

## Dell Client Energy Savings Calculator

### ***Purpose:***

The Dell Client Energy Savings Calculator is intended to provide a tool that will allow customers to estimate the energy consumed by a computer over a year's time and the resulting cost to operate the system over that period. The calculator will reflect the end user usage profile and type of system used along with some amount of system configuration to generate the annual energy usage and cost estimates. The calculator provides the capability to select energy saving features and compare the cost savings they provide.

The calculator provides several options for the customer to configure system components to create a reasonable match between the customer's actual system and the one configured in the calculator. The calculator is intended to provide the customer with an estimate of annual energy consumption and energy costs for the system they own or intend to purchase.

The calculator includes a feature that reflects the time-out to sleep power states on systems equipped with power management options, such as Energy Smart. The energy calculator uses the programmed time-out values associated with the user selected power management options. These values are used to calculate the system energy consumption for example, a one-hour lunch period or morning and afternoon breaks that last 20 minutes. This way, the calculator accounts for the system entering into low power states during daily break periods thereby lowering the annual energy usage and cost estimates to reflect realistic system usage. Figure 2 shows the profile for a system entering into sleep states.

### ***General description of energy consumption in computer systems:***

Energy consumption of modern computers can vary widely depending on the application or task the computer is doing at the time. The task the computer is doing and software (both operating system and application being used) are major factors in the actual energy usage at any given time.

Dell's online energy savings calculator divides the possible workloads for a computer system into three primary categories of active use and two categories of non-active operation as described below:

1. **Hibernate/Off** – Lowest power state the system can achieve with the power cord plugged in. All primary system electronics have power removed with the exception of those circuits required to detect user power switch activation or system Wake events such as Wake On Lan.
2. **Sleep** – Low power state such as suspend to RAM where the system is not actively running code and the monitor is off. Much of the system is turned off except for memory, those circuits required to keep memory state, and those circuits needed for detecting user interaction and wake events. System is able to respond to user actions (i.e. Pressing power button, mouse or keyboard activity, or potentially network activity requests) and resume normal operation within only a few seconds.
3. **Idle** – computer is running and generally sitting with a fixed screen image and no user interaction. The system may be at the desktop or an open but idle application.

4. **Productivity** – The end user is performing typical office work, such as email, document creation or web browsing, using standard office type applications.
5. **Max Performance** – This represents the end user running some high end application, complex scientific calculations, modeling or 3D games that stresses the system causing significant increases in power consumption.

The systems will transition between these states based upon user interaction and or time-out conditions when the system is configured for time-outs to low power states.

## ***Computer Power Management***

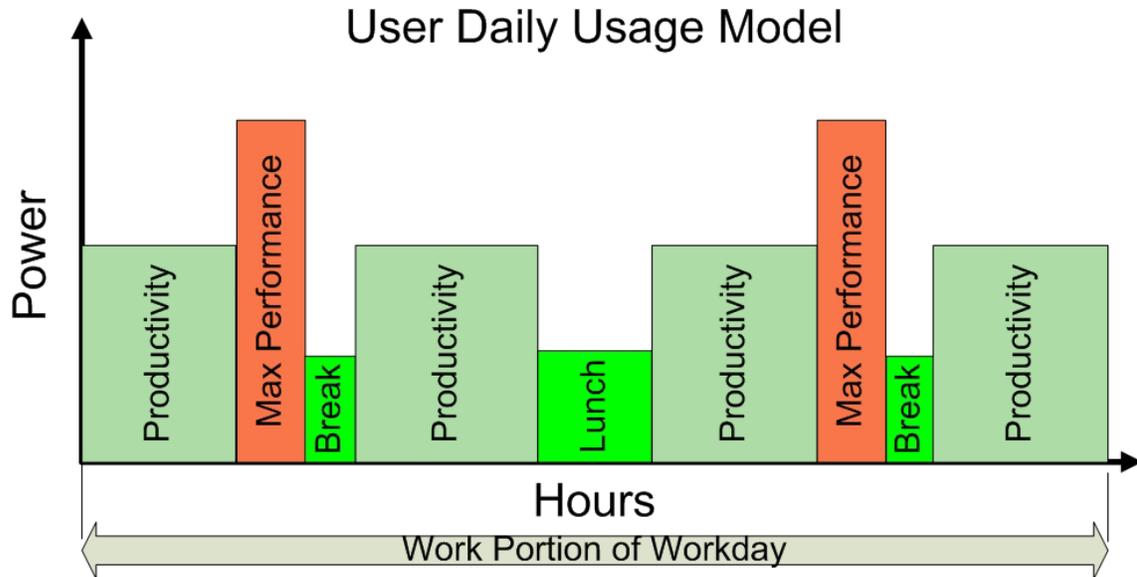
One of the most beneficial energy conservation methods for computer systems is the use of Computer Power Management (CPM). When enabled on a correctly configured system, CPM causes the computer to go into low power state (Sleep or Hibernate) after some period of system inactivity. Computers not configured for CPM will stay in a system idle state and will therefore consume more energy during these periods of inactivity.

The energy calculator provides granularity in selection of power management system time-out values and accurately reflects the time-outs Dell provides in the computer systems we ship.

Customers that provide their own operating system (OS) images or modify the standard image Dell usually provides must check their implemented time-out values against Dell values to determine which settings best reflect their own implementations.

## ***Estimating energy consumption:***

In order to calculate the energy used by a computer over the course of a year, it is necessary to first describe how the system will be used throughout that year. We define the year as a combination of work days and non work days. The user must therefore first define the typical work day and non-work day used in the calculations. The entered values are used to define a typical work day as shown in the Figure 1. The calculator defaults to running seven hours of productivity and one hour of maximum performance applications per day.



Break time periods to be programmed with default of 20 min. 2 per day  
Lunch time to be 1hour

**Figure 1**

Power consumption for Productivity applications are represented by measuring average power while running SysMark Office Productivity benchmarks and high performance workloads are represented by the average power while running 3DMark benchmarks.

Figure 1 shows the typical workday profile with time on the horizontal axis and block heights roughly representing system power during these periods of time. Break and Lunch are depicted as a fixed block height but actually have significant power variations over the time window if time out values are short enough. These periods will be better described in the next section.

The active day is broken into a morning and an afternoon session with a lunch break in between these two sessions. Morning and afternoon periods also allow for a 20 minute break which will allow for additional power reduction opportunities.

Morning and afternoon work periods consist of the following sequence.

1. Productivity work session
2. Max Performance work session
3. Break
4. Productivity Work session

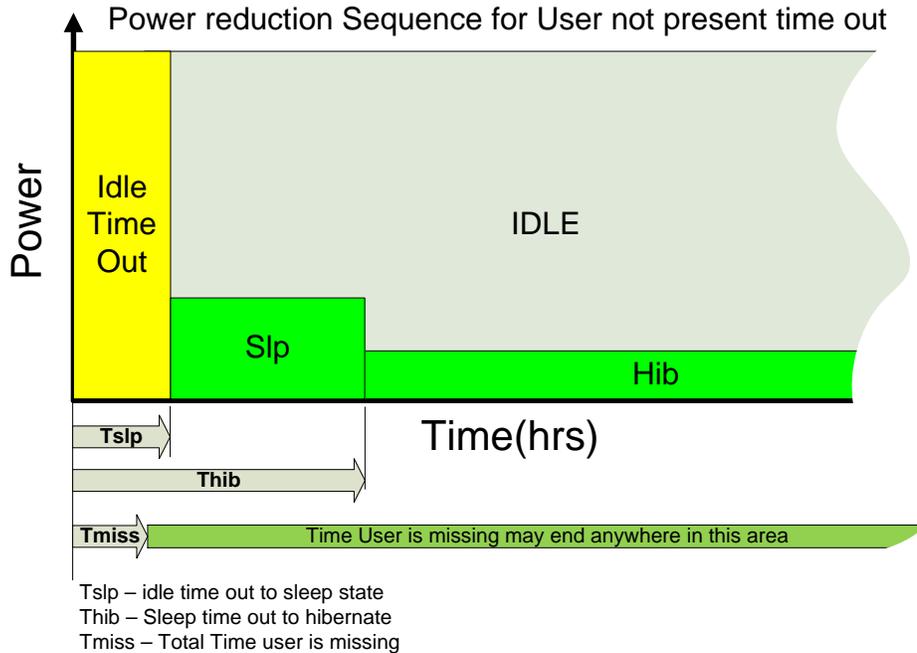
The morning and afternoon breaks provide the model with the ability to reflect some advantage for the shorter time out values of Energy Star and Energy Smart time out values and better reflect end users going to the restroom or having extended periods of reading or discussions during the day.

When power management is enabled in the online calculator this profile with the appropriate shorter time out values Dell implements in BIOS and OS settings are used in the annual energy consumption calculations.

## Idle time out to low power states

Current Microsoft® Windows® operating systems (XP, Vista®, and Windows 7) not only provide the ability to enter low power states but also allow the ability to control how soon systems perform these transitions as well as which power states are used for these transitions.

A typical transition sequence is shown below in Figure 2.



**Figure 2**

Systems without power management enabled will stay at the idle power level for the entire system inactivity time period.

CPM enabled systems will typically be configured to transition into low power states according to this profile by going into Standby or Sleep after the user has been inactive on the system for a set period of time ( $T_{SLP}$ ) and then later transitioning to hibernate or off if the system stays unused for a longer period of time ( $T_{HIB}$ ).

Dell provides default values for these time out functions for all products we ship. Shorter time out values provide more energy savings (system spends more time in low power states) at the expense of potential inconvenience (user has to wait longer for system to be ready to use when he returns). Dell provides more aggressive settings (shorter time out values) for systems that meet Energy Star requirements and for Dell Energy Smart platforms.

Table 1 below shows the power management time out values used in the calculator.

	None	Default	Energy Smart	Energy Star
Time out to sleep (hrs)	Never	1	0.25	0.25
Time out to hibernate (hrs)	Never	Never	4	18
Monitor Time Out	0.5	0.5	0.25	0.25

**Table 1**

Non-Work days are represented by using either the idle, sleep, or hibernate power for the entire 24 hours for the cases of no CPM and CPM enabled respectively.

The number of work days in a year is defaulted to 250 days.

## Energy Usage Calculation

Dell's approach to calculating annual energy consumption is to define a usage profile for a typical work day and one for a non-work or non-use day and calculate the energy consumption for each of these days. Summing these values over the number of work and non-work days in a year yields the estimated annual energy consumption of the system.

### Work Days

The work day is calculated as follows according to Equation 1.

**Equation 1**      $E_{WORKDAY} = E_{PROD} + E_{MAXPERF} + E_{LUNCH} + E_{BREAK}$

Where:

$E_{WORKDAY}$	=	Total energy consumed during typical work day
$E_{PROD}$	=	Total energy consumed during productivity applications
$E_{MAXPERF}$	=	Total energy consumed running max performance applications
$E_{LUNCH}$	=	Total energy consumed over lunch period
$E_{BREAK}$	=	Total energy consumed during breaks

Each of these energy units is calculated by multiplying the average power of the system during that period by the total time the system was in that power state. This is relatively simple for the productivity and max performance periods but is more difficult for the lunch and break times.

During lunch and break times one must factor in the time outs to lower power states relative to the length of time of the break/lunch period. If time outs are very short the unit stays in the idle state and if long enough it will transition to the hibernate state. Sleep times and hibernate times need to be reflected in these calculations and are configured by the user through the power management selections and described above in Table 1.

### Non-Work Days

Non-work days are calculated assuming the system is in the same power state for the entire 24-hour period. The power state used will be determined by the power management setting selected. No power management will keep the system in the idle state. Other selections will have the system enter either the sleep or hibernate state depending on the corresponding time out values.

## System Power Consumption measurements and Calculations

One significant problem with creating a tool such as this calculator is how to acquire the data necessary to calculate the annual energy consumption. With 5 selection boxes and an average of 5 selection options each, the number of possible system configurations addressed by the calculator is over three thousand per system chassis. Testing all these options using the described benchmark applications would require about 12000 test hours to complete.

In order to get around this test time dilemma Dell developed a mathematical model for system power consumption with systems and selection options represented as typical power consumption values. This data is collected on and checked against a select subset of the total possible system configurations.

It is believed that this method provides the end users with much more relevant information than providing only a few system configurations that potentially do not match the systems being purchased while providing a more manageable test matrix.

## Usage related drop down boxes

The drop down boxes dealing with defining the daily usage profile (hours per day doing productivity, hours doing max performance, number of work days per year and energy cost) apply to all three systems in the display window. Configuration options within a system window affect only that particular system.

## Energy Savings Variability

The energy calculator is intended to be a tool to help customers:

- Understand the energy consumption in client products
- Provide numerical values that can be used in typical heat loading calculations and total cost of ownership calculations
- Identify to end users the energy consequences of the system configurations they select
- Point out advantages of implementing power management in client systems.
- Demonstrate advantages in annual energy costs of Dell energy efficient configuration options

The calculator provides estimates based upon the above methodology but is not exhaustive in its scope or accuracy. It does not include every possible system configuration option that a user has when purchasing a product. Some of the configuration options it does provide have fewer choices than are available when the system is purchased.

Any given system may consume more or less energy than estimated by this calculator due to the variation in power consumption of each of the individual components that make up the final product.

## Default Values

The calculator provides end users with the ability to configure the usage profile of the product. This allows the end user to describe the typical work load and annual usage of the product in his environment.

The calculator populates many fields with default values. These default values are based on Dell usability experience and represent the typical usage of our products in an office environment. The default values simulate an eight hour work day with a one hour lunch at mid-day and morning and afternoon breaks. The work load for the day defaults to seven hours of office type applications which simulates what people usually do with their computers such as email, document creation, Web browsing, etc. One hour of high performance applications is included to simulate background virus scan, software update or other periodic high computation needs. The addition of high performance usage in the default configuration also provides visibility in the annual energy costs of the high performance operating power of the system.

The work day definition method is believed to be much easier to understand and configure for end users than a list of system power states and hours per year spent in each state.

The default number of work days in a year is 250. This represents 50 typical work weeks per year.

Table 2 below shows the default values used in the calculator.

These values along with the power management time out values in Table 1 above will be used for defining the estimated annual energy consumption of Dell client products.

	Default Values
Hours per Day running Office Applications	7
Hours per day running High Performance Applications	1
Number of Work days per year	250
Electricity Cost (\$/kWh)	0.10

**Table 2**

## Savings Calculations

Estimated energy savings are calculated for columns 2 and 3 relative to the baseline configuration in column 1 of the tool. (Please clarify the preceding sentence to indicate which Table, Chart or Figure you are referring to for each of the Columns.) Savings are calculated by subtracting the current system annual energy usage from the baseline system annual energy usage. Estimated annual savings in local currency is calculated by then applying the current electricity cost factor to the calculated savings in kilowatt hours. (Legal assumes this changes for each region and is not strictly based upon US energy costs and savings)

Estimates of CO<sub>2</sub> emissions avoided and auto travel miles avoided are calculated using conversion factors found at the EPA Greenhouse Gas Equivalencies Calculator.<sup>1</sup>

The calculator first calculates the amount of CO<sub>2</sub> emissions avoided based upon the annual energy savings using Equation 2 below.

### Equation 2

$$7.18 \times 10^{-4} \text{ metric tons CO}_2 / \text{kWh}$$

Equation 3 describes the combination of conversion factors from the EPA web site used to determine the conversion factor for auto travel avoided in miles.

### Equation 3

$$7.18 \times 10^{-4} \text{ metric tons CO}_2 / \text{kWh} * 1/8.81 \times 10^{-3} \text{ gallons of gasoline /metric ton CO}_2 * 19.7 \text{ miles per gallon}_{\text{car/truck average}} = 1.61 \text{ miles avoided per kWh}$$

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<sup>1</sup> <http://www.epa.gov/cleanenergy/energy-resources/calculator.html>