

Country: USA

Technology: Dishwashers

Sub Category: with a capacity of between six and sixteen place settings

Introduction

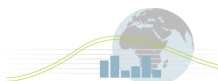
The first stage in the Mapping and Benchmarking process is the definition of the products, i.e. clearly setting the boundaries that define the products for use in data collection and analysis. This ensures that comparison between the participating countries is done against a specific and consistent set of products.

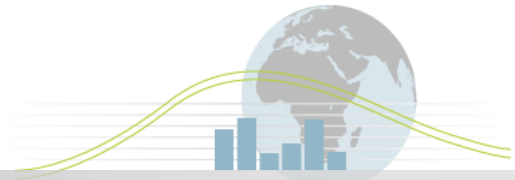
The summary definition for this product is:

| M&B Category | Description |
|--|---|
| Definition and Scope | <p><i>A machine which cleans, rinses, and dries dishware, glassware, cutlery, and, in some cases, cooking utensils by chemical, mechanical, thermal, and/or electric means, normally through the use of water and detergent. The machine may or may not have a specific drying operation at the end of the programme.</i></p> <p>The scope is to primarily include:</p> <ul style="list-style-type: none"> • Single door built-in (this includes freestanding units in European definitions), portable and drawer-type dishwashers; • Both non-soil-sensing and soil-sensing unit. <p>The scope will <i>exclude</i>:</p> <ul style="list-style-type: none"> • Table top dishwashers (with fewer than 6 place settings) |
| Rated Capacity | 6-16 place settings |
| Other Characteristics to be Noted | <p>Wash Cycle Time</p> <p>Cleansing Performance</p> <p>Drying Performance</p> <p>Standby Functionality and Power Levels (Delayed Start, End of Cycle and Off)</p> <p>Load Type</p> |

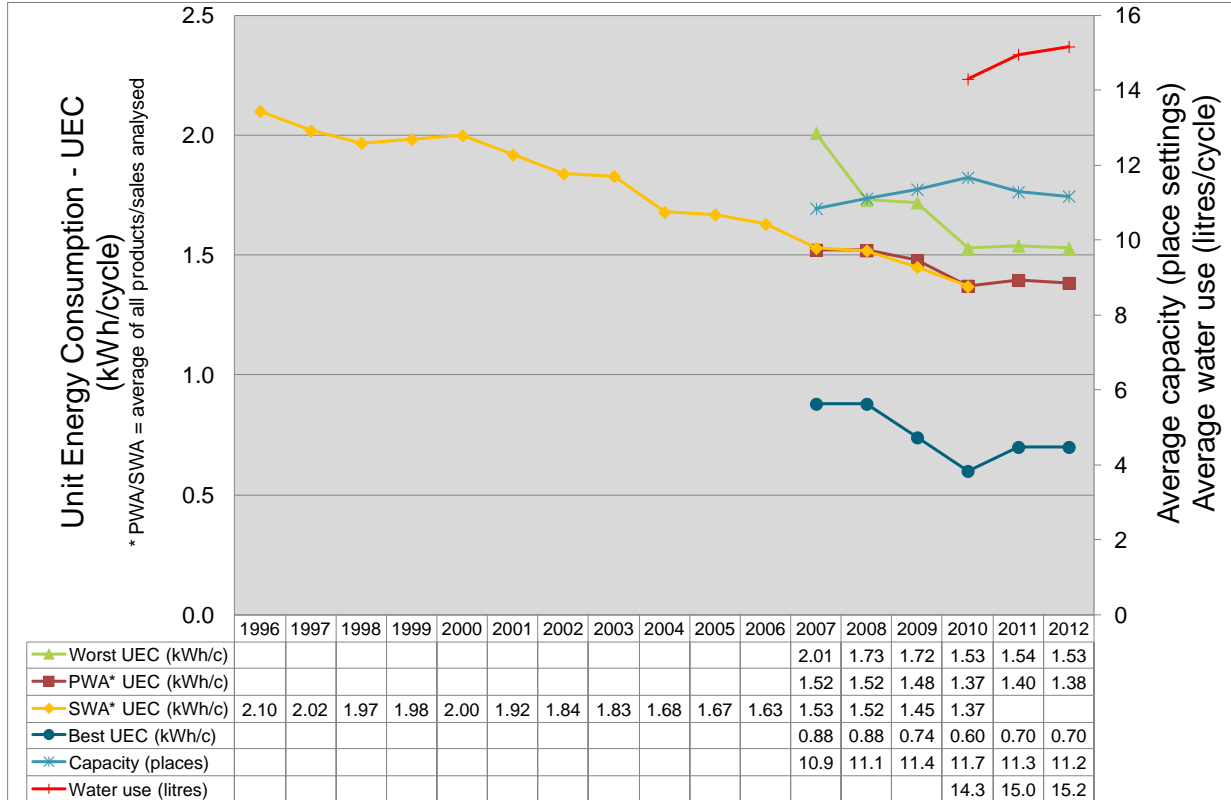
The detailed product definition can be found at the Annex website:

<http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=11>



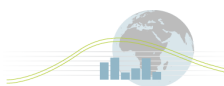


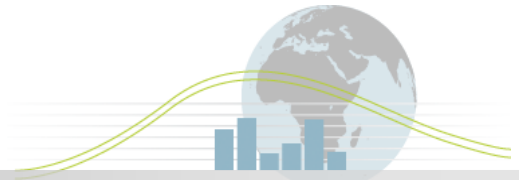
Unit Energy Consumption (UEC) of dishwashers in the USA



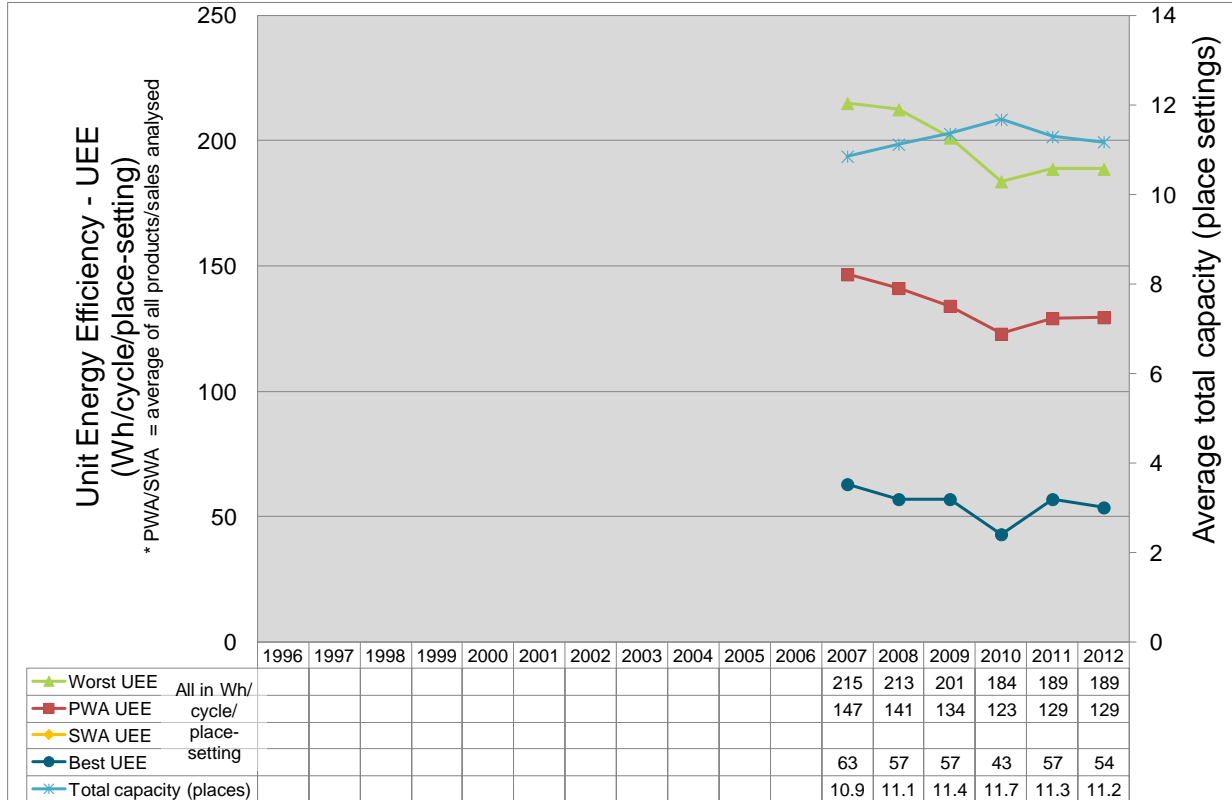
Key notes on Graph (see notes section 1)

- The majority of data presented is drawn from a database collated by California Energy Commission (CEC). The CEC database contains no sales information and so Unit Energy Consumption (UEC) is presented as a product weighted average (PWA) of all products in the in the CEC database. Values for Worst and Best UEC are also derived from the CEC database as are product weighted averages for capacity/water consumption.
- The sales weighted average (SWA) UEC is in fact a shipment weighted average published by the Association of Home Appliance Manufacturers (AHAM).
- Both datasets are considered representative of the USA market. However, it should be noted that:
 - it is unclear what proportion of the market the CEC data set covers, but it is considered representative of the entire market as data is consistent with both the AHAM dataset (in 2007-2010) and the full market results from the similar Canadian market.
 - the AHAM data is believed to include table-top models which are excluded from this analysis. However, the market share of these models is believed to be very low and so the impact on the overall market averages should be negligible.
- The 'Worst UEC' is the UEC of the product at the 'worst 5%' point of a ranked list of products in the dataset.
- All capacity and water consumption values listed are product weighted averages.
- The CEC database only had water consumption data for 32-35% of models by year. This subset has an unknown skew. The average therefore may not reflect the actual water consumption of units available on the market.



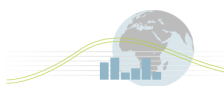


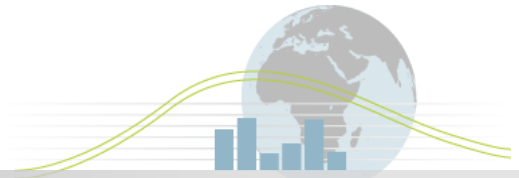
Unit Energy Efficiency (UEE) of dishwashers in the USA



Key notes on Graph (see notes section 1)

- Unit Energy Efficiency (UEE) is calculated for each model by dividing its Unit Energy Consumption (UEC) by its capacity. Averages are then derived from these UEE values.
- The data presented is drawn from a database collated by California Energy Commission (CEC). The CEC database contains no sales information and so UEE is presented as a product weighted average (PWA) of all products in the in the CEC database. Values for Worst and Best UEE are also derived from the CEC database as is the product weighted average capacity.
- No sales weighted average data was available.
- The CEC dataset is considered representative of the USA market. However, it should be noted that it is unclear what proportion of the market the CEC data set covers, but it is considered representative of the entire market as data is consistent with the full market results from the very similar market in Canada.
- The 'Worst UEE' is the UEE of the product at the 'worst 5%' point of a ranked list of products in the dataset.





Energy Consumption of the installed stock of dishwashers in the USA

No data on the total consumption of all dishwashers installed in the stock in the USA was available to the Annex at the time of publication. However, the table below shows the annual energy use distributions of installed dishwashers for the three years in which AHAM provided data (2008-2010, standard-sized only) as well as DOE's forecast for 2013 (the effective date of new consensus standards).

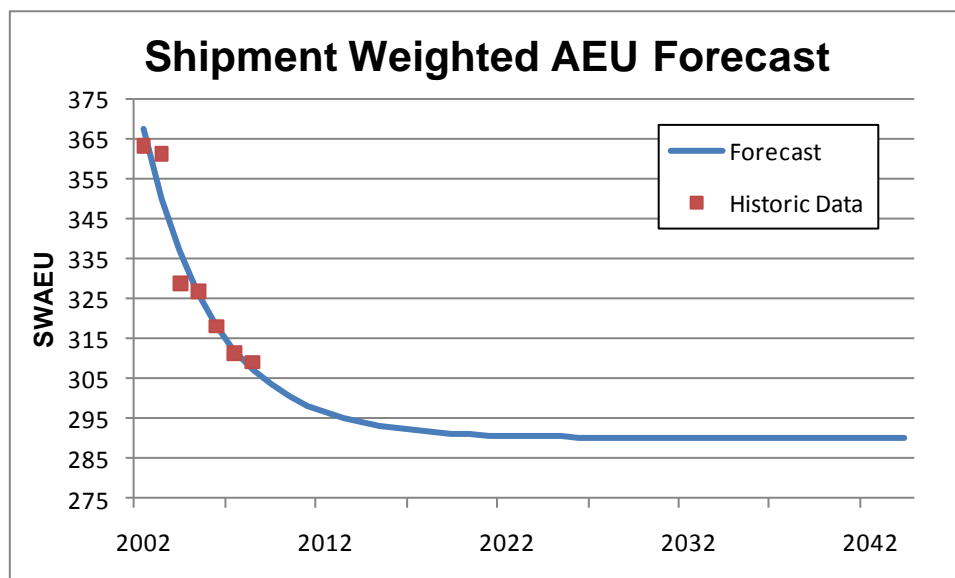
Dishwasher Base-Case Efficiency Distributions

| Annual Energy Use (kWh) | Standard-Sized | | | |
|-------------------------|-----------------------|-----------------------|-----------------------|------------------------------------|
| | 2008 market share (%) | 2009 market share (%) | 2010 market share (%) | Base Case for US Standard 2013 (%) |
| 355 (Baseline) | 56.4 | 38.7 | 3.8 | 3.8 |
| 324 | 30.0 | 41.1 | 51.8 | 32.3 |
| 307 | 7.8 | 8.9 | 21.5 | 28.0 |
| 295 | 5.8 | 5.2 | 15.3 | 16.4 |
| 234 | 0.0 | 4.0 | 5.0 | 13.8 |
| 180 | 0.0 | 2.0 | 2.5 | 5.6 |
| SWAEU | 338.4 | 326.5 | 309.0 | 295.1 |
| SWWU | 6.04 | 5.75 | 5.21 | 4.83 |

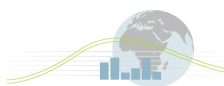
SWAEU: Shipment weighted annual energy use (kWh/year)

SWWU: Shipment weighted water use (gallons)

To determine the base-case efficiencies after 2018, DOE used the exponential function shown in the figure.



Standard-Sized Dishwashers: Base Case Efficiency Forecast



Major Policy Interventions (see notes section 3)

The USA has three primary federal policy¹ interventions related to dishwashers:

- **Minimum Energy Performance Standards:** Based on the 1987 National Appliance Energy Conservation Act, which established the first uniform national efficiency standard for residential dishwashers and gives the Department of Energy the ability to place establish or amend energy standards on various consumer products. The current standards for dishwashers are defined in the Code of Federal Regulations (CFR) at 10 CFR Part 430.32(f)(3).

MEPS for dishwashers first took effect in 1994 with a revision in 2010. Strengthened standards were announced in May 2012 with an effective date 30 May 2013.

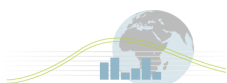
- **Mandatory Labelling: EnergyGuide**, which provides an indication of comparative energy consumption and an estimate of costs to the consumer. First introduced in 1980, with a redesigned label (featuring more prominently displayed costs estimates being announced in 2007).
- **Voluntary Labelling: ENERGY STAR** which seeks to help consumers identify higher performing products that meet a range of performance standards. In the case of dishwashers, at the time of this report, the ENERGY STAR criteria were approximately 4% below federal standards for energy consumption and 15% below federal standards for water consumption. Dishwashers with the ENERGY STAR label were on average 10% more efficient than those without it.

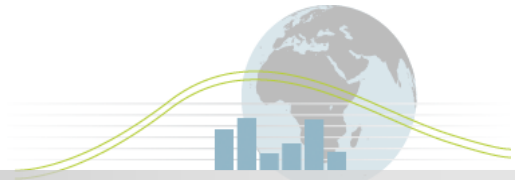
ENERGY STAR was introduced for dishwashers in 1996. The most recent addition of the ENERGY STAR criteria came into effect on 20-1-2012. In 2009, it was estimated that at least 68% of US dishwashers carried the ENERGY STAR label².

In addition there are a large number of regional, state and local policy interventions by a large number of bodies. Such intervention range from state based MEPS through major procurement activities (eg utility DSM programmes), often driven by requirements in states such as California and/or based on ENERGY STAR qualified products.

¹ The majority of policy information sourced from US DOE
http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/67

² http://www.energystar.gov/index.cfm?c=manuf_res_pt_appliances#asd





Cultural Issues (see notes section 4)

In 2008, dishwashers were installed in roughly 61% of all households in the US. Detailed information on energy use within US households, with associated trends and drivers can be found in the Energy Information Administration's "Residential Energy Consumption Survey Home Energy Uses and Costs"³.

Specific aspects of dishwasher use in the USA that are relevant to the energy consumption figures include the fact that almost all dishwashers in the US use a hot water line connection, meaning that hot water is used in all parts of the cycle. Additionally, a significant percentage of dishwashers come with a powered drying functionality, although as of 1989, these units must also have the option to use an unheated dry.

³ Residential Energy Consumption Survey (RECS) <http://www.eia.gov/consumption/residential/>

Section 1. Unit Energy Consumption and Unit Energy Efficiency Graphics

1.1 Test methodologies

1.1.1 Regulations

1.1.1.1 Summary of Changes

A summary of the regulatory framework is as follows⁴:

- May 14, 1991, DOE final rule establishing the first set of performance standards for dishwashers. 56 FR 22250. Effective May 14, 1994 (within this rule, standard and compact dishwashers were classified by unit dimensions rather than rated capacity).
- A 2001 Final rule (66 FR 65091) amended the dishwashers test procedure found at 10 CFR part 430, subpart B, appendix C to allow the use of place setting capacity instead of unit width; reduced the representative average number of use cycles per year from 322 to 264; and included reference to the measurement of Standby Power. Effective June 17, 2002
- In a 2003 final rule (68 FR 51887), the DOE again revised the test procedure to add a method to measure standby power; and a reduction in the average-use cycles per year from 264 to 215. The test procedure includes provisions for determining estimated annual energy use (EAEU), estimated annual operating cost (EAOC), energy factor (EF) expressed in cycles per kilowatt-hour (kWh), and water consumption expressed in gallons per cycle. In addition, perhaps the most significant revision in this rulemaking was to add provisions to measure the performance of soil-sensing dishwashers (i.e., using a soiled load for those models.)
- Most recently, in a 2012 final rule (77 FR 65942), the DOE established new test procedures at 10 CFR part 430, subpart B, appendix C1 with a number of additions, including:
 - adding new provisions for measuring standby and off mode energy consumption;
 - incorporating by reference the updated industry test standard ANSI/AHAM DW-1-2010;
 - a measure of the annual energy and water use associated with periodic water softener system regeneration;
 - clarifies various aspects of the test procedure and definitions within it;
 - amends aspects of the test procedure including specifying the use of two pre-conditioning cycles and changing parts of the load content.

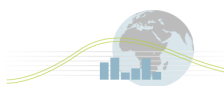
1.1.1.2 Test Methodology

Test methods referenced are primarily:

- ANSI/AHAM DW-1-1992; and
- ANSI/AHAM DW-1-2010.

The test method used for the data included in this analysis is assumed to be the DOE test procedure at 10 CFR part 430, subpart B, appendix C, which references ANSI/AHAM DW-1-1992, the key characteristics of which are described below.

⁴ There were also earlier amendments (in 1983, 1984 and 1987) since the original test methodology in 1977 but these are not likely to have impacted the data presented and so these are not described here.



1.1.1.3 Test Conditions:

General approach: The DOE test procedure provides a methodology for testing the energy consumption based on a single unit. No comparative unit is required as the tests/regulations do not require declaration (or set a minimum) wash or dry performance.

Rated Capacity: The rated capacity of the dishwasher is defined as the whole number of complete place settings plus the corresponding serving pieces which can be cleaned and dried when loaded in accordance with the manufacturer's instructions.

A place setting (a set of crockery, glass and cutlery for use by one person) is defined in ANSI/AHAM DW-1-1992 as: one cup, one saucer, one dinner plate, one bread and butter plate, one fruit bowl, one glass, one dinner fork, one salad fork, one knife, and two teaspoons. The corresponding serving pieces are: one platter, two serving bowls, two serving spoons, and one serving fork.

ANSI/AHAM DW-1-1992 includes the specific brands and model numbers for the items in the test load, as well as sourcing information.

Test load: ANSI/AHAM load type (see ANSI/AHAM DW-1-1992). Specified loads consist of the six serving pieces, plus: eight place settings for all standard machines, four place settings for soil-sensing compact dishwashers (since 2003), or the rated number of place settings for non-soil sensing compact dishwashers.

Soiling Agent: Since 2003, for models with soil sensing, soiling follows the 2003 update of the ANSI/AHAM DW-1-1992 specification:

- Dinner plates: Quarter sections of egg yolk, mashed potatoes, ground beef/tomato paste mix, and red raspberry preserves with coffee grounds
- Bread and butter plates, dessert bowls: Half sections of oatmeal and creamed corn
- Coffee cups and saucers: Coffee
- Glasses: Tomato juice

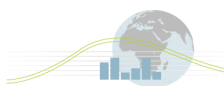
Three tests are undertaken at different levels of soiling with weighted averages calculated for the unit's annual energy consumption and per-cycle water consumption.

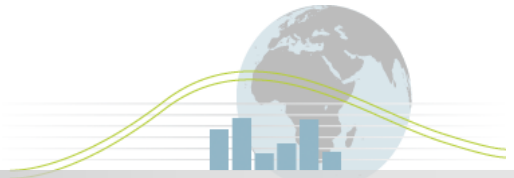
For models without soil sensing, a single test cycle is conducted with a clean load.

Cycle, Programme and Time: A cycle is defined as any complete sequence of operations capable of being pre-set before initiation of machine operation. A cycle can include variations in, or combinations of, the functions of washing, rinsing, and drying.

Normal cycle is defined as: the cycle recommended in the manufacturer's instructions for completely washing a full load of normally soiled dishes, including the powered-dry feature (if such a feature is provided).

Truncated normal cycle is defined as the normal cycle, interrupted to eliminate the powered-dry feature, after termination of the last rinse operation. (Note that this is relevant in the calculation of energy consumption)





The cycle time is not formally defined but it can be inferred to be the time measured from the initiation of the program (excluding any user programmed delay) until all activity ceases. Activity is considered to have ceased when the power consumption reverts to a steady state condition that persists indefinitely without user intervention. If there is no activity after the end of the program, the cycle time is equal to the program time (again adjustments are made for a truncated cycle).⁵

Cleansing Performance: The DOE test procedures in appendix C or appendix C1 do not include provisions for the measurement of the dishwashers cleansing performance, nor are there any mandatory or voluntary limits or labelling requirements for cleansing performance. The ENERGY STAR program is currently in the process of developing a test method for evaluating the cleaning performance of dishwashers.

Drying Performance: No test method prescribed to measure drying performance and no requirements to measure or disclose the information.

Stand-by: The measurement and incorporation of Standby into US regulations was first made in the Department of Energy's Final Rulemaking (66 FR 65091) – effective June 17, 2002.

This defined “Standby mode” as the lowest power consumption mode which cannot be switched off or influenced by the user and that may persist for an indefinite time when the dishwasher is connected to the main electricity supply and used in accordance with the manufacturer's instructions.

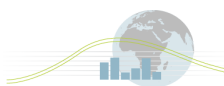
In the 2012 final rule, the option to separately measure standby power in three modes (delayed start, cycle finished and off/inactive) was considered. This proposal was however rejected favouring instead the continued measurement of inactive mode and off mode power consumption only, allocating that power consumption to all hours spent in the low-power modes combined.

Water consumption: The water consumption is the total (hot and cold) water delivered to the machine during the entire test cycle.

As with energy, from 2003 water consumption in soil sensing machines is measured over three varying soil loads and weighted appropriately based on empirically derived consumer usage patterns and the measurement can be considered comparable to the water measurement in non-soil sensing units.

Embodied Water Energy/ Nominal Water Inlet Temperature: Nominal water inlet temperature is 10°C for water-heating dishwashers to be hooked up to a cold water supply, and 48.9°C for water-heating dishwashers to be hooked up to a hot water supply with internal heating. Adjustments for embodied energy in the water are made for supplies that vary from this temperature. There are also provisions to test at 60 °C for those units that are rated at that inlet water temperature (140 °F).

⁵ As of December, 2012, the DOE test procedure in appendix C1 has defined the end of cycle as being indicated to the consumer by means of a display, indicator light, or audible signal. A fan could continue to circulate air for a finite period of time after the end of the cycle before the machine reverts to a steady state that could persist for an indefinite period of time. 77 FR 65942 (Oct. 31, 2012).



Water Hardness: Not controlled as “normal” water supplied to the test facility through mains is specified for use.

Detergent: Half of the quantity and formula proscribed in ANSI/AHAM DW-1-1992.

Noise: Not measured in the test.

Ambient Temperature: 23.9°C +/- 2.8°C.

Order of Tests: A preconditioning operation is performed prior to the test.

Since 2003, energy, water and duration for non-soil sensing dishwashers have been recorded during a single full cycle, or during three full cycles with varying soil levels (in order of heavy soil, medium soil, light soil) for soil-sensing dishwashers.

Energy Consumption:

Energy Consumption Per Cycle (E_C)

$E_C = (\text{machine energy used in the wash and dry cycle plus embodied water temperature energy})^6$

Energy used in the dry function is adjusted for units with an option for truncated dry cycle such that:

$E_C = (\text{machine energy used in the wash and dry cycle plus embodied water temperature energy}) - (\text{dry energy}/2)$

(note that drying energy is given the name E_D)

Annual Stand-by Energy Consumption (S)

$S = \text{hours per year in standby} \times \text{average measured standby power}$

Where

$\text{Hours per year in Standby} = 8766 - (\text{cycle time} * 215)$

(8766 is the number of hours in year accounting for leap years and 215 is empirically derived number of wash cycles per year. Note again that the drying time element is reduced by half for units with an option for truncated cycle).

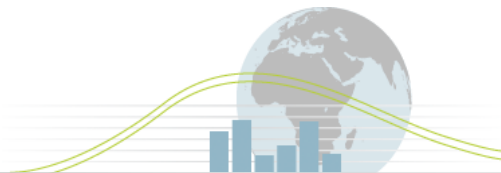
Total Annual Energy Consumption (TEAC)

$TEAC = 215 \times \text{Energy Consumption per Cycle } (E_C) + \text{Annual Stand-by Energy Consumption } (S)$

1.2 Product Classifications

The test method includes the following definitions:

⁶ There are several variations of this definition for specific functionality e.g. soil sensing, but this is the primary derivation.



- Dishwasher — means a cabinet-like appliance which with the aid of water and detergent, washes, rinses, and dries (when a drying process is included) dishware, glassware, eating utensils, and most cooking utensils by chemical, mechanical and/or electrical means and discharges to the plumbing drainage system.
- Compact dishwasher — a dishwasher that has a capacity of less than eight place settings plus six serving pieces as specified in ANSI/AHAM DW-1-1992 (incorporated by reference; see § 430.3), using the test load specified in section 2.7.1 of [appendix C].
- Non-soil-sensing dishwasher — a dishwasher that does not have the ability to adjust automatically any energy consuming aspect of a wash cycle based on the soil load of the dishes.
- Power dry — the introduction of electrically generated heat into the washing chamber for the purpose of improving the drying performance of the dishwasher.
- Soil-sensing dishwasher — a dishwasher that has the ability to adjust any energy consuming aspect of a wash cycle based on the soil load of the dishes.
- Standby mode — the lowest power consumption mode which cannot be switched off or influenced by the user and that may persist for an indefinite time when the dishwasher is connected to the main electricity supply and used in accordance with the manufacturer's instructions.
- Water-heating dishwasher — a dishwasher that, as recommended by the manufacturer, is designed for heating cold inlet water (nominal 10 °C [50°F]) or water with a nominal inlet temperature of 49 °C (120°F) and provides internal water heating to above 49 °C (120°F) in at least one wash phase of the normal cycle.

1.3 Data sources

All product weighted data and best/worst products are based on the California Energy Commission database⁷.

All sales weighted data is in fact the *shipment* weighted data provided by AHAM to the US Department of Energy's Technical Support documents energy efficiency program for consumer products and commercial and industrial equipment⁸.

The respective datasets are believed to be representative in part because the results are consistent with each other and with the Canadian market data which is from a very similar market and based on a compulsory registration database.

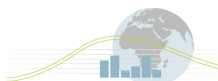
The number of models and sales (shipments) analysed by product category are presented in the tables below.

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Products in CEC dataset | - | - | - | - | - | - | - | - |
| Products analysed | - | - | - | - | - | - | - | - |
| % products included | | | | | | | | |
| Shipments in AHAM dataset | 4,316,828 | 4,655,200 | 5,073,023 | 5,424,973 | 5,827,678 | 5,627,373 | 6,206,792 | 6,428,351 |
| Sales analysed | 4,316,828 | 4,655,200 | 5,073,023 | 5,424,973 | 5,827,678 | 5,627,373 | 6,206,792 | 6,428,351 |
| % Sales included | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

⁷ Current models taken from <http://www.appliances.energy.ca.gov/SearchResults.aspx> (advanced search)

Historical data from: http://www.energy.ca.gov/appliances/database/historical_excel_files/Dishwashers/

⁸ 2000-2010 data taken from the 2012 report (<http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0060-0007>). 1996-1999 taken from the 2007 report.



| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------|------|
| Products in CEC dataset | - | - | - | 382 | 615 | 890 | 1398 | 1060 | 1113 |
| Products analysed | - | - | - | 368 | 601 | 876 | 1262 | 930 | 983 |
| % products included | | | | 96% | 98% | 98% | 90% | 88% | 88% |
| Shipments in AHAM dataset | 7,105,511 | 7,424,196 | 7,251,504 | 6,979,830 | 5,995,124 | 5,403,652 | 5,710,406 | - | - |
| Sales analysed | 7,105,511 | 7,424,196 | 7,251,504 | 6,979,830 | 5,995,124 | 5,403,652 | 5,710,406 | - | - |
| % Sales included | 100% | 100% | 100% | 100% | 100% | 100% | 100% | | |

1.4 Data manipulations and specific limitations

1.4.1 Overview of the mapping and benchmarking process

There are essentially 4 stages to the mapping and benchmarking process for dishwashers as detailed below:

| Stage: | Description |
|---------------------------------------|--|
| 1. Data Cleaning and Pre-processing | <ul style="list-style-type: none"> Removal of duplicate entries Pre-processing to align all terminology and reported test values to be consistent between countries Assigning of local, mapping and benchmarking and EU categories Etc |
| 2. Production of mapping outputs | <ul style="list-style-type: none"> Production of mapping outputs based on local test methodologies |
| 3. Normalisation of test data | <ul style="list-style-type: none"> Calculation of full cycle Unit Energy Consumptions Normalisation for test temperature differentials |
| 4. Production of Benchmarking outputs | <ul style="list-style-type: none"> Post processing of benchmarking results Production of benchmarking report |

The details of this process are described in two supporting documents that accompany this mapping report:

1. The **product definition** describes the exact characteristics of the product being analysed; the energy metrics that will be calculated; the technological, usage and other characteristics that will be considered; and any other policy or cultural information that will be collected
2. The **summary of approach** provides an overview of the mapping and benchmarking process for analyzing dishwashers for all countries and regions.

These documents can be found at the annex website:

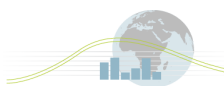
<http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=11>

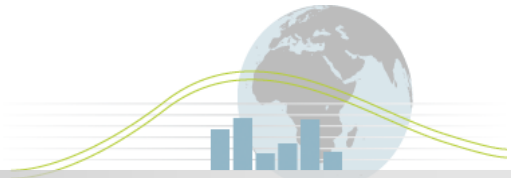
Aspects of the USA analysis that are specific to the local dataset or regulations are described below.

1.4.2 Specific cautions for the USA data

1.4.2.1 Data cleaning

The main steps for cleaning the product weighted data were as follows:





- The two California Energy Commission datasets (current and archive) were merged into one database.
- Models were allocated as being available on the market in a given year if:
 - the listed *Add date* was in or prior to the year, and
 - the listed *Modification (changed/deleted) date* was in or subsequent to the year.
- Potential duplicate models in the combined dataset were identified by comparing concatenated brand, model and energy consumption fields. Any duplicates were removed from each year in which they appeared, with the most complete entry (in terms of data available) being retained where duplicates existed.
- Some models in the current database did not have *Add dates*. Where no duplicate existed in the archived dataset, these models were assumed to be introduced to the market in 2012. If duplicate models did exist in the archive, the current model was assumed to be introduced into the market in the year after the model in the archive database was removed.
- After the above cleaning was undertaken, some models remained in the database that did not meet the USA Minimum Energy Performance Standards introduced from 2010. It was assumed that these products were incorrectly included in the database and these models were therefore removed. The number of models removed by year was as follows: 2010 - 128; 2011 - 116; 2012 - 116.
- Unit energy consumption per cycle was calculated as $1/\text{energy factor}$ and Annual UEC by $\text{UEC}/\text{cycle} * 215$.

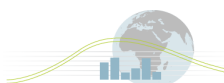
1.4.2.2 Test methodology details used in the analysis

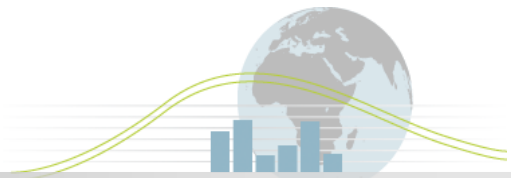
The specific aspects of the USA test methodology that were used in the benchmarking analysis are listed below:

- Ambient temperature is $75^{\circ}\text{F} \pm 5^{\circ}\text{F} = 23.9 \pm 2.8^{\circ}\text{C}$. This is assumed to be the temperature of the load at the start of the cycle.
- Inlet water temperature is either 50°F (10°C) or 120°F (48.9°C)⁹. If 120°F , the test procedure includes a calculation of the energy consumption needed to heat the water from 50°F to 120°F .
- The weight of the load by type is as follows:

| Number of place settings | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|--|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Mass of crockery in USA / Canada load (kg) | 7.48* | 9.185* | 10.27 | 10.27 | 10.27 | 10.27 | 10.27 | 10.27 | 10.27 | 10.27 | 10.27 |
| Mass of cutlery USA / Canada load (kg) | 1.175* | 1.35* | 1.525 | 1.525 | 1.525 | 1.525 | 1.525 | 1.525 | 1.525 | 1.525 | 1.525 |

⁹ The test procedure also has instructions for models with 140°F inlet water, but it is understood that very few, if any, of these models are currently available in the U.S. market and so this has not been included in the analysis.





** this load is for non-soil sensing machines. Soil-sensing compact dishwashers are tested with only 4 place settings. The database did not include any flag for soil-sensing models. However, given there is a maximum of 6 models in this capacity range in any given year, the assumption that all models are non-soil sensing will, if incorrect, have an indiscernible impact on the normalised averages.*

1.4.2.3 USA specific normalisation steps

In order to make the Unit Energy Consumption data comparable with that in other markets, the full cycle consumption needs to be estimated as described in the *summary of approach* report. Some entries in the Californian Energy Commission (product weighted) dataset had no data on whether the model was tested with a truncated cycle. Where this data was not available, and for the AHAM sales weighted averages, prior to the benchmarking analysis model Unit Energy Consumption (UEC) was adjusted to be equivalent to the full cycle consumption using the following formula:

$$UEC \text{ per full cycle} = \text{listed UEC per cycle} * (1 + * 7\%^{10} * 72\%^{11})$$

In order to make the (product weighted) data from the California Energy Commission comparable with that of the Benchmarking test methodology, a number of specific assumptions had to be taken:

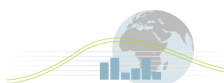
- For models where no capacity data was available (between 6-22% by year), the normalisation for loading was undertaken using the average capacity of dishwashers in the dataset for all models in the closest year for which data was available.
- For models where no water consumption was listed in the CEC dataset (between 65-100% by year), the water consumption of a given model was estimated using a linear trend relationship between water consumption and energy consumption derived from the 2012 models for which both these values were available. While the relationship between water and energy consumption is believed to be well correlated, the upward trend in USA water usage is not expected and is inconsistent with the downward trend seen in a very similar market in Canada (for which full market data is available). The 2012 data is available for 35% of the dataset which is a significant enough sample to provide a reliable correlation provided there is no skew in the sample, but the sample skew is unknown. Consequently, this aspect of the normalisation approach adds to the caution with which normalised USA product weighted results should be viewed.

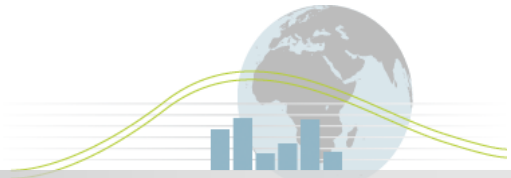
In order to make the (sales weighted) data from the AHAM comparable with that of the Benchmarking test methodology, a number of specific assumptions had to be taken:

- The assumed average capacity for load normalisation was the average across all years for models in the USA (California Energy Commission) dataset. Although this

¹⁰ The average % increase in UEC from truncated to full cycle / 2. This average was based on a series of tests on 18 machines undertaken by CSA International during 2011-13.

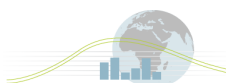
¹¹ The average % of models in the CEC dataset with powered drying functionality in years 2008-12 (those years with the most robust data). This may over estimate the number of models with powered drying in earlier years as there appears to be an increase in this functionality from 2008-12. If this trend extrapolates back in time, i.e. fewer models having powered drying in each previous year, this approach will overestimate UEC in earlier years (by a maximum of 4.9% if no models had powered drying).

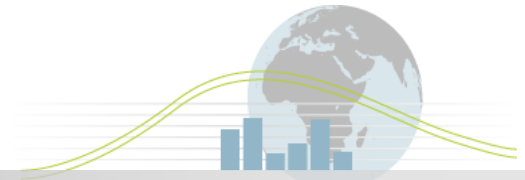




data covers a later time period, capacity has remained consistent and this, coupled with the fact that the load normalisation does not have a substantial effect on results, means that this assumption should not significantly change the caution with which normalised results should be viewed.

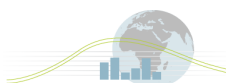
- The average water consumption of all shipments was assumed to be the same as the average of models in the Canadian (NRCAN) database in each year. The limited years for which comparable data was available in the USA (CEC) database suggests that USA machines may use as much as 15% more than Canadian models but this CEC result is from a dataset with only 30-35% coverage of water consumption and consequently, this difference may be due to sample skew i.e. the models for which water data is available may not be a representative sample of the market. While the Canadian data is therefore deemed to be a more robust proxy for USA consumption, this aspect of normalisation is uncertain and adds notably to the caution with which normalised USA sales weighted results should be viewed.

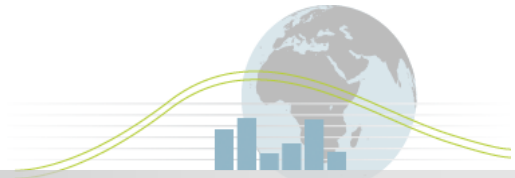




Section 2. Energy Consumption of the installed stock of dishwashers graphic

No additional notes.





Section 3. Major Policy Interventions

3.1 Minimum Energy Performance Standards

From 14 May 1994 the minimum performance standard was set at a minimum performance **Energy Factor (EF)** of:

Compact dishwasher 0.62 kWh/cycle

Standard dishwasher 0.46 kWh/cycle

Energy Factor (EF)

$$EF = 1 / (\text{Energy Consumption Per Cycle } (E_c))$$

From 1 January 2010, the minimum energy performance standard was revised to establish **Maximum** values for total annual energy consumption and water consumption:

Compact dishwasher energy consumption 260 kWh/year, water consumption 4.5 gallons/cycle

Standard dishwasher energy consumption 355 kWh/year, water consumption 6.5 gallons/cycle

From 30 May 2013, the maximum energy and water consumption standards were revised:

Compact dishwasher energy consumption 222 kWh/year, water consumption 3.5 gallons/cycle

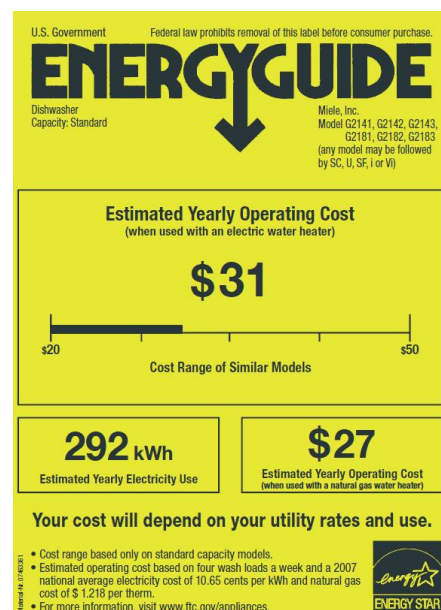
Standard dishwasher energy consumption 307 kWh/year, water consumption 5.0 gallons/cycle

3.2 Mandatory Labelling: EnergyGuide

In 1980, the Federal Trade Commission (FTC) Appliance Labeling Rule became effective, and requires that EnergyGuide labels be placed on all new appliances. The FTC is responsible for the design, implementation and compliance of this program.

The EnergyGuide label on refrigerators indicate how much electricity in kilowatt-hours (kWh) a particular model uses in one year.

The Federal Trade Commission announced in August, 2007 that it has concluded a two-year review of the FTC's Appliance Labeling Rule (16 C.F.R. Part 305) and, after substantial public comment and consumer research, has amended the Rule to improve the design and content of the EnergyGuide



label required on most new appliances sold in the United States¹². The yellow EnergyGuide label, familiar to most appliance shoppers, helps consumers compare the "operating costs" of competing models and aids them in identifying high-efficiency models that will reduce their energy use.

The new EnergyGuide label displays estimated yearly operating costs prominently for most appliance types. This estimated cost information, appears on the labels in dollars per year and provides consumers with a clear context to compare the energy efficiency of different appliance models. It also helps consumers assess trade-offs between the energy costs of their appliances and other expenditures. The new EnergyGuide label design continues to display energy consumption information (e.g., annual electricity use) as a secondary disclosure for most labelled products.

3.3 Voluntary Labelling: Energy Star

ENERGY STAR is jointly managed by the Environment Protection Agency (EPA) and the US Department of Energy (DOE) since 1992 as a voluntary, market-based partnership that seeks to reduce air pollution through increased energy efficiency. The program originally covered only computers, monitors and printers, but has now been expanded to cover a wide variety of appliances, equipment, building products and homes and windows. Products that have earned the Energy Star designation prevent greenhouse gas emissions by meeting strict energy-efficiency specifications set by the government.



- From 1 January 2001 – 31 December 2006, standard dishwashers could become ENERGY STAR qualified with an Energy Factor (EF) of at least 0.58.
- From 1 January 2007 – 10 August 2009, standard dishwashers could be ENERGY STAR qualified with an EF greater than or equal to 0.65, and compact dishwashers with an EF of at least 0.88.
- From 11 August 2009 to 19 January 2012, the minimum energy performance standards were revised to establish **Maximum** consumption values for total annual energy consumption and water consumption per cycle. Maximum values were:

Compact dishwasher energy consumption 234 kWh/year, water consumption 4.0 gallons/cycle

Standard dishwasher energy consumption 324 kWh/year, water consumption 5.8 gallons/cycle

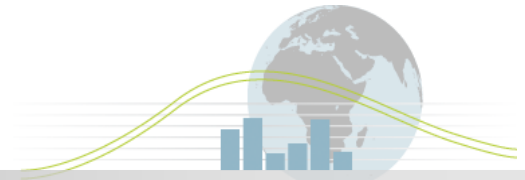
From 20 January 2012, Version 5.0 of the minimum energy performance standard became compulsory with the following revisions:

Compact dishwasher energy consumption 222 kWh/year, water consumption 3.5 gallons/cycle

Standard dishwasher energy consumption 295 kWh/year, water consumption 4.25 gallons/cycle

Subsequently, the ENERGY STAR plans to establish a Tier 2 cleaning performance requirement and at the same time revise the energy and water criteria.

¹² <http://www.ftc.gov/os/2007/08/070807appliancerule.pdf>



Section 4. Cultural Issues

No additional notes.

