	32	685	21.39	**21**	672	87	32	3785	118.27	**118**	3776
38	32	722	22.56	**22**	704	88	32	3872	121.00	**121**	3872
39	32	761	23.77	**23**	736	89	32	3961	123.77	**123**	3936
40	32	800	25.00	**25**	800	90	32	4050	126.56	**126**	4032
41	32	841	26.27	**26**	832	91	32	4141	129.39	**129**	4128
42	32	882	27.56	**27**	864	92	32	4232	132.25	**132**	4224
43	32	925	28.89	**28**	896	93	32	4325	135.14	**135**	4320
44	32	968	30.25	**30**	960	94	32	4418	138.06	**138**	4416
45	32	1013	31.64	**31**	992	95	32	4513	141.02	**141**	4512
46	32	1058	33.06	**33**	1056	96	32	4608	144.00	**144**	4608
47	32	1105	34.52	**34**	1088	97	32	4705	147.02	**147**	4704
48	32	1152	36.00	**36**	1152	98	32	4802	150.06	**150**	4800
49	32	1201	37.52	**37**	1184	99	32	4901	153.14	**153**	4896
50	32	1250	39.06	**39**	1248	100	32	5000	156.25	**156**	4992

Figure 1. TEC Measurement Procedure

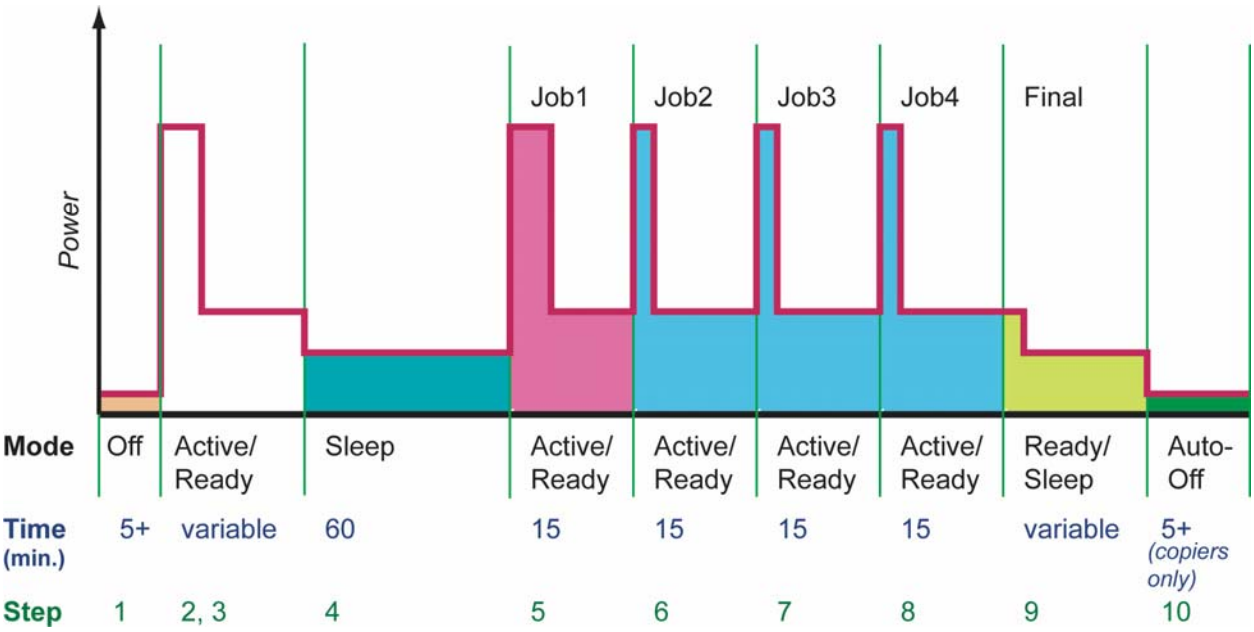

Figure 1 shows a graphic form of the measurement procedure. Note that products with short default-delay times may include periods of Sleep within the four job measurements, or Auto-off within the Sleep measurement in Step 4. Also, print-capable products with just one Sleep mode will not have a Sleep mode in the final period. Step 10 only applies to copiers, digital duplicators, and MFDs without print-capability.

Figure 2. A Typical Day

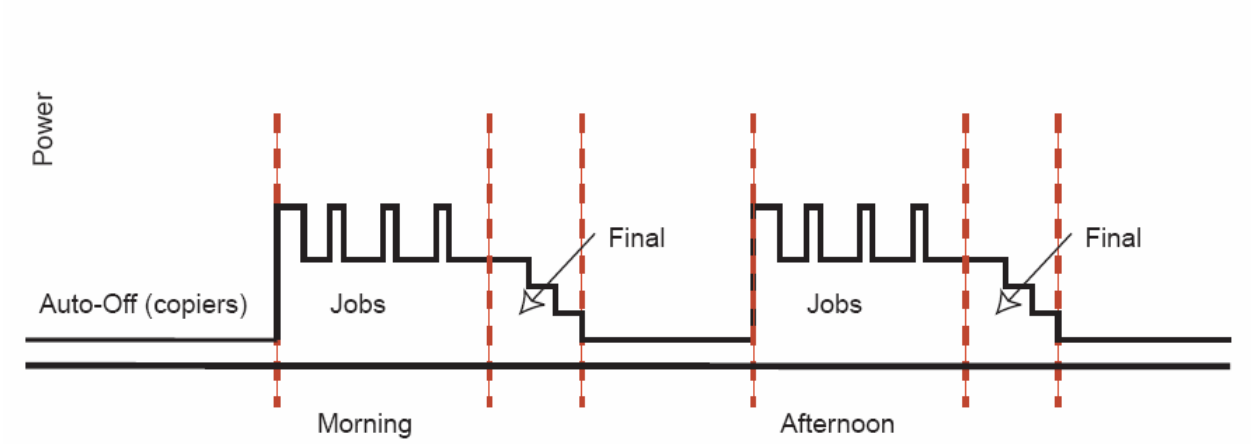

Figure 2 shows a schematic example of an eight-ipm copier that performs four jobs in morning, four jobs in afternoon, has two "final" periods and an Auto-off mode for the remainder of the workday and all of the weekend. An assumed “lunchtime” period is implied but not explicit. The figure is **not** drawn to scale. As shown, jobs are always 15 minutes apart and in two clusters. There are always two full “final” periods regardless of the length of these periods. Printers, digital duplicators and MFDs with print capability, and fax machines use Sleep rather than Auto-off as the base mode but are otherwise treated the same as copiers.